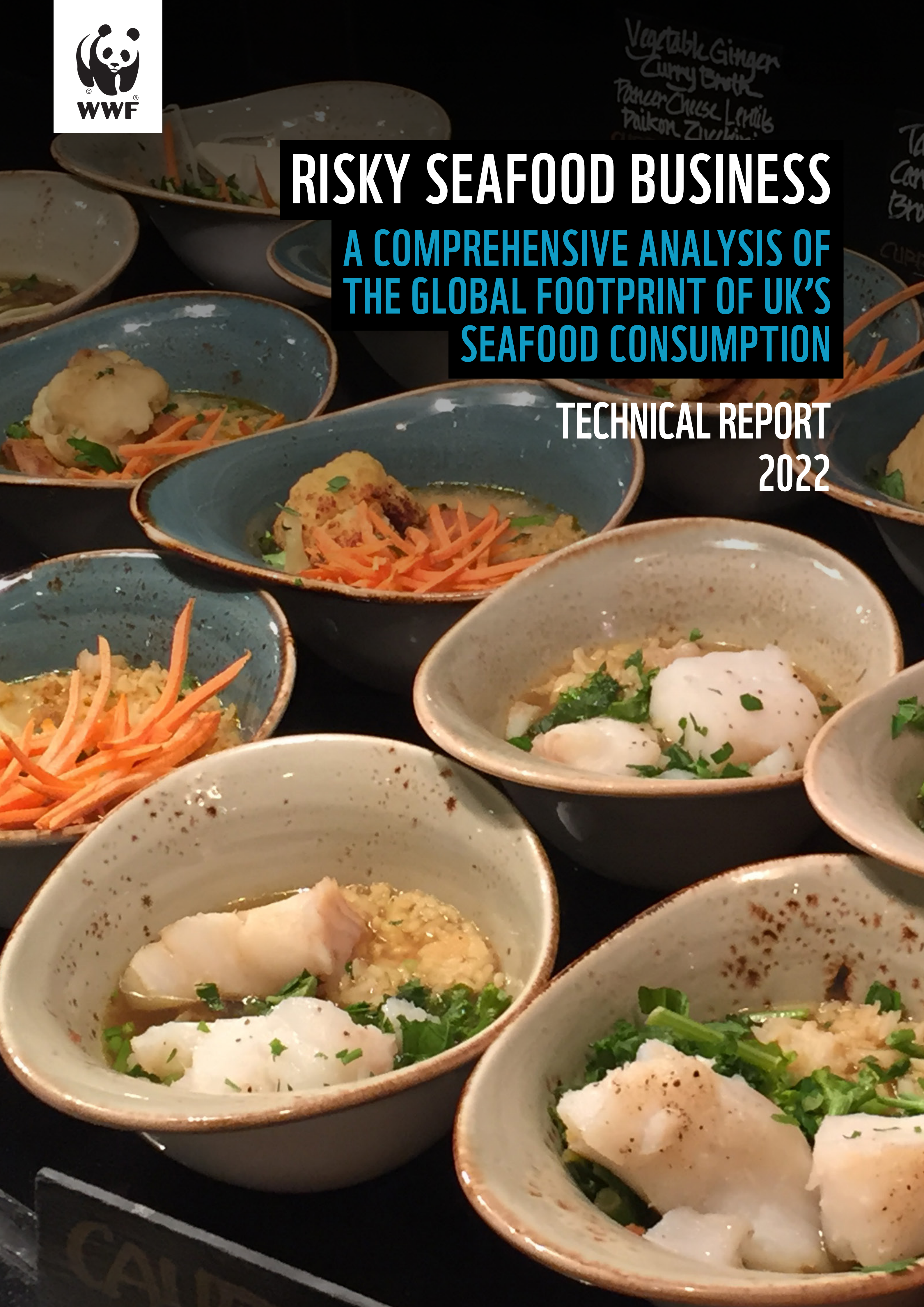

RISKY SEAFOOD BUSINESS

A COMPREHENSIVE ANALYSIS OF THE GLOBAL FOOTPRINT OF UK'S SEAFOOD CONSUMPTION

TECHNICAL REPORT
2022

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Atlantic Mackerel © Clarus Chu/WWF-UK

Executive Summary

For the full summary of this report, please read the 'Risky Seafood Business: Understanding the Global Footprint of the UK's Seafood Consumption Summary Report 2022'.

Why this report

- Humankind faces a triple challenge over the next 30 years: feeding a growing population, while staying on track to keep global warming below 1.5°C and reversing biodiversity loss.
- With the strict scrutiny on seafood sustainability in the late 1990s, the seafood industry has made important strides including the establishment of voluntary certification schemes, improvement projects to address specific ecological, environmental, feed, animal and/or human welfare issues and formation of pre-competitive industry platforms to advocate for sectoral improvement of fisheries policies and industry practices.
- The European Union (EU) and the UK governments have also implemented long-term management plans to rebuild depleted fish stocks such as cod, haddock and hake and introduced key fisheries management measures have included commitments to reduce fishing intensity, rebuild fish stocks in Europe and ban wasteful discards.
- Nevertheless, further urgent and collective action is needed to improve seafood sustainability in the UK.
- Although consumption of UK seafood is a multi-billion (£6.87 billion) business, there is no comprehensive analysis to understand the impact of the UK's global seafood footprint on nature and people.
- Footprint means the impacts of seafood extraction, production, consumption and related socioeconomic activities on nature and the functioning of natural systems, as well as the drivers and pressures that cause those risks and impacts.
- WWF UK's Global Footprint report[1] and the WWF Basket[2] call for 100% of marine resources consumed in the UK to be from sustainable sources by 2030.
- The purpose of this report is to provides evidence, analysis and recommendations to UK governments, businesses and consumers to further improve seafood sustainability and help achieve a reduction in that footprint, and in turn help tackle our nature and climate crises.
- The UK's departure from the EU offers an opportunity for UK governments to review and improve domestic seafood production policies, and to ensure new trade deals with other countries help mitigate the UK's global environmental, social and economic seafood footprint.

[1] https://www.wwf.org.uk/what-we-do/uk-global-footprint

[2] https://www.wwf.org.uk/basket-metric

- UK seafood businesses and consumers can also play important roles to drive the improvement required to build a future in which people live in harmony with nature and where sustainable seafood plays its part in meeting the challenges of the future.

Key Findings

This report analyses the footprint risks of 157 seafood supply chains across the eight most popular seafood groups. The quantity of seafood being eaten in the UK is estimated and the footprint of the UK's domestic seafood production is compared with producing countries that export seafood to the UK. This report also identifies key areas to address and mitigate the risks of the UK's global seafood footprint.

Key findings are:

1. The UK consumed 887,000 tonnes of seafood in 2019, equivalent to 5.2 billion portions of fish and chips. Nevertheless, the average UK consumption of fish is only a half of the government-recommended two portions of fish a week.
2. 81% of the seafood by volume consumed by the UK is imported from overseas but there are no environmental nor social regulatory criteria set for imported seafood apart from ensuring wild caught seafood is legally imported.
3. 70% of our domestic seafood production is exported overseas, but the new Fisheries Act (2020) does not yet have measurable sustainability targets. Additionally, the UK has a higher seafood footprint than some of our neighbouring countries in the Northeast Atlantic but lower than those countries in Africa and Asia.
4. Tuna, swordfish, warm-water prawns, squid and some crab species have the highest environmental and social footprint, while mussels and small pelagic fish (e.g. herring) have the lowest footprint.
5. Certification alone does not guarantee endangered, threatened and protected (ETP) species are free from threats associated with seafood production. The UK's seafood demand directly impacts at least 253 ETP species like birds, sharks and rays, and aquatic mammals and puts their survival at risk. Taking account of the overlapping of natural habitats of these species with fishing and fish-farming activities, the number of potentially affected ETP species increases to a staggering 528.
6. Human rights abuses and slow progress of sustainability certification are also urgent issues to address in reducing the UK's global seafood footprint, followed by issues concerning fish stock health, ecosystem impacts, management effectiveness, and illegal, unreported, and unregulated (IUU) fishing.

Conclusion and Recommendations

As a net importer of seafood, the UK's seafood footprint has significant environmental and social impacts far beyond our shores. In recognition of this, the seafood industry and governments have made some positive progress and improvements on how seafood is produced, managed and sold in the UK in the past two decades, such as commitments to certification schemes, support of fisheries improvement projects and advocacy on fisheries policy reforms, but there is much more still to do.

This report analyses the global footprint of the UK's seafood consumption and highlights opportunities to shift towards lower footprint (or impact) species that could potentially help address the nature and climate crises. The Sustainability performance of major seafood-producing countries for the UK market is assessed and key sustainability issues that require further improvement are identified.

Seafood has the potential to be a part of the solution to the triple challenge of meeting the needs of people while restoring nature and keeping the global temperature within safe limits. It is estimated that global seafood production could increase by 36-74% by 2050 to support the demand for protein if fisheries policy reforms, technological innovations and wider acceptance of new approaches including land-based farmed seafood can be achieved.36 If the public follow the UK governments' recommendation to consume two portions of fish a week, and to account for future human population growth, urgent and collective action must be taken to ensure 100% of our seafood comes from sustainable sources, including an increase in consumption of UK locally produced seafood and a reduced reliance on imported seafood.

Concerted and collaborative efforts from UK governments and retailers are required to shift UK seafood production onto a sustainable footing for the long term and avoid exporting our environmental footprint to other countries. UK governments should lead the way in filling the current gaps in regulations and standards for both imported and domestic seafood. UK businesses should support sectoral transformation on seafood sourcing. At the same time, consumers can help by making responsible seafood choices.

Specific recommendations for the UK governments, business and consumers are as follows.

Recommendations to the UK governments

1. Set meaningful and measurable targets for UK domestic seafood production to meet the objectives of the Fisheries Act (2020), and to ensure fish stocks are healthy, fishing does not exceed sustainable limits, the recovery of ETP species including through implementation of Remote Electronic Monitoring (REM) with cameras, protection of biodiversity, and that seafood production progresses towards Net Zero. The UK seafood production policies need to ensure:
    - There are healthy stocks of fish that are fished at a Maximum Sustainable Yield (MSY) with at least Spawning Stock Biomass (SSB) of 40% unfished stock (i.e. SSB40) together with the fishing mortality at less than 1 (F/Fmsy <1) and catch quotas are set based on the best available evidence and science.
    - Bycatch of ETP species will be minimised and ultimately eliminated through a strengthened UK's Bycatch Mitigation Initiative, better data collection with Remote Electronic Monitoring (with onboard cameras) and innovation of fishing gears.

- Seafood production supports the Climate objectives of the Fisheries Act to contribute to the UK's Net Zero target through decarbonising fleets, protecting the UK's blue carbon ecosystems and reducing greenhouse emissions of feed.
- Support is provided to fishers and fish farmers to transition to sustainable practices.

2. Develop a set of core environmental standards for imported seafood alongside those for agricultural products to help deliver a strong and comprehensive sustainable food strategy. The US Marine Mammal Protection Act (1972) provides an example of how this can be done in the context of protecting marine mammals from the impacts of fishing.
3. Strengthen the illegal, unreported and unregulated (IUU) fishing regulations to develop due diligence requirements for imported seafood (similar to deforestation risk commodities) and demonstrate leadership in international fisheries management and trade forums. The UK governments should:
   - Seek collaboration with other key consumer countries and regions like the EU, US and Japan to reduce global IUU fishing activities and improve traceability.
   - Develop due diligence requirements for imported seafood (similar to deforestation risk commodities in the Environment Act) to mandate annual reporting and increase transparency for UK businesses.
   - Further its influence in the World Trade Organization (WTO) to support the inclusion of seafood supply chains in the development of international environment standards and the proposed *Codex Planetarius*.
   - Support the WTO in ending harmful subsidies in seafood production.
4. Provide financial support, for example through the UK's Blue Planet Fund, to lower income countries and the UK Seafood Fund for UK producers like fishers and fish farmers to help reduce their seafood production footprint and support technical innovations.
5. Improve data product code systems and sourcing data to make them fit for purpose for ensuring traceability of modern supply chains.

Recommendations to the UK businesses

1. Adopt the Seascape approach of the WWF Basket that goes beyond certifications with time-bound and publicly available targets to reduce seafood footprints, including through promoting low footprint seafood consumption and investing in regional seafood processing facilities.
2. Work with supply chains including catching and fish farming sectors to close traceability gaps of their products to reduce IUU fishing risks and increase transparency of fishmeal and fish oil used in feed.
3. Publicly disclose sustainability information on seafood species sold to inform consumer choices.

4. Advocate for improvements to government regulations, third-party certification schemes including small scale fisheries and support seafood producers on technological innovations to reduce seafood footprints.

Recommendations to the UK consumers

1. Opt for lower footprint seafood choices where possible, particularly locally produced seafood such as UK mussels, to decrease the demand for imported seafood.
2. Follow WWF's 'top tips' on seafood consumption, including more diverse and low trophic level species like sardines, to reduce pressure on more popular choices.
3. Support calls for more stringent core environmental standards for imported food and improved labelling requirements, including for seafood.

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Acronyms

ASC	Aquaculture Stewardship Council
ADD	Acoustic Deterrent Device
BAP	Best Aquaculture Practices
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CN-8	8-digit Combined Nomenclature classification
EBIT	Earnings Before Interest and Tax
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
eNGO	(environmental) Non-Government Organisation
ETP	Endangered, Threatened and Protected
EU	European Union
FAOSTAT	Food and Agriculture Organisation Corporate Statistical Database
FCR	Feed Conversion Ratio
FFDR	Forage Fish Dependency Ratio
FIP	Fishery Improvement Project
FMFO	Fish Meal and Fish Oil
GAA	Global Aquaculture Alliance
GES	Good Environmental Status
GDST	Global Dialogue on Seafood Traceability
GHG	Green House Gas
GLOBALG.A.P.	Good Agriculture Practices certification
HCR	Harvest Control Rule
HMRC	Her Majesty's Revenue and Customs
HS-2	Harmonized System of Goods Classification - Chapters

HS-4	Harmonized System of Goods Classification - Headings
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IFFO	The Marine Ingredients Organisation
IOTC	Indian Ocean Tuna Commission
ITUC	International Trade Union Confederation
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated
LCA	Life Cycle Assessment
MEP	MacAlister Elliott and Partners Limited
MMO	Marine Management Organisation
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NEAFC	North-East Atlantic Fisheries Commission
RAS	Recirculatory Aquaculture System
RFMO	Regional Fisheries Management Organisation
TACs	Total Allowable Catches
TARIC	Integrated Tariff of the European Union
UK	United Kingdom
UN FAO	United Nations Food and Agriculture Organisation
US	United States
VME	Vulnerable Marine Ecosystems
WCPFC	Western and Central Pacific Fisheries Commission
WGBYC	Working Group on Bycatch of Protected Species

WWF	World Wild Fund for Nature

1. Introduction

Seafood collectively refers to the fish, shellfish and other types of edible sea life consumed by people, and it can be produced by wild caught fisheries or aquaculture farms. Footprint of the global seafood supply is primarily determined by the collective consumption demands of different nations as opposed to the seafood production within each nation. Hence, nations should be accountable for the environmental footprint of what they consume and not only what they produce. WWF-UK's recent analysis of ten key drivers of environmental impacts including marine resource use, identified the need for significant reform, in order for the UK to vastly reduce (by 75% by 2030) its global environmental footprint to levels which are within planetary limits. Accordingly, WWF-UK has called on the UK government to 'put its own house in order' by reducing the impact of production and consumption, both at home and overseas[3].

Analysis on international supply chains has made the case for international collaboration on long-term sustainability of all seafood production[4], which needs to be underpinned by holistic national policies. A key challenge for governments is to ensure that trade policies are aligned to support policy objectives relating to sustainability of resource use and food security[5]. The UK's departure from the EU offers an opportunity for the UK government to review and improve upon policies that monitor, manage and mitigate the impact of the UK's global environmental, social and economic seafood footprint.

Here, 'footprint' refers to the impacts of seafood extraction, production, consumption and related socioeconomic activities on nature and the functioning of natural systems, as well as the drivers and pressures that cause those risks and impacts. In a nutshell, our 'global seafood footprint' describes the potential impact of the seafood we produce and consume in the UK, on our domestic environment and environments overseas.

UK fisheries turnover about £1 billion per year, with pelagic quota species (such as mackerel and herring) dominating UK landings by volume (54%). The majority of UK fisheries landings from the North-East Atlantic in 2019 (618,000 tonnes) came from UK waters (>80% by volume and value). The second most important waters for the UK fleet were those of the EU, accounting for 15% of landings (8% by value) from North-East Atlantic waters[6].

However, the UK is a net importer of seafood – it has been noted to import what we eat and export what we catch[7]; the majority of UK catch is instead sold overseas. The proportion of UK seafood consumption that comes from imports has risen steadily in recent years[8]. In 2019, over

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[3] https://www.wwf.org.uk/press-release/uk-global-footprint-report

[4] *Guillen J et al. 2019, Global seafood consumption footprint: https://doi.org/10.1007/s13280-018-1060-9*

[5] *Blue Food Assessment: https://www.bluefood.earth/*

[6] https://www.gov.uk/government/statistics/uk-commercial-sea-fisheries-landings-by-exclusive-economic-zone-of-capture-report-2019

[7] *Rutherford J. 2009. "Sea fish" in Feeding Britain, Bridge J & Johnson N, eds., The Smith Institute, London. https://www.bl.uk/britishlibrary/~/media/bl/global/social-welfare/pdfs/non-secure/f/e/e/feeding-britain.pdf*

[8] *Jennings S et al. 2016: https://doi.org/10.1111/faf.12152*

720,000 tonnes of seafood valued at £3.5 billion was imported and more than 450,000 tonnes valued at £1.8 billion was exported[9,10].

Capture fisheries and aquaculture make vital contributions to global food security as a direct source of protein, micronutrients, and fatty acids, but also indirectly via employment income which can be used to purchase other food sources. However, fishing activities have been identified as the greatest threat to ocean biodiversity in 2019[11] and the Food and Agriculture Organization of the United Nations (UN FAO) reported that the global fish stock status has worsened in the past 40 years, with the proportion of stocks considered to be underexploited having reduced from 26% to 7% since the 1970s[12]. Closer to home, a recent analysis of the stock size and exploitation status of over 100 fish and shellfish stocks fished by the UK fleet, primarily in UK waters, found that only around 36-38% were healthy in terms of stock size and / or were being sustainably exploited, whereas 20-30% were in a critical condition and / or were being overfished, with the remainder subject to scientific data limitations, leaving them at greater risk of unsuitable management decisions[13].

The ecological impact of fishing goes well beyond the direct effects on populations of targeted species. Bycatch of non-targeted species – from starfish to seabirds to cetaceans, physical damage to the seafloor by benthic mobile gears, ghost fishing by lost gears and changes in community composition and species diversity are some of the most frequently documented ecosystem impacts of fisheries. The UK's domestic fishing industry is far from innocent in this respect. For example, an estimated 20,371 tonnes of King scallops (*Pecten maximus*) worth over £47 million were harvested in UK waters in 2019, mainly by scallop dredges – considered to be one of the most indiscriminate fishing methods[14]. Further, the current best estimate of annual porpoise bycatch in UK gillnet fisheries is 1,250 (range 606–3,114) animals[15].

Globally, Illegal, Unreported and Unregulated (IUU) fishing[16] is estimated to represent up to 26 million tonnes of fish caught annually, valued at USD 10 to 23 billion (£7.4 to £17 billion GBP). IUU fishing poses a direct threat to food security and socioeconomic stability in many parts of the world. Developing countries that depend on fisheries for food security and income are considered most at risk. IUU fishing undermines national and regional efforts to conserve and manage fish stocks and, as a consequence, inhibits progress towards achieving the goals of long-term sustainability and responsibility[17]. Additionally, human rights abuses in global and

[9] *Uberoi E et al. 2020. UK Fisheries Statistics: https://researchbriefings.files.parliament.uk/documents/SN02788/SN02788.pdf*

[10] *https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2019*

[11] *IPBES Global assessment: https://ipbes.net/global-assessment*

[12] *FAO Sofia 2020: http://www.fao.org/publications/sofia/2020/en/*

[13] *Guille, H., Gilmour, C., Willsteed, E. 2021. UK Fisheries Audit. Report produced by MEP for Oceana: https://europe.oceana.org/en/publications/reports/uk-fisheries-audit*

[14] *Stewart B & Howarth L. 2016: https://doi.org/10.1016/B978-0-444-62710-0.00018-3*

[15] *http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/byc.eu.pdf*

[16] *For a definition of IUU fishing, see: http://www.fao.org/iuu-fishing/background/what-is-iuu-fishing/en/*

[17] *http://www.fao.org/iuu-fishing/en/*

local seafood supply chains are widely reported including modern slavery and death of observers[18][19][20].

Concerns over and evidence of seafood mislabelling have increased over the past decade. Given that seafood is one of the world's most highly traded food commodities[21], this poses significant issues for sustainability, safety and ethics. For example, the European Parliament identified seafood as the second highest category of foods at risk of fraud[22]. One challenge to addressing mislabelling of seafood is that it can take a variety of forms, including misrepresentation of species, farmed versus wild sourcing, and geographical origin[23]. A study of cod products in the UK revealed around 7% were mislabelled, and more worryingly threatened Atlantic cod was being sold as 'sustainably sourced' Pacific cod[24].

Furthermore, global climate change will affect the ability of many fish stocks to withstand the impacts of fishing leading to further population declines and ecosystem impacts if the current levels of unsustainable exploitation continue, as well as directly reducing catch potential – most notably in the regions of the world where food insecurity poses the greatest risk to societies[25,26,27]. The seafood industry itself also has a substantial carbon footprint[28] e.g., through disturbance of blue carbon habitats (carbon captured and stored in marine habitats and species, which can exceed terrestrial ecosystems such as forests and peatlands), fuel use and greenhouse gas emissions by vessels, refrigeration and transport of produce, production of aquaculture products and feed. These impacts are rarely integrated into assessments of sustainability[29].

Aquaculture production has vastly increased in the last couple of decades. Whilst there are obvious benefits for the environment and people, farming carnivorous species like salmon, sea bass and sea bream still requires inputs of wild fish for feed. Some aquaculture systems also inflict ecological impacts such as reduced wild fish supplies through habitat modification, wild seedstock collection – or overharvesting in case of cleaner fish to control lice problems[30].

The level of interaction between capture fisheries and aquaculture and the globalisation of the seafood supply chain, highlights the need to account for inter-industry flows and dependencies,

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[18] *https://www.theguardian.com/environment/2020/may/22/disappearances-danger-and-death-what-is-happening-to-fishery-observers*

[19] *https://www.seafoodsource.com/news/supply-trade/suspected-slavery-victims-rescued-from-uk-fishing-boats*

[20] *https://www.theguardian.com/global/2022/may/17/migrant-workers-exploited-and-beaten-on-uk-fishing-boats#:~:text=A%20third%20of%20migrant%20workers,and%20abuse%20on%20British%20ships.*

[21] *https://research.rabobank.com/far/en/sectors/animal-protein/world-seafood-trade-map.html*

[22] *European Parliament 2013: https://www.europarl.europa.eu/doceo/document/A-7-2013-0434_EN.html*

[23] *Kroetz, K et al. 2020:* https://www.researchgate.net/publication/346256877_Consequences_of_seafood_mislabeling_for_marine_populations_and_fisheries_management

[24] *Miller D et al. 2011: https://doi.org/10.1111/j.1467-2979.2011.00426.x*

[25] *Free et al. 2020: https://doi.org/10.1371/journal.pone.0224347*

[26] *https://www.ipcc.ch/srocc/*

[27] *Plaganyi et al. 2019: https://science.sciencemag.org/content/363/6430/930*

[28] *https://www.wwf.org.uk/achieving-climate-smart-fisheries*

[29] *Madin E & Macreadie P, 2015: https://www.sciencedirect.com/science/article/pii/S0308597X15000585?via%3Dihub*

[30] *Naylor et al. 2000: https://www.nature.com/articles/35016500*

as well as international trade when assessing the long-term sustainability of the seafood supply chain[4].

1.1 Objectives of the report

Although the UK's seafood market is a multi-billion business, there is no comprehensive analysis to understand the UK's seafood footprint regarding the global biodiversity loss or climate change contribution and their associated risks on nature and people. Nor is there a comprehensive estimation of actual UK consumption. Additionally, we are facing a triple challenge: feeding a growing population, while staying on track to keep global warming below 1.5°C and reversing biodiversity loss.

The purpose of the report is to provide a high-level, robust and replicable assessment of the global (domestic and international) footprint of the UK's seafood production and consumption, and of value chains reliant on marine species used as feed in aquaculture.

The report provides a baseline that can i) be used to set and monitor progress towards the UK's global footprint reduction targets; and ii) be shared and used to encourage active participation by the UK government and seafood industry, in the development of domestic policies, trade policies and agreements that act upon the UK's accountability for the impact of its seafood supply chain.

In doing so, the report aligns with the WWF and RSPB's 'Riskier Business' report[31], which focuses on social and deforestation risks posed by seven key terrestrial commodities.

More specifically, the report will help inform WWF-UK's seafood and fisheries policy development alignment with the targets of the WWF-UK's Global Footprint report and Basket Metric of bringing about systemic change in food systems and reducing the UK's global footprint by three quarters by 2030 to meet planetary limits[32]. In order to meet WWF-UK's target of '100% of marine resources from sustainable sources by 2030'[32], there will need to be rapid and significant changes to the UK's seafood sourcing policies and supply chains[33], as well as to the UK's sustainable management of its own resources.

A key limitation to achieving that target is the widespread gaps in data and information relating to sources of seafood, the environmental and social risks associated with that production and understanding of what sustainable marine resource exploitation looks like in reality. This report aims to address some of those gaps where possible, but importantly also attempts to highlight where the priorities lie for further evidence in order for the government, industry and consumers to make informed decisions.

1.2 Scope of the report

The UK has a geographically extensive and complex seafood footprint that has multiple components, including wild capture and aquaculture production. The aim of the report is to

[31] *Riskier Business: https://www.wwf.org.uk/riskybusiness*

[32] *https://www.wwf.org.uk/what-we-do/uk-global-footprint*

[33] *https://www.wwf.org.uk/basket-metric*

inform seafood (fisheries and aquaculture) policy development, sourcing and consumer seafood choices by illuminating the links and sustainability of supply chains associated with key:

- Wild capture fishery produced seafood consumption commodities caught by the UK fleet;
- Wild capture fishery produced seafood consumption commodities imported to the UK;
- Aquaculture produced seafood consumption commodities produced by the UK industry;
- Aquaculture produced seafood consumption commodities imported to the UK;
- Marine species used as feed for aquaculture products that are produced in or imported to the UK (case study).

These five categories of supply chains collectively form a complex network that originate from the UK or are imported into the UK via tropical, temperate and cold-water wild capture fisheries and aquaculture industries scattered around the globe. This network is not well articulated; therefore, this report will provide an evidence base of characteristics of the supply chains and supply chain map that can be used to stimulate the UK government to adopt a strategic approach to reducing the UK's collective seafood consumption footprint.

1.3 About this document

The core of this document comprises a summary overview of the UK's production, imports, exports and estimated consumption of seafood in 2019, and is based on UK fishing vessel landings and aquaculture data and HMRC trade data (Section 3).

While summarised analyses are presented in Section 4, a more detailed analysis of those data then follows in Sections 5-12 for eight 'focus commodities' – seafood commodity groups which are key players in the UK's seafood supply chain and consumption. Within each commodity section, a number of sub-resources are investigated (thirty-three in total). For each seafood resource, an overview of the UK supply chain and the outcomes of a risk assessment, which collectively form the supply chain footprint, are presented for each supply chain. Details of the evidence base and justification for the risk assessment scores are provided in Appendix 1.

Sections 13-16 contain case studies focused on:

- The extent of the UK's global seafood supply chain interaction with Endangered, Threatened or Protected (ETP) species
- An overview of key regulations and players and their influence on the UK's supply chain
- The role of processing / trading countries in the UK seafood supply chain
- The risks associated with fishmeal, feed and oils production for aquaculture commodities in the UK supply chain

In Section 17, the limitations to the analysis are highlighted and discussed. Finally, in Section 18 some key high-level recommendations are provided for the UK government, key players in seafood supply chains and the UK public.

Appendices 1 and 2 contain the evidence base and data underpinning the report, and Appendix 3 provides a full list of ETP species that are at risk owing to UK's seafood consumption. Appendix 4 provides a glossary of stock assessment related terms referred to in the risk assessment.

2. Overview of method

The following section provides an overview of the method used to determine and quantify the UK's main seafood supply chains and seafood consumption. The approach to the supply chain risk assessment and footprint representation is also described. Where applicable, commodity specific methods are also provided within the relevant commodity chapters. Data limitations and issues are documented, with more specific information provided in the commodity sections where applicable.

Data permitting, 2019 was assumed to be representative of recent production and trade patterns. However, due to the impact of the COVID-19 pandemic and Brexit, it should be noted that patterns may not hold true for 2020 and 2021. However, it is anticipated that following the easing of the UK's national lockdown, consumption has largely returned to pre-pandemic levels and trends.

2.1 Focus commodity specification

Whereas Section 3 of the report provides an overview of the range of the UK's seafood production and an estimation of consumption in 2019 (where possible), Sections 5-12 focus on the most important seafood commodities for UK consumers and their domestic and international supply chains. Those commodities and the resource sub-categories were chosen at the start of the project based on published information on the UK's seafood consumption reported by Seafish[34] as well as known knowledge. Analysis of the UK trade data (see below) led to further refinement of the resources under consideration within each commodity category (i.e. those to which the risk assessment and footprint estimation was applied, see Sections 2.3 and 2.4 for more details). The resulting list is as follows (8 commodity groups, 33 resources sub-categories):

Commodity groups	Resource sub-categories
Whitefish	Atlantic cod, Greenland cod[35] Haddock Monkfish Pacific cod, Greenland cod[35] Saithe Alaskan pollock European pollack
Salmonids	Atlantic salmon, Danube salmon[35] Pacific salmon Trout
Crustaceans	European lobster, American lobster Norway lobster (= Scampi, Langoustine or Dublin Bay prawn) Other crab (inc. Blue swimming crab, Snow crab) Edible crab

[34] *Seafish is a UK non-departmental public body supporting the seafood sector: https://www.seafish.org/insight-and-research/retail-data-and-insight/*

[35] *Greenland cod / Stripe-bellied bonito / Danube salmon represent a small proportion of imports within this resource sub-category, however due to the structure and specification of the trade data, no further separation of species was possible.*

	Warm-water prawns Cold-water prawns
Large pelagics	Albacore tuna Skipjack tuna (or Stripe-bellied bonito)[35] Swordfish Yellowfin tuna
Molluscs	Squid (*Loligo* spp.) Scallops (inc. Queen scallops, King scallops) Shortfin squid Mussels (*Perna* spp.) Mussels (*Mytilus* spp.)
Small pelagics	Herring Mackerel Sardines (European pilchard, other)
Farmed whitefish	Catfish (= basa/ *Pangasius* spp.) Sea bream European sea bass
Flatfish	Plaice Sole

2.2 Quantifying the UK's production, imports, exports and consumption

2.2.1 UK seafood consumption in 2019

The UK's seafood consumption was estimated as the product of domestic production (wild capture and / or aquaculture) and international imports, minus exports of the UK's products:

UK consumption of resource X = (UK landings of resource X + UK aquaculture production of resource X + Imports of resource X) – Exports of resource X

where *resource X* is specified at the most detailed level permitted by the data sources e.g., species in some cases, common family group in others. Key assumptions in the estimation of consumption are therefore:

- Imported seafood is consumed in the UK and not re-exported (with some exceptions)
- Exported seafood is not consumed in the UK (i.e., is not re-imported following processing)

The method used to quantify production, imports and exports is described in detail below. Issues arising from data limitations, which in turn result in under- or over-estimation of consumption, are also described.

Also to note, joining of the MMO landings data with HMRC trade data (see Sections 2.2.2 and 2.2.4) meant numerous assumptions were required to determine overlap between specified resources in each data set. This was only done where there was a reasonable level of confidence. Where there was a high level of uncertainty (or it was impossible due to generic commodity codes), the data were kept separate. This adds to the uncertainty in the consumption estimates e.g. because UK production was assumed to be retained in the UK (and eaten), when in fact it was exported – but the two datasets could not be reliably combined for that resource. The consumption estimates should therefore only be viewed on a relative scale, rather than focusing on the precise estimates.

2.2.2 UK wild capture fisheries production

Marine Management Organisation (MMO) landings data[36,37] were used to calculate total volumes landed in 2019 by species / family group (as per the MMO classification system) by the UK fleet. Landings data for all UK vessels (including vessels registered to the four Devolved nations, the Channels Islands, and the Isle of Man) were included in the analysis, as were catches from both within and outside the UK Exclusive Economic Zone (EEZ).

Due to data limitations, for the majority of species the data cannot be separated by location of landing (e.g. UK port or non-UK port). This means there may be some duplication in the figures. For example, UK vessel catches landed in a foreign port and imported into the UK would be both counted as imports from the country where the fish was landed by the UK vessel and included in the UK production figures. However, for some of the most commercially important species[38], data are available that enables the analysis to be based on landings into the UK only[36]. This still means that some of those landings may be categorised as imports from a non-UK country but avoids the over-estimation of UK consumption of key species such as mackerel which are caught in large quantities by the UK fleet, with notable portions of those catches landed in Norway, for example.

Similarly, there are data gaps relating to non-UK vessel catches in UK waters. An analysis was undertaken by the MMO for 2012-2016 to inform the Brexit preparations[36], but this exercise is not routinely carried out and discussions with the MMO suggest that data on non-UK flagged production from UK waters is not easy to obtain. Given the scale and extent of non-UK vessel activity in UK waters, this is a sizeable knowledge gap.

Implications for this report include the issue that non-UK vessel landings in the UK are not available at the species level (e.g. data are more aggregated than UK vessel landings), meaning there will be an underestimation of consumption where those catches are retained in the UK. Where they are exported, they will be incorrectly deducted from the UK fleet's contribution to consumption.

2.2.3 UK aquaculture production

Total quantities of farmed seafood produced in UK waters in 2018[39] (the most recent data available at the time of analysis) was determined from Eurostat 'Production from aquaculture excluding hatcheries and nurseries' data[40].

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[36] https://www.gov.uk/government/statistics/uk-commercial-sea-fisheries-landings-by-exclusive-economic-zone-of-capture-report-2019

[37] https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2019

[38] *For example, cod, monkfish, megrim, plaice, saithe, blue whiting, herring, mackerel, crabs.*

[39] *2019 data were not available at the time of writing the report*

[40] https://ec.europa.eu/eurostat/databrowser/view/fish_aq2a/default/table?lang=en

2.2.4 UK imports of seafood derived from wild capture and aquaculture

Quantifying the UK's imports

Annual import volume (in kg converted to tonnes, t) of all seafood in 2019 (Section 3) and for the focus commodities for the period 2015-2019 (Sections 5-12) were obtained from HMRC trade data[41]. The data allow analyses by source country (imports), recipient country (exports – see later) and variable levels of taxonomic nomenclature (e.g. species in some cases, family groups in others, etc).

Import data were extracted for the following two HS-2 commodity codes[42]:

- *03 Fish and crustaceans, molluscs and other aquatic invertebrates*
- *16 Preparations of meat, fish or crustaceans, molluscs or other aquatic invertebrates*

corresponding to the following ten HS-4 codes[42]:

- *03 HS2 Below Threshold Trade*
- *0302 Fish, fresh or chilled (excl. fish fillets and other fish meat of heading 0304)*
- *0303 Frozen fish (excl. fish fillets and other fish meat of heading 0304)*
- *0304 Fish fillets and other fish meat, whether or not minced, fresh, chilled or frozen*
- *0305 Fish, fit for human consumption, dried, salted or in brine; smoked fish, fit for human consumption, whether or not cooked before or during the smoking process; flours, meals and pellets of fish, fit for human consumption*
- *0306 Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine, even smoked, incl. crustaceans in shell cooked by steaming or by boiling in water; flours, meals and pellets of crustaceans, fit for human consumption*
- *0307 Molluscs, fit for human consumption, even smoked, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; flours, meals and pellets of molluscs, fit for human consumption*
- *0308 Aquatic invertebrates other than crustaceans and molluscs, live, fresh, chilled, frozen, dried, salted or in brine, even smoked; flours, meals and pellets of aquatic invertebrates other than crustaceans and molluscs, fit for human consumption*
- *1604 Prepared or preserved fish; caviar and caviar substitutes prepared from fish eggs*
- *1605 Crustaceans, molluscs and other aquatic invertebrates, prepared or preserved (excl. smoked)*

The main code exclusion was '*Fats and oils of fish or marine mammals*' (1503) on the basis that the product could not be attributed to any specific fish species, nor could it be confirmed that the product was used for human consumption alone. Further, aquaculture feed falls under the category of '*Flours, meals and pellets, of meat or meat offal, of fish or of crustaceans, molluscs or other aquatic invertebrates, unfit for human consumption*' (2301). Whilst feed falls within the scope of the project, the lack of information associated with this data category (i.e. composition,

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[41] https://www.uktradeinfo.com/

[42] HS commodity codes refer to the Harmonized System (HS) of goods classification developed by the World Customs Organisation. The HS is organised into sections divided into chapters (2 digit codes, HS-2), headings (4 digit codes, HS-4) and subheadings (6 digit codes, HS-6). The EU's Combined Nomenclature (CN) system classifies goods at 8 digit level, with the first 6 digits based on the HS. For further information, see: https://www.uktradeinfo.com/find-commodity-data/help-with-classifying-goods/ and associated links.

end usage) severely limited its application and so a more descriptive case study approach was applied to this component of the assessment (see Section 136).

Key data limitations and assumptions

Since HMRC trade data are used primarily for taxation purposes, the data presented some limitations and therefore assumptions were required to enable analysis for the purposes of this report, as discussed below.

Data were selected using the most detailed 8-digit Combined Nomenclature classification (CN-8) where possible / applicable (amounting to around 400 individual CN-8 codes being analysed)[42]. As trade data commodity codes often include more than one seafood species, the data were categorized as best as possible to facilitate comparison and co-joining with the MMO landings data and to assign CN-8 codes to the focus commodities. A key limitation to this task is the prevalence of generic commodity codes in the trade data, for example providing minimal specification of taxonomic nomenclature, referring to multiple genera or families or even simply to 'fish fillets' alone[43].

Further, trade of businesses that falls below a statistical threshold (defined by weight or monetary value) are permitted to aggregate the items they trade in their trade declarations[44,45]. This results in significant quantities of data (e.g. 4.8% of imported seafood in 2019, equivalent of 34,700 tonnes) being assigned to the '03 HS2 Below Threshold Trade' code for which no further composition detail is available. Both imported and exported products that are assigned to these generic codes may help explain any over- or under-estimation of the UK's seafood commodity consumption. It is also assumed, for example, that the more exotic seafood products that appear on the UK market, such as tropical fish species at Billingsgate Fish Market[46], are hidden within this commodity code.

In some cases, trade data commodity codes with a mixture of or undefined species were reassigned to focus commodities. For example, in 2019, nearly 109,000 tonnes of tuna were imported under 27 CN-8 codes with ~6% of that tuna (6,000 tonnes) recorded under generic codes which did not specify a species (e.g. '*tunas of the genus Thunnus*', or similar). Therefore, the unspecified data were proportionally reassigned across the main resource sub-categories (for tuna this was skipjack and yellowfin which collectively accounted for around 93% of imported tuna) and countries (those from which ~90% of the imports of the main resource-subcategories were derived). This clearly represents a notable, but reasonable, assumption in the analysis and results. For resources such as tuna, the alternative approach was discounting relatively large quantities of data and potentially misrepresenting the main supply chains.

A further limitation that arises from the lack of seafood traceability data is the inability to establish precise ratios of farmed to wild for each resource (where applicable). Instead, wild

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[43] *In 2019, over 68,000 tonnes of seafood imports and 37,000 tonnes of exports were recorded against the most non-descript commodity codes.*

[44] https://www.gov.uk/government/statistics/overseas-trade-statistics-methodologies/overseas-trade-in-goods-statistics-methodology-and-quality-report

[45] https://www.gov.uk/guidance/check-the-statistical-threshold-for-the-uk-in-2020-cip17

[46] *For example,* see http://www.jbennetts.co.uk/exotic.html

capture and aquaculture production data[47] were used to estimate whether the majority of a given resource (i.e. salmon, warm-water prawns, catfish, sea bass and sea bream) imported from a source country are farmed. For the purposes of this report, the assumption has been made that where the majority of supply is estimated to be farmed, the resource is classified as being derived from aquaculture production.

The available taxonomic information was extracted to produce as complete a list as possible of all species / genera consumed in the UK, although a volume (tonnage) could not necessarily be assigned to each entry due to the data specification issues stated above.

In a number of cases, estimates of negative UK consumption of a seafood species / family group (etc) were derived (see Section 3). This occurred where production was estimated to be less than exports. While this is entirely possible that some imports were re-exported, this may in part be due to errors during the aggregation of the different data sources (i.e. UK landings, UK aquaculture, HMRC trade data), for example arising from mismatches of species categories in the landings data and commodity codes in the trade data. It is also perhaps due to the data errors e.g. in quantities recorded, misreporting against an incorrect code / category, or indeed the absence of a suitable code.

Such recording issues also led to some unexpected consumption estimates. For example, the UK fishing industry landed 20,300 tonnes of whelks in 2019, of which just 5,400 tonnes were recorded as having been exported (against two identifiable commodity codes), leading to an erroneous UK consumption estimate of nearly 15,000 tonnes. Whelks are however almost entirely destined for the export market (mainly Southeast Asia, but also Europe) but the recording of this activity within the trade data appears to lack transparency.

Consumption estimates have not been verified for other species, however. Given the variety of issues associated with using landings and trade data for such a purpose as this report, it is highly likely that there are other notable errors and therefore the consumption estimates should be viewed with caution.

In order to correct negative estimates of consumption, it was assumed that the export volume for the particular species / species group was too high and thereby the export volume was manually adjusted. In reality, it could be any one of the productions, import or export values that are inaccurate or, more likely, some combination of the three. It should also be noted that in some case that re-export without processing of certain seafood is possible, for example tinned skipjack tuna. However, it was beyond the scope of this report to investigate such data issues in more detail. Adjusting the export volume was therefore considered to be most appropriate as the report is otherwise not interested in where seafood from the UK ends up. Further, if the export volume is incorrectly reduced, this is more likely to result in an overestimate of consumption rather than underestimate, which is in line with the precautionary approach taken throughout this report. For the sake of simplicity and consistency, the following approach was taken to the manual adjustment of the export volume for species / species groups which were not included in the focus commodities / resources:

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[47] *Primarily http://www.fao.org/faostat/en/#home and https://ec.europa.eu/eurostat/databrowser/view/fish_aq2a/default/table?lang=en*

- If UK production is not equal to 0, adjusted exports = UK production
- If UK production is equal to 0, adjusted exports = imports

For one focus resource, Albacore tuna, the same rules were applied to correct the negative consumption estimate. For a number of other focus resources, whilst the estimated consumption was not negative, it proved to be too low when it came to the risk assessment analysis (Sections 5-12) when estimating the percentage contribution of the main supply chains to the UK's consumption. Again, the reasons for these discrepancies are unknown, but is likely to in part be due to the need to assign general commodity codes to specific resources, for example. Similar rationales were applied to amend the export volumes and thereby consumption estimates.

The data used to provide an overview of the UK's production and consumption of seafood (Section 3), including where these manual adjustments have been made, are provided in Appendix 2.

Limitations to assigning the provenance of the UK's imports

HMRC trade data are structured by 'country of dispatch' (referred to as source country). However, country of dispatch may be different from the:

- Country of origin (e.g. wild capture or aquaculture production in this case)
- Country of manufacture or processed
- Last country from which the goods were shipped to the UK[48] but as a processing country

This represents a major limitation to using trade data for quantifying and mapping supply chains and therefore the analysis undertaken for this report. Given the complexity of seafood supply chains, it was not possible to reliably assign the provenance of some commodities to the country of origin. For example, China is an important 'country of dispatch' for Atlantic cod but clearly is not a producer of that resource. However, many nations' fishing fleets catch Atlantic cod and determining which of those export their catches to China for processing (or for which China is one of several steppingstones in the UK supply chain) and in what quantities is a severely challenging and time-consuming task. Therefore, where a country was identified as being unlikely to produce the resource or commodity in the quantities indicated by the UK trade data[49] (such as Denmark in the case of European lobster) or at all (such as China in the case of Atlantic cod), the country was categorised as 'processing' rather than 'producing' and the risk assessment process was not applied. Instead, a case study approach has been applied to the consideration of the risks associated with these supply chain 'intermediaries', which represent processing and / or trade routes (Section 15).

Cut-off criteria

The complexity of seafood production and supply chains means that most commodities / resources are imported from numerous (e.g. usually >10, often >20, sometimes >30) countries. To achieve the scope of this research within the available resources and to avoid the multiple pitfalls arising from the limitations of trade data (see above), only those source countries

[48] https://www.uktradeinfo.com/trade-data/help-with-using-our-data/#key-terms-and-definitions

[49] *This decision was primarily informed by analysis of FAOSTAT food and agriculture data:* http://www.fao.org/faostat/en/#home

(ranked by average import volume for the period 2015-2019) which were collectively responsible for around 90% of UK imports of each resource on average were included in the assessment. This still resulted in 157 production supply chains and an additional 37 processing supply chains being included in the analysis.

For those commodities / resources where the UK is also a producer (through wild capture and / or aquaculture), the percentage (%) contributions of the UK and the main source countries (of imports) to the UK's overall consumption (as estimated in Section 3) was calculated.

2.2.5 UK exports of seafood derived from wild capture and aquaculture production

The HMRC trade data were again used to quantify exports of different species / family groups (etc) in 2019 and those data were combined with the MMO landings data in the same way as the method described above for imports. As such, the same data limitations and issues were encountered. In addition, a key assumption for this part of the analysis was that the country to which the product is exported according to HMRC trade data, is the final destination rather than an intermediary country, which is likely to be incorrect for some supply chains.

2.3 Supply Chain Risk Assessment

The risk assessment and footprint estimation method set out below was applied to most[50] production supply chains (wild capture and aquaculture) i.e., resource and main producing country combinations identified through analysis of the UK fisheries landings and HMRC trade data described above (157 in total). A risk-based approach was chosen as it allows a broader set of potential impacts to be considered across multiple commodities and provides a robust and repeatable approach that can be applied to other studies.

Intermediary (processing and / or trade route) supply chains were not subject to the risk assessment because several of the indicators could not be considered within a processing / trade only context. A case study approach was therefore taken instead (see Section 15). Assessing the scope and scale of risks associated with the processing 'steppingstones' within a supply chain is noted as an important area for future research.

However, a key barrier to achieving such an assessment is the limited traceability and transparency of supply chains, with the seafood sector being no exception. Ultimately, the ecological, social and governance risks associated with wild capture and aquaculture production tend to vary considerably between, for example, fishing métiers[51] (and even vessels) and production systems (and operations), and thereby within the producing country, as well as between processing facilities and countries - between which seafood products may move in multiple steps during the journey from 'ocean to plate'. It is however not possible to trace the majority of the UK's seafood imports back through processing or trade intermediaries in the supply chain, or even to the specific point of production, and therefore it is not possible to assess the full extent of risks associated with the supply chain.

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[50] Seven (7) production supply chains (6 for loligo and 1 for sea bream) were excluded from the risk assessment due to the very low or zero import volumes

[51] With a fishing métier defined as a group of vessels fishing with the same gear in same area

The risk-based approach does not specify any direct link or cause from UK imports and consumption to impacts in producer countries. It also uses risk factors covering approximately the same period as production, which may not be a reliable indicator of the risks associated with future imports. Despite its limitations, the risk-based approach highlights the need for UK actors to manage their potential risk of creating negative impacts both overseas[52] and in UK waters.

2.3.1 Indicators of Risk

The risk assessment is comprised of 10 indicators (Table 1) which attempt to capture the range of key ecological, social and governance risks associated with seafood supply chains at a deliberately high level. The same indicators are applied to both wild capture and aquaculture supply chains, although the interpretation and approach to scoring necessarily differs slightly between the production types, as set out in Table 2 and Table 3.

Table 1: Overview of the risk assessment indicators

Indicator number	**Indicator code**	**Indicator description**	**Scale applied at (where possible)**	
			Supply chains (wild capture / aquaculture	Country (supply chain production location)[53]
1	Env_1	Direct impact on population(s) or stock(s) of resource	X	
2	Env_2	Ecosystem impact	X	
3	Env_3	Climate change impact	X	
4	Env_4	Endangered, Threatened and Protected (ETP) species impact	X	
5	Social_1	Social concerns associated with supply chain	X	X
6	Mgt_1	Management effectiveness	X	
7	Mgt_2	Sustainability certification progress	X	
8	Mgt_3	Fisheries Governance: IUU Fishing		X
9	Social_2	Rule of Law		X
10	Social_3	Labour Rights		X

For each production supply chain, each indicator was assigned a traffic light score of 1 (Low), 2 (Medium) or 3 (High) risk based on independent assessment of the best available evidence (particularly where extrapolation of evidence from another resource or supply chain was required).

The indicators themselves are inevitably gross simplifications of what are complex, non-linear and variable (in space and time) risks and potential impacts. The risk assessment should

[52] https://www.wwf.org.uk/sites/default/files/2017-10/WWF%20and%20RSPB%20-%20Risky%20Business%20Report%20-%20October%202017.pdf

[53] *With exception of mussels – see explanation further below*

therefore only be used to, for example, signpost priorities for further investigation, data collection or discussion and not as the basis for commercial or public decision-making.

Scoring of **indicators 1-7** (Table 1) required interpretation of available evidence by the project team. Those evidence sources and our corresponding justification of the scores are detailed within the commodity chapters (in part) and risk assessment justifications in Appendix 1 (in full). The indicators were applied at the supply chain level to the greatest extent possible within the scope of the available evidence and project resources. For example, consideration was given to most recent scientific information on status of the stock(s), dominant fishing method(s), evidence of ecosystem impacts and records of third-party certification. However, given the complexity of the supply chains (e.g. each is typically associated with multiple fishing métiers or aquaculture businesses, some involve several fish stocks, etc), the extent and scale of data / information deficiencies, and therefore the necessarily high-level approach to the risk assessment, scores were typically assigned on a conservative basis. For example, if catches from bottom trawling are likely to make a notable contribution to the supply chain, the scoring of the environmental indicators will be based on that activity, even if part of the supply chain is derived from lower impact gears.

Where evidence to support assessment of an indicator is lacking, this is noted. Where evidence cannot be extrapolated from a comparable fishery / supply chain, for example, with a reasonable level of confidence, a risk assessment score of medium (=2) is applied and lack of evidence is flagged within the rationale. However, a medium score should not automatically be interpreted as limited evidence as some assessments resulted in a score of 2 because 'medium risk' was supported by the evidence base. The two types of medium scores can be distinguished within the risk assessment tables (see Sections 5-12) and the risk assessment justifications (Appendix 1).

Risk indicator scoring methodology and evidence sources

An overview of the scoring methodology and key evidence sources for each of the risk indicators are provided in Table 2 (wild capture supply chains) and Table 3 (aquaculture supply chains). In the following paragraphs, some further details are provided for specific indicators. Additional or alternative evidence sources, that were used to inform the risk assessment for each supply chain, are provided in Appendix 1.

A key evidence source for four of the indicator assessments (**Env_1, Env_2, Env_4, Mgt_1 -** Table 1) applied to wild capture production supply chains (not aquaculture) were assessments included in the WWF sustainable seafood guides[54]. Given the scope of the project and limited resources, the full assessments were only reviewed where further clarification of the WWF scoring was required, otherwise the assessment scores provided by WWF were converted to our indicator based, three-tier risk assessment. Independent assessment was typically used to select the most applicable WWF assessment or assessments for the wild capture supply chain (based on species, FAO area of capture and country) and in some cases, none were available or there was lack of confidence in alignment between the assessments. Other sources therefore formed the primary evidence base for the risk assessment. In many cases however, it was

[54] https://wwf.panda.org/act/live_green/out_shopping/seafood_guides/methodology/

determined that multiple WWF assessments were applicable to one supply chain and so the scores were typically transposed on a precautionary (worst case scenario) basis. As with all evidence sources, independent assessment was applied where for example more recent evidence was available than that used in the WWF assessment (e.g. stock status) or where understanding of the fishery indicated that a precautionary approach to application of multiple WWF assessments was not justified.

When assessing a supply chain's risk of **climate change impact (Env_3),** a necessarily high level and relatively simple approach was taken. As such, the assessment only considers the likely impacts of the main production process, without accounting for scale of that production or indeed the multitude of other factors which would affect total greenhouse gas emissions from an individual supply chain. Most notably, the transport, processing, and storage costs after a product's harvest are highly variable and data to accurately calculate such carbon costs are difficult to obtain[55]. Further, the assessed production method is chosen on a worst-case scenario basis, i.e. if the supply chain is approximately equally based on multiple fishing methods, the one with the likely highest carbon footprint is typically used as the basis of the assessment.

For wild capture production, independent assessment is applied to two main evidence sources to determine the risk score for Env_3. Parker and Tyedmers (2014)[56] compiled global data on fisheries fuel use in a Fisheries and Energy Use Database. We used the average fuel use intensity data reported for different combinations of species class, gear type and geographical region to categorise main gear types as low, medium or high fuel users and therefore low, medium or high risk of climate change impact.

The second main evidence source used for our study is the Seafood Carbon Emissions Tool[55] (the Tool), a partnership between the Monterey Bay Aquarium Seafood Watch program and Dalhousie University. The Tool displays information on the carbon footprints of fisheries and aquaculture products based on their production alone. For fisheries, the data inputs used to calculate carbon footprints include the amount of fuel consumed by fishing vessels and (if applicable) the amount of bait used in fishing operations. For aquaculture, data inputs include types of feed used in operations and the amount of source energy used to power the farm facilities. Carbon footprints are reported in the tool as the carbon dioxide equivalent (CO_2-eq) per kilogram (of total wet weight) of harvested fish (or per kilogram of protein). For each seafood type and production combination a range of carbon footprints are provided. Scoring of Env_3 for a given supply chain considered in this study is based on the average of that range for the best matched entry in the Tool. The thresholds for low, medium and high scores were determined from the full range of carbon footprints contained in the Tool. Where a good match for a supply chain was not available in the Tool (species and main production method), the risk assessment for Env_3 was based on Parker and Tyedmers (2014). Where a match was available but the resulting risk scores were different based on the two evidence sources, independent assessment was applied to determine the most appropriate score. For example, in a number of

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[55] *http://seafoodco2.dal.ca/*

[56] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

cases the carbon footprint for bottom trawling was relatively low (resulting in a 'low risk' score) in The Seafood Carbon Emissions Tool, whereas such activity is considered 'high risk' based on Parker & Tyedmers (2014). As it was felt the evidence contained in the Tool therefore likely underestimates the impact on blue carbon habitats[57], a 'medium risk' score was typically applied on a more precautionary (and pragmatic) basis.

For aquaculture supply chains, independent assessment of evidence provided by The Seafood Carbon Emissions Tool, Boyd (2013)[58] and Gephart *et al.* (2021)[59] was used to inform the score for Env_3. The assessment was largely based on the resource production stage as a result, but the carbon footprint associated with the feed supply (e.g. wild capture of forage fish) was accounted for to the extent possible given the data limitations and necessary extrapolations.

To fully understand the strengths and limitations of this Risk indicator, the methodologies associated with these key evidence sources should be referred to.

Indicator 4 – ETP impact (Env_4) considers the likely relative level of risk posed by the supply chain to ETP species. A number of different evidence sources are used to support the risk assessment, in particular the WWF seafood guides as described above and Marine Stewardship Council (MSC) assessments or Fishery Improvement Project (FIP) reports, along with other primary and secondary evidence sources (detailed in Appendix 1). The analysis for, and findings of, the ETP case study (Section 13) directly informed the assessment of Env_3. The indicator deliberately attempts to assess risk of impact rather than risk of mortality, where impact includes both interactions that may not result in death of the animal and those that do. This is in part due to data limitations – there are notable data gaps relating to levels of interaction between fisheries and aquaculture activities and ETP species, and even greater data deficiencies when it comes to estimates of mortality and moreover the population level consequences of those deaths (see the ETP case study in Section 13 for further discussion of this). It is also to recognise that even if an interaction does not directly result in mortality, it can have consequences at both the individual level and population level, through behavioural changes, for example[60,61].

Indicator 5 (Social_1) considers social risks associated with the fishery or supply chain. Whereas Social_2 and Social_3 are applied at the country level, this indicator takes into account evidence of specific strengths / issues associated with the supply chain (although evidence of this is typically rare) or nation's fishing industry (evidence more frequently available) and highlights the need for further investigation / consideration. Where evidence is cited in the literature or media reports are available, scoring is based on independent assessment of the content and reliability of those resources. In addition, or instead (where no other evidence is

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[57] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[58] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[59] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

[60] *Northridge, S. (2018). Encyclopedia of Marine Mammals (Third Edition). Eds: Würsig, B,. Thewissen, J and Kovacs K. Academic Press, Pages 375-383, ISBN 9780128043271*

[61] *Olaya Meza, C., Akkaya, A., Affinito, F., Öztürk, B., & Öztürk, A. (2020). Behavioural changes and potential consequences of cetacean exposure to purse seine vessels in the Istanbul Strait, Turkey. Journal of the Marine Biological Association of the United Kingdom, 100(5), 847-856*

found or where evidence is considered out of date, for example), risk scoring is based on the Global Slavery Index 2018 – Spotlight on modern slavery in the fishing industry report[62]. The Global Slavery Index categorises the top 20 fishing countries as high, medium or low risk of modern slavery in their fishing industry. For these countries, that risk rating is directly transferred to the Risk assessment. For other countries, each is classified as high, medium, or low risk for national fisheries policy (catch outside EEZ, distant water fishing and subsidies) and wealth and institutional capacity (GDP per capita, value landed per fisher, and unreported landings). The combination of these two scores is used to inform Social_1:

- Two high risk classifications for a country, results in a high risk rating for Social_1
- One high risk rating results in a medium risk rating for Social_1
- Two medium, 1 medium and 1 low, or two low risk ratings results in a 'low risk' rating for Social_1.

Indicator 8 (IUU rating, Mgt_3), applied at the country level, is based on the Illegal, Unreported and Unregulated Fishing Index[63]:

"*The IUU Fishing Index comprises 40 indicators, with each indicator applied globally to 152 countries with a maritime coastline. The suite of indicators provides a reliable and robust basis for an Index of IUU fishing and for assigning scores to countries. The scores provide the basis for comparison between countries, regions and ocean basins, and serve to identify where action to combat IUU fishing is most needed. For each country, a score is provided between 1 and 5 (1 = good / strong; 5 = bad / weak) comprised of weighted indicators belonging to different 'indicator groups'".*

The overall IUU score for each country[64] is used in the risk assessment, with the risk categories (L, M, H) applied to the score ranges as per Table 2, based on the distribution of scores within the IUU Fishing Index report.

The same index is used in the assessment of IUU risk associated with aquaculture (farmed) resources (except mussels) and their supply chains. This extrapolation means that we assume the IUU risk associated with a country's fishing industry is indicative of the level of risk associated with the country's aquaculture industry, in the absence of an equivalent metric specifically for aquaculture. The rationale for this assumption is that the key factors which contribute to wild capture IUU risk would contribute to IUU related issues for aquaculture, such as mis-recording / labelling, unlicenced farms, etc. Moreover, it assumes that the IUU risk applies to the supply of fishmeal / feed, which typically involves wild capture fisheries. This therefore means we also assume the country itself is involved, at least in part, in the production of that feed (rather than all feed being imported).

On the basis that mussels do not require feed, a 'low risk' score is applied to all mussel supply chains for IUU indicator Mgt_3.

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[62] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at:* *https://www.globalslaveryindex.org/resources/downloads/*

[63] *https://globalinitiative.net/analysis/iuu-fishing-index/*

[64] *Where data from these external sources are not available for a country (e.g. the Faroe Islands), the index score for comparable nations in the region are applied (e.g. Denmark).*

Indicators 9-10 (Social_2, Social_3) are again applied at the country level[64], using external indices, namely the World Bank Rule of Law (Estimate) Indicator[65] and the International Trade Union Confederation (ITUC) Global Rights Index 2020[66], respectively. The same risk categorisation of the index scores was applied as that used in Risky Business (2017)[52].

Being based on national-level datasets, **indicators 8-10 (Mgt_3, Social_2, Social_3)** in particular, represent the generic level of risk (although the same caution needs to be applied to interpretation and application of the supply chain level indicator assessments, as discussed above), not the risk specific to a commodity or even the fishing industry in the case of the latter two indicators. It also represents an unmitigated level of risk i.e. before any action may have been taken to ensure the commodity's production is not directly linked to risk of IUU fishing or social challenges[52].

2.4 Supply Chain Footprint

For previous WWF Risky Business[67] reports which focused on terrestrial commodities such as soy, palm oil and beef, it was possible to estimate the spatial footprint or land area at risk from the UK's imports of those commodities (e.g. area at risk of deforestation or habitat conversion). However, an equivalent metric cannot be developed to represent the risks associated with production of seafood commodities for many reasons. This includes the multi-dimensional environment that fishing and aquaculture take place in (the ocean), the non-uniform distribution (in space and time) of the resources within that environment, the extent of fishing activity that takes place within international waters (the 'high seas') and our poor understanding of the spatial and temporal extent of fishing activity, as well as the complexity of the risks associated with seafood production which cannot be readily summarised through a single metric.

However, in order to facilitate some comparison of the relative levels of risk associated with different supply chains for a commodity, and more cautiously different commodities, the sum of the ten risk indicator scores is considered the supply chain footprint – the higher the score, the bigger the footprint (minimum of 10 for a 'low risk' score of 1 for all 10 indicators, maximum of 30 for a 'high risk' score of 3 for all 10 indicators).

No weighting was applied to the indicators to avoid introducing further complexity to the analysis which may not be fully supported by the available evidence base nor by the scope of the analysis. Further, the scores are independent of the relative scale (e.g. volume of imports) of the supply chain, which is necessary because the assessment of risk is also independent of scale of production. Whilst this greatly limits meaningful comparison of supply chain footprint scores, it was considered the only defendable approach at the current time to what is an inherently complex and poorly evidenced subject.

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[65] https://databank.worldbank.org/source/worldwide-governance-indicators

[66] https://www.ituc-csi.org/ituc-global-rights-index-2020

[67] https://www.wwf.org.uk/riskybusiness

Table 2: Description of risk assessment indicators and general approach to scoring – Wild capture production supply chains

Indicator number and code	Indicator	Main source(s)[68]	Rationale	Scoring		
				High risk (=3)	Medium risk (=2)	Low risk (=1)
(1) Env_1	Direct impact on population(s) or stock(s) of resource	WWF Seafood Guide assessments, IUCN Red List, CITES Appendices For tuna, WWF Back to Biology report[69]	Indicator of potential sustainability of fishery, considering stock assessment estimates and / or species vulnerability ratings, where available	CITES Appendix I or II and / or IUCN Red List CR / EN / VU and / or assessed as overfished and depleted (*e.g. F above fishing mortality reference points and stock biomass below biological reference points*) For tuna, the stock level is below SSB40	IUCN Red List NT and / or assessed as overfished but not depleted OR depleted but not overfished (*e.g. stock above limit reference points and/or target reference points (or equiv.) but F above limit reference points*) Or lack of direct or indirect evidence to support assessment For tuna, information on SSB is missing	Not listed by CITES and IUCN Red List LC and / or assessed as below fishing mortality and above biomass target reference points (or equiv.) For tuna, the stock level is above SSB40
(2) Env_2	Ecosystem impact	WWF Seafood Guide assessments, independent assessment based on available evidence	Indicator of potential wider ecosystem impacts of fishery, for example bycatch of other target and non-target species (excluding ETP species), habitat / VME damage due to physical impacts of	Evidence of high likelihood of risk / evidence of significant impacts	Evidence of moderate likelihood of risk Or lack of direct or indirect evidence to support assessment	Evidence of low likelihood of risk / no significant impacts

[68] *Details of all evidence and information used to inform the indicator assessment are provided within commodity chapters and Appendix 1*

[69] https://www.wwf.org.uk/sites/default/files/2021-05/WWF%20-%20Back%20to%20Biology%20report%20%28new%29.pdf

			gear and sensitivity of exposed habitats			
(3) Env_3	Climate change impact	Based on Parker & Tyedmers (2014)[70] and The Seafood Carbon Emissions Tool[71]	Indicator of fishery's relative contribution to climate change. For sake of simplicity and high level application, only takes into account production method (on worst case scenario basis).	Independent assessment based on combination of Parker & Tyedmers (2014): Bottom trawling responsible for notable portion of production and The Seafood Carbon Emissions Tool: Average GHG emissions (tonnes of CO2 per kg of fish) greater than 10	Independent assessment based on combination of Parker & Tyedmers (2014): Pots & traps / Hooks & Lines / Gillnets / Pelagic trawls (large pelagics) / Dredges responsible for largest portion of production and The Seafood Carbon Emissions Tool: Average GHG emissions (tonnes of CO2 per kg of fish) between 5 and 10	Independent assessment based on combination of Parker & Tyedmers (2014): Divers / Surrounding nets / Pelagic trawls (small pelagics) responsible for largest portion of production and The Seafood Carbon Emissions Tool: Average GHG emissions (tonnes of CO2 per kg of fish) less than 5
(4) Env_4	ETP impact	ETP case study, WWF Seafood Guide assessments, MSC assessment / Fisheries Progress FIP reports, independent assessment based on other available evidence	Indicator of ETP (Endangered, Threatened and Protected) impact associated with fishery. Considered separately to Env_2 as flags this specific risk for further investigation / consideration	Evidence of high levels of interactions / known impacts on ETP species	Evidence of moderate levels of interaction / ETP bycatch at levels considered to not be having a detrimental effect on the population (with some evidence to support assumption) Or lack of direct or indirect evidence to support assessment	Evidence of low levels of interaction / evidence to support no significant impacts of interactions

[70] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[71] *http://seafoodco2.dal.ca/*

(5) Social_1	Social concerns associated with supply chain	Independent assessment based on available evidence and / or Global Slavery Index 2018 – Spotlight on modern slavery in the fishing industry[72]	Indicator of social risks associated with the fishery or supply chain, such as human trafficking, forced labour and poor working conditions.	Evidence of high risk *e.g. recent (<5 years) examples of issues or concerns raised in literature* and/or country's fishing industry categorised as high risk based on Global Slavery Index[73]	Evidence of moderate risk *e.g. older (>5 years) examples of issues or concerns or proxy evidence of relevant social risks available* And / or country's fishing industry categorised as medium risk based on Global Slavery Index[73] Or lack of direct or indirect evidence to support assessment	Evidence of low risk And / or country's fishing industry categorised as low risk based on Global Slavery Index[73]
(6) Mgt_1	Management effectiveness	WWF Seafood Guide assessments, independent assessment combined with evidence sources such as FishChoice[74], MCS Good Fish Guide[75]	Indicator of governance effectiveness associated with fishing industry. Whereas Social_3 and Mgt_3 are at the country level and consider specific outcomes of governance effectiveness (e.g. prevalence of IUU fishing – Mgt_3), this indicator takes into account evidence of specific strengths /	Governance / management considered ineffective or largely absent	Known issues with governance / management regime that require improvement Or lack of direct or indirect evidence to support assessment	Governance / management considered effective

[72] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at:* https://www.globalslaveryindex.org/resources/downloads/

[73] *Two high risk classifications for a country results in a high risk rating for Social_1. One high risk rating results in a medium risk rating for Social_1. Two medium, 1 medium and 1 low, or two low risk ratings results in a 'low risk' rating for Social_1.*

[74] https://fishchoice.com/

[75] https://www.mcsuk.org/goodfishguide/

			issues associated with management of the fishery			
(7) Mgt_2	Sustainability certification progress	MSC[76], Fishery progress FIP reports[77] and WWF MSC objection information	Indicator of extent of third-party sustainability certification associated with supply chain	No evident sustainable certification or FIP progress or with WWF's objection not withdrawn or with WWF's unsustainable statement	Production partially certified and/or production (partially or in full) part of a FIP. Where applicable, WWF's objection was withdrawn. or Production largely / fully certified and without WWF's objection, but the certification is associated with conditions	Production largely / fully certified and without WWF's objection or conditions
(8) Mgt_3	Fisheries Governance: IUU Fishing	IUU Fishing Index[63]	Index of countries' vulnerability, prevalence and response to IUU fishing	Index >3	Index 2-2.99	Index <2
(9) Social_2	Rule of Law	Rule of Law Indicator[65] World Bank Governance Indicators	Perception of how good laws are and how well they are implemented	Indicator <-0.3	Indicator -0.3-1	Indicator ≥1
(10) Social_3	Labour Rights	ITUC Global Rights Index[66]	Perception of how well basic labour rights are implemented	Index 4-5	Index 2-3	Index=1

[76] https://fisheries.msc.org/en/fisheries/

[77] https://fisheryprogress.org/

Table 3: Description of risk assessment indicators and general approach to scoring – Aquaculture production supply chains

Indicator number and code	Indicator	Main source(s)[78]	Rationale	Scoring: High risk (=3)	Scoring: Medium risk (=2)	Scoring: Low risk (=1)
(1) Env_1	Direct impact on population(s) or stock(s) of resource	Independent assessment based on available evidence	Indicator of potential impacts of production method on wild stock, for example through genetic modification or disease	Documented evidence of high risks / known impacts	Evidence of potential risk but extent of impacts unknown Or lack of direct or indirect evidence to support assessment	Evidence of low likelihood of risk / no significant impacts
(2) Env_2	Ecosystem impact	Independent assessment based on available evidence	Indicator of potential wider ecosystem impacts of farming method, for example mortality of non-ETP bycatch, habitat impacts	Evidence of high likelihood of risk/evidence of significant impacts	Evidence of moderate likelihood of risk Or lack of direct or indirect evidence to support assessment	Evidence of low likelihood of risk / no significant impacts
(3) Env_3	Climate change impact	Based on Boyd (2013)[79], The Seafood Carbon Emissions Tool[80] and Gephart et al. (2021)[81]	Indicator of aquaculture production methods' relative contribution to climate change (on worst case scenario basis)	Independent assessment based on conclusion that production method likely to have high carbon footprint relative to most wild capture fisheries and The Seafood Carbon Emissions Tool: Average GHG emissions (tonnes of	Independent assessment based on conclusion that production method likely to have moderate carbon footprint relative to most wild capture fisheries and The Seafood Carbon Emissions Tool: Average GHG	Independent assessment based on conclusion that production method likely to have low carbon footprint relative to most wild capture fisheries and The Seafood Carbon Emissions Tool: Average GHG emissions (tonnes of CO2 per kg of fish) less than 5

[78] *Details of all evidence and information used to inform the indicator assessment are provided within commodity chapters and Appendix 1*

[79] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture. https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/*

[80] *http://seafoodco2.dal.ca/*

[81] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods. Nature, 597(7876), 360-365.*

				CO_2 per kg of fish) greater than 10	emissions (tonnes of CO_2 per kg of fish) between 5 and 10	
(4) Env_4	ETP impact	ETP case study, independent assessment based on available evidence	Indicator of ETP impact associated with aquaculture production method. Considered separately to Env_2 as flags this specific risk for further investigation/ consideration.	Evidence of high levels of interactions/known impacts on ETP species	Evidence of moderate levels of interaction/ETP bycatch at levels considered to not be having a detrimental effect on the population (with some evidence to support assumption) Or lack of direct or indirect evidence to support assessment	Evidence of low levels of interaction / evidence to support no significant impacts of interactions
(5) Social_1	Social concerns associated with supply chain	Independent assessment based on available evidence	Indicator of social risks associated with aquaculture industry or supply chain.	Evidence of high risk *e.g. recent (<5 years) examples of issues or concerns raised in literature*	Evidence of moderate risk *e.g. older (>5 years) examples of issues or concerns or proxy evidence of relevant social risks available* Or lack of direct or indirect evidence to support assessment	Evidence of low risk or of compliance with social standards

(6) Mgt_1	Management effectiveness	Independent assessment based on available evidence	Indicator of governance effectiveness associated with aquaculture industry. Whereas Social_2 and Mgt_3 are at the country level and consider specific outcomes of governance effectiveness (e.g. prevalence of IUU fishing – Mgt_3), this indicator takes into account evidence of specific strengths / issues associated with management of the aquaculture industry	Governance / management considered ineffective or largely absent	Known issues with governance/ management regime that require improvement Or lack of direct or indirect evidence to support assessment	Governance / management considered effective
(7) Mgt_2	Sustainability certification progress	ASC[82], BAP[83], GlobalGAP[84] or other* *For mussels, this includes MSC[85]	Indicator of extent of third-party sustainability certification associated with supply chain	No evident sustainable certification progress	Production partially/fully certified by body other than ASC	Production largely / fully certified by ASC (or MSC for mussels)

[82] https://www.asc-aqua.org/

[83] https://www.bapcertification.org/

[84] https://www.globalgap.org/uk_en/

[85] https://fisheries.msc.org/en/fisheries/

(8) Mgt_3	Fisheries Governance: IUU Fishing	IUU Fishing Index[63]	Index of countries' vulnerability, prevalence and response to IUU fishing. Extrapolated to a country's aquaculture industry (except mussels) as assume that IUU risk for the two industries would be largely comparable, mainly in relation to supply of feed.	Index >3	Index 2-2.99	Index <2 Also for all mussel (Mytilus spp. and Perna spp.) supply chains
(9) Social_2	Rule of Law	Rule of Law Indicator[65] World Bank Governance Indicators	Perception of how good laws are and how well they are implemented	Indicator <-0.3	Indicator -0.3-1	Indicator ≥1
(10) Social_3	Labour Rights	ITUC Global Rights Index[66]	Perception of how well basic labour rights are implemented	Index 4-5	Index 2-3	Index=1

3. Overview of UK's production and consumption of seafood

3.1 UK wild capture fisheries

The UK fleet caught a total of 621,886 tonnes in waters within and outside the UK EEZ in 2019, with around 81% of that landed directly into the UK. Mackerel (*Scomber scombus*) accounted for the largest volume of landings (152,147 tonnes) (Figure 1). Herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou)* followed but were far less significant in terms of landed weight (75,458 tonnes and 60,791 tonnes respectively). Norway lobster (*Nephrops norvegicus*) represented the largest volume of shellfish landings (34,519 tonnes), followed closely by Edible (brown) crab (*Cancer pagurus*, 31,837 tonnes), scallops (mainly *Pecten maximus,* 29,179 tonnes) and whelks (20,335 tonnes).

Species such as hake (mainly *Merluccius merluccius)*, European plaice (*Pleuronectes platessa*), megrim (*Lepidorhombus whiffiagonis)* and lemon sole (*Microstomus kitt*) are caught in quantities ranging from 2,000 tonnes to 11,000 tonnes. These landings are still considerable when compared with the smallest quantities of landings for species such as boarfish, bigeye tuna (*Thunnus obesus*) and mullets, which could be viewed as negligible (Appendix 2).

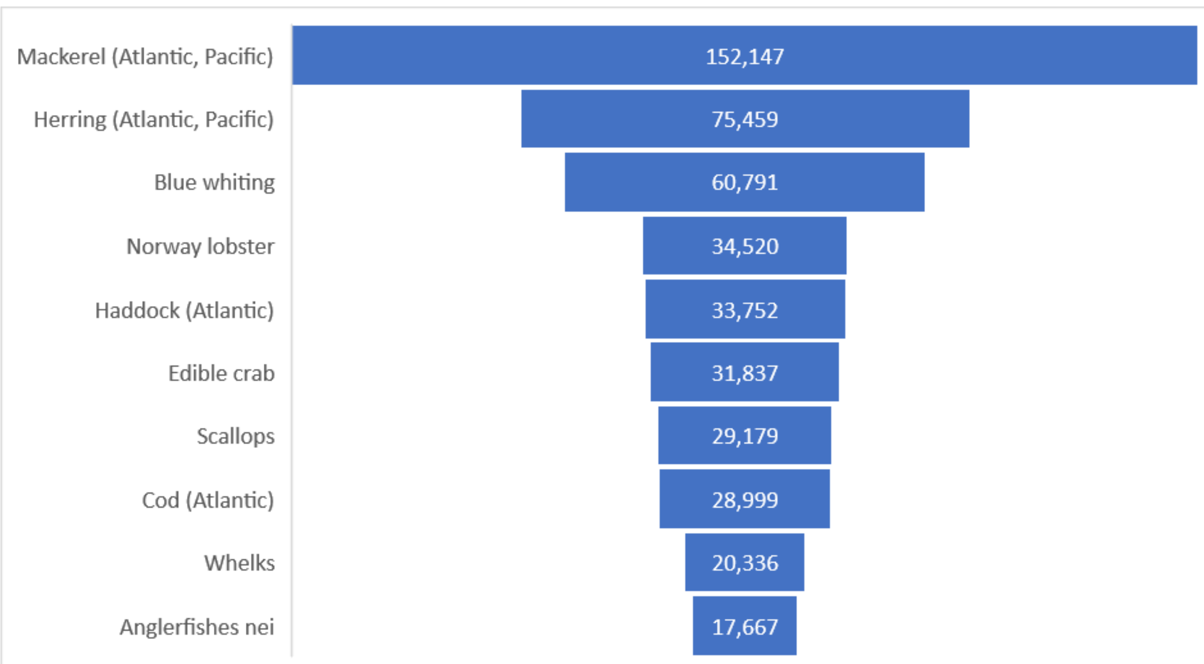

Figure 1: Top 10 marine species caught by the UK fishing fleet by volume (tonnes) in 2019

3.2 UK aquaculture production

The aquaculture industry is considerably less established in the UK than capture fisheries but has expanded relatively rapidly. This global trend is largely driven by the increasing demand for seafood export and the limiting nature of capture fisheries, as well as technology advancement which has the potential to reduce the environmental impacts of aquaculture[86]. The industry has increased on average by 5.3% per year between 2001 and 2018[87] and has a production value in excess of £590[88] million to the UK.

In 2018, the total UK aquaculture production was 189,921 tonnes (live weight)[89], the majority of which was produced in Scotland. Only a small number of species contribute to overall aquaculture production. Salmon farming constitutes the largest proportion in the UK and accounted for 82% of all production in 2018 (156,025 tonnes) (Figure 2). Trout (including rainbow, sea, brown, etc.) production contributes similar quantities as that of mussel farming (approximately 12,000 tonnes to 14,200 tonnes). England, Wales and Northern Ireland place more importance on shellfish farming, particularly mussels (*Mytilus edulis*) and to a lesser extent, oysters (14,247 tonnes and 2,239 tonnes respectively).

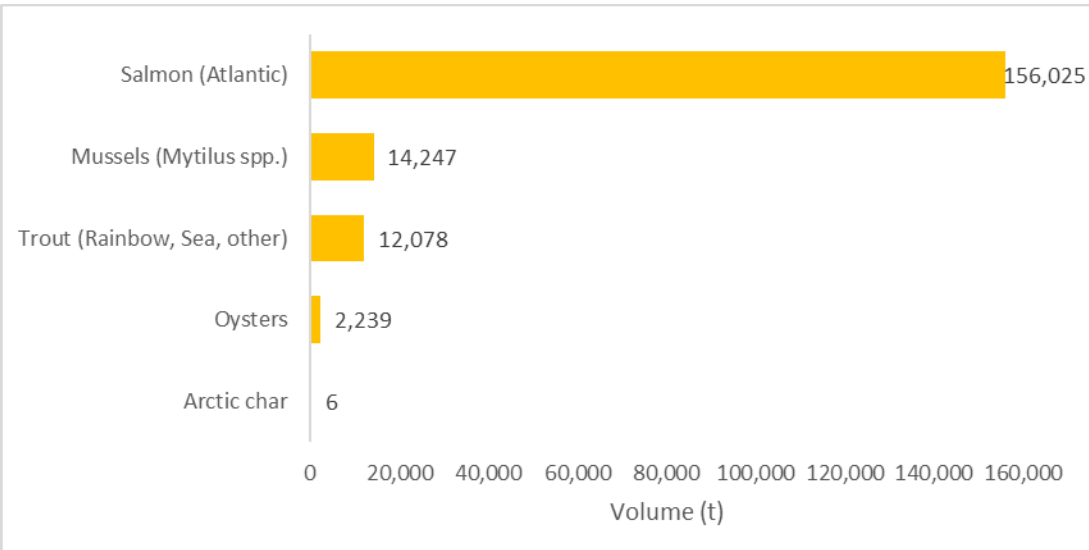

Figure 2: Summary of UK aquaculture production (tonnes) in 2018

3.3 Imports and exports

The UK has been a net importer of seafood since 1984, due to the faster market growth over time for imports in comparison with exports[90]. In 2019, 719,350 tonnes of seafood (for human consumption) was imported, and 412,635 tonnes of seafood was exported.

The primary purpose of HMRC trade data is calculation of tariffs and taxes, as opposed to aiding the understanding of seafood trade within the context of scientific research or supply

[86] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/635209/Future_of_the_sea_-_trends_in_aquaculture_FINAL_NEW.pdf

[87] https://www.seafish.org/insight-and-research/aquaculture-research-and-insight/value-and-importance-of-aquaculture/

[88] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/635209/Future_of_the_sea_-_trends_in_aquaculture_FINAL_NEW.pdf

[89] https://www.seafish.org/insight-and-research/aquaculture-research-and-insight/aquaculture-production-scales/

[90] https://researchbriefings.files.parliament.uk/documents/SN02788/SN02788.pdf

chain assessment. As a result, analyses of import / export figures are challenging to accurately determine whether the originating country is classified as the catching country or the processing / trading country, and whether this is aquaculture or wild capture fisheries. Though this is the case, the available data still demonstrates the extent of imports and exports in the UK.

Seafood imports were largely represented by demersal or pelagic fish, dominated by Atlantic cod (*Gadus morhua*, 99,116 tonnes), Skipjack tuna (*Katsuwonus pelamis*, 1,000,026 tonnes)[91] and Atlantic salmon (*Salmo salar*, 81,572 tonnes)[92]. Shellfish, characterised largely by shrimps or prawns (warm-water and cold-water), also plays a notable part in the UK's imports of seafood (Figure 3). In addition, around 105,600 tonnes of '*Flours, meals and pellets, of meat or meat offal, of fish or of crustaceans, molluscs or other aquatic invertebrates, unfit for human consumption*' (HS code 2301) were imported in the UK, for use as aquaculture feed, amongst other purposes.

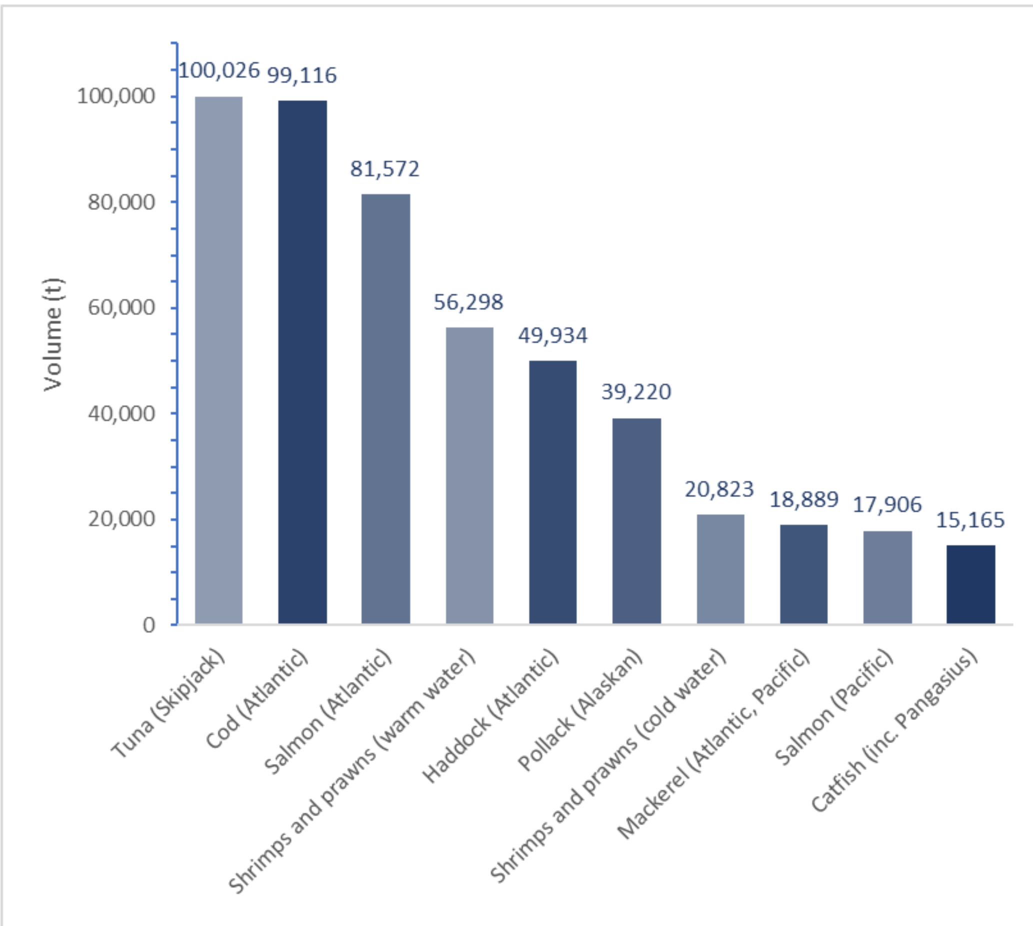

Figure 3: Top ten species / seafood resources imported into the UK in 2019 by volume (tonnes)

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[91] For the purposes of the analysis, imports recorded under commodity codes which referred to 'Tuna nei' (undefined species – around 6,140 tonnes) were reassigned to the two main imported tuna species – skipjack tuna and yellowfin tuna. To do this, the average proportional representation of each species in 2019 imports, calculated during the detailed supply chain analysis (see Section 5) was used – 92% skipjack, 8% yellowfin. In the absence of more detailed analyses for export data, the same percentages were applied to redistribute exports of undefined tuna species.

[92] As with tuna, imports of 'Salmon nei' (undefined species – around 29,150 tonnes) were reassigned to Atlantic salmon (82%) and Pacific salmon (18%). Exports of 'Salmon nei' were assumed to be Atlantic salmon.

The global nature of the UK's import supply chains can be seen in Figure 4, with imports from all continents and most coastal nations. The largest share of seafood imports into the UK is shipped from China (73,642 tonnes), although it is highly likely that this is largely attributable to processing as opposed to Chinese production (see Section 15). According to a House of Commons briefing paper[93], 80% of this was frozen fish fillets. Iceland and Germany (58,175 tonnes and 57,763 tonnes respectively) are also large contributors of seafood imports into the UK. Whereas Iceland largely supplies wild capture species such as cod and haddock, Germany's supply is largely comprised of processed commodities. Sweden (42,995 tonnes) and Faroe Islands follow closely (41,502 tonnes), the former representing processed farmed salmon (see Section 4) and the latter representing wild capture whitefish and farmed salmon.

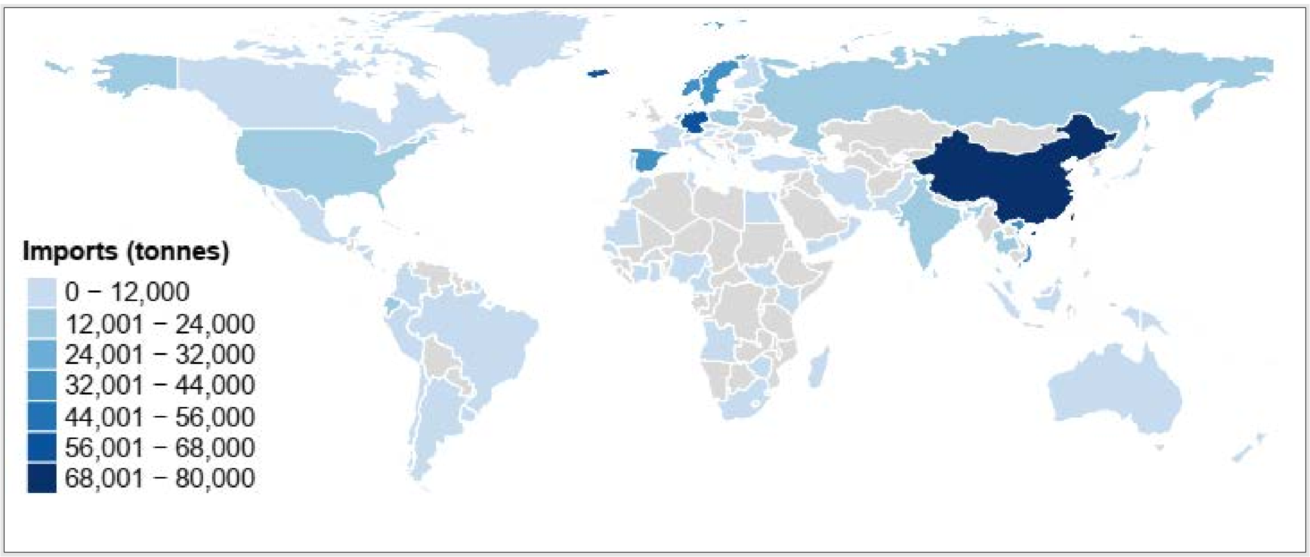

Figure 4: UK's global imports supply chain map (based on total imported volumes (tonnes) in 2019)

Of those 2019 imports, nearly 568,000 tonnes were comprised of the resources assessed in more detail in the remainder of the report. Table 4 provides the distribution of those imports across the eight commodity groups, showing that they were dominated by large pelagics, salmonids and whitefish resources (representing 72% of the commodities assessed in the remainder of the report and 57% of exports in total).

[93] https://researchbriefings.files.parliament.uk/documents/SN02788/SN02788.pdf

Table 4: Total volume (tonnes) of imports of seafood commodities in 2019.

Commodity	Import volume in 2019 (tonnes)	% of total imports of all resources in the study
Whitefish	197,191	27.4%
Large pelagics	109,220	15.2%
Salmonids	100,627	13.9%
Crustaceans	84,120	11.7%
Small pelagics	37,425	5.2%
Farmed whitefish	26,539	3.7%
Molluscs	9,763	1.4%
Flatfish	2,599	0.4%
Other seafood (not assessed)	151,866	21.1%
Total	**719,350**	**100%**

Farmed UK salmon accounts for the largest proportion of exported volume (117,274 tonnes or 40% of exports of 'top 10'), followed by mackerel (61,288 tonnes or 21%), and herring (34,121 tonnes or 12%). Norway lobster and edible crab represent key shellfish species (Figure 5). In reality, the UK's supply of pelagic species such as mackerel, blue whiting and herring, as well as cold-water prawns, to the foreign market is larger than this, due to the volume of UK vessel catches that are landed outside the UK rather than into UK ports. Whilst some of these non-UK landings by the UK fleet may feature in the UK imports data, it is likely to be a relatively small proportion for the small pelagic fish species at least.

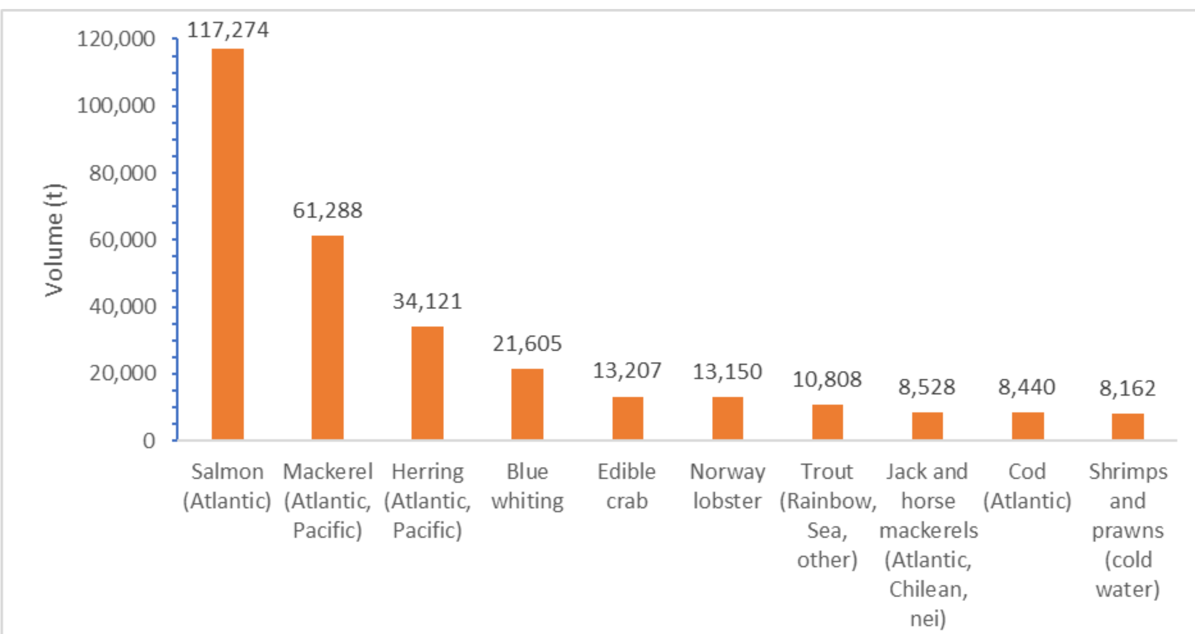

Figure 5: Top ten species / seafood resources exported from the UK in 2019 by volume (tonnes)

The UK also exported around 31,600 tonnes of fishmeal, flours and pellets in 2019.

The UK's seafood export supply map is again geographically extensive, although not to the same extent as our import supply chains. The majority of exports go to France (94,403 tonnes) and the Netherlands (57,703 tonnes), whilst the United States also receives a significant amount of seafood by volume from the UK (40,173 tonnes) (Figure 6).

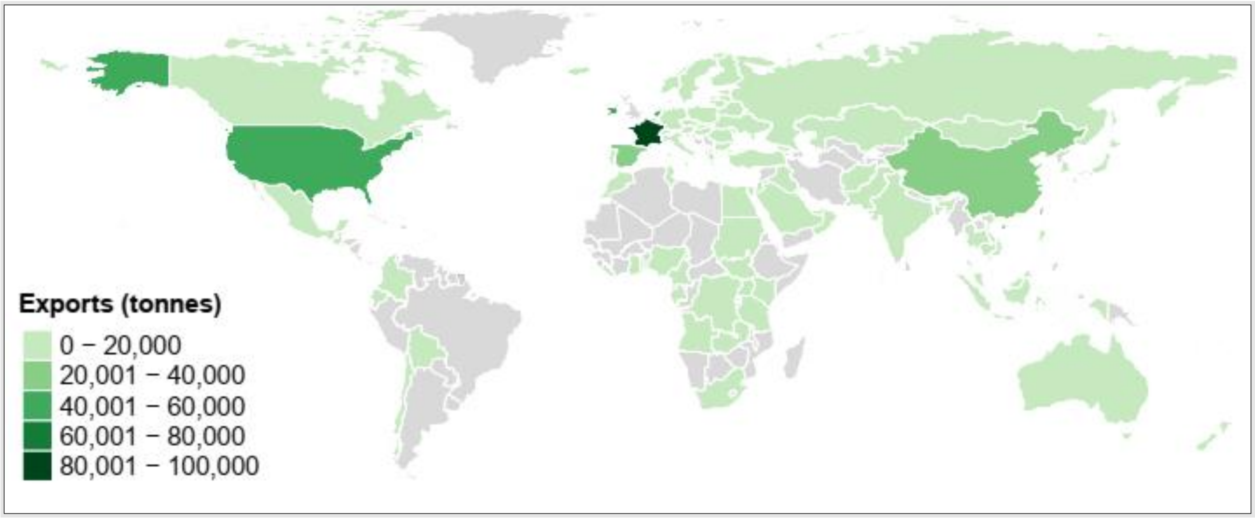

Figure 6: UK's global exports supply chain map (based on total exported volumes (tonnes) in 2019)

In 2019, around 316,000 tonnes of the UK's seafood exports were comprised of the resources assessed in more detail in the remainder of the report. Table 5 contains the distribution of those exports across the eight commodity groups, showing that they were dominated by small pelagic and salmonid resources (representing 75% of the commodities assessed in the remainder of the report and 57% of exports in total).

Table 5: Total volume (tonnes) of exports of seafood commodities in 2019.

Commodity	Export volume in 2019 (tonnes)	% of total exports of all resources assessed in the study
Salmonids	134,311	32.5%
Small pelagics	102,348	24.8%
Crustaceans	33,795	8.2%
Whitefish	23,759	5.8%
Molluscs	13,030	3.2%
Large pelagics	4,464	1.1%
Flatfish	2,879	0.7%

Farmed whitefish	1,313	0.3%
Other seafood (not assessed)	96,736	23.4%
Total	**412,635**	100.0%

3.4 UK seafood consumption

According to a report conducted by Seafish in 2019[94], seafood consumption has been in general decline since 2007 and this is predominantly reflective of seafood eaten 'in home' which has fallen by 25% in the past 10 years. Seafood consumption via foodservice has remained relatively consistent in recent years. Furthermore, observations from the same report suggest the emergence of three key trends which include: a growth in chilled seafood consumption, growth in farmed species consumption and growth of seafood sales in the quality-focused retailers. Consequently, those trends drive higher average prices, which could in part explain the gradual fall in overall seafood consumption by volume.

In term of seafood for human consumption, it is estimated that a total of 886,902 tonnes of seafood were consumed in the UK in 2019 (Table 6). This is estimated by combining the imports (719,350 tonnes) of seafood from other parts of the world and the UK domestic production (580,187 tonnes) of seafood and subtracted the exports (412,635 tonnes) of seafood that were not consumed in the UK.

It should be noted that while adjustments were made to avoid negative consumption, it is assumed that very small quantities (~1%) of imported seafood (e.g. large pelagics and farmed whitefish) were re-exported to other seafood market. This indicates that the UK acts not only as an importer but also a trader for certain commodity group of seafood like tuna and farmed whitefish. Furthermore, assuming that exports of UK's seafood are mainly come from UK's domestic wild capture and aquaculture production, it is estimated about 70% by volume of UK's domestic production was exported to overseas and only around 30% of our own production was consumed in the UK.

[94] https://www.seafish.org/document/?id=7ce7cae2-9ae9-48ef-87b3-b833a5e0d04f

Table 6: Total estimated consumed volume (tonnes) of the seafood commodities in 2019.

Commodity	Imported (tonnes)	Domestically produced (tonnes)	Exported (tonnes)	Consumed volume (tonnes)	% consumption of all resources in the study	Self-sufficiency rate (%)
Whitefish	197,191	83,945	23,759	257,377	29%	23%
Salmonids	100,627	168,106	134,311	134,422	15%	25%
Crustaceans	84,120	67,674	33,795	117,999	13%	29%
Large pelagics	109,220	356	4,464	105,112	12%	0.3%
Molluscs	9,763	45,7692	13,030	42,494	5%	77%
Small pelagics	37,425	103,259	102,348	38,335	4%	2%
Farmed whitefish	26,539	412	1,313	25,639	3%	2%
Flatfish	2,599	5,433	2,879	5,152	1%	50%
Other seafood (not assessed)	151,241	105,241	96,736	160,371	18%	5%
Total	719,350	580,187	412,635	**886,902**	100%	19%

Nevertheless, the UK's preference for the commonly referred 'big five' (cod, salmon, tuna, haddock and warm-water prawns) is supported by the consumption estimates for the commodities assessed in the report (Figure 7, Table 6). Salmon and cod are the most heavily consumed seafood in the UK (estimated as around 120,000 tonnes and 113,000 tonnes, respectively, in 2019), closely followed by tuna (at nearly 96,000 tonnes – mainly skipjack tuna). Along with warm-water prawns, scallops are a popular choice of shellfish in the UK (around 22,500 tonnes were estimated to have been consumed in 2019) (Figure 7). The 33 commodity groups covered in this report make up around 82% of the total volume (Table 6) that UK consumed in 2019. Whilst assumptions were required during analysis (see above), trends follow similar patterns to those presented by Seafish[94] and Defra Family food datasets[95].

[95] https://www.gov.uk/government/statistical-data-sets/family-food-datasets

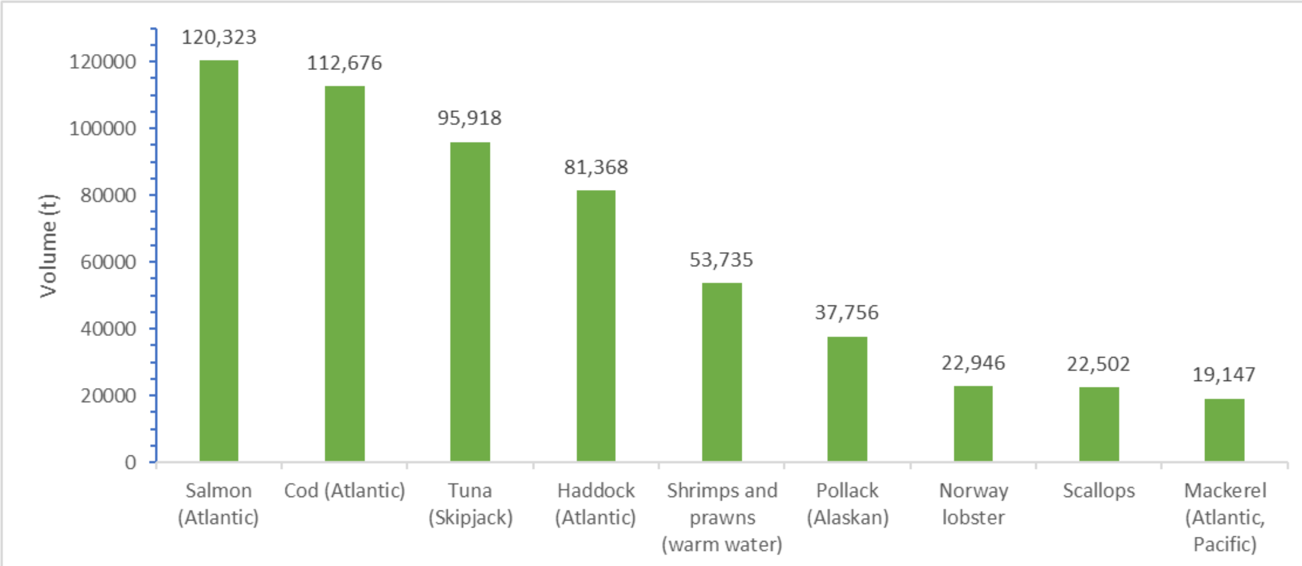

Figure 7: Top ten species / seafood resources consumed in the UK in 2019 by volume (tonnes)

However, focusing on the 'top 10' or the top 33 commodity groups mask the extent and diversity of the UK's seafood choices. Whilst most types of seafood are consumed in relatively small volumes, the variety is quite surprising that a total of 124 species or species groups (including the 33 commodity groups) were identified in this report (Figure 8 and Table 7). Of these 124 species or species groups, 81% is wild-caught species, 10% is farmed species and 8% is produced by wild-caught fisheries and farms. It also serves to explain the global nature of the UK's supply chain network and demonstrates that the UK's footprint is much larger than that associated with the 'top 10' (or indeed the resources assessed during the remainder of the report). Whilst the absolute consumption figures should be viewed with caution (see above), the relative quantities are likely to be reasonably informative.

Missing from these data, presumably due to the small quantities they are imported in resulting in them being 'hidden' within the '03 HS2 Below Threshold Trade' code of the HMRC data, are the exotic species that can be found in the UK at places such as Billingsgate Market in London96,97. These include parrot fish, grouper and white pomfret.

[96] https://www.billingsgatefish.co.uk/product-category/exotic-fresh-fish/

[97] http://www.jbennetts.co.uk/

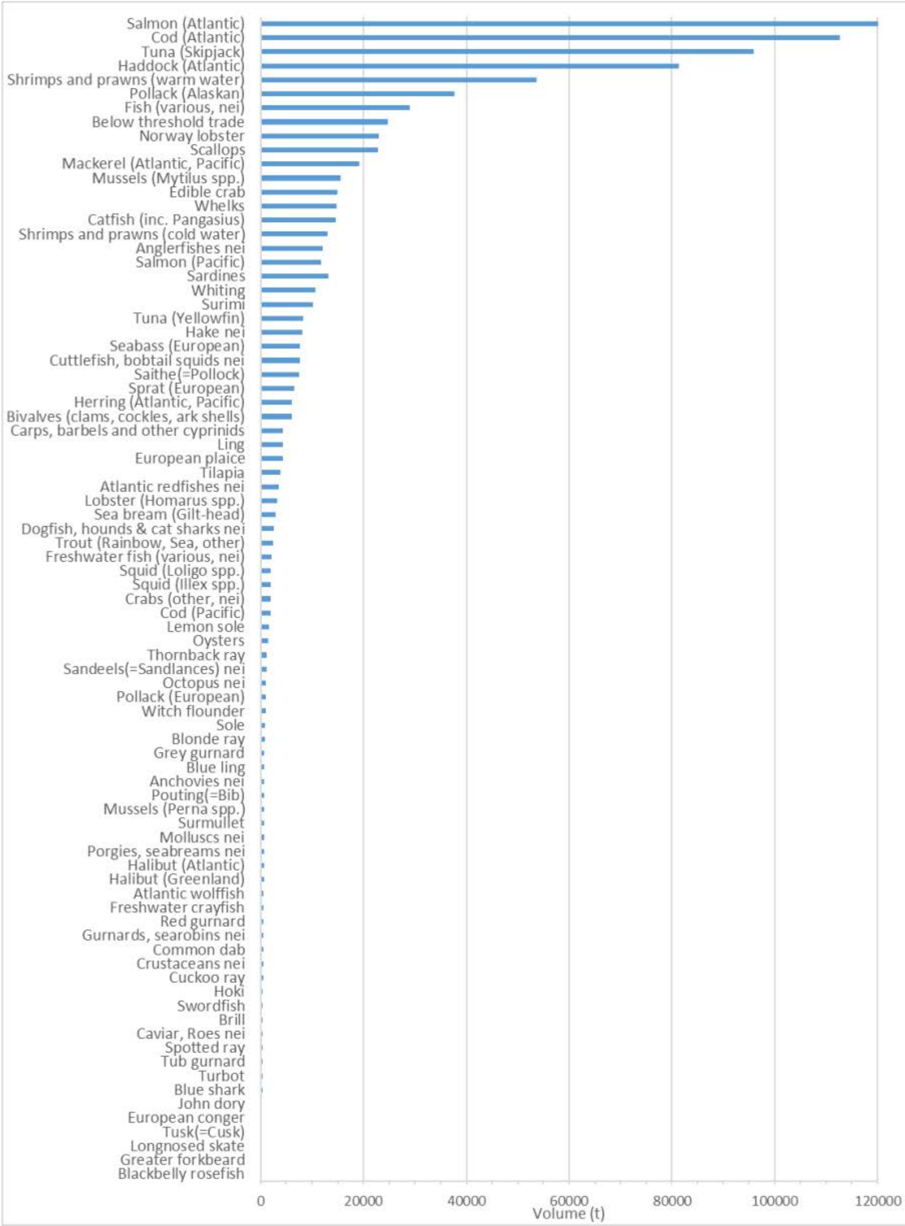

Figure 8: Variety of seafood resources consumed in the UK in 2019. List contains those species / resources for which UK consumption was estimated to be >100 tonnes.

Table 7: Variety of seafood resources consumed in the UK in 2019. List contains those species / resources for which UK consumption was estimated to be <100 tonnes. An estimate of consumption is not provided for entries with an asterix (*) as these were calculated as negative values, due to issues reconciling the production, imports and exports data. 'Nei' refers to undefined / multiple species.

Species / family group	Volume (tonnes)	Species / family group	Volume (t)
Small-eyed ray	90.6	Argentines	1.5
Mullets nei	71.4	Arctic skate	1.2
Shortfin mako	70.7	Marlins, sailfishes, etc. nei	1.1
Tuna (Atlantic bluefin)	70.5	Rock cook	1.1
European flounder	69.8	Wahoo	1.0
Raja rays nei	69.3	Norway pout	0.7
Sea urchins nei	64.1	Rudderfish	0.6
Undulate ray	56.3	Red codling	0.6
Black scabbardfish	44.9	Thresher sharks nei	0.6
Jellyfish nei	39.9	Starry ray	0.5
Ballan wrasse	36.9	Alfonsinos nei	0.4
Sandy ray	36.0	Allis and twaite shads	0.4
Goldsinny-wrasse	34.7	Patagonian grenadier	0.3
Sand sole	33.2	Weeverfishes nei	0.3
Tuna (Bigeye)	32.3	Garfish	0.2
Halibut (Pacific)	32.1	Roughhead grenadier	0.2
Boarfish	30.2	Queen snapper	0.2
Northern quahog(=Hard clam)	24.8	Oilfish	0.1
Periwinkles nei	23.3	Angelshark	0.1
Wrasses, hogfishes, etc. nei	22.1	Common stingray	0.1
Bonito	19.4	Red scorpionfish	0.1
Escolar	17.6	Triggerfishes, durgons nei	0.1
Tope shark	15.6	Sea cucumbers nei*	
Shagreen ray	15.0	Tuna (Albacore)*	
Black marlin	13.0	Abalone nei*	
American plaice(=Long rough dab)	12.8	Tuna (Pacific bluefin))*	
Corkwing wrasse	11.3	Sharks nei*	
Tadpole codling	10.4	Eels (European, Pink cusk-eel, nei)*	
Greater argentine	6.8	Squid (other, nei)*	
Velvet belly	6.8	Toothfish nei*	
Beaked redfish	6.7	Invertebrates nei*	

Arctic char	6.1	Nile perch*	
Roundnose grenadier	6.0	Megrim nei*	
Forkbeard	4.4	Cobia*	
Common dolphinfish	3.9	Lobster (Palinurid spiny)*	
Greater weever	3.2	Salmonidae nei*	
Indo-Pacific sailfish	2.9	Jack and horse mackerels (Atlantic, Chilean, nei)*	
Pink cusk-eel	2.5	Blue whiting*	
White skate	2.2		
Wreckfish	2.0		
Blue skate	1.7		

4. Overview of footprint analysis by risk indicators and seafood commodities

The scope and depth of analysis achieved in this report allows some general findings to be discussed about the environmental and social risks associated with the UK's seafood trade and consumption. What is abundantly clear is that the UK's network of seafood supply chains has a global influence, including its impacts on far more species than those consumed.

However, the inherent complexity in the supply chains which cannot be adequately accounted for - in part due to the widespread data limitations - is inevitably masked when high level conclusions are drawn.

It therefore may not always be realistic or desirable to make recommendations over increased supply through lower risk supply chains and reduced trade through higher risk ones. Such actions could serve to displace risks and jeopardise the livelihoods and food security of responsible producers. Moreover, it could divert attention from the need to support investment in better, more environmentally sustainable, and socially acceptable, production and trade processes[98]. However, it does reveal the need for improved transparency and traceability in supply chains and improvements on how data is collected and reported for purposes of trade.

Full details of the analysis of individual commodities are provided in Sections 5 – 12.

4.1 Footprint analysis summary by indicator

A mixed picture of the environmental and social risks associated with the UK's consumption of seafood emerges from the risk assessment (Figure 9). Firstly, the greatest proportion of 'high and medium risk' ratings typically arise in the category of 'Sustainability certification progress'. This is because many fisheries or farms, despite being certified, have not achieved the desired level of sustainability as shown by the improvement actions (i.e. conditions) associated with the certificate of sustainability. Furthermore, a significant proportion of consumed seafood is neither certified nor in improvement projects.

[98] https://www.wwf.org.uk/sites/default/files/2017-10/WWF%20and%20RSPB%20-%20Risky%20Business%20Report%20-%20October%202017.pdf

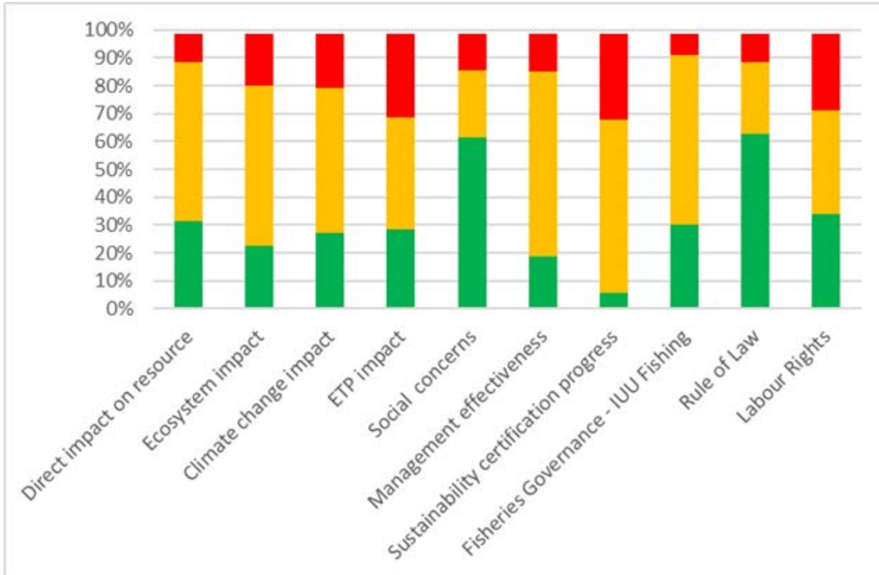

Figure 9: Percentage (%) of supply chains associated with low (green), medium (amber) or high (red) risk scores for each of the 10 risk indicators.

Secondly, concerns over social issues such as Labour Rights[99] of the producing countries are another relatively widespread cause for concern (Figure 9). However, for the majority of supply chains, social concerns (i.e. reported human rights abuse) associated with the fishery / aquaculture industry are considered to be lower risk. This might be a reflection of how difficult it is to uncover these types of illegal activities.

Thirdly, this report estimated that 31% of the UK's assessed seafood supply chains are at high risk of impacting ETP species (Figure 9) and that at least 528 species are at risk of interacting with fisheries and farms. As these findings are based on limited publicly available information, it is very likely this is a significant underestimate of the reality.

Further, for most of the risk indicators, a 'medium' level of risk was determined suggesting widespread improvements are required and in a number of cases, there is a need for increased evidence or transparency (as a medium risk score was also applied where there was limited evidence or information to base the assessment on).

[99] https://www.ituc-csi.org/ituc-global-rights-index-2020

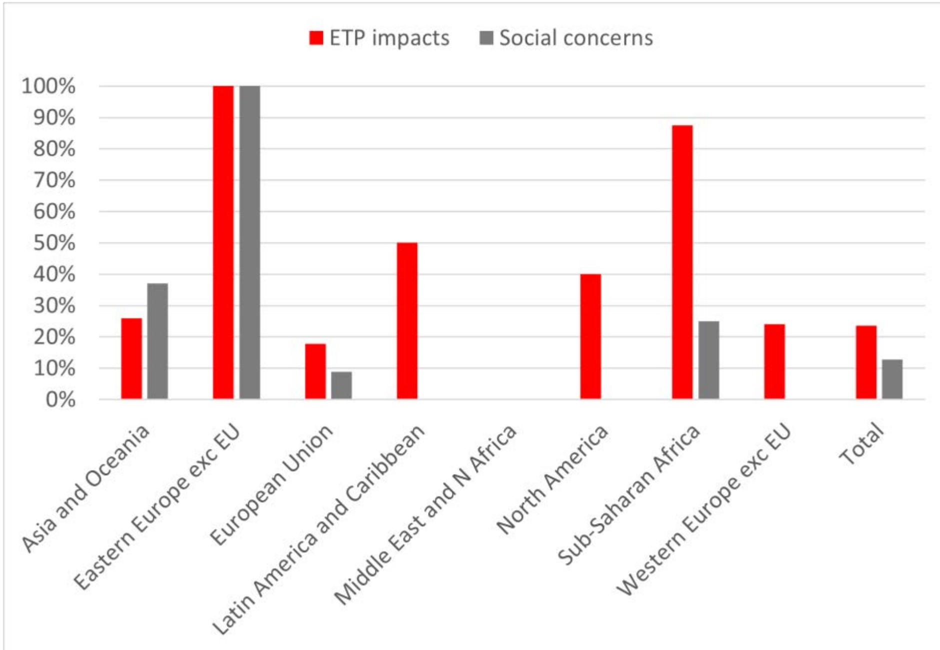

Figure 10: Percentage (%) of supply chains associated with high risk scores for two of the risk indicators – ETP impact and Social concerns, by continent of the producing country. Data labels indicate the total number of supply chains associated with each continent.

Breaking the ETP and social concerns risk scores down reveals different stories. For example, high risk social concerns associated with the fishery / aquaculture industry represent a relatively high proportion (%) of assessments for supply chains associated with Asia and Oceania (e.g. China, Vietnam and Thailand), Eastern Europe (= Russia) and Africa (e.g. Seychelles, Mauritius), although the number of supply chains associated with that high level of risk is relatively low (e.g. 4 for Eastern Europe). Whilst high risks of ETP impact are more geographically widespread, there are again hot spots of risk such as supply chains associated with Latin America and the Caribbean and Africa (Figure 10). This relatively high level of regional risk is largely associated with large pelagic fisheries (tuna and swordfish) (Figure 11).

The distribution of risk across the commodity categories reveals some further notable patterns. Risks associated with large pelagic resources (e.g. tuna, swordfish) are typically 'medium' to 'high' (Figure 11). Conversely, the UK's preference for salmonids and small pelagics (see Section 3.4) is reassuringly associated with lower levels of risk, with the notable exception of 'Sustainability certification progress' (as discussed above) and 'Management effectiveness' for small pelagics (Figure 11).

Risks posed by the UK's seafood consumption on the stocks or populations of wild marine resources again indicates areas of concern. In general, potential impacts of finfish aquaculture (salmonids, farmed whitefish) are considered lower risk than wild capture fisheries, particularly for large pelagics and whitefish (Figure 11). However, data limitations were also a feature of many of the supply chain assessments, particularly for small pelagics (e.g. herring), molluscs (e.g. squid) and large pelagics (e.g. albacore tuna).

The UK's import and production of seafood is also largely associated with medium to high levels of risk to the wider environment, particularly relating to potential for habitat damage by bottom towed gears (e.g. the majority of whitefish fisheries and a number of crustacean and wild capture bivalve (e.g. scallop) fisheries) and bycatch of non-target species by low-selectivity gear (e.g. whitefish trawls and large pelagic purse seines). Farmed seafood is associated with specific risks to the ecosystem, namely the effects of waste products on the benthic habitat and wider water column through eutrophication. Conversely, the relatively 'clean' small pelagic fisheries are associated with the lowest level of risk of environmental impact (Figure 11).

For the purposes of the risk assessment of individual production supply chains, we chose to focus on the relative carbon footprint risks of the production methods, given the absence of more complete data on seafood supply chain climate change impacts such as the impacts on blue carbon that are captured in the aquatic habitats. Where possible, data on emissions per kilogram (kg) of production were taken into account, in combination with more general evidence on fuel use by different fisheries, as well as consideration of the impacts of towed gear on blue carbon stored in habitats. This simplified and incomplete picture of carbon footprint risk of the UK's seafood consumption suggests that particular causes for concern are the UK's preference for crustaceans (particularly lobster species) and whitefish (particularly monkfish) (Figure 11).

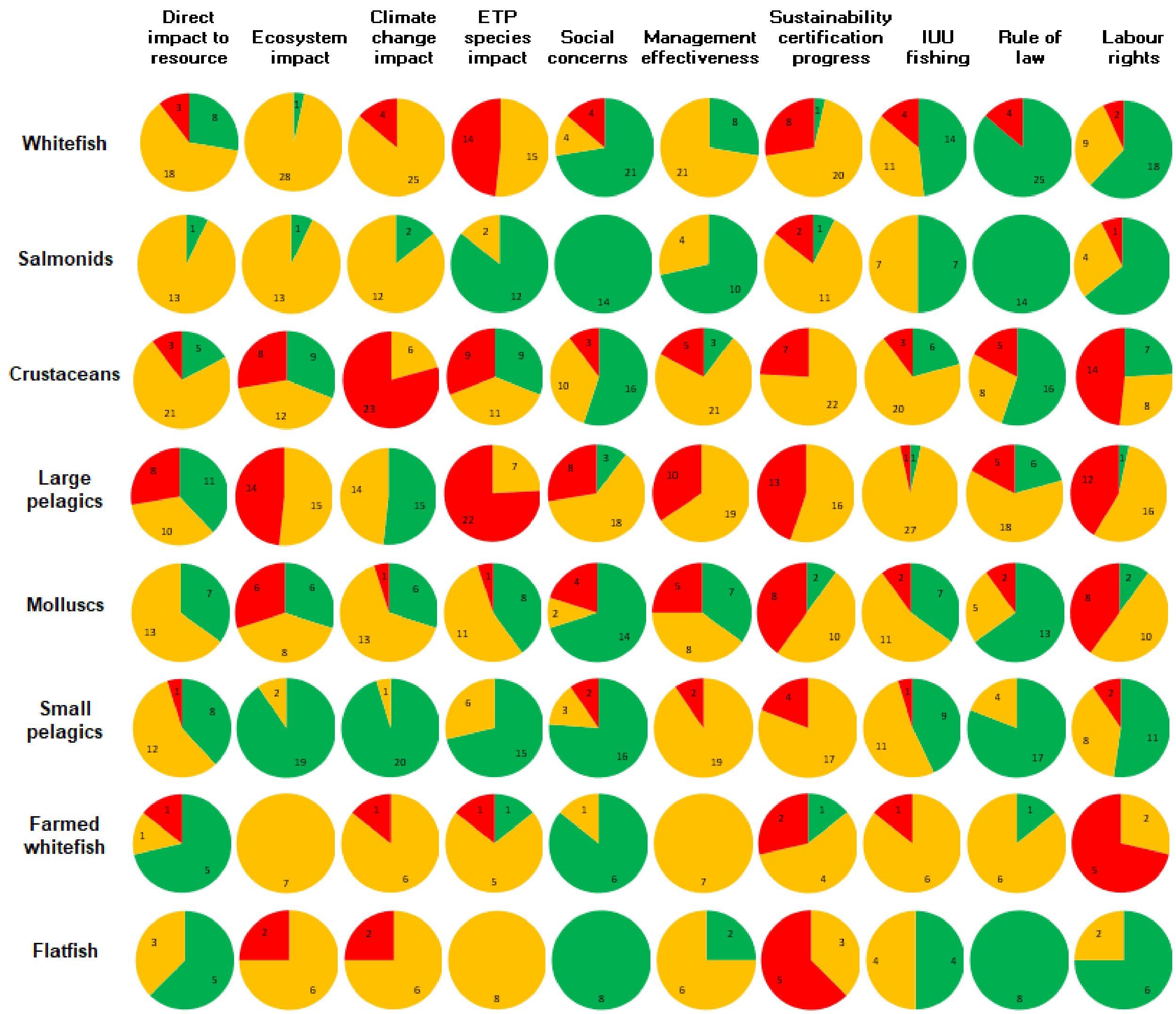

Figure 11: Distribution of Risk assessment scores for the 10 indicators of risk for each commodity category. Red = high risk, amber = medium risk, green = low risk. Numbers indicate number of supply chains assessed.

4.2 Footprint analysis summary by species category and sub-category sources

The average footprint scores for the supply chains assessed in the report again present a mixed picture (Figure 12). The eight commodity categories highlight the potential environmental and social impacts of the UK's demand for large pelagic species like tunas, which have the highest average footprint. At the other end of the scale is the relatively positive picture painted by our consumption of small pelagic species like herring.

Looking at specific sub-category resources (Figure 12) provides a better picture of the footprint of the UK's consumption. While small pelagics like herring and mackerel have the lowest average footprint by category, mussels have the lowest footprint when compared with all other species. This is because farmed mussels, particularly rope-grown mussels, do not require inputs of feed or energy to raise them. As filter feeders, mussels capture food and nutrients from their surroundings, meaning they have a positive effect on water quality. Rope-grown mussel farms do not alter the habitat, as ropes float in the water column and the greenhouse gas emission of farmed mussels is very low.

Although small pelagics also have lower footprint scores, disagreements on catch quota of Atlantic mackerel and herring between the Northeast Atlantic coastal states like the EU, Faroe Islands, Iceland, Norway, Russia and the UK have cast doubt on the long-term sustainability of these seafood resources.

Large pelagics (e.g. swordfish and yellowfin tuna), warm-water prawns, other crab species and squid (e.g. *Loligo* spp. and shortfin squid) on the other hand have the highest footprint scores among the seafood the UK consumes. Management of large pelagic species like tuna and swordfish is under the jurisdiction of tuna Regional Fisheries Management Organisations (tRMFOs) and the effectiveness of these management authorities is questionable. Bycatch of marine life like turtles, birds, sharks and even marine mammals has been widely reported. Since fishing of these large pelagic species occurs in international waters, human rights abuses are known to be prolific in these fisheries.

Farming of warm-water prawns has caused deforestation and alteration of mangrove into pond farms in tropical Asia and Latin America. This in turns destroys the habitats of the mammals, reptiles and birds which rely on these important ecosystems. Furthermore, biological and chemical pollution, use of unsustainable feed and ineffective management of farming activities have increased the footprint of these seafood resources.

Lack of management of target stock resources, including monitoring, reporting and bycatch reduction in the producing (often developing) countries, are the main contributing factors to the high footprint scores for crab and squid.

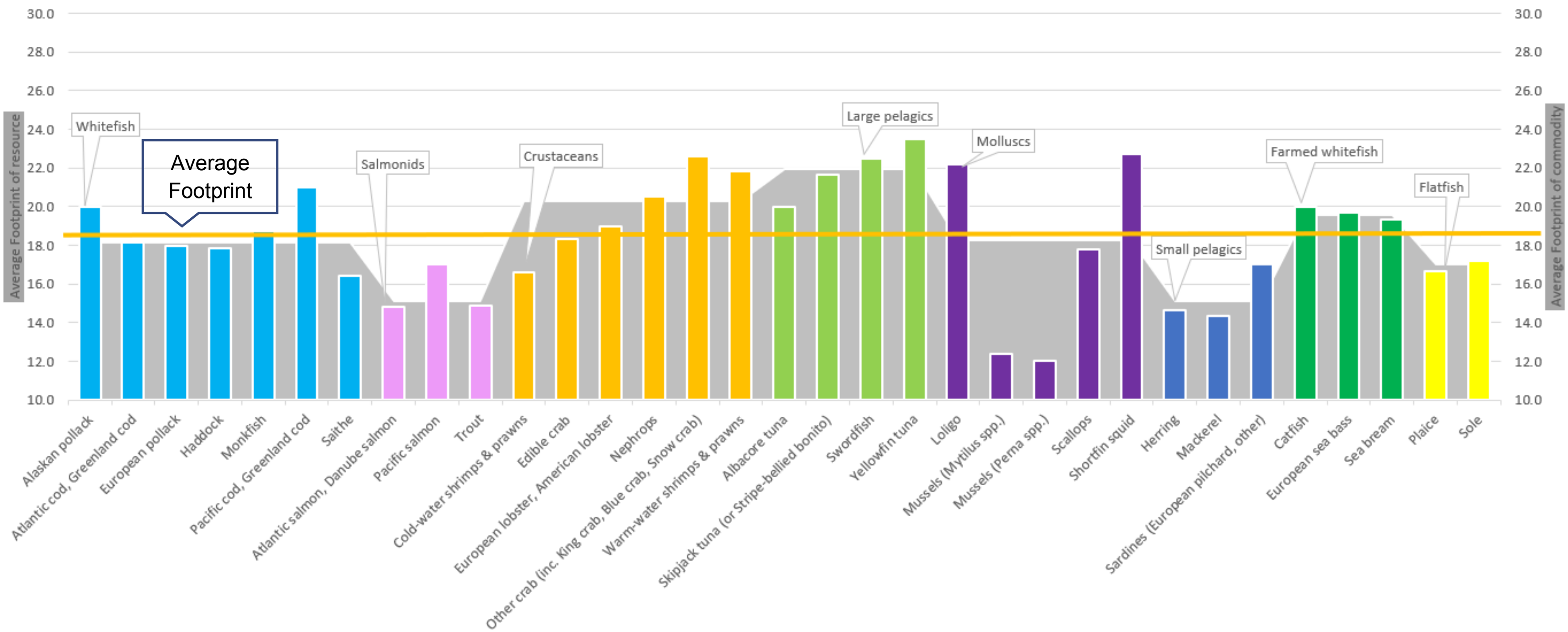

Figure 12: Average footprint of seafood resources, grouped by commodity category, consumed in the UK.

4.3 Footprint analysis summary by country

A total of 40 countries are included in the assessment of the 33 resources (eight commodities and 157 supply chains) in this report. The average seafood footprint of producing countries (including the UK) provides a general picture of how these countries perform against each other. It also allows us to understand the seafood footprint of the UK's own domestic production when compared with other seafood producing countries.

In general, producing countries (or regions) with established and more robust fisheries or aquaculture management systems perform better (i.e. lower scores) than those without such systems (Figure 13). For example, countries like New Zealand, Canada and Iceland have the lowest footprints whilst countries like Taiwan and Bangladesh have the highest.

Furthermore, developing countries of Asia, Africa and Latin America tend to have a higher footprint than Europe (except southern European countries like Malta and Greece). This means the UK's seafood consumption has impacts on the marine resource management of these developing countries and actions should be taken to avoid 'exporting' our footprint to meet our seafood demand.

While it is slightly below the average footprint, the performance of the UK's production in terms of footprint score is not as good as neighbouring countries in the Northeast Atlantic such as Iceland, Sweden and Norway (Figure 13). Therefore, the UK needs to improve our own production systems (e.g. fisheries regulations and policies and corporate sourcing policies) to better manage our own seafood resources.

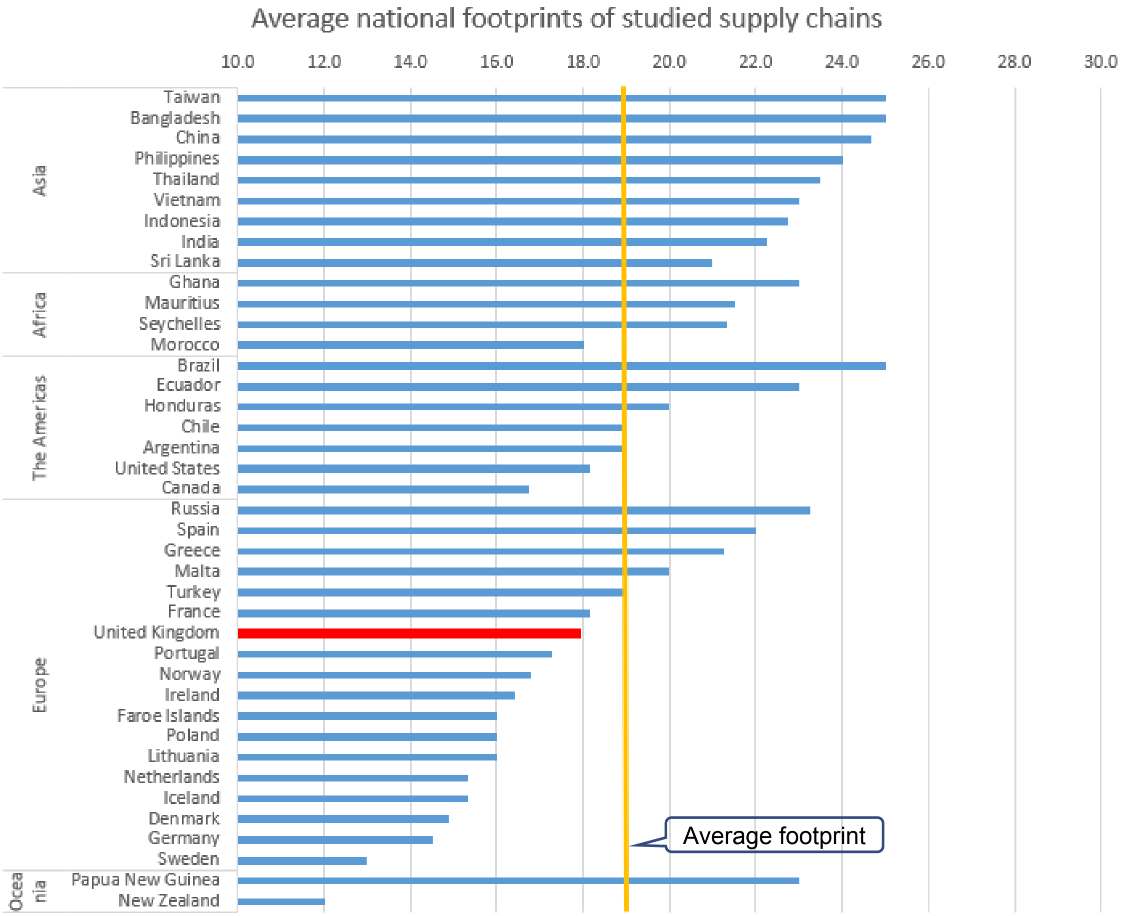

Figure 13: Average footprint of each seafood producing country based on the studied 157 supply chains. Each supply chain undergoes a risk assessment comprised of 10 indicators to capture the range of key ecological, climate, social and governance risks associated with production seafood supply chains (Appendix I & II). Each indicator is assigned a risk score of Low (1), Medium (2) or High (3) risk based on independent assessment of the best publicly available evidence. The average footprint of a seafood producing countries is calculated according to the total sum of the 10 risk indicators scores divided by the total number of supply chains assessed. Seafood footprint is measured as the higher the score, the bigger the footprint (minimum of 10 and maximum of 30 for all 10 indicators). It should be noted that the average footprint of each country only represents the supply chains that are covered in this report. Therefore, it does not include the footprints of any supply chains of these seafood producing countries that are not covered in this report. Full methodology details in Section 2 of this report.

5. Seafood commodity – Whitefish

5.1 Summary of whitefish supply chains

The whitefish commodity group is relatively diverse. For the purposes of this report, we focus on the following resources:

- Atlantic cod (*Gadus morhua*), some commodity codes also feature Greenland cod (*Gadus ogac*)
- Pacific cod (*Gadus macrocephalus*), some commodity codes also feature Greenland cod (*Gadus ogac*)
- Haddock (*Melanogrammus aeglefinus*)
- Monkfish (*Lophius spp.*) (also known as anglerfish)
- Saithe (*Pollachius virens*) (also commonly referred to as pollock or coley and not to be confused with Alaska pollock or European pollack)
- Alaska pollock (*Theragra chalcogramma*)
- European pollack (*Pollachius pollachius*)

For several of the whitefish resources, the trade data contains commodity codes featuring one or more species / resources. As indicated above, for both Atlantic and Pacific cod, multiple codes also feature Greenland cod, likely because Greenland cod is imported from countries which catch both species and / or difficulties distinguishing between the species in catches. However, the relative quantities of Greenland cod compared to the other cod species is likely to be relatively low and therefore Greenland cod is not assessed separately (and even if it were, the risk assessment is likely to be very similar). Further, there are 'cod' commodity codes which include all three species. For the purposes of the assessment, the volumes associated with the mixed commodity codes were assumed to be Atlantic cod, based on the dominance of the species on the UK market and the supply chains associated with the data. Similarly, mixed commodity codes for Alaska pollock and European pollack were assumed to be Alaska pollock, again because Alaska pollock is imported / consumed in significantly higher quantities than European pollack.

'Whitefish' represents one of the most important seafood commodities for the UK. Based on 2019 trade data alone, and the resources assessed in this report, whitefish represented around 27% of UK imports (amounting to over 264,000 tonnes). The average for 2015-2019 was however higher, with over 34% of imports comprising whitefish resources (although the average volume of those imports was lower at 174,700 tonnes).

Breaking the commodity group down by resource, it is clear that Atlantic cod drives the UK whitefish market with 43% of whitefish imports in 2019 (53% as an average for the five year time period) comprised of Atlantic cod. A further 24% and 18% of imports on average are represented by haddock and Alaska pollock, respectively.

UK production of whitefish is however also significant. In fact, when considering individual supply chains, the UK provides the majority of the nation's consumption of several whitefish resources – haddock, saithe, monkfish and European pollack.

The UK's cod fishery is, and always has been, an important feature of the UK fishing industry. However, the current poor status of cod stocks in UK waters, a picture that has been present for several decades albeit with brief periods of partial recovery in the North Sea, leaves the fishery in a fragile state. The UK's reliance on imports of cod caught in the lower footprint fisheries of Iceland and Norway could therefore be viewed as fortunate from an environmental and social footprint perspective. However, the situation is of course not that simple when other factors such as cod being largely caught as part of mixed demersal fisheries is taken into account, as well as the economic drivers of the UK's cod trade and its potential impacts on demand[100].

According to the trade data, cod was imported from 38 countries between 2015 and 2019, with around 102,000 tonnes to 119,000 tonnes imported annually (average ~109,000 tonnes). However, for many of the low ranking countries (not analysed here), annual imports were intermittent / infrequent and quantities were very low. It is therefore uncertain whether many of these are true data points or anomalies. What is clear however is the importance of China (Figure 14) as an intermediary in the UK's cod supply chain network (see Section 5.2).

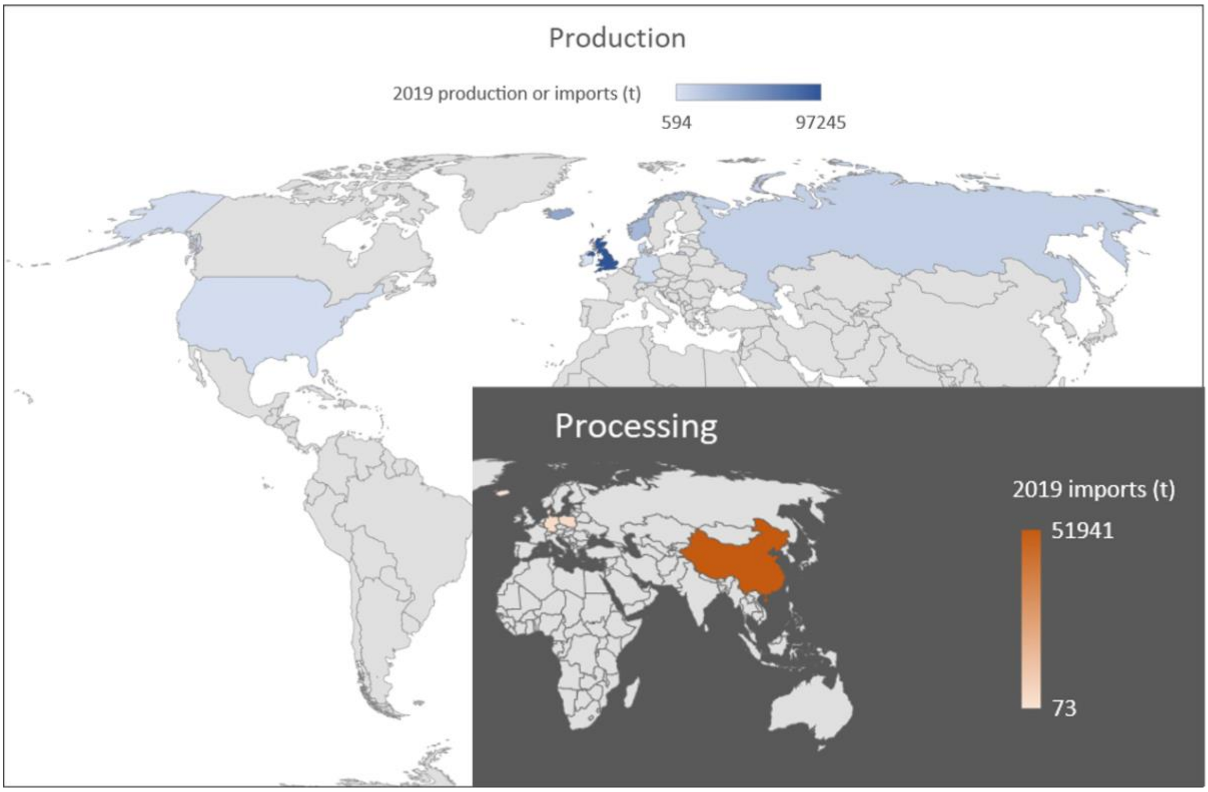

Figure 14: Map showing source countries for whitefish seafood commodities (Atlantic cod, Pacific cod, Alaska pollack, European pollack, Haddock, Saithe, Monkfish) consumed in the UK. Large map shows those countries which are primarily considered to be producers, whereas the inset map shows intermediary countries in the supply chains where whitefish products are largely processed rather than produced. Total (all whitefish resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

Most average footprint scores for the commodity and its supply chains fall into the 'medium' category. Considering all of the main supply chains together, saithe is associated with the lowest footprint whilst Pacific cod and Alaskan pollock (fished by Russia in particular) are scored the highest. There is a relatively high range in footprint scores when considering the countries associated with one or more of the whitefish resources, with the United States and

[100] https://planet-tracker.org/cod-astrophe-unsustainable-uk-cod-exports-face-demand-side-squeeze/

Iceland falling at the lower end of the scale, and UK, Republic of Ireland and Russia at the upper (Table 8).

Table 8: (a) Average footprint scores for each producing country in the UK's whitefish supply chains and (b) for each whitefish resource sub-category.

Producing country	Average Footprint
Iceland	15.6
Faroe Islands	16.5
United States	17.0
Norway	17.3
Denmark	17.3
Germany	18.0
United Kingdom	19.4
Republic of Ireland	20.0
Russia	23.3

Resource	Average Footprint
Saithe	16.4
Haddock	17.8
Atlantic cod, Greenland cod	18.1
European pollack	18.0
Monkfish	18.8
Alaskan pollack	20.0
Pacific cod, Greenland cod	21.0

Table 9: Supply chain information, risk assessment and footprint for Whitefish commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Whitefish	Cod	Atlantic cod, Greenland cod	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	3	2	2	3	2	2	2	2	1	2	21	18.1	18.6
			94%	Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	1	2	2	2	1	1	2	1	1	1	14		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	2	2	3	1	1	2	2	1	1	17		
				European Union	NE Atlantic	Germany	Prod	Cap	3	2	2	3	1	2	2	1	1	1	18		
				Eastern Europe exc EU	NE Atlantic	Russia	Prod	Cap	1	2	2	3	3	1	2	3	3	2	22		
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Cap	2	2	2	2	1	2	2	1	1	1	16		
				European Union	NE Atlantic	Denmark	Prod	Cap	3	2	2	3	1	2	3	1	1	1	19		
				Asia and Oceania		China	Process									3	2	3			
		Pacific cod, Greenland cod	6%	North America	NE Pacific	United States	Prod	Cap	1	2	2	3	1	1	2	2	1	3	18	21.0	
				Eastern Europe exc EU	NW Pacific	Russia	Prod	Cap	2	2	2	3	3	2	2	3	3	2	24		
				Asia and Oceania		China	Process									3	2	3			
				European Union		Denmark	Process									1	1	1			
				Western Europe exc EU		Iceland	Process									1	1	1			
	Haddock	Haddock	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	1	2	2	2	2	2	2	2	1	2	18	17.8	
			100%	Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	2	2	3	1	1	2	2	1	1	17		
				Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	2	2	2	2	1	2	2	1	1	1	16		
				Asia and Oceania		China	Process									3	2	3			
				European Union	NE Atlantic	Denmark	Prod	Cap	1	2	2	2	1	2	3	1	1	1	16		
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Cap	2	2	2	3	1	2	2	1	1	1	17		
				Eastern Europe exc EU	NE Atlantic	Russia	Prod	Cap	2	2	2	3	3	1	2	3	3	2	23		
	Saithe	Saithe	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	2	2	2	2	2	2	1	2	19	16.4	
			100%	Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	1	2	2	2	1	1	2	1	1	1	14		
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Cap	1	2	2	2	1	2	2	1	1	1	15		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	2	2	2	1	2	2	2	1	1	17		
				European Union	NE Atlantic	Denmark	Prod	Cap	2	2	2	2	1	2	3	1	1	1	17		
	Monkfish	Monkfish	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	3	3	1	2	2	2	1	2	20	18.8	
			100%	European Union	NE Atlantic	Republic of Irelanc	Prod	Cap	2	2	3	3	2	2	3	1	1	1	20		
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Cap	2	2	3	2	1	2	3	1	1	1	18		
				Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	2	2	3	2	1	2	2	1	1	1	17		
	Pollack	Alaskan pollack	99.6%	Asia and Oceania		China	Process									3	2	3		20.0	
				North America	NE Pacific	United States	Prod	Cap	1	1	2	3	1	1	1	2	1	3	16		
				European Union		Germany	Process									1	1	1			
				European Union		Poland	Process									1	2	2			
				Eastern Europe exc EU	NW Pacific	Russia	Prod	Cap	2	2	2	3	3	2	2	3	3	2	24		
		European pollack	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	2	2	1	2	3	2	1	2	19	18.0	
			0.4%	Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	2	2	2	1	2	3	2	1	1	18		
				Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	2	2	2	2	1	2	3	1	1	1	17		

5.2 Seafood resource: Atlantic cod

5.2.1 Supply chain overview

In 2019, the UK fishing fleet landed around 29,000 tonnes of Atlantic cod, although 7,000 tonnes of this was landed outside the UK. The UK imported a further 90,500 tonnes through seven main supply chains (which collectively represented around 90% of the UK's average annual imports of Atlantic cod for the period 2015-19). Accounting for exports of Atlantic cod (around 8,400 tonnes in 2019 – assumed to be cod caught by the UK fleet and landed in the UK), the UK's production represented approximately 12% of the UK's estimated Atlantic cod consumption in 2019, with a further 22% and 13% of the consumed cod having been imported from Iceland and Norway, respectively (Figure 15)[101].

Confusingly, nearly 19% of the Atlantic cod consumed in the UK in 2019 (21,200 tonnes) arrived from China. Lack of transparency in the trade data means that determining the original source of those imports is difficult. However, according to UN Comtrade data[102], in 2019 the following volumes (tonnes) of mainly frozen cod were exported to China from four of the key countries in the UK's supply chain:

Country	Volume exported to China in 2019 (tonnes)
Iceland	739
Norway	55,778
Russia	35,438
United Kingdom	1,042

These data suggest that a notable portion of the Atlantic cod imported by the UK from China may have been caught by the Norwegian and Russian fleets, although this cannot be confirmed. The UK press[103] have noted the idiosyncrasies of frozen cod – including that caught by the UK fleet - being transported to China from the North Atlantic for processing, and then returned for consumption in the UK. Clearly, the environmental footprint of the food miles associated with the trade route deserves greater attention. Furthermore, additional environmental and potentially social risks arise from the opaqueness of Chinese supply chains relative to European equivalents[104]. For example, a study in 2018 found up to 60% of premium Chinese cod fillet products in China were mislabelled and were actually other species of fish such as pollock[105].

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[101] Within the HMRC trade data, sixteen commodity codes exist for 'cod' (covering fresh or chilled, frozen, dried/salted/in brine and prepared or preserved products). Only three of these codes refer to Atlantic cod alone, although

[102] https://comtrade.un.org/

[103] https://www.thesun.co.uk/news/10775752/fresh-fish-caught-off-britain-goes-on-10000-mile-round-trip-before-being-sold-in-uk-supermarkets/

[104] https://planet-tracker.org/cod-astrophe-unsustainable-uk-cod-exports-face-demand-side-squeeze/

[105] Xiong Xiong, Lili Yao, Xiaoguo Ying, Lixia Lu, Lisa Guardone, Andrea Armani, Alessandra Guidi, Xiaohui Xiong. (2018). Multiple fish species identified from China's roasted Xue Yu fillet products using DNA and mini-DNA barcoding: Implications on human health and marine sustainability, Food Control, 88, 123-130.

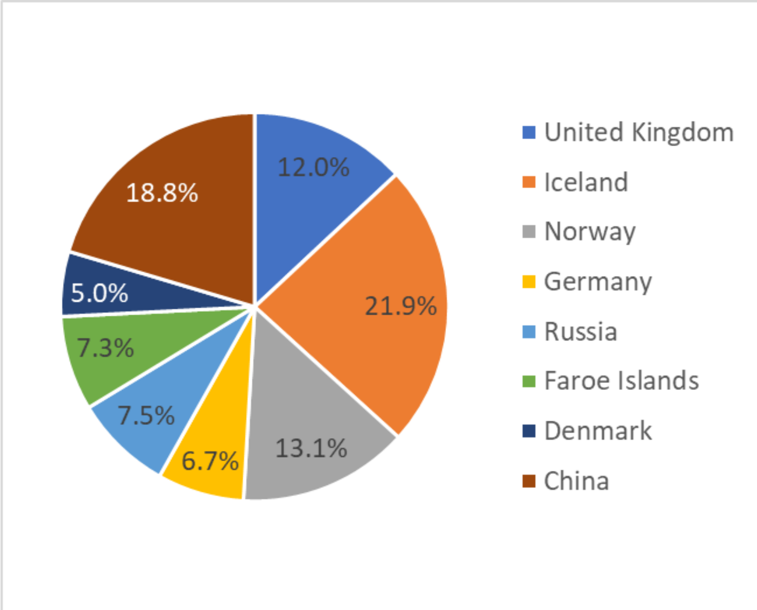

Figure 15: Percentage (%) contribution by the UK and the main countries from which Atlantic cod is imported, to the UK's estimated Atlantic cod consumption in 2019.

Imports from China have increased over the period 2015-2019, whereas they have shown a decline for the Iceland and Norway supply chains (Figure 16). Between 2015 and 2019, 76% - 88% of annual Atlantic (or Greenland) cod imports were in the form of frozen fillets as opposed to fresh or chilled cod.

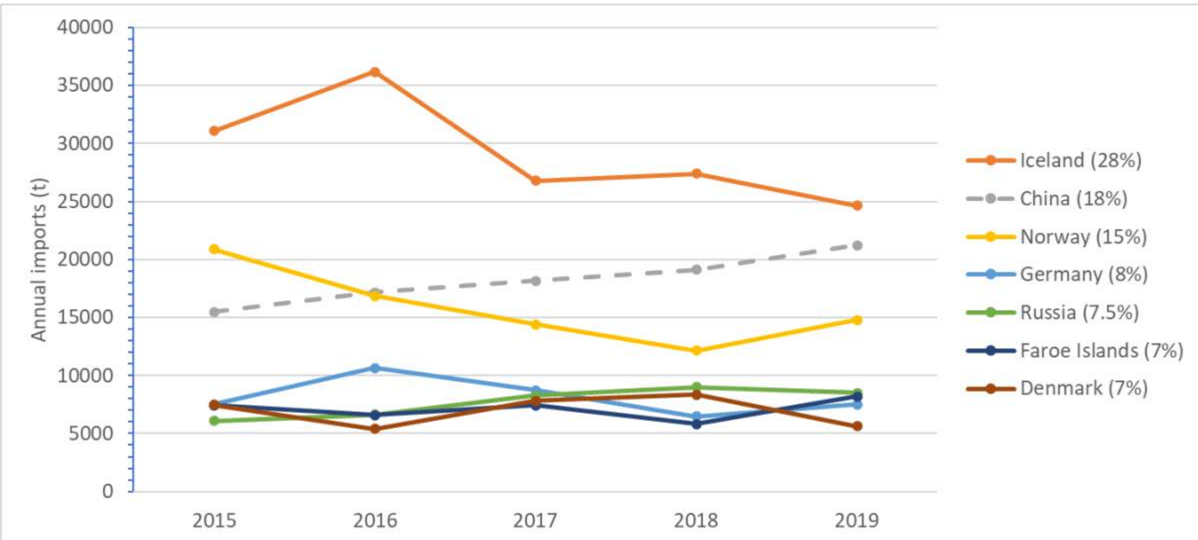

Figure 16: Volume (tonnes, t) of Atlantic cod imported by the UK annually between 2015 and 2019. China is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

5.2.2 Risk assessment and footprint summary

Supply chain scores range from a 'low' 14 to a 'medium' 22, with the UK at the top end of the scale, marginally lower than Russia (Figure 17). The footprint for Iceland is the lowest, which is encouraging given the country's dominance in the UK's market supply. A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 10 below with full details available in Appendix 1.

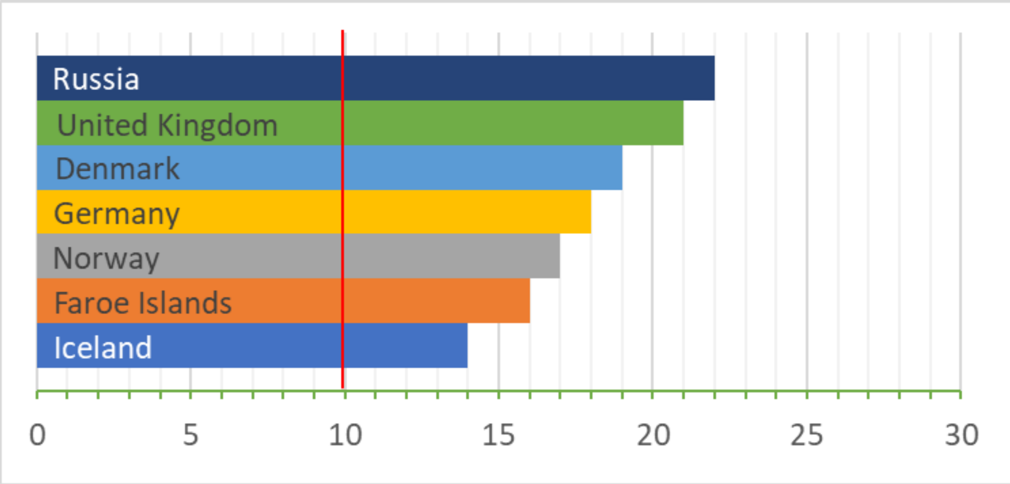

Figure 17: Total footprint for each of the UK's main Atlantic cod supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 10: Risk assessment summary for main supply chains for Atlantic cod consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United Kingdom	Iceland	Norway	Germany	Russia	Faroe Islands	Denmark
Direct impact on resource (Env_1)	Depleted state and subject to overfishing	Sustainably fished relative to MSY	Rebuilding plan is in place due to low biomass of coastal stock	Stocks in depleted state and subject to overfishing	Sustainably fished relative to MSY	*Data limited*, with the latest assessment in 2018 - no reference points are defined	Stocks in depleted state and subject to overfishing
Ecosystem impact (Env_2)	Bottom towed gear and gillnets pose risk to the ecosystem through habitat damage and bycatch of target and non-target species						
Climate change impact (Env_3)	Bottom towed gear associated with high risk. However, average score of 2 tonnes of CO2 per kg of fish ('low risk') provided by the Seafood Carbon Emissions Tool – likely to underestimate blue carbon habitat impacts though.						
ETP impact (Env_4)	Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals	Some risk posed to seabirds	Risk of bycatch of cetaceans such as harbour porpoise, seabirds and other ETP species			More information required (*data limited*)	Risk of bycatch of cetaceans such as harbour porpoise
Social concerns (Social_1)	Reports of social concerns associated with Scottish whitefish fisheries have featured in the media in past years	No known social concerns			Significant social concerns associated with Russia's fishing industry	No known social concerns	
Management effectiveness (Mgt_1)	Scope for improvements in management	Considered to be effective		Scope for improvements in management	Joint management of this fishery with Norway is considered good	Lack of catch control and management plan	Scope for improvements in management

Sustainability certification progress (Mgt_2)	MSC certification for the North Sea cod fishery was suspended in 2019 due to concerns about the status of the stock	MSC certified, with conditions	WWF previously submitted objections to its MSC certification, which were subsequently withdrawn	Fishery targeting Northeast Arctic cod is partially MSC certified with conditions	Largely MSC certified, some with conditions and some subject to previous objections	Northeast Arctic cod fishery is MSC certified, however there is no progress in relation to the Faroe Bank or Faroe Plateau fisheries	North Sea fishery partially MSC certified (with conditions). Objections to certification submitted and not withdrawn.
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator				External, country level indicator	External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator			External, country level indicator	External, country level indicator	

5.3 Seafood resource: Pacific cod

5.3.1 Supply chain overview

Between 2015 and 2019, the UK imported on average just over 6,000 tonnes of Pacific cod per year, with a declining trend seen across the five-year period. The majority (~97%) of that product arrives in frozen form.

On average, 90% of the UK's annual imports of Pacific cod for the period 2015-2019 arrived from China (79% of imports on average), Denmark (8% of imports) and Iceland (3% of imports). It is therefore assumed that all three of these countries represent intermediary steps in the UK's Pacific cod supply chains, as whilst China does catch Pacific cod, landings are estimated to have been around 11,000 tonnes in recent years[106], meaning that China would have exported around 45% of its cod catches to the UK alone. This is assumed to be unlikely and therefore that a notable proportion of the imports from China are instead the result of processing of catches of other key Pacific cod producing nations, such as the United States, Russia, Norway and Japan[107].

Therefore, for the purposes of the assessment, the UK's imports of Pacific cod from China were assumed to have originated from the United States and Russia in equal proportions[108] in the absence of data to more accurately inform the provenance of the imports (Figure 18).

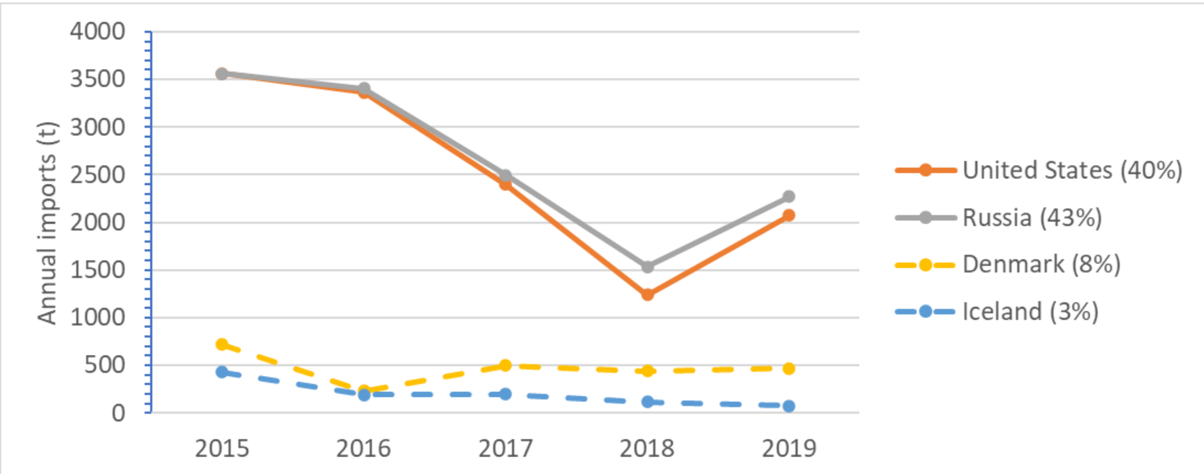

Figure 18: Volume (tonnes, t) of Pacific cod imported by the UK annually between 2015 and 2019. Denmark and Iceland are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The contribution of these supply chains to the UK's estimated consumption of Pacific cod in 2019 (5,159 tonnes)[109] is therefore approximately the same as their relative roles in the UK's imports (Figure 19).

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[106] *http://www.seaaroundus.org/data/#/taxon/600308?chart=catch-chart&dimension=eez&measure=tonnage&limit=10*

[107] *See 'China | Imports from all partners | Cod – Frozen – All', 'Russia | Exports to all partners | Cod – Frozen – All' and 'United States | Exports to all partners | Cod – Frozen – All' in Groundfish report at: https://www.fao.org/in-action/globefish/fishery-information/tradestatistics/en/*

[108] *In addition to the recorded imports from the countries in the HMRC trade data*

[109] *Based on HMRC import and export data, consumption in 2019 was closer to 1,900 tonnes (as imports were recorded as 5,159 tonnes and exports as 3,294 tonnes). However, it seems likely that some of the exports are incorrectly recorded as Pacific cod (when they were in fact Atlantic cod). For the purposes of the assessment, consumption was therefore assumed to be equal to imports.*

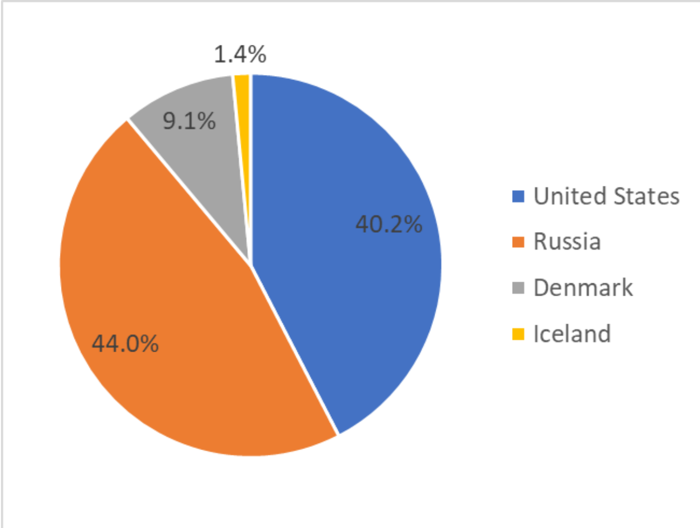

Figure 19: Percentage (%) contribution by the main countries from which Pacific cod is imported, to the UK's estimated Pacific cod consumption in 2019.

5.3.1 Risk assessment and Footprint Summary

The footprint of the United States' supply of Pacific cod to the UK is lower (falling into a 'medium' category) than that of Russia (falls with the 'high' range of footprint scores) (Figure 20). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 11 below with full details available in Appendix 1.

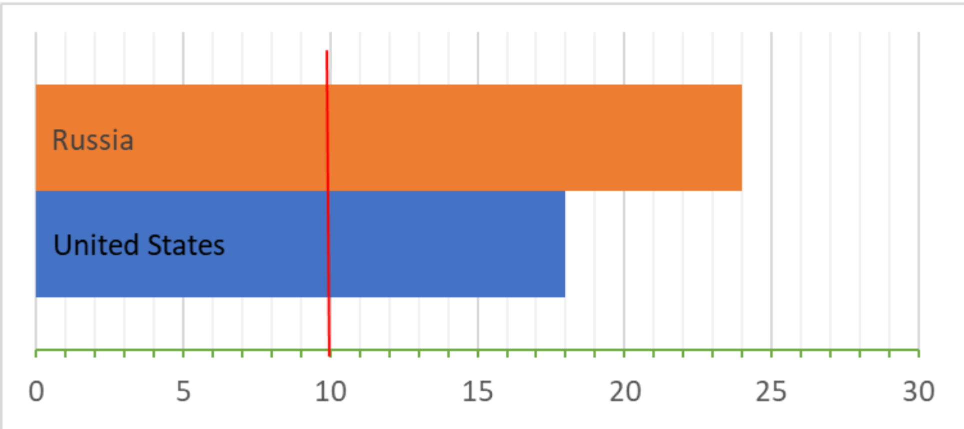

Figure 20: Total footprint for each of the UK's main Pacific cod supply chains (available score range: 10 – 30), excluding processing / trading countries

Table 11: Risk assessment summary for main supply chains for Pacific cod consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United States	Russia
Direct impact on resource (Env_1)	Main stocks are considered to be above target population levels and not subject to overfishing	Data from recent years not available / not available to public
Ecosystem impact (Env_2)	Mixture of bottom towed gear, longlines and pots used in fishery. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch	
Climate change impact (Env_3)	Bottom towed gear associated with high risk. However, average score of 2.6-3 tonnes of CO2 per kg of fish ('low risk') provided by The Seafood Carbon Emissions Tool – likely to underestimate blue carbon habitat impacts though.	
ETP impact (Env_4)	Interaction occurs with a number of ETP species and there are uncertainties over impacts of this bycatch mortality. More data needed, particularly for Russia.	
Social concerns (Social_1)	No known concerns	Significant concerns regarding modern slavery in fishing industry
Management effectiveness (Mgt_1)	Management of the fishery by NOAA, the North Pacific Fishery Management Council and Pacific Fishery Management Council considered effective	Lack of transparency over policy making and operational management, minimal data availability and economic prosperity as a key objective of management measures
Sustainability certification progress (Mgt_2)	Largely MSC certified, some with conditions	Longline fishery (only) MSC certified
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator

5.4 Seafood resource: Haddock

5.4.1 Supply chain overview

In 2015, just over 40,300 tonnes of haddock were imported by the UK, rising to nearly 50,000 tonnes in 2019. Six countries were jointly responsible for 91% of those imports on average (Figure 21). The majority of imports arrived from Norway and Iceland (32% and 22% on average, respectively). A further 13% came from China, assumed to be an intermediary in the supply chain where haddock is imported for processing and then re-exported.

Twenty-five other countries feature in the HMRC trade data in relation to imports of haddock between 2015 and 2019, ranging from Sweden and the Republic of Ireland (jointly supplying around an additional 5% of imports on average) to Vietnam (44 tonnes on average, or <0.1% of imports) and Kenya (7.2 tonnes in 2019 only). The accuracy of some of these data points is questionable, or even if they are accurate, determining the original source of the haddock is impossible.

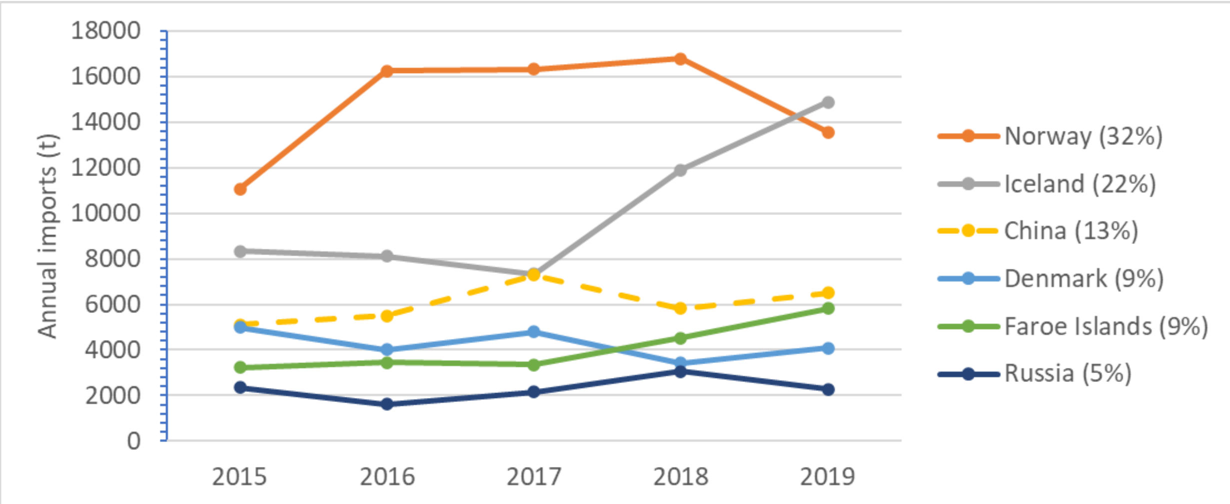

Figure 21: Volume (tonnes, t) of haddock imported by the UK annually between 2015 and 2019. China is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The UK's own production of haddock is significant, with over 33,700 tonnes landed by the UK fleet in 2019 (around 400 tonnes of this was landed outside of the UK), compared to the 47,000 tonnes imported through the six main supply chains alone. With just 1,900 tonnes of haddock exported by the UK in 2019, the UK's production represents an estimated 39% of its own consumption, with a further 35% having arrived from Norway and Iceland (Figure 22).

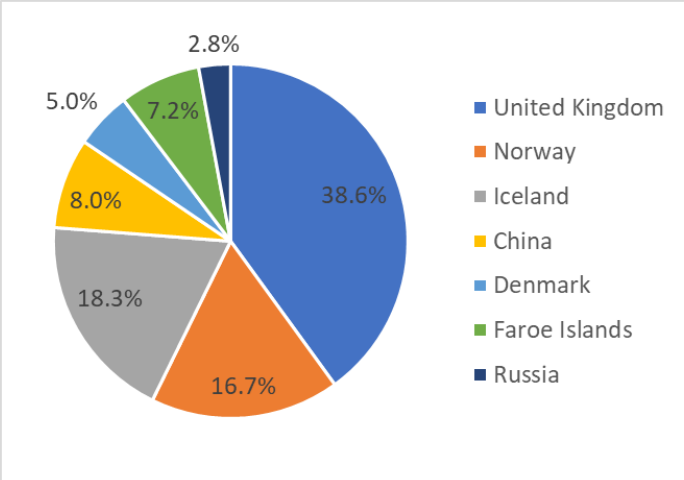

Figure 22: Percentage (%) contribution by the UK and the main countries from which haddock is imported, to the UK's estimated haddock consumption in 2019.

5.4.2 Risk assessment and Footprint Summary

The supply chain footprints associated with the UK's consumption of haddock all fall within the 'medium' range, with the UK and Norway having the lowest footprint (score of 16) and Russia the highest (footprint of 23) (Figure 23). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 12 below with full details available in Appendix 1.

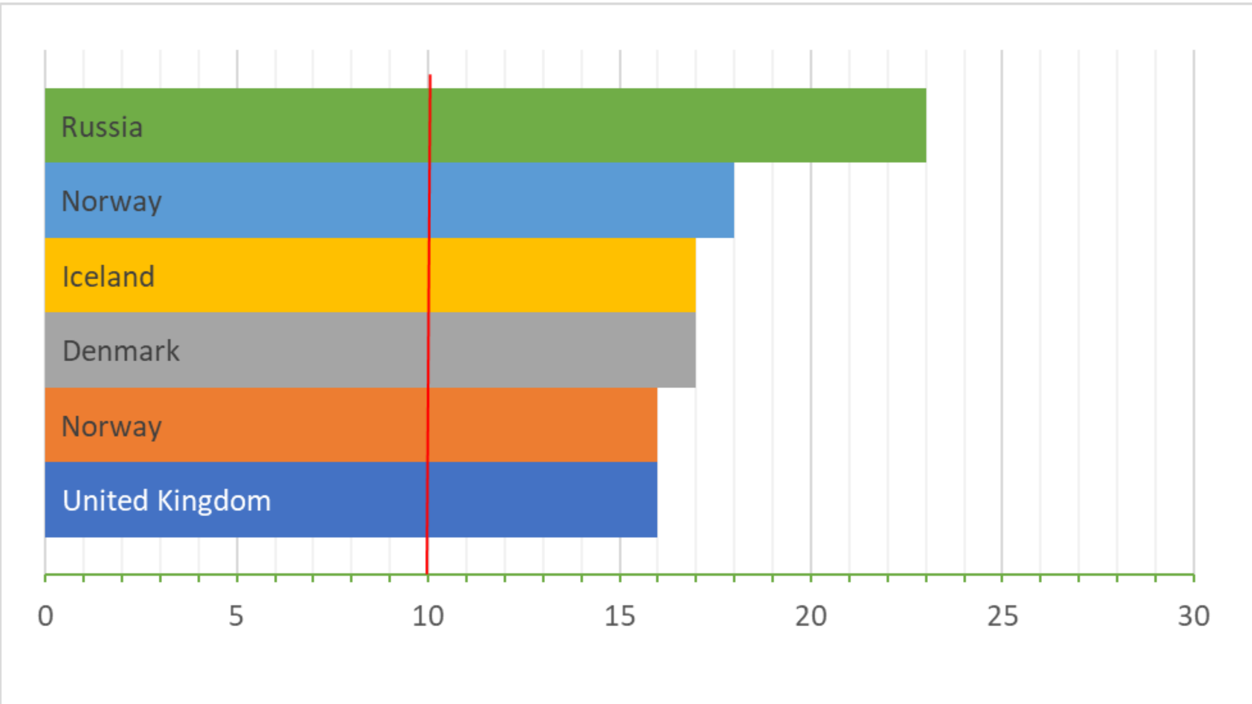

Figure 23: Total footprint for each of the UK's main haddock supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 12: Risk assessment summary for main supply chains for haddock consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United Kingdom	Norway	Iceland	Denmark	Faroe Islands	Russia
Direct impact on resource (Env_1)	Healthy state and fishing pressure compatible with Fmsy	Healthy biomass but exploitation rate just above Fmsy		Healthy state and fishing pressure compatible with Fmsy	Healthy biomass but exploitation rate is just above Fmsy	
Ecosystem impact (Env_2)	Bottom towed gear poses a risk to the ecosystem through habitat damage and bycatch of target and non-target species					
Climate change impact (Env_3)	Bottom towed gear associated with high risk. However, average score of 4 tonnes of CO2 per kg of fish ('low risk') provided by The Seafood Carbon Emissions Tool – likely to underestimate blue carbon habitat impacts though					
ETP impact (Env_4)	More limited use of gillnets in fishery compared to cod, however ETP risk still exists, plus bycatch of North Sea cod	Low level threat to seabirds through longline fishing, and golden redfish through trawling.	Potential threat to seabirds by longlines	Sime ETP interactions documented, whilst risk of impact considered low, medium risk on precautionary basis	Low level threat to seabirds through longline fishing, and golden redfish through trawling.	
Social concerns (Social_1)	Concerns associated with Scottish whitefish fisheries have featured in the media in past years	No known risk				High risk of modern slavery in fishing sector
Management effectiveness (Mgt_1)	Scope for improvements	Management considered to be effective	Scope for improvements			Joint management of this fishery with Norway is considered good
Sustainability certification progress (Mgt_2)	MSC certified with conditions			Partially certified with conditions, objections not withdrawn by WWF	Partially MSC certified	Largely MSC certified, but some with conditions and some with objections (not withdrawn)

Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator		External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator			External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator		External, country level indicator

5.5 Seafood resource: Monkfish

5.5.1 Supply chain overview

Monkfish, a product that is comprised of multiple species, is imported in relatively small quantities by the UK. However, the imported product weight is likely to be significantly less than the original landings they represent, as it is typically only the tail of the fish that is consumed. As such, comparison of the 1,485 tonnes of monkfish imported through the three main (94% of annual imports on average, 2015-19) supply chains – the Republic of Ireland, Faroe Islands and Iceland – in 2019 to the nearly 17,700 tonnes of landings by the UK fleet (14,400 tonnes of which were landed in the UK) is somewhat misleading. Nevertheless, by converting the UK's total landings to tails based on a conversion factor of 3[110], the UK's own production of monkfish (which converts to around 5,900 tonnes) dominates the nation's consumption of this relatively high value product (around 88% of the estimated consumption in 2019 was provided by the UK fleet (Figure 24), based on assumed landings of tails and trade data), despite relatively high exports of UK caught monkfish (e.g. around 3,800 tonnes in 2019).

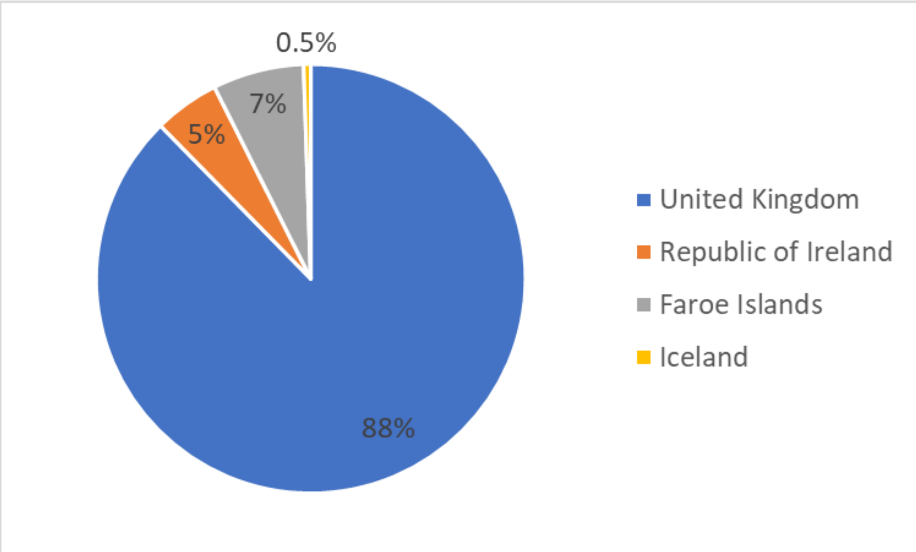

Figure 24: Percentage (%) contribution by the UK and the main countries from which monkfish is imported, to the UK's estimated monkfish consumption in 2019.

The majority of the UK's imports (62% on average per year between 2015 and 2019) arrive from the Republic of Ireland, whose fishing fleet largely catch the same stocks of monkfish as the UK fleet. There has been a notable increase (of around 500 tonnes between 2018 and 2019) in imports from the Faroe Islands during the time period, the reason for which is unknown. Therefore, whilst the Faroes has provided around 25% of imports of monkfish to the UK for the time period, in 2019 the supply chain was responsible for 54%, compared to 39% for the Republic of Ireland and 4% for Iceland (Figure 25).

[110] https://www.gov.uk/government/publications/calculate-your-fisheries-catch-limits/conversion-factors

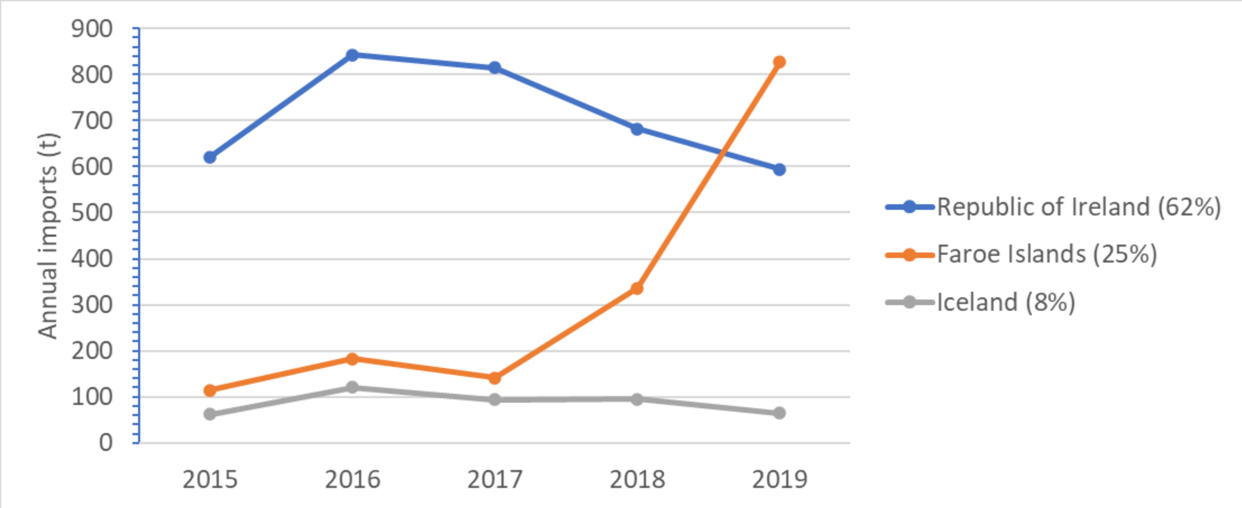

Figure 25: Volume (tonnes, t) of monkfish imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

5.5.2 Risk assessment and footprint summary

The UK supply chain footprint for monkfish is the joint highest ('medium' footprint score of 20) out of the four countries supplying the market (Figure 26), which is something that warrants further attention given UK domestic production far exceeds that of imports. A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 13 below with full details available in Appendix 1.

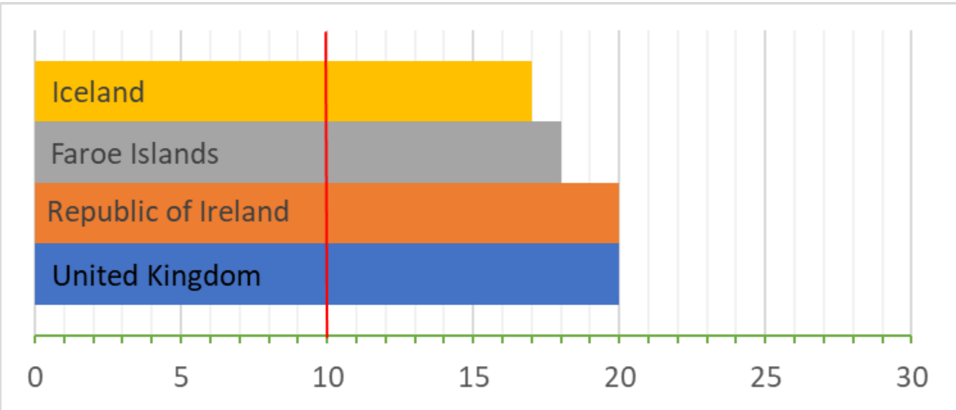

Figure 26: Total footprint for each of the UK's main monkfish supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 13: Risk assessment summary for main supply chains for monkfish consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United Kingdom	Republic of Ireland	Faroe Islands	Iceland
Direct impact on resource (Env_1)	Concerns over limited consideration of stock and species structure in scientific advice and management approaches. Stock status variable / some data limited.			*Data limited* but indication that stock in poor state
Ecosystem impact (Env_2)	Bottom towed gear poses risk to the ecosystem through habitat damage. Bycatch of depleted cod stocks is of particular concern.			
Climate change impact (Env_3)	Bottom towed gear is associated with a high carbon footprint			
ETP impact (Env_4)	Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals		Absence of information on ETP interactions (*data limited*)	Lack of monitoring, limited data and lack of a specific bycatch management strategy
Social concerns (Social_1)	No known concerns	Potential human trafficking issues raised in media, applicability to fishery uncertain (*data limited*)	No known concerns	
Management effectiveness (Mgt_1)	Scope for improvements			
Sustainability certification progress (Mgt_2)	The Southwest UK fishery is part of a FIP	No known third-party sustainable certification progress		MSC certified, with conditions
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator		
Rule of Law (Social_2)	External, country level indicator			
Labour Rights (Social_3)	External, country level indicator	External, country level indicator		

5.6 Seafood resource: Saithe

5.6.1 Supply chain overview

Similar to the other whitefish commodities assessed so far, the UK's own production of saithe serves to meet the majority of the UK's consumption demands (around 75.5% of estimated consumption in 2019), despite almost 50% of the UK's catches being exported. In 2019, around 15,300 tonnes of saithe was landed by the UK fleet (around 12,900 tonnes was landed in the UK), largely from the northern North Sea, West of Scotland and further north into the waters of the Northeast Atlantic, with around 7,300 tonnes exported.

A further 14.5% of the saithe eaten in the UK in 2019 arrived from Iceland, amounting to around 1,000 tonnes. Relatively small additional quantities came from other Northeast Atlantic fishing nations - the Faroe Islands, Norway and Denmark (Figure 27)

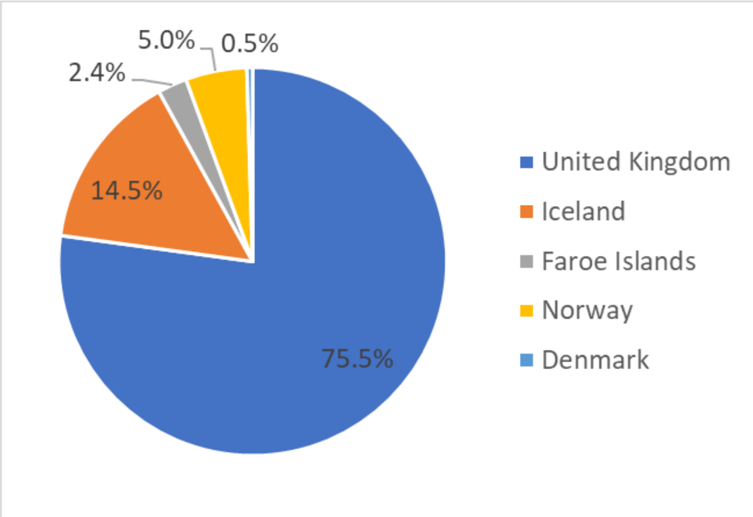

Figure 27: Percentage (%) contribution by the UK and the main countries from which saithe is imported, to the UK's estimated skipjack tuna consumption in 2019.

Iceland has persistently dominated the UK's imports of saithe for the period 2015-2019, with an average of 63% of imports arriving from Iceland on an annual basis. Imports from the Faroe Islands and Norway are comparable (13.4% and 11.6% on average, respectively) whilst only small quantities typically arrive from Denmark (5.4% on average), with the exception of 2018 when Denmark alone provided over 400 tonnes of saithe to the UK, with the same quantity arriving from the Faroes and Norway combined (Figure 28).

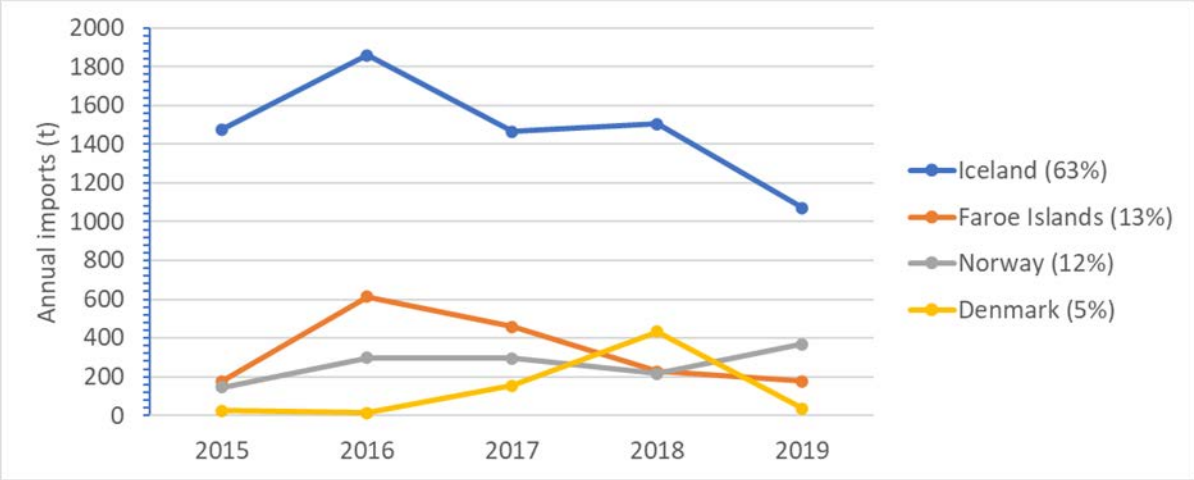

Figure 28: Volume (tonnes, t) of saithe imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

5.6.2 Risk assessment and footprint summary

Supply chain footprint scores range from a 'low' 14 (Iceland), up to a 'medium' 19 (United Kingdom), with the Faroe Islands, Norway and Denmark falling in between (14, 17 and 17 respectively) (Figure 29). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 14 below with full details available in Appendix 1.

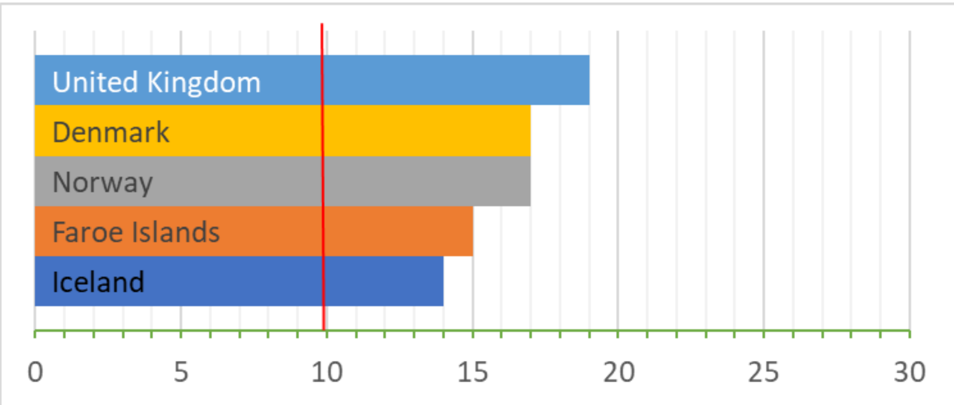

Figure 29: Total footprint for each of the UK's main saithe supply chains (available score range: 10 – 30).

Table 14: Risk assessment summary for main supply chains for saithe consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United Kingdom	Iceland	Faroe Islands	Norway	Denmark
Direct impact on resource (Env_1)	Stocks are lower than the MSY biomass level and fishing pressure is just above Fmsy	Biomass level and exploitation rate that are in line with MSY reference points		Stocks in the North Sea, Skagerrak and Kattegat are lower than the MSY biomass level and fishing pressure is just above Fmsy	
Ecosystem impact (Env_2)	Habitat damage and bycatch of target and non-target species through the use of bottom towed gear				
Climate change impact (Env_3)	Bottom towed gear associated with high risk. However, average score of 2 tonnes of CO2 per kg of fish ('low risk') provided by The Seafood Carbon Emissions Tool – likely to underestimate blue carbon habitat impacts though.				
ETP impact (Env_4)	Potential interactions with ETP species (plus bycatch of North Sea cod for all but Iceland)				
Social concerns (Social_1)	Forced labour and human trafficking concerns in media in past years	No known concerns			
Management effectiveness (Mgt_1)	Scope for improvements	Considered effective	Lack of catch control & management plan	Scope for improvements	
Sustainability certification progress (Mgt_2)	MSC certified with conditions				Partially certified but objections submitted which were not withdrawn
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator		External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator				
Labour Rights (Social_3)	External, country level indicator	External, country level indicator			

5.7 Seafood resource: Alaska pollock

5.7.1 Supply chain overview

China has persistently dominated the UK's imports of Alaska pollock for the period 2015-2019, responsible for 46% of annual imports on average, amounting to around 15,500 tonnes, with a peak in imported volumes in 2019 of over 20,300 tonnes (Figure 30). China, along with Poland (~7% of annual imports on average) and Germany (~15% of average annual imports), represent processing stepping stones in the UK's supply chains. The same concerns raised for Atlantic cod relating to lack of traceability to the fishery of origin, and therefore the potential environmental and social risks that may be unknowingly associated with these processing trade-routes may apply here.

An average of nearly 6,700 tonnes of Alaska pollock arrives from the Unites States each year, although a declining trend in imports can be seen since 2017. Conversely, imports from Russia have increased over the same period (Figure 30). This may have implications for the environmental and social footprint of the UK's Alaska pollock consumption, given that US fisheries are typically rated more favourably than Russian fisheries for such factors. However, it is also possible that greater quantities of pollock from 'good' fisheries in the United States have passed through China for processing in recent years (Figure 30). Further investigation would be required to determine whether this is the case, and whether risks of mislabelling for example are present. The issue of food miles is therefore also a concern with these supply chains.

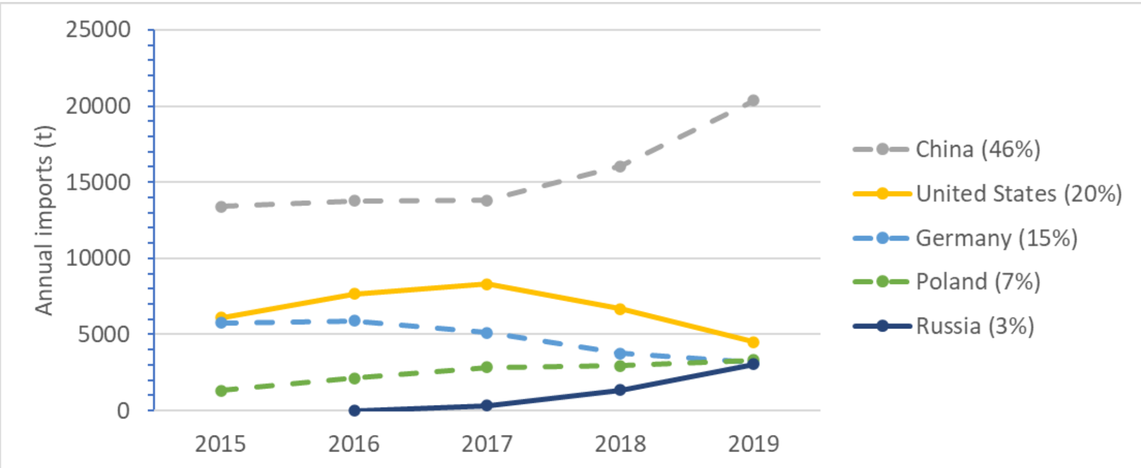

Figure 30: Volume (tonnes, t) of Alaska pollock imported by the UK annually between 2015 and 2019. China, Germany and Poland are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

An estimated 37,756 tonnes of Alaska pollock was consumed in the UK in 2019 based on the total imports (39,220 tonnes) and exports (1,464 tonnes) reported in the HMRC trade data. The contribution of the main supply chains to this consumption therefore again shows the dominance of product arriving through the processing trade routes (China 54%, Germany and Poland 17%) (Figure 31).

Alaska pollock largely arrives in the UK in frozen form, with >86% of imports categorised as frozen between 2015 and 2019, with frozen surimi representing between 1% and 7% of those frozen products (average of 5% for the time period). A further 8.5 to 15% of imports are processed or preserved in some way.

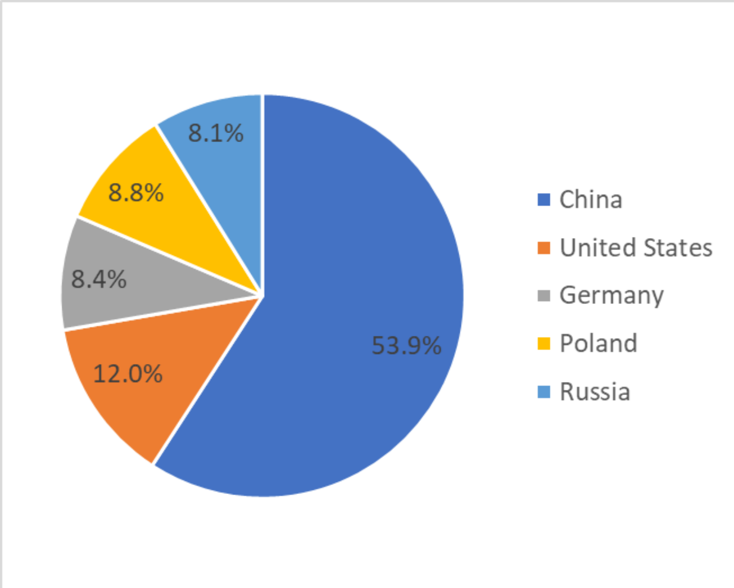

Figure 31: Percentage (%) contribution by the main countries from which Alaska pollock is imported, to the UK's estimated Alaska pollock consumption in 2019.

5.7.2 Risk assessment and Footprint Summary

Only two countries in the UK supply chain for Alaska pollock are producers rather than processors – the United States and Russia. A notably lower supply chain footprint is associated with the United States ('low' score of 16 compared to 'high' score of 24 for Russia) (Figure 32). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 15 below, with full details available in Appendix 1.

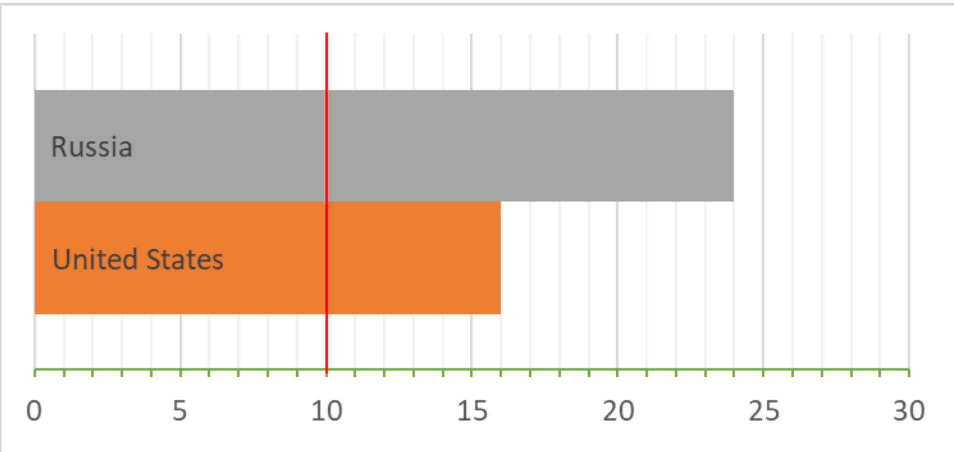

Figure 32: Risk assessment indicator scores for Alaska pollock UK supply chains.

Table 15: Risk assessment summary for main supply chains for Alaska pollock consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United States	Russia
Direct impact on resource (Env_1)	Healthy stock size. Not being overfished.	Sea of Okhotsk pollock stock is considered healthy, west Bering stock depleted
Ecosystem impact (Env_2)	Pelagic trawls which do not interact with the seafloor. Bycatch minimal.	Pelagic trawls so no habitat damage. Concerns over inadequate strategies for addressing trophic interactions in relation to Stellar sealions
Climate change impact (Env_3)	Moderate carbon footprint of the production method	
ETP impact (Env_4)	Risk of, or recorded interaction with, a number of species of marine mammals such as seals, dolphins and whales. More information needed for Russia.	
Social concerns (Social_1)	No known concerns	Significant concerns associated with modern slavery in fishing industry
Management effectiveness (Mgt_1)	Considered effective	Concerns about TACs being set above scientific advice and lack of strategies for addressing trophic interactions
Sustainability certification progress (Mgt_2)	MSC certified	WWF previously submitted objections to the Russian Sea of Okhotsk certification, which were subsequently withdrawn
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator

5.8 Seafood resource: European pollack

5.8.1 Supply chain overview

Compared to its Pacific cousin, European pollack is a minor contributor to the UK's whitefish consumption. In 2019, the UK fleet landed around 1,500 tonnes of pollack, representing 56% of the estimated 977 tonnes of consumption of the species, despite around 50% (790 tonnes in 2019) of the UK's catches being exported (and 200 tonnes being landed outside the UK in the first place). A further 43% of the European pollack eaten in the UK in 2019 arrived from Norway, with just an additional 9 tonnes arriving from Iceland (representing ~1% of the UK's estimated consumption of pollack) (Figure 33).

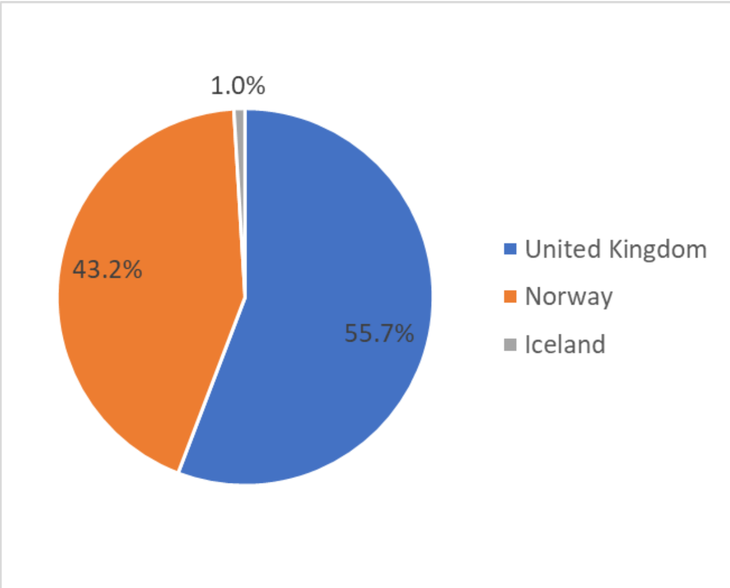

Figure 33: Percentage (%) contribution by the main countries from which European pollack is imported, to the UK's estimated European pollack consumption in 2019.

However, imports of European pollack are variable. Norway has only featured in, and dominated, the UK's non-domestic supply chain since 2018 (Figure 34). No other nations previously filled this gap and between 2015 and 2017 - a total of 19 to 44.5 tonnes of European pollack was imported by the UK per year, from seven countries combined (Norway, Iceland, the Republic of Ireland, France, Denmark, Germany, Sweden), although imports were not received from every country on an annual basis.

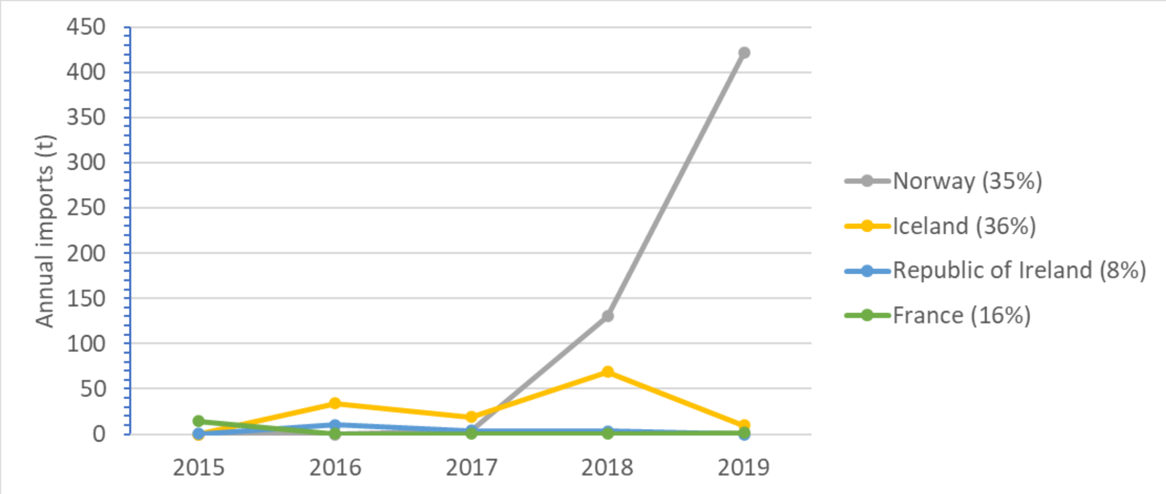

Figure 34: Volume (tonnes, t) of European pollack imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

5.8.2 Risk assessment and Footprint Summary

Supply chain footprint scores for European pollack vary little, the lowest being Iceland ('medium' score of 18), followed by Norway (19), and as with other whitefish supply chains, the UK appears to have the highest footprint ('medium' score of 20) (Figure 35). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 16 below, with full details available in Appendix 1.

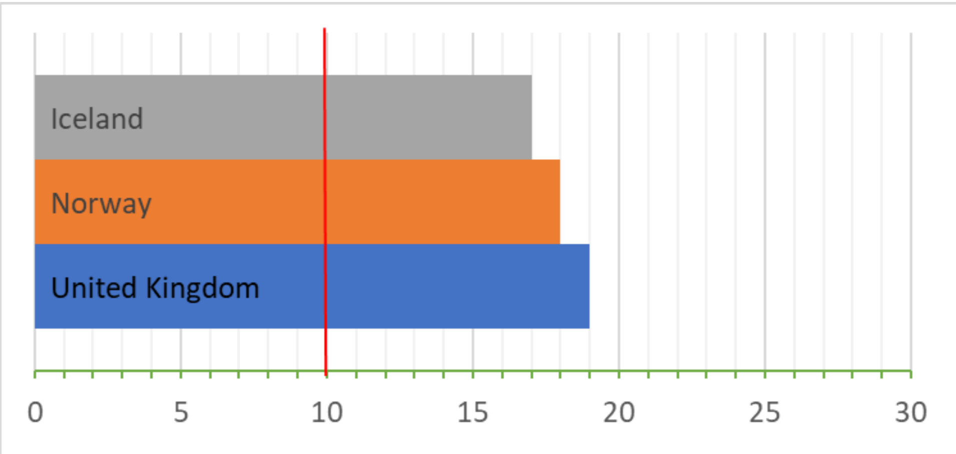

Figure 35: Total footprint for each of the UK's main European pollack supply chains (available score range: 10 – 30)

Table 16: Risk assessment summary for main supply chains for European pollack consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United Kingdom	Norway	Iceland
Direct impact on resource (Env_1)	Data limited, status is unknown		
Ecosystem impact (Env_2)	Fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species.		
Climate change impact (Env_3)	Mix of gear types suggests moderate carbon footprint, limited data available.		
ETP impact (Env_4)	Potential risk of porpoise / shark / other marine mammal mortality through the use of gillnets		
Social concerns (Social_1)	No known social concerns		
Management effectiveness (Mgt_1)	Scientific advice has frequently been exceeded in the setting of TACs, along with uncertainties associated with the stock status' and structure	Limited information available, although fisheries management generally good	
Sustainability certification progress (Mgt_2)	No known third-party sustainable certification progress		
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator		External, country level indicator
Rule of Law (Social_2)	External, country level indicator		
Labour Rights (Social_3)	External, country level indicator	External, country level indicator	

6. Seafood commodity – Salmonids

6.1 Summary of salmonid supply chains

In 2019, just over 255,000 tonnes (26% of the seafood assessed in this report) of salmonids – Atlantic salmon (*Salmo salar*), Danube salmon (*Hucho hucho*), Pacific salmon (Oncorhynchus spp.) and Trout (Oncorhynchus spp., *Salmo trutta*) – were imported into or produced by the UK. Over 90% of salmonid imports or production was comprised of Atlantic salmon (or Danube salmon), with just over 4% of the volume of salmonids assessed in this report being Pacific salmon and the remaining 5% being trout. Considering salmon imports alone, Atlantic salmon represents around 82% of average annual imports (2015-2019) compared to 18% for Pacific salmon. With the exception of Pacific salmon[111], salmonid consumption in the UK is dominated by aquaculture (farmed) produce.

Figure 36 shows the geographical distribution of salmonid source countries (countries that are primarily producers are shown on the larger map, whilst those which are considered intermediaries in the supply chain are shown on the inset map). All salmonids that are consumed the UK are imported from Northern Europe or North America or are produced by the UK (farmed Atlantic salmon). As a major processor of fish products from all over the world, including salmon, China greatly expands the spatial extent of UK salmonid supply chains.

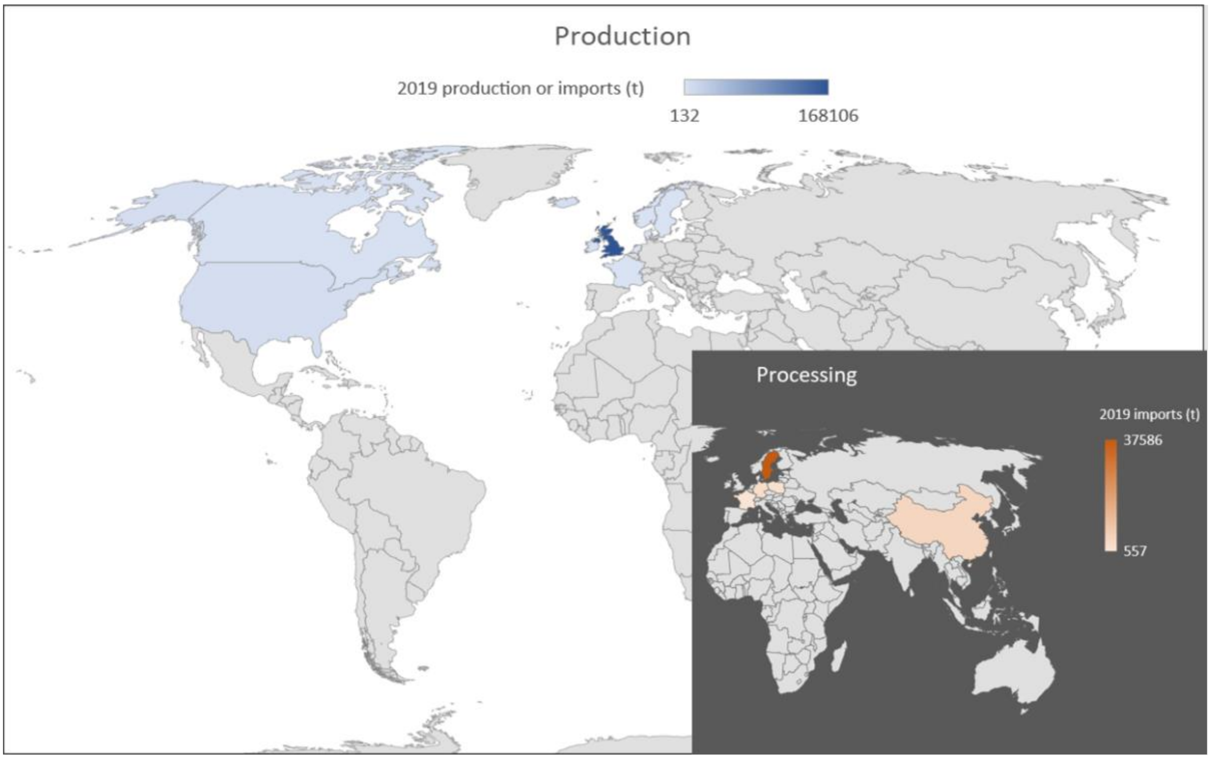

Figure 36: Map showing source countries for salmonid seafood commodities (Atlantic salmon, Pacific salmon, Trout) consumed in the UK. Large map shows those countries which are primarily considered to be producers, whereas the inset map shows intermediary countries in the supply chains where salmonid products are largely processed rather than produced. Total (all salmonid resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

[111] *Whilst Pacific salmon are farmed in Canada and the US, it was assumed for the purposes of the assessment that imports were of wild-capture fish. Lack of transparency in the trade data does not enable the product origin to be determined.*

Of those countries which produce farmed salmonids for the UK market, Denmark and the Faroe Islands are considered to have a lower footprint than the UK and Norway (Table 17), in part due to IUU fishing, rule of law and labour rights being lower risk. In particular, salmon from Denmark are farmed on-land using RAS systems and therefore have no contact with the marine environment. The majority of salmon farms in the Faroe Islands are ASC certified, resulting in a low risk for sustainability certification progress. Wild-capture production of Pacific salmon in Canada and the United States is associated with a slightly higher footprint ('medium' overall) (Table 17), largely to do with the variable status of the stocks and risk of bycatch, including of ETP species. However, the volume of wild-capture salmon imported from North America, or farmed salmonid imports from other countries, is significantly lower than that produced by the UK. This combination of scale and risk (i.e. footprint) therefore poses the greatest concern for the UK's salmonid supply chain.

Table 17: (a) Average footprint scores for each producing country in the UK's salmonid supply chains and (b) for each salmonid resource sub-category.

Producing country	Average Footprint
Faroe Islands	13
Denmark	13.5
Sweden	14
Republic of Ireland	14
Iceland	15
Netherlands	15
Norway	15.5
France	16
United Kingdom	16.5
Canada	17
United States	17

Resource	Average Footprint
Atlantic salmon, Danube salmon	14.8
Trout	14.9
Pacific salmon	17

Table 18: Supply chain information, Risk assessment and Footprint for Salmonids commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Salmonids	Salmon	Pacific salmon	18%	North America	NW Atlantic, NE	United States	Prod	Cap	2	2	1	2	1	1	2	2	1	3	17	**17.0**	**15.1**
				North America	NW Atlantic, NE	Canada	Prod	Cap	2	2	1	2	1	2	3	1	1	2	17		
				European Union		Poland	Process									1	2	2			
				European Union		France	Process									2	1	2			
				Asia and Oceania		China	Process									3	2	3			
		Atlantic salmon, Danube salmon	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Aquac	2	2	2	1	1	2	2	2	1	2	17	**14.8**	
			82%	Western Europe exc EU	NE Atlantic	Norway	Prod	Aquac	2	2	2	1	1	2	2	2	1	1	16		
				European Union		Sweden	Process									1	1	1			
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Aquac	2	2	2	1	1	1	1	1	1	1	13		
				European Union	NE Atlantic	Denmark	Prod	Aquac	1	1	2	1	1	1	3	1	1	1	13		
				Asia and Oceania		China	Process									3	2	3			
				European Union		Germany	Process									1	1	1			
				Western Europe exc EU	NE Atlantic	Iceland	Prod	Aquac	2	2	2	1	1	2	2	1	1	1	15		
	Trout	Trout	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Aquac	2	2	2	1	1	1	2	2	1	2	16	**14.9**	
			100%	European Union	NE Atlantic	Sweden	Prod	Aquac	2	2	2	1	1	1	2	1	1	1	14		
				European Union	NE Atlantic	Netherlands	Prod	Aquac	2	2	2	1	1	1	2	2	1	1	15		
				European Union	NE Atlantic	Republic of Irelanc	Prod	Aquac	2	2	2	1	1	1	2	1	1	1	14		
				European Union	NE Atlantic	Denmark	Prod	Aquac	2	2	2	1	1	1	2	1	1	1	14		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Aquac	2	2	2	1	1	1	2	2	1	1	15		
				European Union	NE Atlantic	France	Prod	Aquac	2	2	2	1	1	1	2	2	1	2	16		

6.2 Seafood resource: Atlantic Salmon

6.2.1 Supply chain overview

Atlantic salmon has been produced in aquaculture systems since the 1960s but has undergone exponential growth in the past 50 years. Today, it represents one of the most valuable production systems in aquaculture globally, with the vast majority produced in marine sea cages. Salmon requires cool water to grow well and so countries in the far north and south of the globe have shown the greatest growth potential. Coupled with a need for sheltered waters for cage production, it has been Norway, Canada, Chile, Faroe Islands, and the UK (Scotland) that have been responsible for most of the salmon production in the past decade. Leading the way by some considerable distance is Norway with production of 1.35 million tonnes in 2019. This is followed by Chile (697,000 tonnes), the UK (204,000 tonnes), Canada (118,000 tonnes) and the Faroe Islands (73,000 tonnes). Other countries producing Atlantic Salmon but in much smaller quantities are Sweden, Finland, Denmark, Iceland, the United States and Russia.

In 2019, the UK imported a total of 74,715 tonnes of Atlantic salmon (*Salmon salar*) and Danube salmon (*Hucho hucho*) from seven countries, which collectively accounted for 93% of the UK's average annual imports of Atlantic salmon (average total imports 2015-2019: 65,531 tonnes). Of these, three – Sweden, China[112] and Germany[113] are considered to primarily be intermediaries in the supply chain. However, it is assumed that the majority of Atlantic salmon imports from Sweden were originally produced in Norway[114,115] and therefore, import volumes for Sweden were reassigned to Norway. As a result, imports from Norway accounted for on average 40% of the UK's imported Atlantic salmon for the period 2015-2019 and the Faroe Islands contributed a further 32%. The remaining producing supply chains (Denmark, Iceland) contributed around 10% of imports on average, with a further 10% arriving from China and Germany (Figure 37).

Imports from Norway (based on import data for Sweden) and Iceland have increased from 2015-2019, whereas for other Atlantic salmon supply chains, imports have remained fairly stable (Faroe Islands, China, Denmark) or have shown slight declines (Germany) (Figure 37). Over 3,700 tonnes of Atlantic salmon were imported from Iceland to the UK in 2019. This was unexpected but appears to link to a significant rise in salmon farming in the country, with production rising to 34,200 tonnes in 2020 (from only 1,100 tonnes in 2011).

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[112] *China does not produce Atlantic salmon currently and is known as a major processor for the UK of fish products. It is therefore assumed that the imports of salmon from China are based on processing and not production.*

[113] *Germany does not produce Atlantic salmon currently and is known as a significant processor for the UK of fish products. It is therefore assumed that the imports of salmon from Germany are based on processing / trade and not production.*

[114] *Sweden is reported as being the largest import source of Atlantic salmon for the UK according to HMRC trade data. Sweden though as a country is a very minor producer of salmon with the Government figures showing a total production estimate for salmon of 39 tonnes in 2018 (Swedish Board of Agriculture). It is therefore assumed that the imports of salmon from Sweden are based on processing / trade and not production. The absence of Norway in the list of highest import sources is surprising, and may explain why Sweden features e.g. the product travels through Sweden to the UK.*

[115] *https://www.fishsec.org/2010/03/12/swedish-export-boom-is-mostly-norwegian/ and https://oec.world/en/visualize/tree_map/hs92/import/swe/show/1030212/2019/*

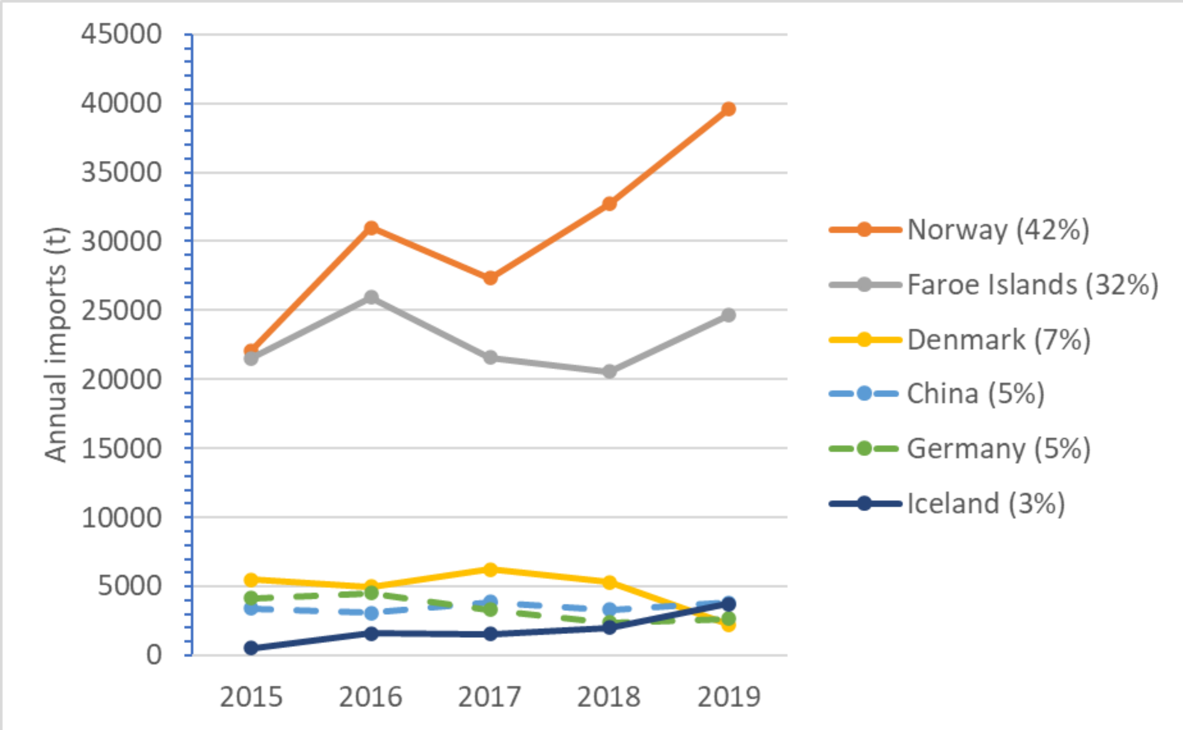

Figure 37: Volume (tonnes, t) of Atlantic salmon imported by the UK annually between 2015 and 2019. China and Germany are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

An additional 156,025 tonnes of Atlantic salmon was produced by UK aquaculture[116], meaning the UK contributed around 32% of the estimated salmon consumption (120,323 tonnes) by the UK in 2019, once exports were taken into account (assumed that the 117,274 tonnes of exports in 2019 were of UK farmed salmon rather than imported salmon)[117]. A further 31% was provided by Norway and 21% from the Faroe Islands (Figure 38.

[116] Due to data availability, this figure is from 2018 but is assumed to be approximately correct for 2019

[117] This assumption may mean the UK's contribution to salmon consumption is underestimated as other sources suggest the UK sources around 70% of all of its salmon production from its own farms located in Scotland.

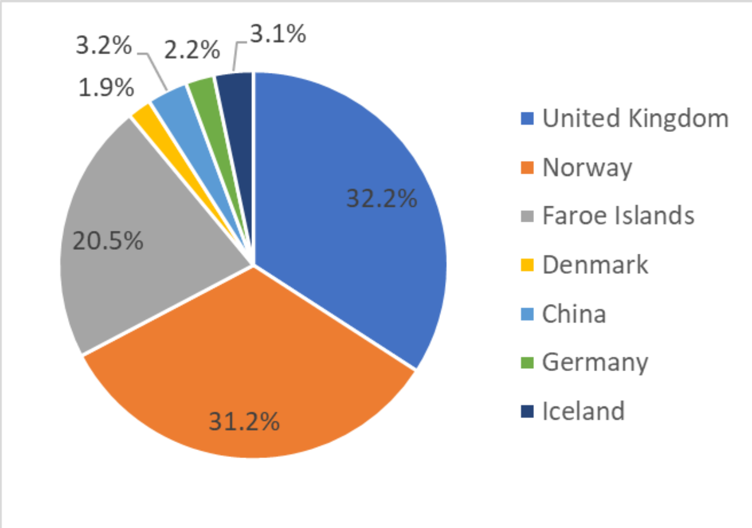

Figure 38: Percentage (%) contribution by the UK and the main countries from which Atlantic salmon is imported, to the UK's estimated Atlantic salmon consumption in 2019. Note it is assumed that exports of Atlantic salmon are derived from domestic (UK) production

Farmed salmon dominates the UK seafood category, accounting for an estimated 28% of all seafood sales by value and 16.4% by volume in 2019; and makes up nearly 60% of all the farmed species purchases. Similarly, 42% by value and 28% by volume of the top 5 farmed seafood species (salmon, haddock, cod, tuna, warm-water prawns) sold in the UK in 2019 was salmon[118]. The majority (>95%) of imported Atlantic salmon is in chilled or processed form (rather than frozen). Salmon continues to dominate chilled seafood retail in the UK, with an 11% growth in volume sold in 2020 compared to 2019. Salmon represented 46.5% of the UK chilled seafood sector (top 10 products) in 2020 by value (equating to £1,019 million), selling over four times its nearest competitor (warm-water prawns). Smoked salmon makes up around a quarter of chilled salmon sales (25.7%) but continued to lose volume share in 2020[119].

[118] https://www.seafish.org/document/?id=11052a6f-6c8e-423c-8d8c-1c4fa696a68e

[119] https://www.seafish.org/document/?id=19b3d61f-04ef-481e-affb-2abcda67dff0

6.2.2 Risk assessment and Footprint summary

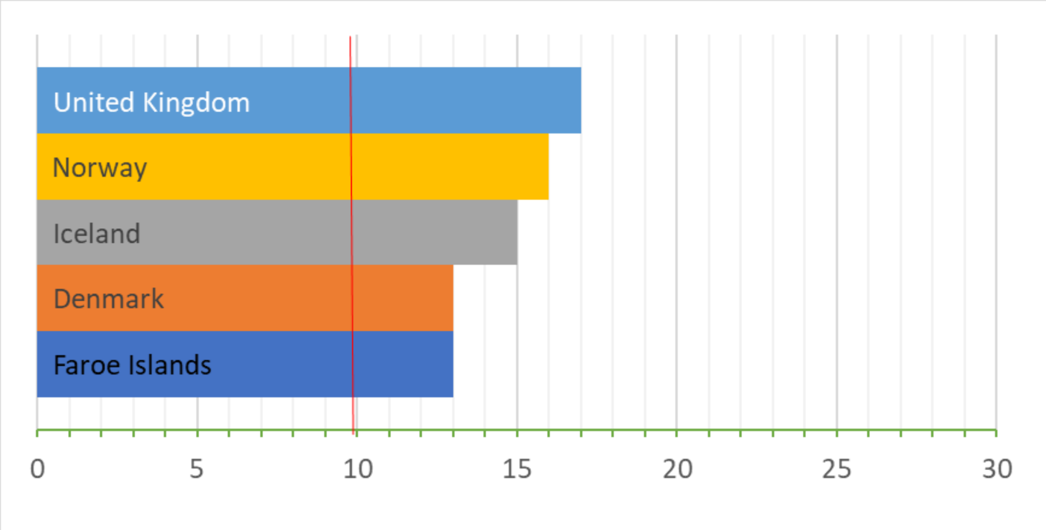

Figure 39: Total footprint for each of the UK's main Atlantic salmon supply chains (available score range: 10 – 30), excluding processing / trading countries

Overall, the footprint of the UK's farmed Atlantic salmon consumption is relatively lower than other seafood resources, with all supply chains associated with a footprint score of 13 – 17 (Figure 39). The footprint of the UK's imports is typically lower (footprint score of 13-15 for Faroe Islands, Iceland and Denmark) than that of UK farmed salmon (footprint score of 17). The UK's main supply of imported Atlantic salmon (Norway) is also associated with one of the highest footprint scores for the resource (score of 16).

It is noted that the salmon farming industry has seen a large increase in interest in the use of Recirculating Aquaculture Systems (RAS) in the past few years. These systems are seen as having many environmental benefits over traditional cage culture, but questions remain over their profitability. Only one small source of RAS is considered for the UK supply chain (from Denmark). Other than this, all major sources are from cage-based farming.

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 19 below, with full details available in Appendix 1.

Table 19: Risk assessment summary for main supply chains for Atlantic salmon consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

<table>
<tr><th>Risk Indicator</th><th>United Kingdom</th><th>Norway</th><th>Faroe Islands</th><th>Denmark</th><th>Iceland</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td colspan="3">Potential impact on wild salmon production via sea lice & inter-breeding</td><td>Based on RAS farming (no interaction with wild populations)</td><td>Data limited</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td colspan="3">Risk of creation of anoxic conditions, nitrate / phosphate release</td><td>RAS farming – little environmental interaction</td><td>As per UK, etc</td></tr>
<tr><td>Climate change impact (Env_3)</td><td colspan="3">Farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method</td><td>Contradictions in evidence base. RAS farming has high electricity use, but good potential to use renewable resources (data limited)</td><td>As per UK, etc</td></tr>
<tr><td>ETP impact (Env_4)</td><td colspan="3">Potential interaction with grey seals, harbour porpoise, common bottlenose dolphin. Also risk of impacts on cleaner fish populations. However, none are currently ETP nor are risks considered significant</td><td>RAS farming (no interaction)</td><td>As per UK, etc</td></tr>
<tr><td>Social concerns (Social_1)</td><td colspan="5">No known concerns</td></tr>
<tr><td>Management effectiveness (Mgt_1)</td><td colspan="2">Relatively good monitoring and controls; improvements to reduce identified risks needed</td><td>Considered one of best managed in world</td><td>Considered effective</td><td>Management systems in place but data limited</td></tr>
<tr><td>Sustainability certification progress (Mgt_2)</td><td colspan="2">Retailers require evidence of third-party certification of farmed salmon – majority certified by mixture of third party standards (Global GAP, ASC, BAP)</td><td>Uptake of certification relatively recent – industry now largely certified (ASC)</td><td>No third-party certification but RAS farming considered ‘gold standard’ in ratings</td><td>Majority certified by mixture of third party standards (AquaGAP, ASC)</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td colspan="2">External, country level indicator</td><td colspan="3">External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td colspan="5">External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td>External, country level indicator</td><td colspan="4">External, country level indicator</td></tr>
</table>

6.3 Seafood resource: Pacific Salmon

6.3.1 Supply chain overview

According to HMRC trade data, on average the UK receives nearly 90% of its Pacific salmon (Oncorhynchus spp.) from five countries, although three of those (Poland, France and China) are intermediaries in the supply chain. The majority (46% on average, amounting to 7279 tonnes) of Pacific salmon comes from the United States in chilled form, although annual import volumes have decreased since 2015, as is also the case for Canada (except for 2018), from which the UK receives an additional 22% of its annual imports on average (Figure 40).

Based on FAO GLOBEFISH Trade Statistics[120], it is likely that a notable portion of the Pacific salmon arriving in the UK from China were caught by the Russian fishing fleet, as 145,000 tonnes and 90,000 tonnes are reported to have been exported to China in 2018 and 2019, respectively. The same could apply to Poland and France, but the GLOBEFISH data are too aggregated to resolve the provenance of Pacific salmon from those intermediary countries in the UK supply chain.

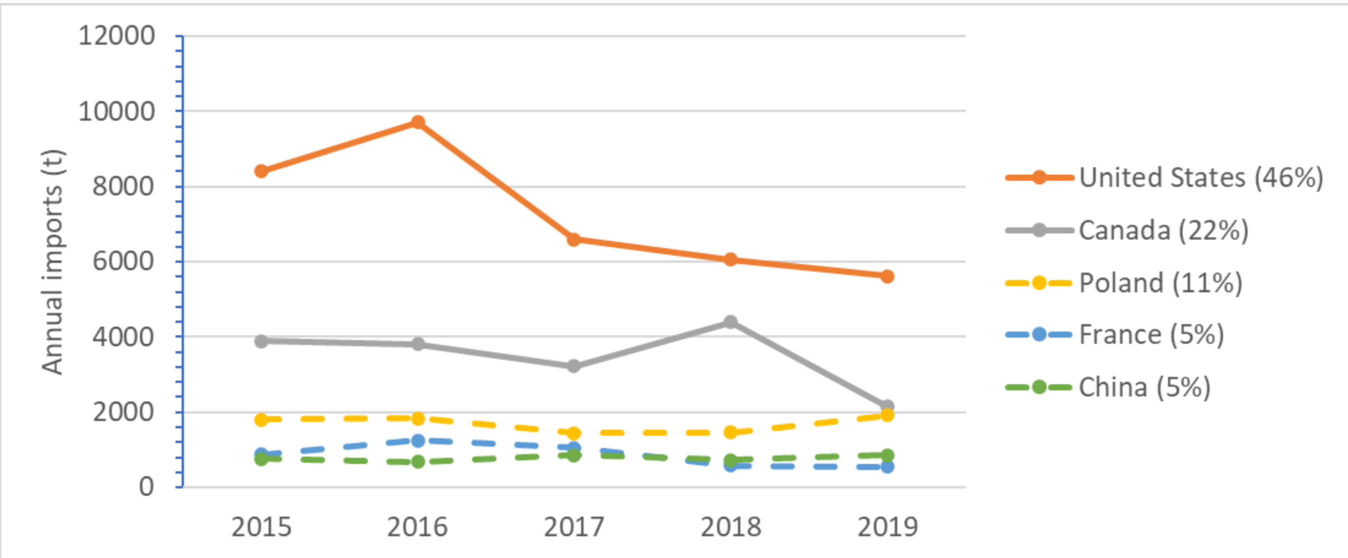

Figure 40: Volume (tonnes, t) of Pacific salmon imported by the UK annually between 2015 and 2019. Poland, France and China are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

An estimated 11,677 tonnes of Pacific salmon were consumed in the UK in 2019, based on the 17,906 tonnes of imports and 6,229 tonnes of exports, according to HMRC data. An explanation for why imported Pacific salmon was exported is not known and the possibility of some portion of the volumes representing product being reported under incorrect codes (e.g. Pacific rather than Atlantic salmon) cannot be verified. It is also possible that salmon are imported, processed (e.g. smoked) or packed and re-exported with British brands. On the basis of this estimation however, Pacific salmon arriving directly from the United States contributed around 48% of the UK's consumption in 2019, with a further 18% arriving from Canada (Figure 41).

[120] https://www.fao.org/in-action/globefish/fishery-information/tradestatistics/en/

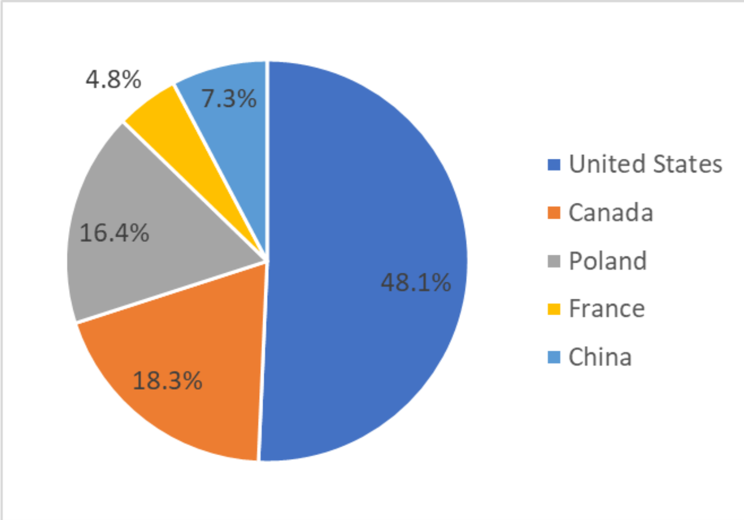

Figure 41: Percentage (%) contribution of the main countries from which Pacific salmon is imported, to the UK's estimated Pacific salmon consumption in 2019.

There are five species of Pacific salmon, chinook (or king salmon, *O. tshawytscha*), chum (*O. keta*), coho (or silver salmon, *O. kisutch*), pink (*O. gorbuscha*) and sockeye (or red salmon, *O. nerka*). Most Pacific salmon consumed in the UK is wild caught, although farming does occur (mainly coho and sockeye)[121]. The Alaskan salmon fishery is responsible for around 90% of wild caught salmon in North America and is certified by the Marine Stewardship Council[122]. The Alaskan salmon fishery is classed as partially enhanced (i.e., some of the fishery is entirely based on wild salmon runs, while the rest of the fishery is based on a 'hatch and catch' enhancement system, which takes advantage of the natural homing instinct of Pacific salmon that typically brings them back to their natal rivers to spawn after the marine feeding phase)[123].

6.3.2 Risk assessment and Footprint Summary

The footprint of the two main supply chains for Pacific salmon consumed in the UK is the same – a medium footprint score of 17 for both the United States and Canada.

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 20 below with full details available in Appendix 1.

[121] https://www.asc-aqua.org/aquaculture-explained/how-asc-can-help-you-eat-seafood-responsibly/farming-and-eating-salmon-responsibly/

[122] https://fisheries.msc.org/en/fisheries/alaska-salmon/@@view

[123] https://fisheries.msc.org/en/fisheries/alaska-salmon/@@assessments

Table 20: Risk assessment summary for main supply chains for Pacific salmon consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

Risk Indicator	United States	Canada
Direct impact on resource (Env_1)	The status of the different Pacific salmon species / stocks is variable. Concerns also exist over interbreeding between hatchery reared and wild fish, resulting in impacts on genetic diversity and populations that are less well adapted to their environment and therefore less likely to survive	As United States, but status of some populations is uncertain (*data limited*)
Ecosystem impact (Env_2)	Typically caught using gillnets, purse seines, and trolling gear, which has limited or no interaction with the seafloor. Bycatch of depleted stocks an issue. Concerns over the potential ecosystem effects of large-scale hatchery production	
Climate change impact (Env_3)	Average tonnes of CO2 per kg of fish caught by gill nets and purse seines is relatively low (with slightly higher values for troll lines). Low confidence in data should be noted.	
ETP impact (Env_4)	Variable levels of bycatch across the different fisheries. Additional data limitations to fully inform risk assessment (*data limited*)	
Social concerns (Social_1)	No known concerns	
Management effectiveness (Mgt_1)	Considered highly effective	Presence of depleted populations and other complex factors
Sustainability certification progress (Mgt_2)	Some MSC certification, with conditions	Currently no certified Canadian salmon fisheries nor any under a FIP
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator	
Labour Rights (Social_3)	External, country level indicator	External, country level indicator

6.4 Seafood resource: Trout

6.4.1 Supply chain overview

Rainbow (*Onchorynchus mykiss*) and Brown trout (*Salmo trutta*) are both farmed in Europe and eaten in the UK. Approximately 90% of imported trout comes from six countries (Sweden, Netherlands, the Republic of Ireland, Denmark, Norway and France; Figure 42), which collectively contributed around 46% of the UK's estimated trout consumption of 2,422 tonnes in 2019 (Figure 43), illustrating the relatively low volume of imports (with the exception of a peak in 2017 in imports from Sweden; Figure 42). The majority (~90%) of the UK's production of trout (around 12,100 tonnes in 2018) is exported, however the UK was estimated to still be responsible for over 50% of the UK's trout consumption in 2019 (Figure 43).

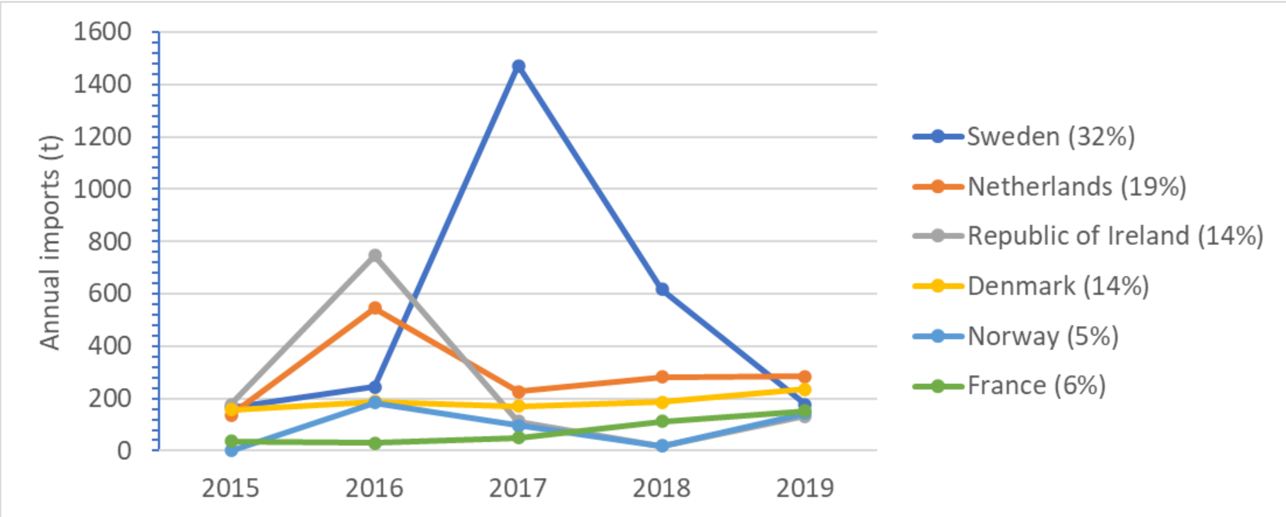

Figure 42: Volume (tonnes, t) of trout imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

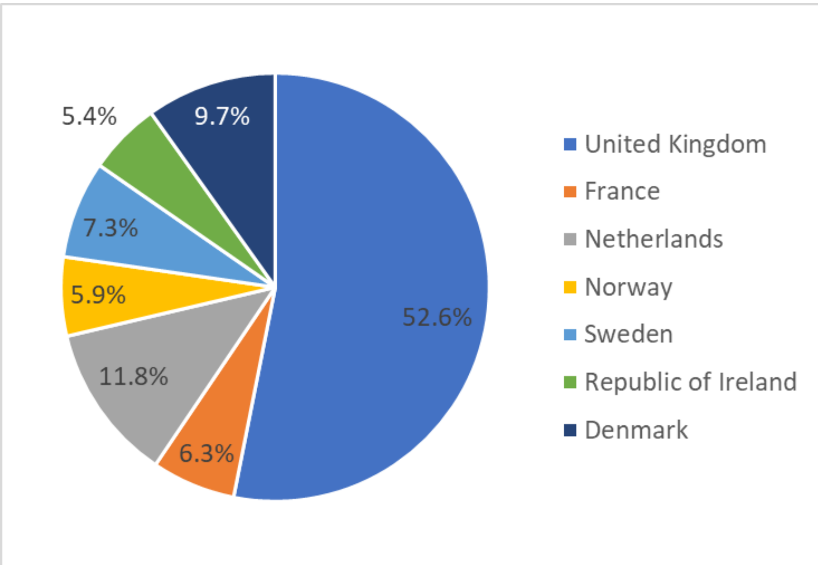

Figure 43: Percentage (%) contribution by the UK and the main countries from which trout is imported, to the UK's estimated trout consumption in 2019. Note it is assumed that exports of trout are derived from domestic (UK) production.

The majority (71% on average, 2015-2019) of imported product is fresh / chilled, rather than frozen (21% on average) or smoked (7% on average). According to Seafish's analysis of chilled seafood in multiple UK retail in 2020[124] compared to 2019, chilled trout showed one of the largest declines (-15.2%) in volume, and continued a longer-term trend in decreasing trout consumption (-54.6% by volume over the last decade).

In the UK, the vast majority of production takes place on relatively small farms using ponds or raceway systems, with most located in the South of England. A limited amount of cage-based production also occurs (mainly on lakes within Scotland).

A similar industry exists in most other European countries which supply the UK, although in some Scandinavian countries cage production plays a greater role.

6.4.2 Risk assessment and Footprint Summary

The environmental and social footprint of the UK's trout consumption is relatively low overall (≤14). However, the footprint of the majority of the UK's main farmed trout supply chains is slightly lower (footprint score of 14 for Denmark, Republic of Ireland and Sweden; score of 15 for Norway and the Netherlands) than that of UK farmed trout (footprint score of 16), with the exception being France (footprint score of 16) (Figure 44). A summary of the key contributing factors to the risk assessment and footprint scores is provided in

Table 21 below, with full details available in Appendix 1.

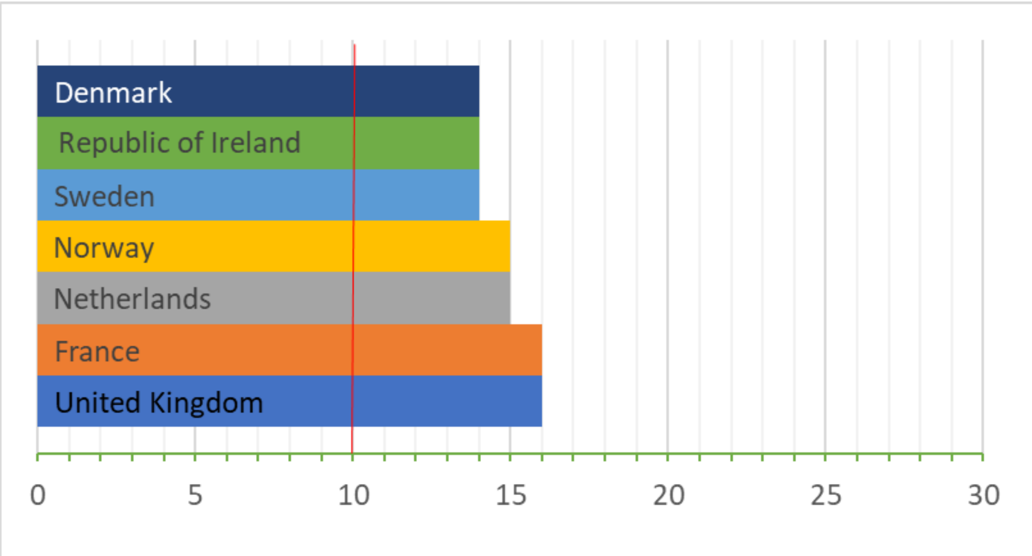

Figure 44: Total footprint for each of the UK's main trout supply chains (available score range: 10 – 30)

[124] https://www.seafish.org/document/?id=19b3d61f-04ef-481e-affb-2abcda67dff0

Table 21: Risk assessment summary for main supply chains for trout consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

<table>
<tr><th>Risk Indicator</th><th>United Kingdom</th><th>Sweden</th><th>Netherlands</th><th>Republic of Ireland</th><th>Denmark</th><th>Norway</th><th>France</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td colspan="7">Species is not indigenous and may have some impacts on wild stocks (although reported interactions are relatively limited)</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td colspan="7">Releases of liquid effluent into natural rivers have some negative impacts on water courses during periods of high effluent release</td></tr>
<tr><td>Climate change impact (Env_3)</td><td colspan="7">Farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method</td></tr>
<tr><td>ETP impact (Env_4)</td><td colspan="7">The otter has shown an increasing interaction with pond-based farms and commercial angling sites, however it is not considered at risk from trout farming.</td></tr>
<tr><td>Social concerns (Social_1)</td><td colspan="7">No specific social concerns exist</td></tr>
<tr><td>Management effectiveness (Mgt_1)</td><td colspan="7">Well-defined and effective management system</td></tr>
<tr><td>Sustainability certification progress (Mgt_2)</td><td colspan="7">Limited uptake of global certification standards, some GlobalGAP and national (for UK) certification</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td>External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td colspan="2">External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td colspan="7">External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td>External, country level indicator</td><td colspan="5">External, country level indicator</td><td>External, country level indicator</td></tr>
</table>

7. Seafood commodity – Crustaceans

7.1 Summary of crustacean supply chains

In 2019, around 84,500 tonnes of six key crustacean resources – Lobster (Homarus spp.), Norwegian lobster (*Nephrops norvegicus*), Edible crab, 'Other' crabs (mainly Blue swimming crab, Red swimming crab, Spider crab, Velvet crab), Warm-water prawns (mainly Whiteleg shrimp and Tiger prawn), Cold-water prawns (mainly Brown shrimp and Northern prawn) – was imported into the UK. The countries responsible for the majority (approx. 90%) of imports of those resources are spread across Northern Europe, North America, Asia and Latin America (Figure 45). Whilst most are considered to be the producing countries, some such as China, the Netherlands, and India and Vietnam for certain resources, are intermediaries in the supply chains (predominantly or entirely processors, or trade points, rather than producers). A further 73,500 tonnes of these crustacean resources (excluding warm-water prawns) were produced by the UK in 2019.

Whilst the majority of imported crustacean resources are derived from wild capture fisheries, warm-water prawns are largely (although not exclusively) sourced from aquaculture production. In 2019, around 69% (58,000 tonnes) of the UK's key crustacean imports were warm-water prawns – the majority of which were produced in intensive farming systems in Vietnam and India (collectively responsible for around half of the UK's warm-water prawns imports), as well as other Asian and South American nations.

A further 22% of the imports were comprised of cold-water prawns, fulfilling the UK's demand for such products. Whilst the UK produces this resource, its supply cannot meet demand – in 2019, around 700 tonnes was landed by the UK fleet, and an additional 17,400 tonnes was imported from Iceland, Denmark, Canada and Norway.

Globally, American lobster (*Homarus americanus*) is by far the main lobster species targeted by commercial fisheries, accounting alone for about 60% of total world lobster landings[125]. Its catches have increased during the past 30 years, from 37,000 tonnes in 1980 to about 140,000 tonnes in recent years[126]. The Canadian American lobster fishery is the largest in the world and is divided into around 40 Lobster Fishing Areas, from which it is estimated that 80–85% of landings are typically exported[127]. Whilst the specificity of the trade data means imports of American and European lobster (*Homarus gammarus*) cannot be fully distinguished, based on the key source countries it is estimated that around half of the UK's lobster consumption is American lobster imported from Canada (mainly) and the US (around 1,600 tonnes in total in 2019) and the other half is its European cousin *H. gammarus*, largely caught by the UK fleet (landings were approximately 3,350 tonnes in 2019, although around half was exported).

However, the UK's shellfish demand is only very partially satiated by *Homarus* lobsters, largely due to their status as a relatively expensive, luxury product. In 2019, around 74,500 tonnes of *Nephrops norvegicus* (aka Norway lobster, langoustines or scampi), edible crab and other crab species were produced by or imported into the UK. The majority was caught by the UK fleet – just 5,000 tonnes were imported across the three resources. Crabs

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[125] http://www.fao.org/3/i6816e/i6816e.pdf

[126] http://www.fao.org/3/i6816e/i6816e.pdf

[127] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/220/

dominated that supply (around 51% of landings and imports on 2019), followed closely by Norwegian lobster (49%). Whilst the UK exports around 46% of its crab and Norwegian lobster catches (see Section 3), consumption in 2019 was still estimated to be around 40,000 tonnes compared to 3,150 tonnes of *Homarus* lobster.

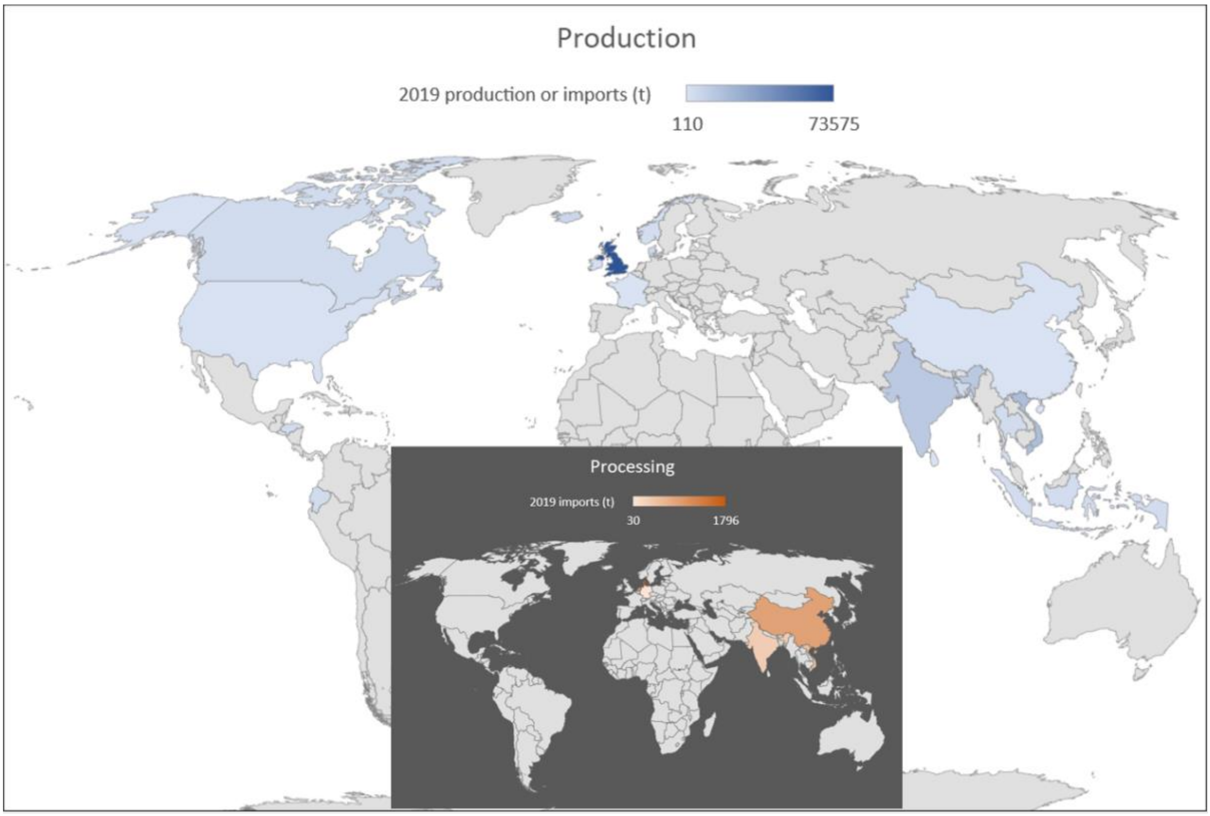

Figure 45: Map showing source countries for crustacean seafood commodities (Lobster, Norwegian lobster, Edible crab, Other crabs, Warm-water prawns, Cold-water prawns) consumed in the UK. Large map shows those countries which are primarily considered to be producers, whereas the inset map shows intermediary countries in the supply chains where crustacea products are largely processed rather than produced. Total (all crustacea resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

Given the range of resources included in the crustacean commodity, and the diversity of methods and geographical scope associated with their production, there is unsurprisingly a large variation in the footprint scores for the producing countries and resource categories. Iceland's supply of wild caught Northern prawns falls at the lowest end of the footprint scale whereas south-east Asia's production of warm-water prawns, and wild caught crabs are associated with the highest footprint. Approximately the same pattern can be seen when looking at the average resource footprint score, although Norway lobster also falls at the upper end of the footprint scale for the commodity (Table 22). The individual risk assessments are further described in the following resource sub-chapters and Appendix 1, and the scores themselves are presented in Table 23 below.

Table 22: (a) Average footprint scores for each producing country in the UK's crustacean supply chains and (b) for each crustacean resource sub-category.

Producing country	Average Footprint
Iceland	16.0
Denmark	17.0
Canada	17.0
Norway	18.0
Republic of Ireland	18.0
France	19.0
United Kingdom	19.2
Ecuador	20.0
United States	20.0
Honduras	20.0
Sri Lanka	21.0
India	21.5
Thailand	23.0
Indonesia	24.0
China	24.0
Vietnam	25.0
Bangladesh	25.0

Resource	Average Footprint
Cold-water prawns	16.6
Edible crab	18.3
European lobster, American lobster	19.0
Warm-water prawns	20.5
Norway lobster	21.9
Other crab (inc. King crab, Blue crab, Snow crab)	22.6

Table 23: Supply chain information, Risk assessment and Footprint for Crustaceans commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Crustaceans	Lobster	European lobster, American lobster	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	1	3	3	1	2	2	2	1	2	19	19.0	20.3
			91%	North America	NW Atlantic	Canada	Prod	Cap	2	1	3	3	1	2	2	1	1	2	18		
				North America	NW Atlantic	United States	Prod	Cap	2	1	3	3	1	2	2	2	1	3	20		
				European Union	NE Atlantic	France	Prod	Cap	2	1	3	2	1	2	3	2	1	2	19		
				European Union		Denmark	Process									1	1	1			
	Nephrops	Nephrops	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	3	3	3	2	2	2	2	1	2	22	20.5	
			100%	European Union	NE Atlantic	Republic of Irelanc	Prod	Cap	2	3	3	2	2	2	2	1	1	1	19		
				Asia and Oceania		Vietnam	Process									3	2	3			
				Asia and Oceania		China	Process									3	2	3			
				Asia and Oceania		India	Process									2	2	3			
	Crabs	Edible crab	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	1	3	3	1	2	2	2	1	2	19	18.3	
			19%	European Union	NE Atlantic	Republic of Irelanc	Prod	Cap	2	1	3	3	1	2	2	1	1	1	17		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	1	3	3	1	2	3	2	1	1	19		
		Other crab (inc. King crab, Blue crab, Snow crab)	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	1	3	1	1	2	3	2	1	2	18	22.6	
			81%	European Union		Denmark	Process									1	1	1			
				Asia and Oceania	W Pacific	Vietnam	Prod	Cap	3	3	2	3	2	3	3	3	2	3	27		
				Asia and Oceania	Indian Ocean/W	Indonesia	Prod	Cap	3	3	2	2	2	3	2	2	3	3	25		
				Asia and Oceania	W Pacific, Indian	Thailand	Prod	Cap	3	2	2	2	3	3	2	2	2	3	24		
				Asia and Oceania	NW Pacific	China	Prod	Cap	2	2	2	2	3	3	2	3	2	3	24		
				Asia and Oceania	Indian Ocean	Sri Lanka	Prod	Cap	2	2	2	2	2	2	2	2	2	3	21		
				Asia and Oceania	Indian Ocean	India	Prod	Cap	2	2	2	2	2	3	3	2	2	3	23		
				European Union		Germany	Process									1	1	1			
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	1	3	3	1	2	3	2	1	1	19		
	Shrimps & prawns	Warm-water shrimps & prawns	73%	Asia and Oceania	W Pacific	Vietnam	Prod	Aquac	2	3	3	1	2	2	2	3	2	3	23	21.9	
				Asia and Oceania	Indian Ocean	India	Prod	Aquac	1	2	3	1	2	2	2	2	2	3	20		
				Asia and Oceania	Indian Ocean	Bangladesh	Prod	Aquac	2	3	3	1	3	2	3	2	3	3	25		
				Asia and Oceania	W Pacific, Indian	Thailand	Prod	Aquac	2	3	3	1	2	2	2	2	2	3	22		
				Latin America and Caribbeai	W Atlantic	Honduras	Prod	Aquac	1	2	3	1	1	2	2	2	3	3	20		
				Asia and Oceania	Indian Ocean/W	Indonesia	Prod	Aquac	2	3	3	1	2	2	2	2	3	3	23		
				Latin America and Caribbeai	SE Pacific	Ecuador	Prod	Aquac	1	2	3	1	1	2	2	2	3	3	20		
				Asia and Oceania		China	Process									3	2	3			
				European Union		Denmark	Process									1	1	1			
				European Union		Netherlands	Process									2	1	1			
		Cold-water shrimps & prawns	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	3	1	1	2	2	2	1	2	18	16.6	
			27%	Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	2	2	3	2	1	1	2	1	1	1	16		
				European Union	NE Atlantic	Denmark	Prod	Cap	2	2	3	2	1	2	2	1	1	1	17		
				North America	NE Atlantic	Canada	Prod	Cap	1	2	3	2	1	1	2	1	1	2	16		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	1	2	3	2	1	1	2	2	1	1	16		

7.2 Seafood resource: European lobster, American lobster

7.2.1 Supply chain overview

In 2019, the UK imported about 1,650 tonnes of American lobster (*Homarus americanus*) from the other side of the Atlantic, with three quarters of that produced by the Canadian fishing industry and the remainder caught by the United States fisheries. A relatively small quantity of European lobster (*H. gammarus*) was also imported from France[128]. According to FAOSTAT data, total annual Danish landings in 2015-2016 of European lobster was 30-40 tonnes so it is assumed that processing accounts for a large portion of UK imports from Denmark (96 tonnes in 2019) (Figure 46).

Interannual variation in lobster imports has been relatively small since 2017 for all source countries, with a notable increase in imports of American lobster between 2016 and 2017. Canada was consistently the main source of lobster imports for the five-year period, representing 57% of imports of both species on average (Figure 47).

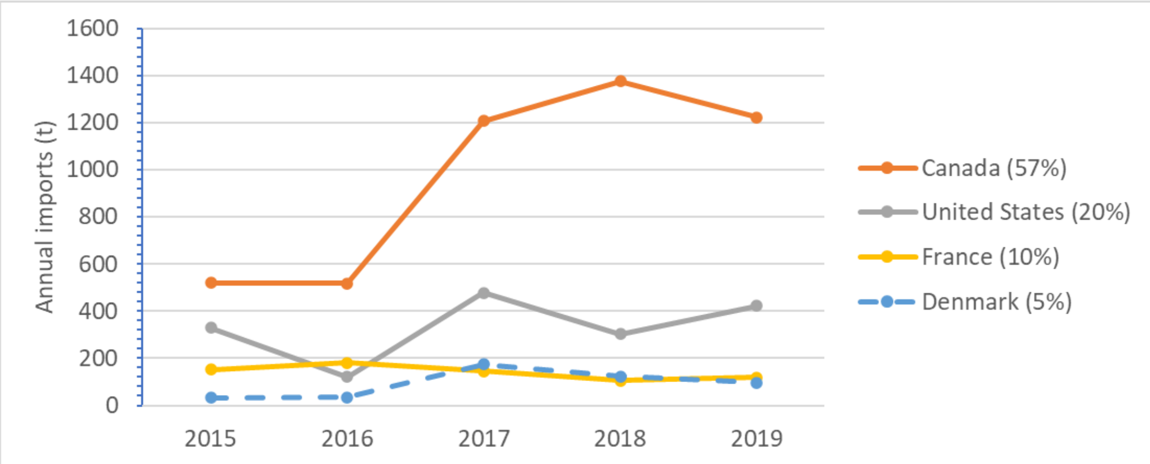

Figure 46: Volume (tonnes, t) of European and American lobster imported by the UK annually between 2015 and 2019. Denmark is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The UK fleet landed around 3,350 tonnes of European lobster in 2019. Because it is assumed that the UK typically exports what it produces rather than what it imports and that it consumes the net quantity remaining in the UK, and the UK exported approximately 65% of its lobster catches in 2019 (mainly to the EU), the UK's contribution to estimated lobster consumption in 2019 of 3,159 tonnes is approximately equal to that of Canada (37-39%) (Figure 47).

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[128] *Some of this product may well have been caught in UK waters and/or by the UK fleet, including the Channel Islands, and re-imported having been landed / processed in France*

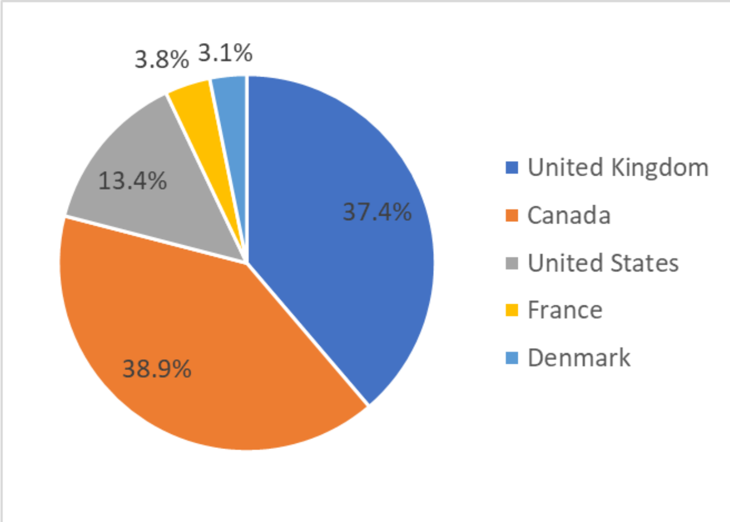

Figure 47: Percentage (%) contribution by the UK and the main countries from which European and American lobsters are imported, to the UK's estimated lobster consumption in 2019.

7.2.2 Risk assessment and Footprint Summary

Of the four supply chains, the United States has the highest footprint ('medium' score of 20) and Canada has the lowest (footprint score of 18, still within the 'medium' category) (Figure 48). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 24 below, with full details available in Appendix 1.

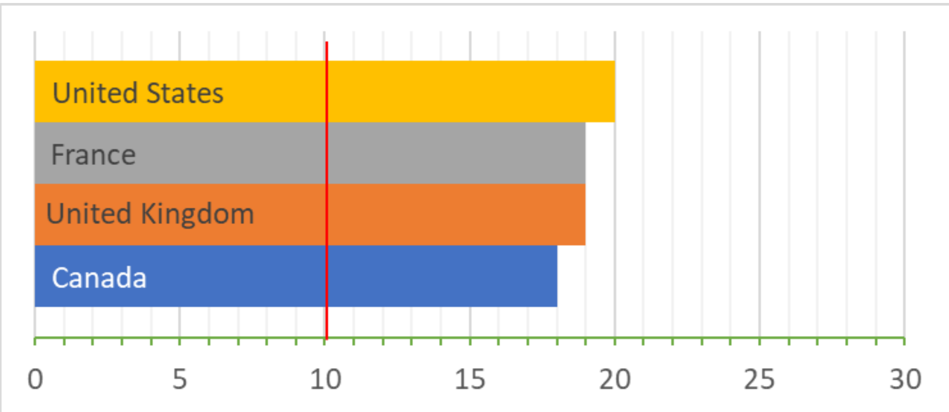

Figure 48: Total footprint for each of the UK's main European and American lobster supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 24: Risk assessment summary for main supply chains for European and American lobster consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Canada	United States	France
Direct impact on resource (Env_1)	Stocks likely at or around minimum reference size and fully exploited (or close), but assessments are data constrained (*data limited*)	Significant variation between the 40 Lobster Fishing Areas	Stock status variable	Indications are stocks are healthy, but *data limited*
Ecosystem impact (Env_2)	Pots and traps have relatively low ecosystem impacts			
Climate change impact (Env_3)	An average score of 11.7 tonnes of CO2 per kg of fish indicates a high risk			
ETP impact (Env_4)	Evidence of high rates of entanglement of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries	Incidences of entanglements of the IUCN critically endangered north Atlantic right whale and humpback whales in buoy ropes		*Data limited* – also uncertainty over extrapolation of Scottish study to French fisheries
Social concerns (Social_1)	No known social concerns			
Management effectiveness (Mgt_1)	Given a generally poor status of stocks, effectiveness of management seems questionable	Management considered variable across Lobster Fishing Areas	Management considered variable	Limited management measures in place
Sustainability certification progress (Mgt_2)	Partially MSC certified and part of a FIP, large North East fishery undergoing assessment	Multiple components MSC certified, with conditions	Gulf of Maine fishery MSC certified, with conditions	Only the Jersey and Normandy fishery is MSC certified
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator	
Rule of Law (Social_2)	External, country level indicator			
Labour Rights (Social_3)	External, country level indicator		External, country level indicator	External, country level indicator

7.3 Seafood resource: Norway lobster

7.3.1 Supply chain overview

Nephrops norvegicus, commonly known as Norway lobster, scampi, langoustines or Dublin bay prawns, is one of the most important commercial crustaceans in Europe and the fishery has developed into one of Europe's most economically important fisheries, particularly for the UK, the Republic of Ireland and Sweden[129]. Virtually all UK creel-caught Norway lobster are stored in sea water and sold to the live (langoustine) market which is predominantly Spain, France, and Italy (~50% of UK landings), whereas the trawl fishery usually supplies fresh or frozen tails which require on-shore processing (marketed as breaded scampi) and are sold to the UK market[130].

Norway lobster makes a notable contribution to the UK's frozen seafood retail with over 6,000 tonnes of frozen scampi sold in multiple retail settings alone in 2020, worth over £62 million, a trend that has declined in volume since 2010 (by around 22%) but remained approximately constant in price (2% drop in value of sales between 2010 and 2020)[131].

In 2019, the UK landed around 34,500 tonnes of Norway lobster of which just less than 40% was exported. That domestic supply was estimated to have provided about 91% of the UK's consumption of 22,946 tonnes in 2019 (Figure 49).

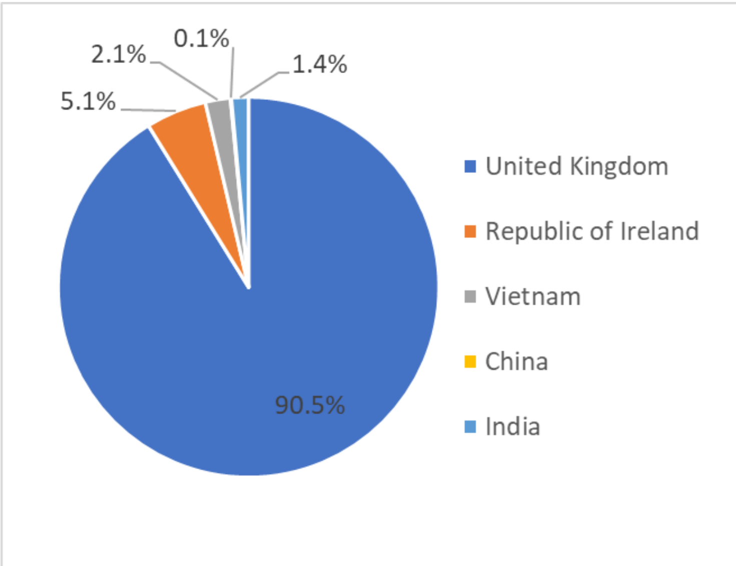

Figure 49: Percentage (%) contribution by the UK and the main countries from which Norway lobster is imported, to the UK's estimated Norway lobster consumption in 2019.

Small quantities of Norway lobster were also imported from the Republic of Ireland (approximately 1,200 tonnes in 2019, average of 1,000 tonnes per year 2015-19) where the species is caught on fishing grounds which overlap with the UK's, in the Irish and Celtic Sea. A further 833 tonnes (average total annual imports 2015-19 from these countries was 1,218 tonnes) were imported from Vietnam, China and India which can only be assumed to be

[129] *Anette Ungfors, Ewen Bell, Magnus L. Johnson, Daniel Cowing, Nicola C. Dobson, Ralf Bublitz, Jane Sandell, (2013). Chapter Seven - Nephrops Fisheries in European Waters, Editor(s): Magnus L. Johnson, Mark P. Johnson, Advances in Marine Biology, Academic Press, Volume 64, Pages 247-314*

[130] https://neweconomics.org/uploads/files/Griffin-Nephrops-latest.pdf

[131] https://www.seafish.org/document/?id=d4a7cc42-0aec-42f0-91fd-f510a860ce46

processing countries for product that is caught in the North Atlantic and possibly Mediterranean – possibly even by the UK and / or Irish fleets (Figure 50).

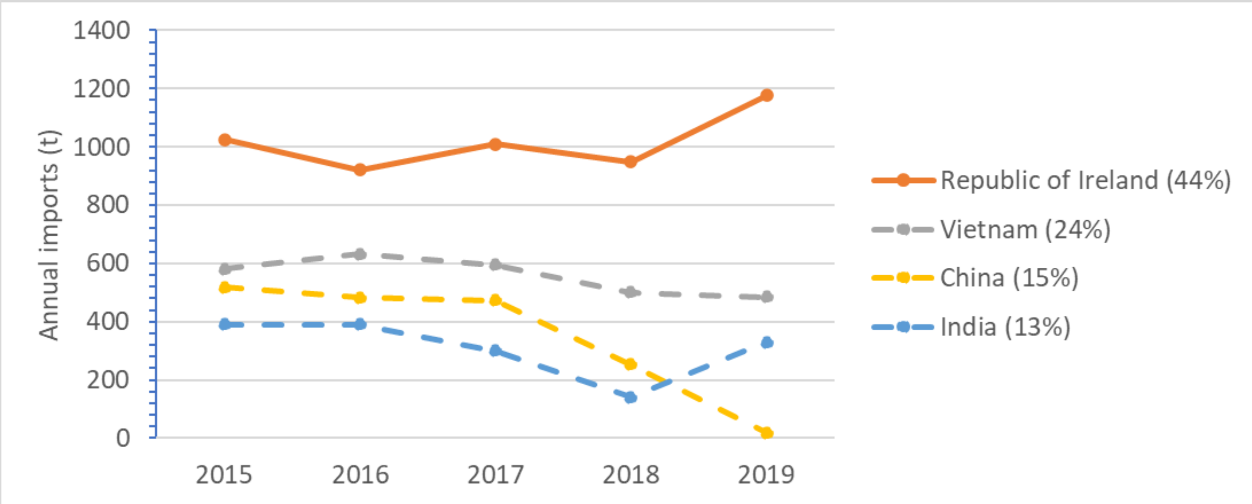

Figure 50: Volume (tonnes, t) of Norway lobster imported by the UK annually between 2015 and 2019. Vietnam, China and India are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

7.3.2 Risk assessment and footprint summary

The risk assessment is focused on the UK and the Republic of Ireland given they are the only sources of Norway lobster for the UK market which are producers rather than processors. Both supply chains fall in the 'medium' category with scores of 19 and 22 (Figure 51), with the UK's higher score driven by recent evidence of ETP impacts in Scottish creel fisheries as well as higher scores for two of the 'external' risk indicators (IUU risk and Labour Rights). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 25 below with full details available in Appendix 1.

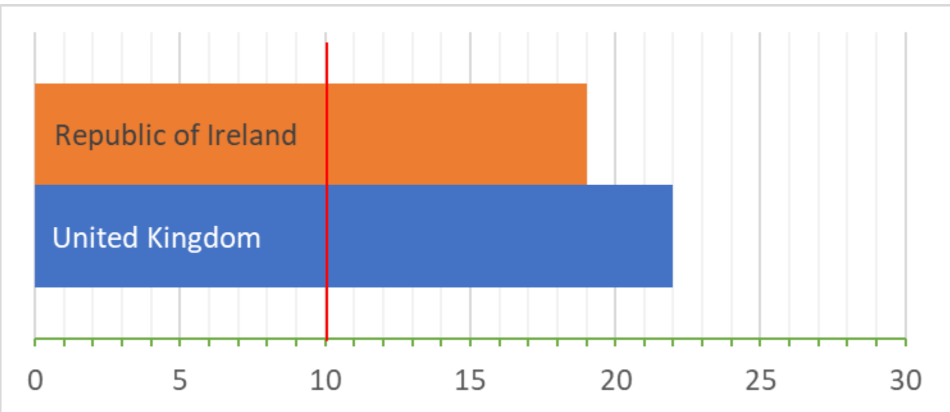

Figure 51: Total footprint for each of the UK's main Norway lobster supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 25: Risk assessment summary for main supply chains for Norway lobster consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Republic of Ireland
Direct impact on resource (Env_1)	Many Functional Units are data limited (with additional concerns over mismatches between management units and biological populations)	
Ecosystem impact (Env_2)	Bottom otter trawls associated with damage to the seabed and sessile fauna, and bycatch of various other commercial and non-commercial species.	
Climate change impact (Env_3)	High carbon footprint associated with gear	
ETP impact (Env_4)	Evidence of high rates of entanglement of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries	May pose risk to several species of skates, rays and sharks although *data limitations*. Extrapolation of Scottish creel fishery report to Irish Sea *uncertain*
Social concerns (Social_1)	Previous reports of risk of trafficking and abuse to workers, but *uncertainty* due to age of reports	
Management effectiveness (Mgt_1)	Variable status of the FUs and the ongoing issues with bycatch of vulnerable species	
Sustainability certification progress (Mgt_2)	A number of other previous certifications or accreditation efforts have been withdrawn. FIP in progress.	FIP in progress
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator	
Labour Rights (Social_3)	External, country level indicator	External, country level indicator

7.4 Seafood resource: Edible crab

7.4.1 Supply chain overview

Edible crabs (often known as brown crabs) make up the largest crab fishery in Western Europe, with more than 60,000 tonnes caught annually, mostly around the coast of the British Isles. The crabs are caught in baited creels or pots and largely processed for canned and frozen products for the European and domestic market on land[132].

Similarly to Norway lobster, the UK's domestic wild capture of edible crab dominates the supply chain, accounting for around 95% of the UK's estimated consumption of 14,842 tonnes in 2019. Of the almost 27,300 tonnes landed by the UK fleet into the UK in 2019[133], around 13,200 tonnes (48%) was exported (Figure 52).

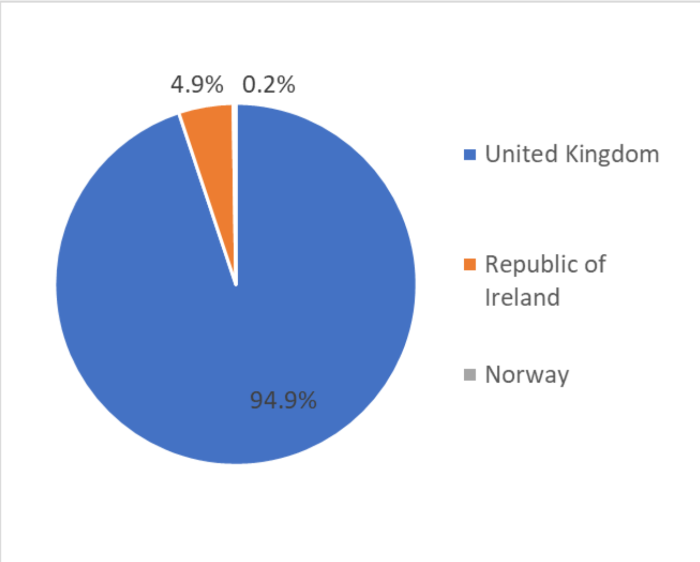

Figure 52: Percentage (%) contribution by the UK and the main countries from which Edible crab are imported, to the UK's estimated Edible crab consumption in 2019.

In 2019, an additional 724 tonnes was imported from the Republic of Ireland and just 34 tonnes from Norway (for 2015-19, the average annual imports were 426 and 42 tonnes, respectively) (Figure 53).

[132] *https://fisheries.msc.org/en/fisheries/ssmo-shetland-inshore-brown-crab-and-scallop/@@view*

[133] *An additional 4,500 tonnes were landed in non-UK ports by the UK fleet*

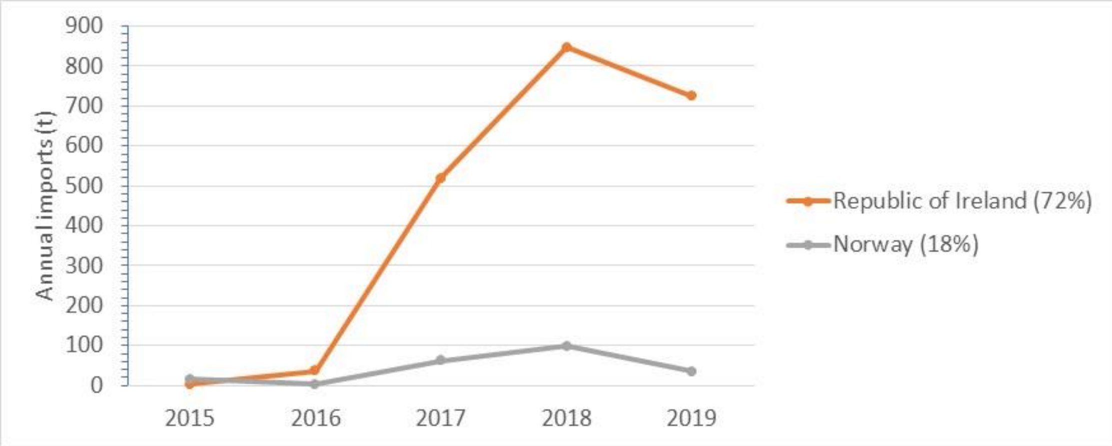

Figure 53: Volume (tonnes, t) of Edible crab imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

7.4.2 Risk assessment and footprint summary

There is little difference in the footprint of the three source countries supplying the UK edible crab market with all falling within the 'medium' range of footprint scores (17-19) (Figure 54). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 26 below, with full details available in Appendix 1.

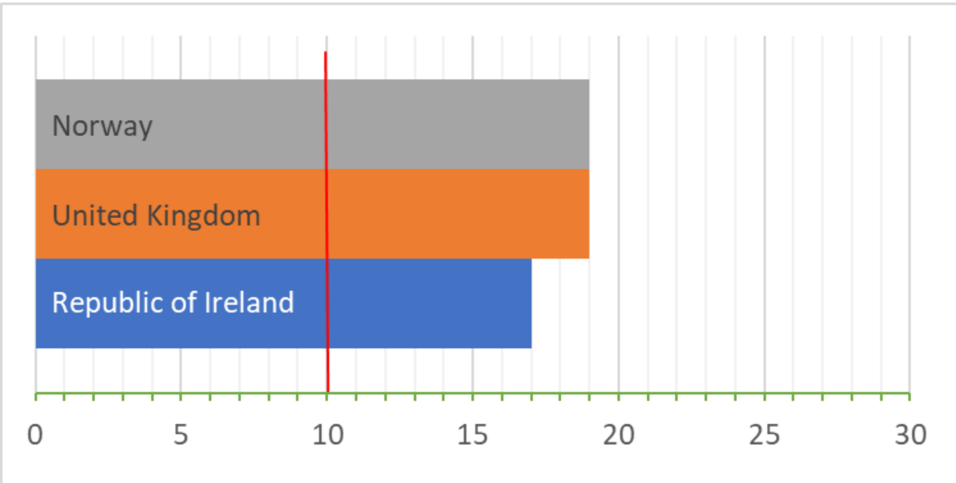

Figure 54: Total footprint for each of the UK's main Edible crab supply chains (available score range: 10 – 30).

Table 26: Risk assessment summary for main supply chains for Edible crab consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Republic of Ireland	Norway
Direct impact on resource (Env_1)	Indications that some stocks have a biomass around the MSY and are being exploited at a rate that is close to MSY but *data limited*	No assessment available (*data limited*), indications of some stock declines	Information indicates a robust status of the stock and a sustainable fishing pressure but *data limited*
Ecosystem impact (Env_2)	Pots and traps have relatively low ecosystem impacts beyond removal of the target species		
Climate change impact (Env_3)	Uncertainty over the robustness of extrapolating static gear data to crab fisheries, however scoring based on average score of 11.7 tonnes of CO2 per kg of fish ('high risk') for lobster trap fisheries		
ETP impact (Env_4)	Evidence of high rates of entanglement of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries. Extrapolated to Irish and Norwegian fisheries on precautionary basis.		
Social concerns (Social_1)	No known concerns		
Management effectiveness (Mgt_1)	Variable / unknown status of stocks, effectiveness of management is uncertain. Further measures likely to be needed.		
Sustainability certification progress (Mgt_2)	Partial MSC certification and FIP progress	FIP in progress	No known progress
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator		
Labour Rights (Social_3)	External, country level indicator	External, country level indicator	

7.5 Seafood resource: Other crab

7.5.1 Supply chain overview

Given the lack of detail in the HMRC trade data, a number of assumptions over the species and fisheries associated with the assessed supply chains had to be made.

For the UK, the assumption was that 'other' crab species was mainly focused on velvet crabs and spider crabs. The velvet crab is the largest swimming crab in British coastal waters and is often caught alongside edible crabs and lobsters. The spider crab fishery is the second largest crab fishery in England and Wales. Within the UK, it is generally targeted along the South and West coasts[134]. Although it has grown in popularity over recent years, spider crab is undergoing a rebranding in Cornwall and being renamed 'Cornish King Crab' in an effort to help improve consumption of local 'sustainably' fished products such as Cornish spider crab[135].

The blue swimming crab (*Portunus pelagicus*) is an important target species for a number of Asian countries which also feature in the UK's crustacean supply chain network, namely Vietnam, Indonesia, Thailand, Sri Lanka and India. Almost all blue swimming crab fisheries in Asia are facing similar challenges, including: a lack of nationwide stock assessments; inadequate management, enforcement, and monitoring; and insufficient precaution in protecting the stocks. Of particular concern are the landing, harvest, and sales of juvenile crabs and berried females (female crabs bearing eggs) and the declining trend in crab size and catch per unit effort. In addition, there are some significant impacts on bycatch and retained species, especially in bottom trawl and gillnet fisheries[136]. Many of the fisheries have previously been involved in or remain part of FIPs, in order to help improve the sustainable exploitation of this valuable resource for many communities. Similarly, China's Fujian Province red swimming crab (*Portunus haanii* and *P. sanguinolentus*) fishery, which represents an important export market for the country in the form of processed (e.g. canned) crab, is part of an ongoing FIP which aims to improve the sustainability of the fishery which catches around 40,000 tonnes per year[137].

In 2019, 4,426 tonnes of 'other crab' species were produced by or imported into the UK through the main supply chains (those responsible for around 90% of imports), and of that total, 61% (2,704 tonnes) was produced by the UK[138]. Production countries in the supply chain include Vietnam, Thailand, Indonesia, China, Sri Lanka, India and Norway, but imports from individual countries are 360 tonnes or less. Imports from Denmark are higher in volume (contributing 30% of annual imports on average, Figure 55), but Denmark is assumed to be an intermediary country in the supply chain (processing / trade rather than production), along with Germany.

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[134] https://www.mcsuk.org/goodfishguide/species/spider-crab/

[135] https://www.seafoodcornwall.org.uk/sif-scoping-project/

[136] https://www.sustainablefish.org/Programs/Improving-Wild-Fisheries/Seafood-Sectors-Supply-Chain-Roundtables/Crab/SE-Asia-Blue-Swimming-Crab-SR

[137] https://fisheryprogress.org/fip-profile/china-fujian-zhangzhou-red-swimming-crab-bottom-trawl-pottrap

[138] *Counting UK 'other' crab landings in UK ports only – an additional ~450 tonnes were landed outside the UK in 2019*

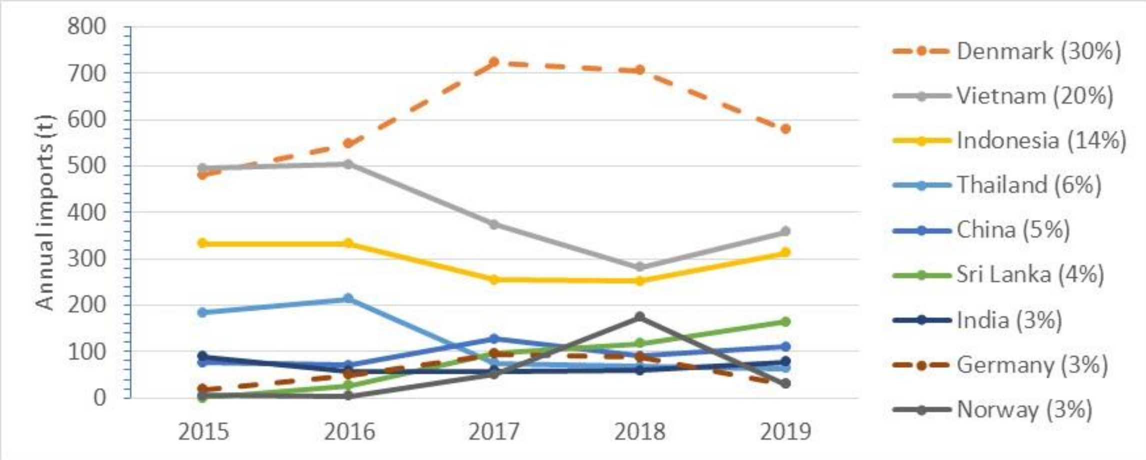

Figure 55: Volume (tonnes, t) of 'other' crab imported by the UK annually between 2015 and 2019. Germany and Denmark are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The largest proportion of the UK's 'other crab' consumption in 2019 (around 2,090 tonnes[139]), is estimated to have arisen from products that were processed in Denmark (28% of estimated consumption), compared to other countries which contributed between 1 and 17% of the consumed 'other crab' in 2019. This includes the UK's own domestic production, which after accounting for exports of around 2,900 tonnes, was estimated to be responsible for approximately 3% of the UK's consumption in 2019 (Figure 56).

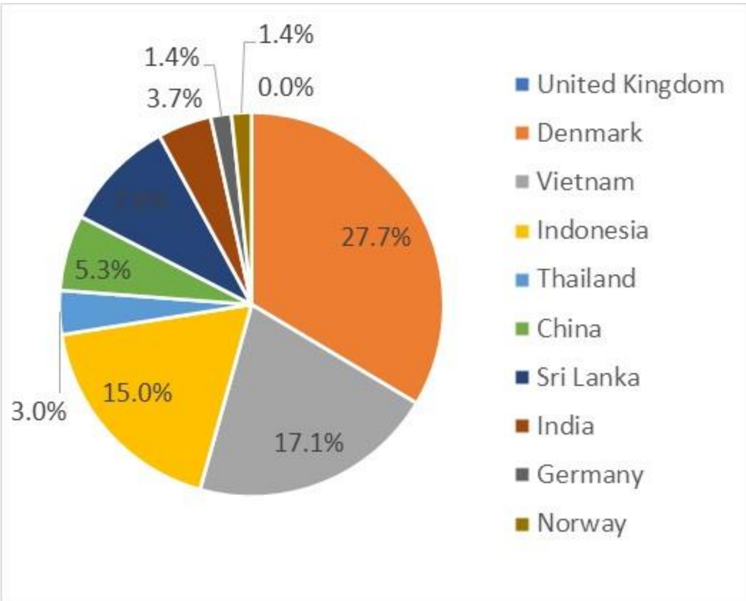

Figure 56: Percentage (%) contribution by the UK and the main countries from 'other' crabs are imported, to the UK's estimated 'other crab' consumption in 2019.

[139] *After accounting for the UK catches which were landed outside of the UK, UK production was less than exports in 2019. Therefore, for the purposes of the assessment, consumption in 2019 was assumed equal to total imports (e.g. it was assumed that exports were UK production only.*

7.5.2 Risk assessment and footprint summary

Supply chain footprints for ‘other’ crab species presents a large range of variability, from a ‘medium’ footprint score of 18 (UK), to a very high footprint score of 27 for Vietnam (Figure 57). Indonesia, China and Thailand also have relatively high footprint scores (24-25). This is worrying given Vietnam, Thailand and Indonesia are in the top four countries in terms of volume of ‘other’ crab imports to the UK. A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 27 below, with full details available in Appendix 1.

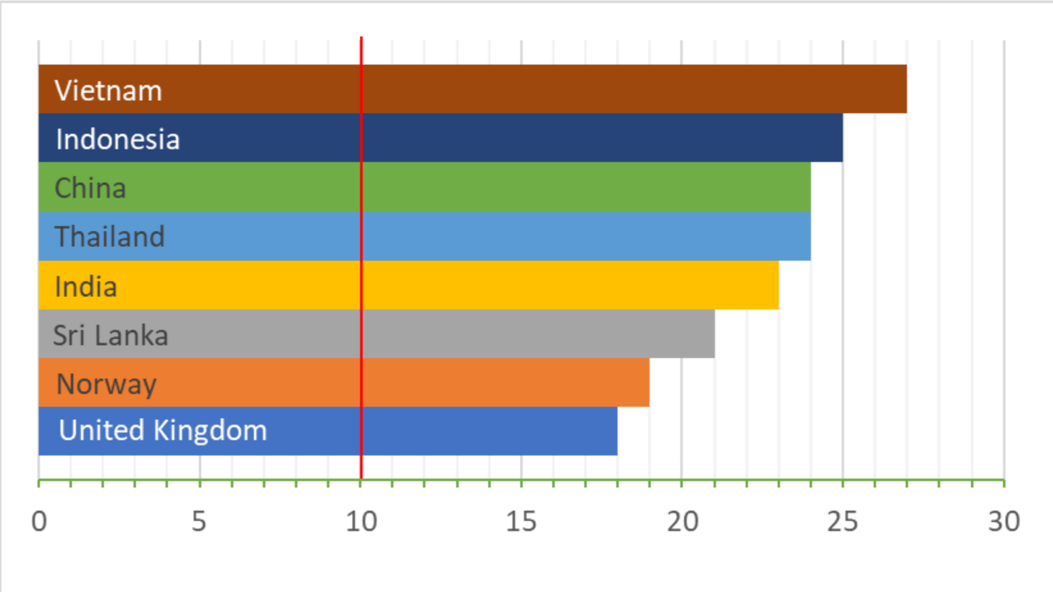

Figure 57: Total footprint for each of the UK’s ‘other’ crab supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 27: Risk assessment summary for main supply chains for 'other crab' consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Vietnam	Indonesia	Thailand	China	Sri Lanka	India	Norway
Direct impact on resource (Env_1)	No assessment of population status or exploitation rate (*data limited*)	Considered to be threatened by overfishing (*data limited*)	Stocks considered subject to overfishing		The status of the red swimming crab stock(s) is unknown due to data limitations and lack of monitoring	Conflicting and limited information on stock status	*Data limited* but indications are stocks are overexploited	*Data limited* but population likely to have increased
Ecosystem impact (Env_2)	Pots and traps have relatively low ecosystem impacts. Gillnets and tangle nets (spider crabs) are less selective, but considered low risk on relative scale	Gillnets and entangling nets are associated with relatively high levels of bycatch of over 100 species. Traps & pots also in use.	Gillnets and entangling nets are associated with bycatch. Pots & traps also in use.		Bottom trawls and gillnets associated with bycatch, as well as risk of habitat damage from trawls. Traps also in use.	Gillnets and tangle nets pose bycatch risk and potential damage of sensitive habitats such as seagrass	Bottom trawls and gillnets pose bycatch risk as well as potential habitat damage	Conical pots likely to have relatively low ecosystem impacts
Climate change impact (Env_3)	Uncertainty over extrapolating static gear data to crab fisheries, however scoring based on average score of 11.7 tonnes of CO_2 per kg of fish ('high	Mixture of gear types associated with a 'medium risk'						Uncertainty over extrapolating static gear data to crab fisheries, however scoring based on average score of 11.7 tonnes of CO_2 per kg of fish ('high risk') for lobster trap fisheries

	risk') for lobster trap fisheries							
ETP impact (Env_4)	ETP mortality risks are considered negligible	Concerning levels of bycatch of a number of vulnerable species	Considered to be a risk to a number of ETP species (*data limited*)			Small quantities of bycatch of ETP species recorded	Limited research on the interactions with ETP species	Evidence from Scottish creel fisheries of high rates of marine animal entanglement extrapolated on precautionary basis
Social concerns (Social_1)	No known social concerns	Medium risk of modern slavery in fishing sector		High risk of modern slavery in fishing industry		Medium risk of modern slavery in fishing sector		No known social concerns
Management effectiveness (Mgt_1)	Limited measures or monitoring in place	Management considered to be poor				Management considered moderately effective – improvements required	Lack of monitoring and measures to prevent removal of juvenile and spawning crabs	Limited information available
Sustainability certification progress (Mgt_2)	No known progress		FIP in progress				FIP covers around 5% of total landings	No known progress
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator		External, country level indicator	External, country level indicator		
Rule of Law (Social_2)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator				External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator						External, country level indicator

7.6 Seafood resource: Warm-water prawns

7.6.1 Supply chain overview

A variety of warm-water prawns are produced in aquaculture systems globally and represent a significant industry and export market to the UK.

Traditionally, the most commonly farmed prawn was the tiger prawn (*Penaeus monodon*). However, significant disease issues have seen a shift away in production towards the whiteleg shrimp (*Penaeus vannamei*). Though they can be sourced from wild capture fisheries, sources from aquaculture are most prevalent.

Globally, it is currently estimated that around 5 million tonnes of prawns are produced every year, with 80-90% of this now thought to be *P. vannamei*. Production is dominated by Asia and Latin America, with China considered by most to be the leading producer at around 1 million tonnes per year (although much of this product is destined for internal markets). Second to this is India at 600,000 tonnes, then Indonesia (490,000 tonnes), Ecuador (480,000 tonnes) and Vietnam is in fifth position with national production of around 450,000 tonnes[140].

Virtually all prawn production is pond based but with a variety of different systems used between countries and markets. The main production is focused on highly intensive pond production (with the use of aeration and significant feed inputs). Some markets (for example the Organic market supplied mainly from Vietnam or niche market from Madagascar) use much less intensive methods.

For the purposes of this risk assessment, we have concentrated on the intensive farming systems which make up most of the exports to the UK. Extensive methods of farming tend to have less environmental impacts than the intensive methods through reduced stocking densities. By reducing shrimp stocking densities, the farm is less susceptible to disease outbreaks, produces less waste effluent and requires far less chemical interventions during the production cycle.

Warm-water prawns are largely imported in frozen form to the UK, with frozen retail comprising around 32% of sales in 2019. The product is largely in ‘natural’ form (around 73% of sales) as opposed to preparations (such as batter, cakes, breaded, prepared meals)[141]. Within the foodservice sector, prawn and shrimp account for approximately 10% or 118 million servings of total ‘seafood’ purchases (1.2 billion servings). The ‘shellfish’ category (230 million servings) represents about 19% of all seafood servings sold in foodservice. Within this ‘shellfish' category, prawn and shrimp purchases account for around 51%, making it the most popular type of shellfish sold[142].

Following the dominant production trend in Asia, 26% and 24% of average annual (2015 – 2019) UK imports for warm-water prawns and prawns originate in Vietnam and India, respectively (Figure 58). Vietnam in particular has displayed an upward trend since 2015 in the supply of warm-water prawns to the UK, and it is estimated that 34% of warm-water prawn consumption in the UK in 2019, was derived from Vietnam and a further 24% was

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[140] *A Strategic Approach to Sustainable Shrimp Production in Vietnam The case for improved economics and sustainability:* http://media-publications.bcg.com/BCG-A-Strategic-Approach-to-Sustainable-Shrimp-Production-in-Vietnam-Aug-2019.pdf

[141] https://www.seafish.org/document/?id=14501ed6-60d1-4d6e-b630-da2d96c50908

[142] *NPD (YE Dec 2018) Q4 Seafood Data Sheet*

imported from farms in India (Figure 58). The other countries in the supply chain network contribute far less (<9% of imports on average per year and <8% of UK's estimated consumption in 2019).

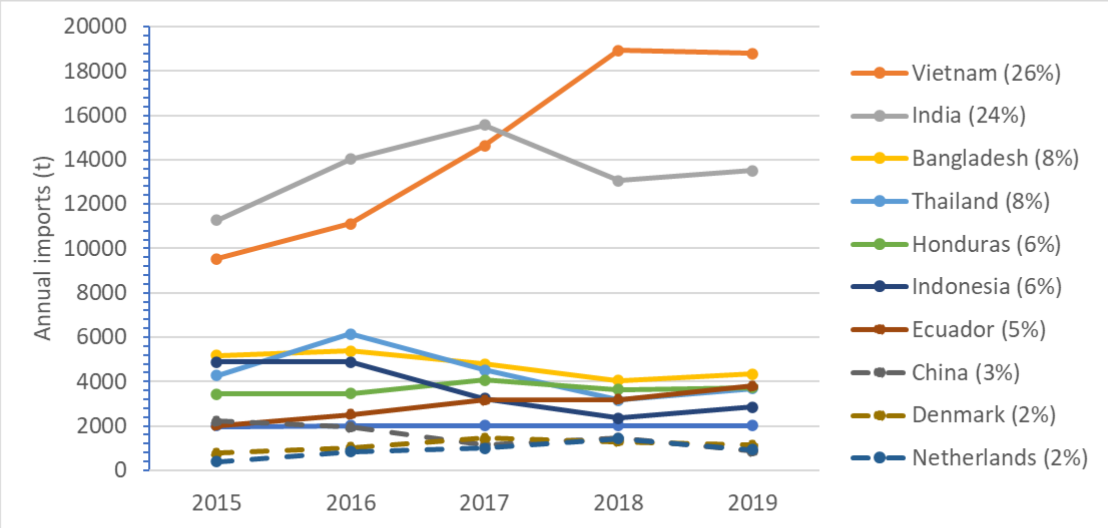

Figure 58: Volume (tonnes, t) of warm-water prawns imported by the UK annually between 2015 and 2019. China Denmark and Netherlands are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Accordingly, a similar picture of Vietnam and India's dominance over the UK's consumption in 2019 (estimated as 53,735 tonnes) can be seen (Figure 59).

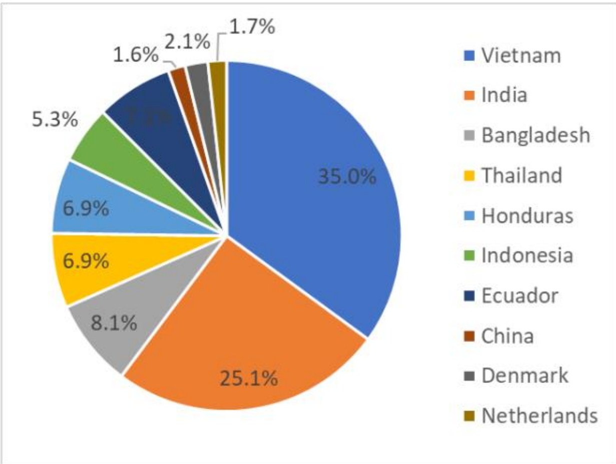

Figure 59: Percentage (%) contribution by the main countries from which warm-water prawns are imported, to the UK's estimated warm-water prawns consumption in 2019.

7.6.2 Risk assessment and footprint summary

The highest supply chain footprint score is associated with Bangladesh ('high' footprint of 25), with Vietnam and Indonesia not far behind (both countries with 'medium' score of 23). At the lower end of the supply chain footprint scale (still within the 'medium' category) are Ecuador, India and Honduras (all countries have a footprint of 20) (Figure 60). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 28 below, with full details available in Appendix 1.

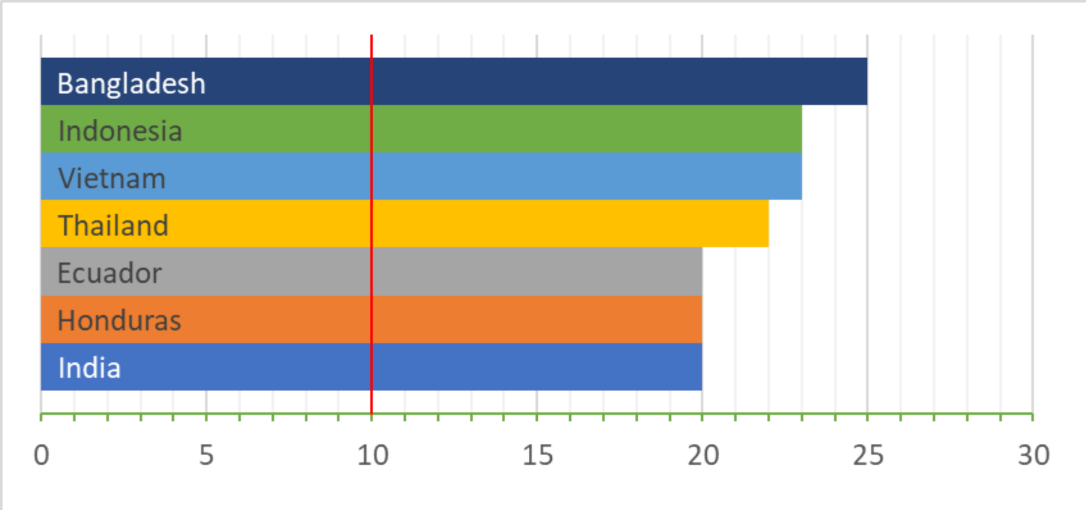

Figure 60: Total footprint for each of the UK's main warm-water prawns supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 28: Risk assessment summary for main supply chains for warm-water prawns consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	Vietnam	India	Bangladesh	Thailand	Honduras	Indonesia	Ecuador
Direct impact on resource (Env_1)	Concerns about use of wild broodstock	Limited concerns	Concerns about wild broodstock		No evidence of harm to wild stocks	Concerns about wild broodstock	No evidence of harm to wild stocks
Ecosystem impact (Env_2)	Mangrove destruction, saltwater intrusion, water pollution	Lower environmental risks than other Asian producers	Mangrove destruction, saltwater intrusion, water pollution		Mangrove destruction, saltwater intrusion, antibiotic use	Mangrove destruction, saltwater intrusion, water pollution	Mangrove destruction, saltwater intrusion, antibiotic use
Climate change impact (Env_3)	Farming method has high climate impacts (fossil fuel use), and significantly higher that cage-based production methods, when considered across the life cycle of the production method						
ETP impact (Env_4)	No specific concerns						
Social concerns (Social_1)	Trafficking concerns and labour conditions more generally, not specific to shrimp sector		Debt labour, sexual violence, abuse and harassment, child labour and low earnings	Trafficking and labour conditions concerns, but improvements have been made	Limited concerns	Some human rights concerns	Limited concerns
Management effectiveness (Mgt_1)	Poor environmental regulation, improvements to management required						
Sustainability certification progress (Mgt_2)	Intensive production largely ASC or BAP certified		Very low coverage by certification	Intensive production largely ASC or BAP certified	Notable ASC and BAP certification coverage, but gaps remain	Partial ASC and BAP certification	Notable ASC and BAP certification coverage, but gaps remain

Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator			
Rule of Law (Social_2)	External, country level indicator		External, country level indicator	External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator				

7.7 Seafood resource: Cold-water prawns

7.7.1 Supply chain overview

The majority of cold-water prawns sold in the UK come from the wild capture fisheries in the North Atlantic around Greenland and Eastern Canada. The group consists of several species mainly Northern or Pink shrimp or prawn (*Pandalus borealis*) and Common or Brown shrimp (*Crangon crangon*), with the latter being the species most landed by the UK fleet. Alongside the UK, brown shrimp are targeted by German, Dutch, Danish, Belgian and French vessels with several of those countries featuring in the UK's supply chain.

Similar to warm-water prawn, the majority of cold-water prawn products sold in UK retail outlets are in chilled (that could be previously frozen) rather than frozen form[143]. In the case of brown shrimp, the catch is typically sorted and cooked on-board before being landed for further processing and onwards sale.

On average between 2015 and 2019, Iceland supplied the largest proportion of cold-water prawns for the UK market (30%) and import volumes have remained largely stable over the five-year period (Figure 61). Denmark and Canada also provide a large contribution (around 29% and 25% respectively), but the volume of imports from Canada has been falling from a peak in 2015.

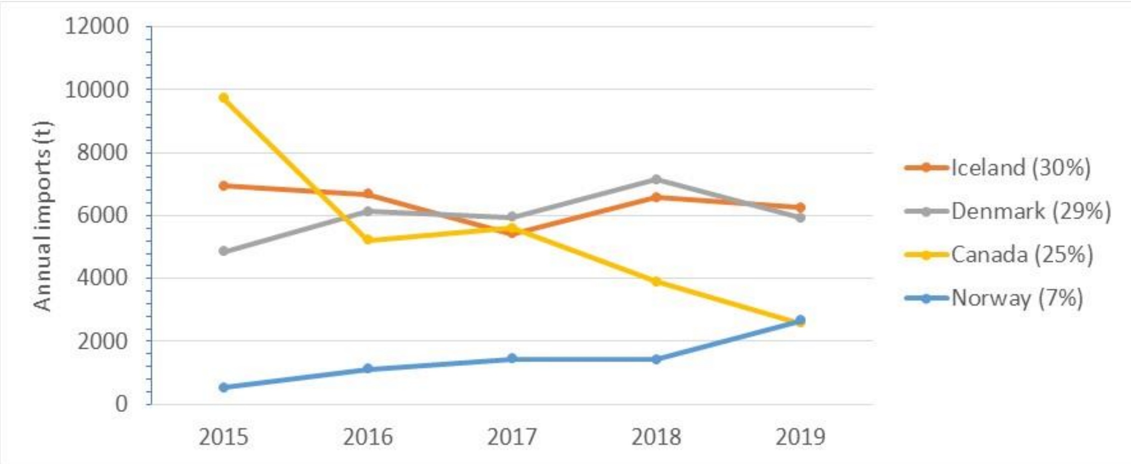

Figure 61: Volume (tonnes, t) of cold-water prawns imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The UK, along with Norway, are the more minor components of domestic demand with the UK producing just 714 tonnes in 2019 (although 300 tonnes of this was landed in non-UK ports) , primarily through its relatively small-scale brown shrimp fisheries. As a result, prawns from Iceland (35%) and Denmark (33%) also dominated the UK's estimated consumption (21,237 tonnes) (Figure 62).

[143] https://www.seafish.org/document/?id=14501ed6-60d1-4d6e-b630-da2d96c50908

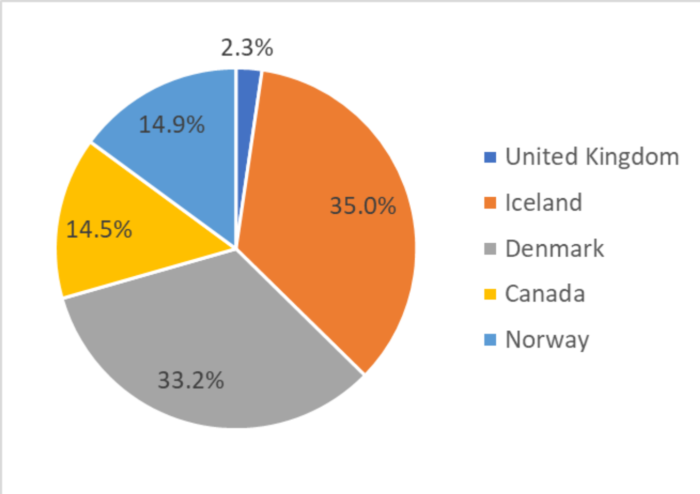

Figure 62: Percentage (%) contribution by the UK and the main countries from which cold-water prawns are imported, to the UK's estimated cold-water prawns consumption in 2019.

7.7.2 Risk assessment and footprint summary

There is little variation in the footprint of the five countries supplying the UK cold-water shrimps & prawn market (including the UK's domestic production). Norway, Canada and Iceland have the lowest supply chain footprints ('low' score of 16), whereas the UK has the highest footprint ('medium' score of 18) (Figure 63). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 29 below, with full details available in Appendix 1.

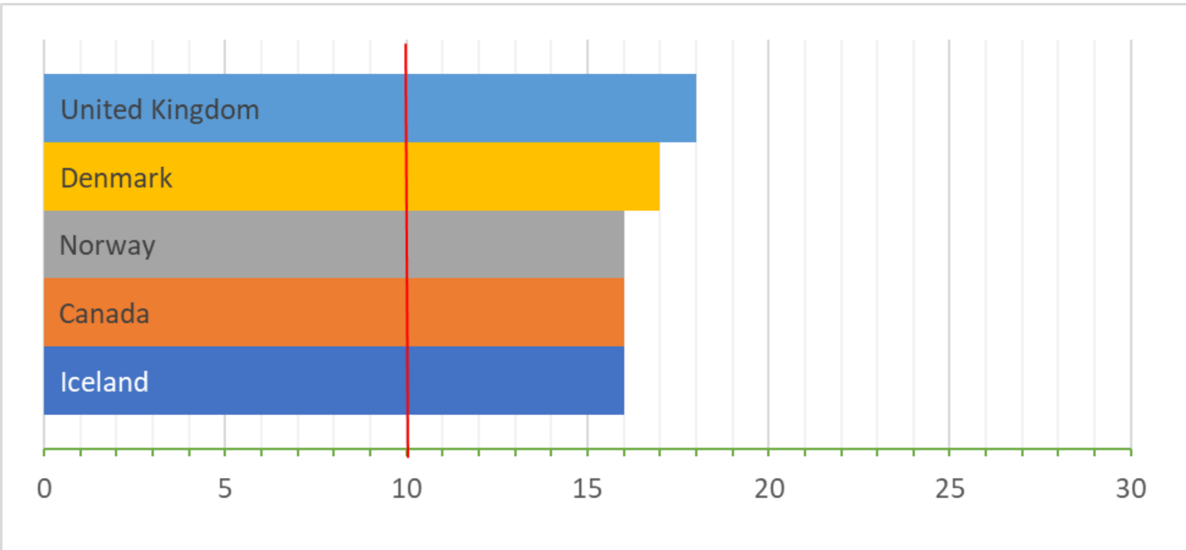

Figure 63: Total footprint for each of the UK's main cold-water prawns supply chains (available score range: 10 – 30).

Table 29: Risk assessment summary for main supply chains for cold-water prawns consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Iceland	Denmark	Canada	Norway
Direct impact on resource (Env_1)	Indications that stock size is low due to fishing pressure and predation pressure (*data limited*)	*Data limited*	Indications of overfishing (*data limited*)	Considered to be in a healthy state and fished at sustainable rate	
Ecosystem impact (Env_2)	Shrimp (beam) trawls are associated with damage to the seabed and bycatch	Otter trawls pose risk of habitat damage and bycatch	Shrimp (beam) trawls and otter trawls pose risk of habitat damage and bycatch		Otter trawls pose risk of habitat damage and bycatch
Climate change impact (Env_3)	High risk due to dominance of bottom towed gears				
ETP impact (Env_4)	Risks to ETP mortality are considered negligible	Records of ETP bycatch despite risk of ETP impact being considered low			
Social concerns (Social_1)	No known social concerns				
Management effectiveness (Mgt_1)	Fishery is not subject to catch controls and there are uncertainties over how effective the harvest control rule will be	Management considered to be effective	Improvements required to ensure stocks do not further decline and are adequately monitored	Management of the fishery is considered to be effective	
Sustainability certification progress (Mgt_2)	Largely MSC certified, with conditions	MSC certified, with conditions	Partially MSC certified, however objections were not fully withdrawn	Largely MSC certified, with conditions	
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator			External, country level indicator
Rule of Law (Social_2)	External, country level indicator				
Labour Rights (Social_3)	External, country level indicator	External, country level indicator		External, country level indicator	External, country level indicator

8. Seafood commodity – Large pelagics

8.1 Summary of large pelagics supply chains

Large pelagic species, including Skipjack tuna (*Katsuwonus pelamis*), Yellowfin tuna (*Thunnus albacares*), Albacore tuna (*Thunnus alalunga*) and Swordfish (*Xiphias gladius*) are not produced directly by the UK, but are collectively imported in large quantities (over 109,000 tonnes imported in 2019). Over 90% of imported tuna species were comprised of skipjack tuna, the majority of which was imported from the Seychelles and Ghana (16% and 15% respectively). However, there is a decreasing trend in volume of imports from these countries between 2016 and 2019. Yellowfin tuna comprised 6.5% of total large pelagic imports, whereas less than 1% was comprised of albacore tuna.

The geographic distribution of the UK's imports of large pelagic species is displayed in Figure 64 and Figure 65. Figure 64 shows the source capture country, and Figure 65 reflects countries perceived to be intermediaries in the supply chain as they primarily process or trade the resource. On average for the period 2015-2019, the Seychelles, Mauritius, and Ghana represent the primary tuna supply chains for the UK, representing 15.3%, 14.9% and 14%, of total tuna (including small quantities of Bigeye *T. obesus*, Atlantic bluefin *T. thynnus*, Southern bluefin *T. maccoyii* and Pacific bluefin *T. orientalis* tuna imports), respectively. For swordfish, Sri Lanka is the most important supply chain (providing ~19% of average annual imports for the period 2015-2019), followed by Vietnam (13.6%) and Brazil (12.9%), although the volume of swordfish imported by the UK is significantly less than tuna (around 500 tonnes in 2019 in total). Thailand appears to be a primary intermediary country for skipjack and to a lesser extent yellowfin tuna.

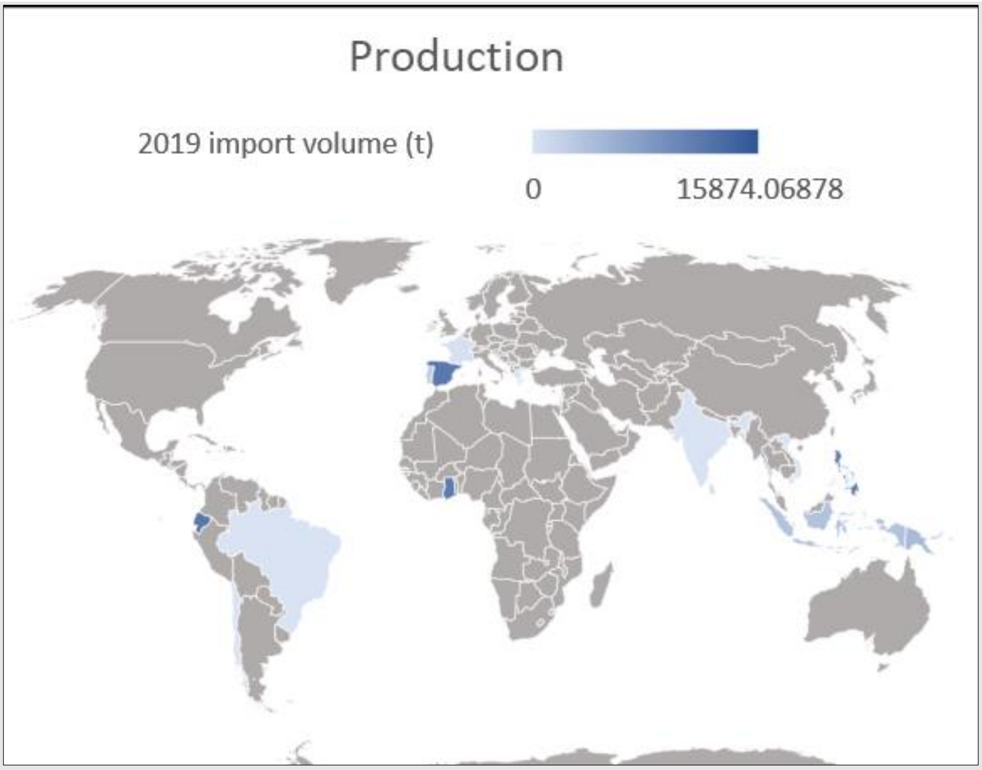

Figure 64: Map showing source countries of large pelagic seafood commodities (swordfish, skipjack tuna, yellowfin tuna and albacore tuna) consumed in the UK. These countries are primarily considered as producing countries. Total (all large pelagic resources) annual import volume (tonnes) in 2019 are shown by the colour scales.

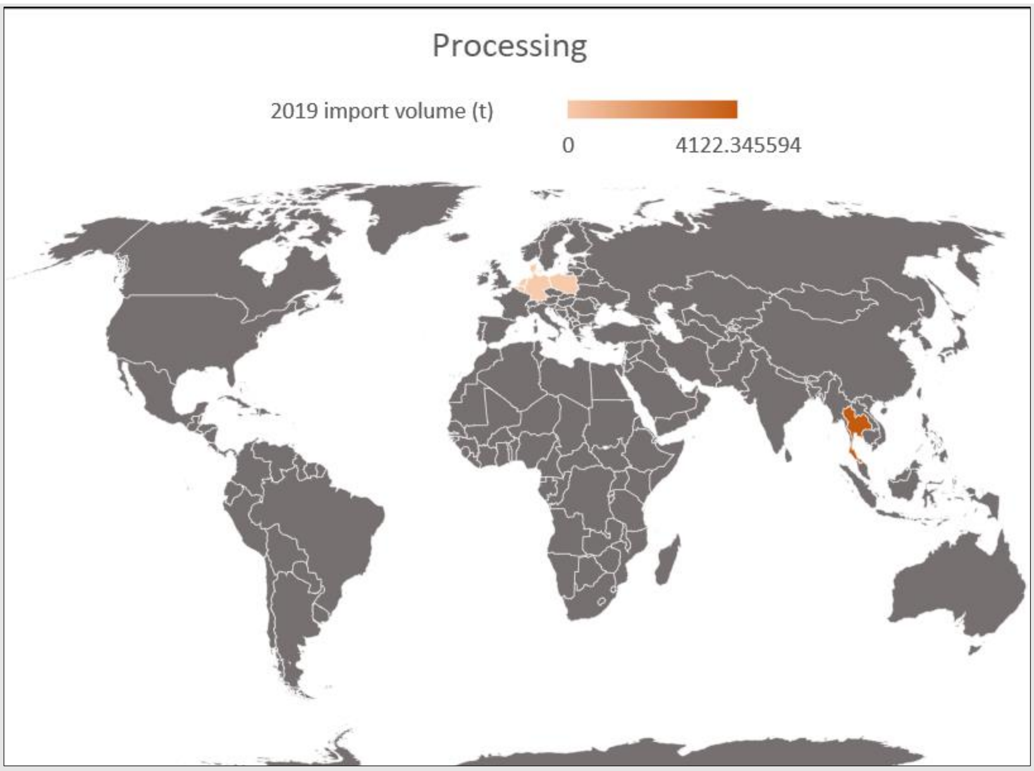

Figure 65: Map showing source countries for large pelagic seafood commodities which are assumed to intermediary countries in the supply chain. Total (all large pelagic resources) annual import volume (tonnes) in 2019 are shown by the colour scales.

The environmental and social footprint associated with the UK's consumption of large pelagic species is relatively high, with all supply chains and resources having a medium to high average footprint score (Table 30). The Republic of Ireland and Portugal have the lowest average footprints of the supply chains, however, the volume of annual imports from both countries is low (<40 tonnes and ~ 2,900 tonnes, respectively). At the other end of the scale, Ecuador and Brazil have the highest footprints (Table 30). Again, the average volume of imports from Brazil is low (around 70 tonnes of swordfish), but Ecuador is a more important supply chain for the UK, with more than 12,500 tonnes of mainly skipjack tuna imported from the country on average between 2015 and 2019.

For all supply chains and species except albacore tuna, the risk of ecosystem impact and ETP impact is high due to the high rates of bycatch (e.g. juvenile fish) associated with the pelagic gears (purse seines, longlines, gill nets) deployed by the fisheries, particularly when used with Fish Aggregating Devices (FADs). For yellowfin tuna, the risk of direct impact on the resource and poor management effectiveness is also high because of the depleted and / or overfished status of some yellowfin populations, including the spawning stock biomass (SSB) being below SSB40[144]. This explains the highest footprint being associated with the species (Table 30). For albacore tuna, which has the lowest footprint of the large pelagic resources assessed in the report, there are data gaps and limitations for most of the environmental risk indicators (direct impact on the resource, ecosystem impact, ETP impact), which influences the more moderate footprint (as data limitations result in a medium risk score of 2). It is therefore not surprising that for 45% of the assessed large pelagic supply chains, there is no progress on third party sustainability certification or where certification has been sought, it has been subject to objection by WWF or with conditions.

Social risks are another relatively common feature of large pelagic supply chains, either relating directly to the fishery itself or in terms of the country-level external risk indicators, such as the Rule of Law or Labour Rights.

[144] https://www.wwf.org.uk/sites/default/files/2021-05/WWF%20-%20Back%20to%20Biology%20report%20%28new%29.pdf

Table 30: (a) Average footprint scores for each producing country in the UK's large pelagics supply chains and (b) for each large pelagic resource sub-category.

Producing country	Average Footprint
Republic of Ireland	18.0
Portugal	19.0
Malta	20.0
Indonesia	20.0
Sri Lanka	21.0
Seychelles	21.3
France	21.5
Mauritius	21.5
Spain	21.8
India	22.0
Greece	22.0
Ghana	22.0
Vietnam	22.0
Papua New Guinea	22.0
Chile	23.0
Philippines	23.0
Ecuador	23.5
Brazil	25.0

Resource	Average Footprint
Albacore tuna	20.0
Skipjack tuna	21.7
Swordfish	22.5
Yellowfin tuna	23.5

Table 31: Supply chain information, Risk assessment and Footprint for Large pelagics commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Large pelagic	Swordfish	Swordfish	100%	Asia and Oceania	Indian Ocean	Sri Lanka	Prod	Cap	1	2	2	3	2	2	2	2	2	3	21	22.5	21.9
				Asia and Oceania	W Pacific	Vietnam	Prod	Cap	1	2	2	3	2	2	2	3	2	3	22		
				Latin America and Caribbea	S Atlantic	Brazil	Prod	Cap	3	2	2	3	2	3	3	2	2	3	25		
				European Union	Mediterranean	Greece	Prod	Cap	3	2	2	3	2	3	3	2	2	3	25		
				European Union	Indian Ocean/ N	Spain	Prod	Cap	1	2	2	3	3	2	2	2	2	2	21		
				Asia and Oceania	Indian Ocean	India	Prod	Cap	1	2	2	3	2	2	3	2	2	3	22		
				Latin America and Caribbea	SE Pacific	Chile	Prod	Cap	2	2	2	3	2	3	3	2	1	3	23		
				Sub-Saharan Africa	Indian Ocean	Seychelles	Prod	Cap	1	2	2	3	2	2	3	2	2	2	21		
	Tuna	Skipjack tuna (or Stripe-bellied bonito)	93%	Sub-Saharan Africa	Indian Ocean	Seychelles	Prod	Cap	1	3	1	3	2	2	2	2	2	2	20	21.7	
				Sub-Saharan Africa	E Atlantic	Ghana	Prod	Cap	2	3	1	3	3	2	2	2	2	2	22		
				Latin America and Caribbea	SE Pacific	Ecuador	Prod	Cap	2	3	1	3	2	3	2	2	3	3	24		
				Sub-Saharan Africa	Indian Ocean	Mauritius	Prod	Cap	1	3	1	3	2	2	2	2	2	2	20		
				Asia and Oceania	W Pacific	Philippines	Prod	Cap	1	3	1	3	3	2	3	2	3	3	24		
				Asia and Oceania		Thailand	Process									2	2	3			
				European Union	Indian Ocean/ N	Spain	Prod	Cap	1	3	1	3	3	2	3	2	2	2	22		
				Asia and Oceania	Indian Ocean/W	Indonesia	Prod	Cap	1	2	1	2	2	2	2	2	3	3	20		
				European Union	N Atlantic	Portugal	Prod	Cap	2	3	1	3	1	2	3	2	1	2	20		
				Asia and Oceania	W Pacific	Papua New Guinea	Prod	Cap	1	3	1	3	3	2	2	2	3	3	23		
	Tuna	Yellowfin tuna	6%	Sub-Saharan Africa	Indian Ocean	Mauritius	Prod	Cap	3	3	1	3	2	3	2	2	2	2	23	23.5	
				European Union	Indian Ocean/ N	Spain	Prod	Cap	3	3	1	3	3	3	2	2	2	2	24		
				Sub-Saharan Africa	E Atlantic	Ghana	Prod	Cap	3	3	1	3	3	3	2	2	2	2	24		
				Sub-Saharan Africa	Indian Ocean	Seychelles	Prod	Cap	3	3	1	3	2	3	2	2	2	2	23		
				European Union		Netherlands	Process									2	1	1			
				European Union	NE Atlantic	France	Prod	Cap	3	3	1	3	2	3	2	2	1	2	22		
				Latin America and Caribbea	SE Pacific	Ecuador	Prod	Cap	3	3	1	3	2	3	2	2	3	3	25		
				Asia and Oceania		Thailand	Process									2	2	3			
	Tuna	Albacore tuna	0.1%	European Union		Denmark	Process									1	1	1		20.0	
				European Union	NE Atlantic	Republic of Irelanc	Prod	Cap	2	2	2	2	2	2	3	1	1	1	18		
				European Union	Indian Ocean/ N	Spain	Prod	Cap	2	2	2	2	3	2	2	2	2	2	21		
				European Union	NE Atlantic	France	Prod	Cap	2	2	2	2	2	2	3	2	1	2	20		
				European Union	Mediterranean	Malta	Prod	Cap	2	2	2	2	1	2	3	2	2	2	20		
				European Union	Mediterranean	Greece	Prod	Cap	2	2	2	2	2	2	3	2	2	3	22		
				European Union		Germany	Process									1	1	1			
				European Union	N Atlantic	Portugal	Prod	Cap	2	2	2	2	1	2	3	2	1	2	19		

8.2 Seafood resource: Swordfish

8.2.1 Supply chain overview

In 2019, swordfish (*Xiphias gladius*) imports to the UK only accounted for 0.45% of total UK large pelagic resource imports at a volume of 455 tonnes. Around 90% of the UK's average annual imports (2015-2019) were sourced from eight different countries. In 2019, the majority (19%) of imported swordfish came from Sri Lanka (174 tonnes) and Greece (101 tonnes), although the UK imported no swordfish from Greece directly in 2016 and 2017, meaning the average contribution of the supply chain for the time period is lower at 11% (Figure 66). Spain, Vietnam, Seychelles, India, Chile and Brazil are also notable suppliers of swordfish to the UK, although relatively small volumes were imported from these countries in 2019. For some countries like Vietnam and Brazil, there has been an evident decline in the supply of swordfish to the UK in recent years.

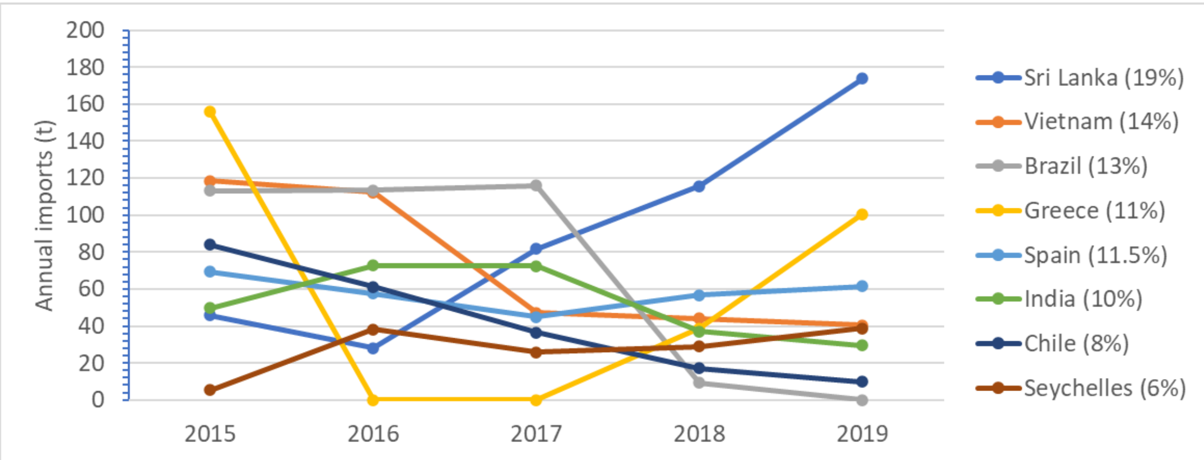

Figure 66: Volume (tonnes, t) of swordfish imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

It is noted that in 2015, the EU imposed a ban on swordfish imports from Sri Lanka due to their inadequate attempt to combat illegal fishing[145], which explains the lower volumes of imports in 2015 and 2016 (Figure 66). The ban was later lifted after 15 months.

An estimated 494 tonnes of swordfish was consumed in the UK in 2019[146], to which Sri Lanka contributed 35% and Greece 20%, with other supply chains responsible for smaller proportions of the UK's consumption (Figure 67).

[145] https://www.seafoodsource.com/news/supply-trade/eu-fishing-ban-takes-its-toll-on-sri-lanka#:~:text=Once%20a%20prominent%20exporter%20of,fishing%20to%20the%20acceptable%20standard.

[146] *Estimation of the UK's swordfish consumption was problematic as total imports (494 tonnes) were very similar to total exports (476 tonnes). In addition, the MMO landings data reported 340 tonnes of swordfish were caught by the UK fleet in international (non-EU) waters. However, information on this fishery is lacking, including whether the fish were landed in UK or foreign ports (and then potentially imported). For the purposes of the analysis, and simplicity, it was therefore assumed that UK production = exports and all imports (494 tonnes) were consumed.*

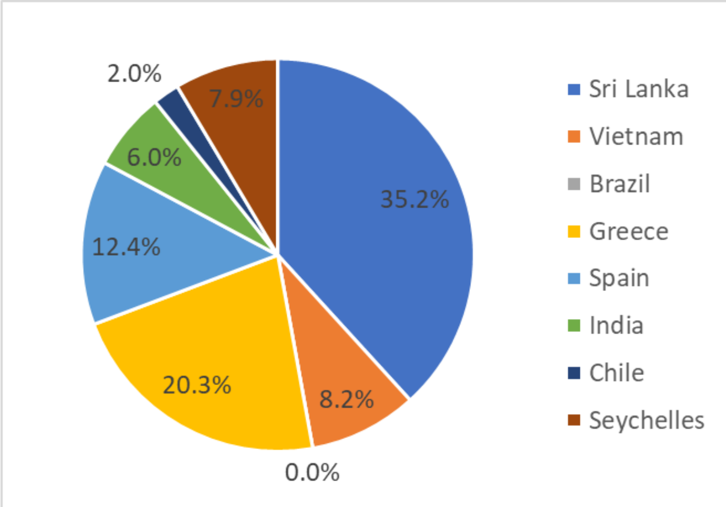

Figure 67: Percentage (%) contribution by main countries from which swordfish is imported, to the UK's estimated swordfish consumption in 2019.

Although swordfish is not imported to the UK in comparable quantities to tuna, the majority that is imported is fresh or chilled fillets (82%), whereas only 18% is frozen.

8.2.2 Risk assessment and footprint summary

The footprint of imported swordfish to the UK is the second highest when considering large pelagic species as one commodity (average footprint score of 22.5). All of the supply chains are associated with medium to high footprint scores, with the UK's main sources of swordfish imports in 2019 – Sri Lanka and Greece – associated with the lowest and highest footprints, respectively (Figure 68).

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 32 below with full details available in Appendix 1.

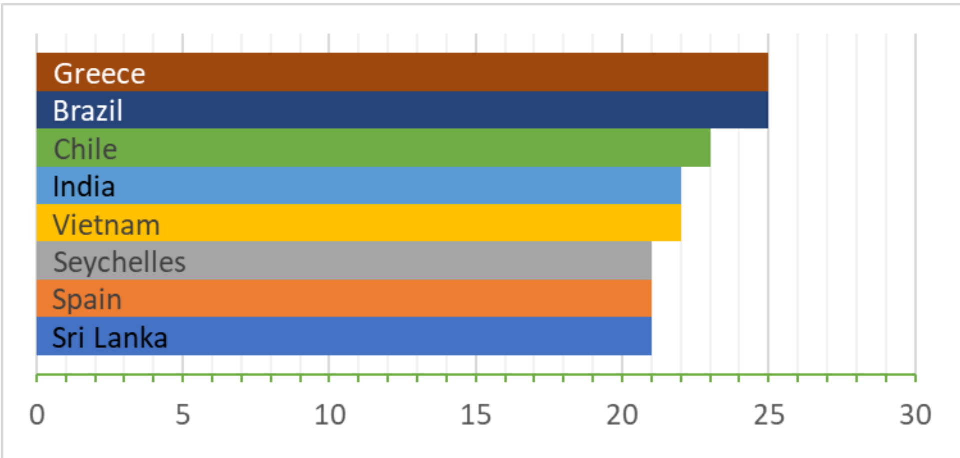

Figure 68: Total footprint for each of the UK's main swordfish supply chains (available score range: 10 – 30).

Table 32: Risk assessment summary for main supply chains for swordfish consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

<table>
<tr><th>Risk Indicator</th><th>Sri Lanka</th><th>Vietnam</th><th>Brazil</th><th>Greece</th><th>Spain</th><th>India</th><th>Chile</th><th>Seychelles</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td>IOTC (2020) state the Indian Ocean stock is not overfished</td><td>WCPFC (2019) state the North Pacific stock as not overfished</td><td>ICCAT (2019) concluded stock was overfished and overfishing likely to be occurring (based on 2017 assessment)</td><td>ICCAT (2020) considered Mediterranean stock to be overfished</td><td>ICCAT (2019) considered the North Atlantic stock as not overfished</td><td>As Sri Lanka</td><td>Lack of stock assessment in recent years by IATTC (data limited)</td><td>As Sri Lanka</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td colspan="8">Main gear type is pelagic longlines, driftnets and handlines are also used. Bycatch of non-target species, including other fish, marine mammals, sea turtles, elasmobranchs and seabirds is well documented and remains a concern (also see ETP impact). Minimal impact to benthic habitat.</td></tr>
<tr><td>Climate change impact (Env_3)</td><td colspan="8">Pelagic gears associated with a moderate carbon footprint</td></tr>
<tr><td>ETP impact (Env_4)</td><td colspan="8">As per ecosystem impact – ETP species potentially include Olive Ridley turtle, Green turtle, Hawksbill turtle, Leatherback turtle, shortfin mako, thresher shark, hammerhead shark, albatross (various)</td></tr>
<tr><td>Social concerns (Social_1)</td><td colspan="4">Medium risk of modern slavery in fisheries sector</td><td>High risk of modern slavery in fisheries sector</td><td colspan="3">Medium risk of modern slavery in fisheries sector</td></tr>
<tr><td>Management effectiveness (Mgt_1)</td><td colspan="2">Stock status good, but management could be strengthened to reduce or mitigate threat of bycatch for ETP species</td><td colspan="2">Management measures are not adequate (e.g. poor stock status, bycatch)</td><td colspan="2">Stock status good, but management could be strengthened to reduce or mitigate threat of bycatch for ETP species</td><td>Management measures are not adequate (e.g. poor stock status, bycatch)</td><td>Stock status good, but management could be strengthened to reduce or mitigate</td></tr>
</table>

							threat of bycatch for ETP species
Sustainability certification progress (Mgt_2)	Involved in a FIP		Not currently associated with a sustainability certification scheme	Involved in a FIP	Not currently associated with a sustainability certification scheme		
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator				
Rule of Law (Social_2)	External, country level indicator					External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator			External, country level indicator	External, country level indicator		External, country level indicator

8.3 Seafood resource: Skipjack tuna

8.3.1 Supply chain overview

In 2019, skipjack tuna accounted for the highest volume of total imports into the UK (100,026 tonnes) for large pelagics. This represented over 90% of total large pelagic imports to the UK and around 91% was sourced from ten different countries (Seychelles, Ghana, Ecuador, Mauritius, Philippines, Thailand, Spain, Indonesia, Portugal and Papua New Guinea). Thailand is assumed to be an intermediary country, where the product is primarily processed or traded.

The majority of tuna imported to the UK comes from the Indian Ocean, Pacific Ocean and Atlantic Ocean tuna stocks, managed through the Regional Fisheries Management Organisations (RFMOs) like Western and Central Pacific Fisheries Commission (WCPFC), Inter-American Tropical Tuna Commission (IATTC), Indian Ocean Tuna Commission (IOTC) and International Commission for the Conservation of Atlantic Tuna (ICCAT). Mauritius, Seychelles, Ecuador, Philippines and Ghana collectively accounted for 67% of skipjack tuna imports in 2019, within which Mauritius contributed only slightly more than other countries. On average between 2015 and 2019, Seychelles was instead the origin of most (16%) skipjack imports to the UK, closely followed by Ghana (15%) and Mauritius (13%) (Figure 69). Imports from the Seychelles and Ghana both peaked significantly in 2016, whereas imports from Ecuador, Philippines and Indonesia peaked in 2018.

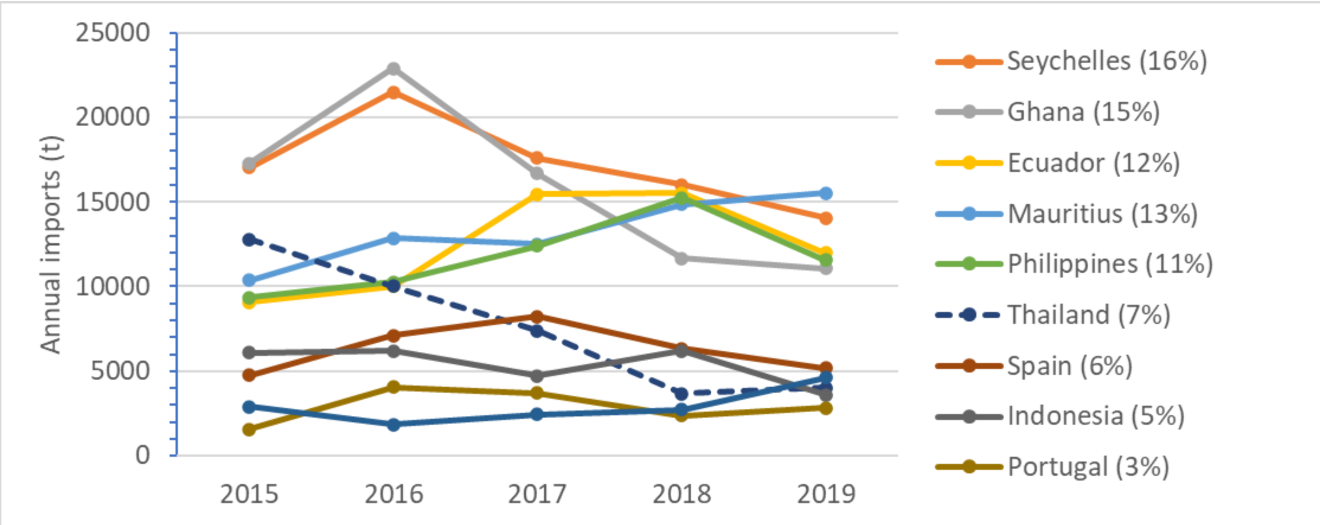

Figure 69: Volume (tonnes, t) of skipjack tuna imported by the UK annually between 2015 and 2019. Thailand is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The proportion of estimated UK consumption of skipjack tuna in 2019 (95,918 tonnes) attributed to each of the source countries, displayed a similar trend to the proportions of imports from each country (Figure 70). Consumption of skipjack tuna was lowest from Portuguese imports (2.9%) and highest from Mauritius imports (16.2%), which are unsurprising given the distribution of imports across each country.

By product format, the overwhelming majority of skipjack imported to the UK is 'prepared or preserved' (93,831 tonnes) which reflects the UK preference for tinned tuna.

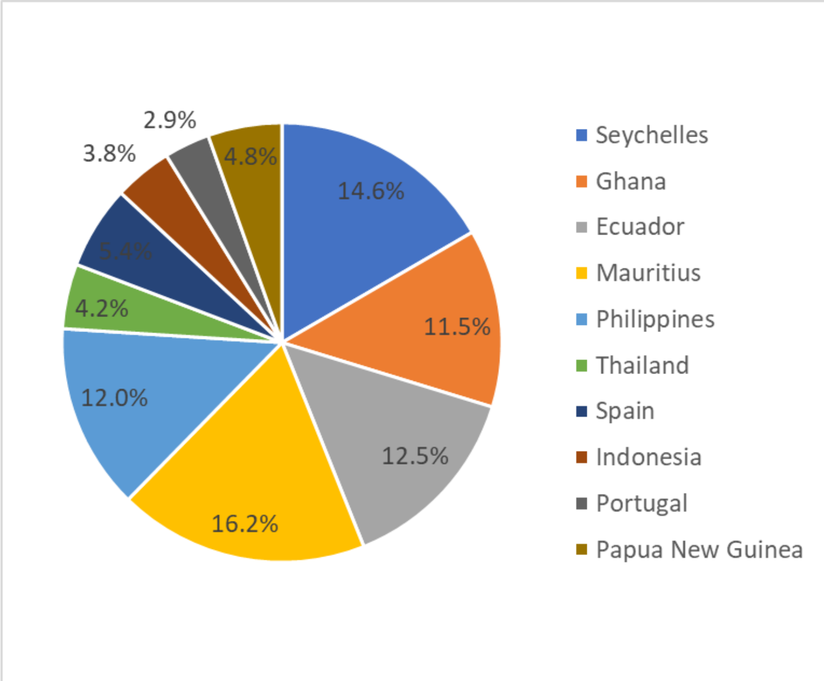

Figure 70: Percentage (%) contribution by the main countries from which skipjack tuna is imported, to the UK's estimated skipjack tuna consumption in 2019.

8.3.2 Risk assessment and footprint summary

The average footprint of the UK's skipjack tuna imports is 21.7, which is on the lower end of the scale when comparing all large pelagic species imported into the UK. Most of the supply chains are associated with medium footprint scores, with the Philippines and Ecuador just falling into the high category (score of >23). The UK's main sources of skipjack tuna imports in 2019 – Seychelles and Mauritius – are associated with the lowest footprints (Figure 71). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 33 below, with full details available in Appendix 1.

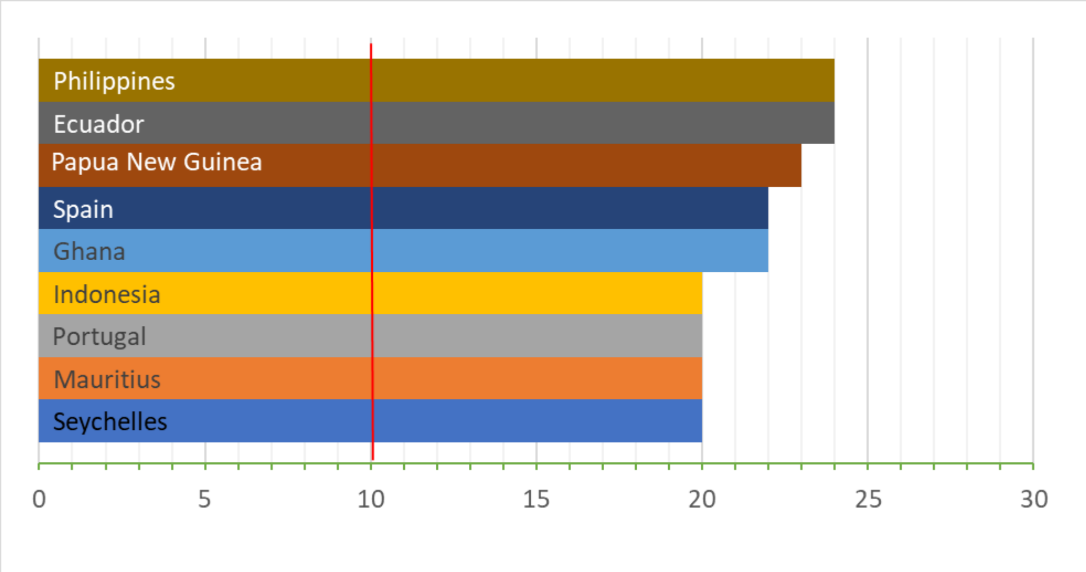

Figure 71: Total footprint for each of the UK's main skipjack tuna supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 33: Risk assessment summary for main supply chains for skipjack tuna consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

<table>
<tr><th>Risk Indicator</th><th>Seychelles</th><th>Ghana</th><th>Ecuador</th><th>Mauritius</th><th>Philippines</th><th>Spain</th><th>Indonesia</th><th>Portugal</th><th>Papua New Guinea</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td>IOTC (2020) state the Indian Ocean stock is not overfished</td><td colspan="2">Lack of recent quantitative stock assessment (data limited)</td><td>As Seychelles</td><td>WCPFC (2019) state the western pacific stock is not overfished</td><td>As Seychelles</td><td>As Seychelles & Philippines</td><td>Lack of recent quantitative stock assessment (data limited)</td><td>As Philippines</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td colspan="6">Pelagic gears (purse seines, longlines, gill nets, pole & line) cause minimal impact to benthic habitat but frequent bycatch from purse seines and gill nets, particularly where FADs are used</td><td>Large % of imports likely come from low impact pole & line fishery (data limited)</td><td colspan="2">Pelagic gears (purse seines, longlines, gill nets, pole & line) cause minimal impact to benthic habitat but frequent bycatch from purse seines and gill nets, particularly where FADs are used</td></tr>
<tr><td>Climate change impact (Env_3)</td><td colspan="9">Average score of 2.4 tonnes of CO2 per kg of fish is provided by ‘The Seafood Carbon Emissions Tool’ based on purse seines</td></tr>
<tr><td>ETP impact (Env_4)</td><td colspan="6">Bycatch is an issue for purse seine skipjack fisheries, particularly where FADs are used (see Env_2), high number of ETP interactions (including sharks, turtles and cetaceans) reported in MSC assessments. Precautionary high risk.</td><td>Large % of imports likely come from low impact pole & line fishery (data limited)</td><td colspan="2">Bycatch is an issue for purse seine skipjack fisheries, particularly where FADs are used (see Env_2), high number of ETP interactions (including sharks, turtles and cetaceans) reported in MSC assessments. Precautionary high risk.</td></tr>
</table>

Social concerns (Social_1)	Little available informatio n (*data limited*)	High risk of modern slavery in fishing sector	Medium risk of modern slavery in fishing sector Risk for women to be employed on informal, low paid and vulnerable contracts with little benefits or access to labour rights in Ecuador		High risk of modern slavery in fishing sector		Medium risk of modern slavery	Low risk of modern slavery in fishing sector	High risk of modern slavery in fishing sector
Managemen t effectiveness (Mgt_1)	Stock not overfished but IOTC exceeded HCR	Lack of stock assessm ents to inform manage ment	As Ghana, plus EU yellow card received in 2019	Stock not overfished but IOTC exceeded HCR	Moderately effective given stock status	Stock not overfished but IOTC exceeded HCR	Moderately effective given stock status	Lack of stock assessments to inform management	Moderately effective given stock status
Sustainability certification progress (Mgt_2)	Involved with FIPs for their purse seine fisheries			Undergoing assessment for portions of its purse seine fisheries	Not associated with any sustainabili ty certificatio n / FIP	WWF submitted objections to Spain's MSC certificatio n	MSC certified (with conditions) and FIPs for large portions of their pole and line fisheries	Not associated with any sustainability certification / FIP	Part of a FIP and MSC certified. However, there have been objections supported by WWF
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator								
Rule of Law (Social_2)	External, country level indicator		External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator

Labour Rights (Social_3)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator

8.4 Seafood resource: Yellowfin tuna

8.4.1 Supply chain overview

Yellowfin tuna represented 6.5% of large pelagic imports into the UK in 2019 (8,665 tonnes), with 91% of imports originating from eight different countries (Mauritius, Spain, Ghana, Seychelles, Netherlands, France, Ecuador and Thailand). Of these, two (Netherlands[147] and Thailand[148]) are considered to be primarily intermediary countries in the supply chain (Figure 72). It is also likely that a notable portion of the imports arriving from Mauritius have been processed there[149] rather than caught by vessels under a Mauritius flag, however quantifying this contribution to the supply chain was beyond the scope of the analyses.

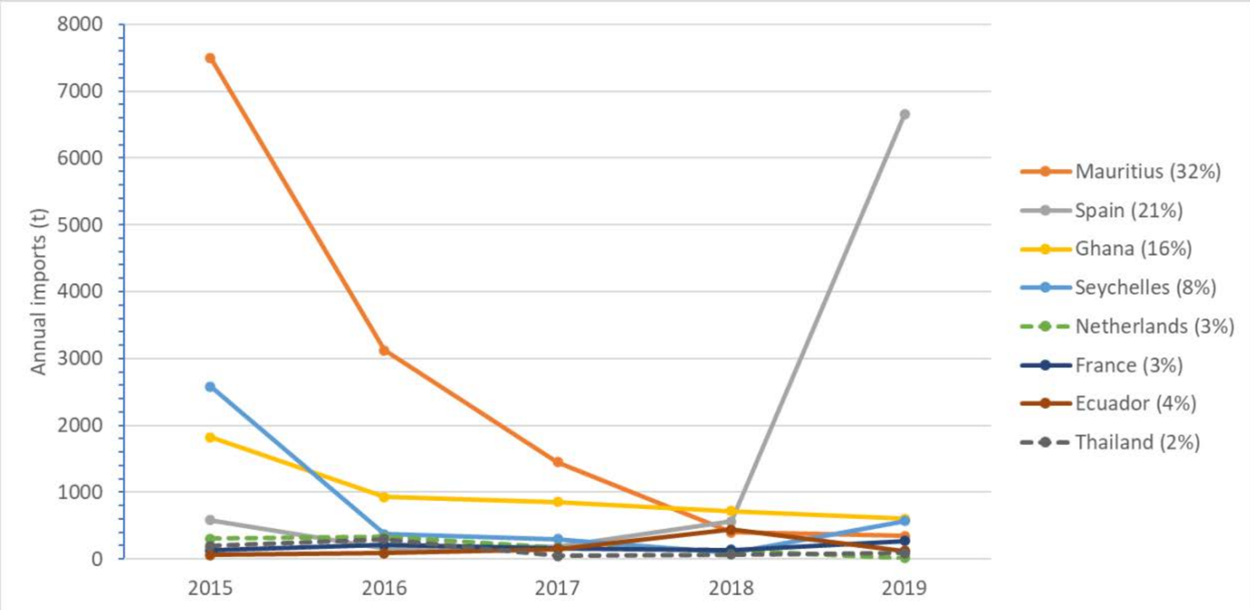

Figure 72: Volume (tonnes, t) of yellowfin tuna imported by the UK annually between 2015 and 2019. The Netherlands and Thailand are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

On average between 2015 and 2019, Mauritius accounted for the majority of yellowfin imports (32%), followed by Spain (20.8%) and Ghana (16.3%) (Figure 73), whilst the remaining countries contributed a less significant amount (between 2% and 9%). However, imports from Mauritius have declined significantly from a peak in 2015 (7,502 tonnes) to the lowest volume of imports in 2019 (345 tonnes). Contributions from Spain on the other hand has risen substantially from low values in 2015 to 2018 to 6,650 tonnes in 2019 (Figure 73).

In 2019, an estimated 77% of yellowfin tuna consumed in the UK was produced by the Spanish fleet which reflects their prominent purse seine fishery in the Indian Ocean, Pacific Ocean or Atlantic Ocean (Figure 73). Only 7% and 4% of estimated yellowfin consumption in 2019 was sourced from Seychelles and Mauritius, respectively, however consumption

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[147] Netherlands is not currently known to produce yellowfin tuna but is considered a major processor. It is therefore assumed that imports of yellowfin from Netherlands are based on processing / trade and not production.

[148] Thai flagged vessels were not permitted to operate outside of Thai waters between 2016 and 2018 in order to inspect whether they comply with regulations under the Royal Ordinance on Fisheries B.E. 2258 (https://www.iotc.org/documents/WPTT/21/17)

[149] For example, see: https://www.princesgroup.com/location/princes-tuna-mauritius-riche-terre/

figures attributed to each of the source countries would likely have been comparable in previous years.

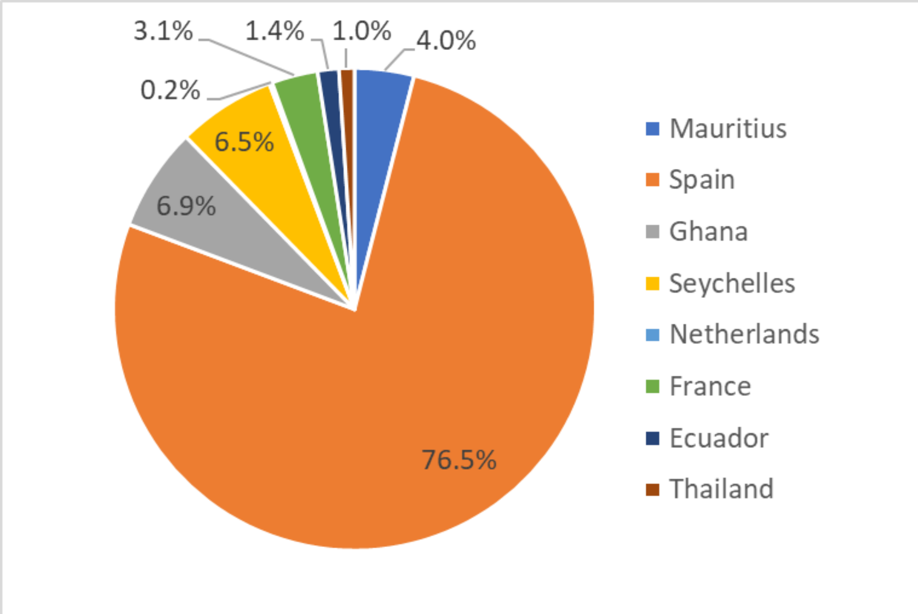


Figure 73: Percentage (%) contribution by the main countries from which yellowfin tuna is imported, to the UK's estimated yellowfin tuna consumption in 2019.

8.4.2 Risk assessment and footprint summary

The yellowfin tuna supply chain footprint is rated the highest out of all large pelagic species imported into the UK with an average footprint risk score of 23.5, as a result of many poorly scored risk assessment factors. Overall, the supply chain footprint for Ecuador was the greatest (footprint score of 25), followed closely by Ghana and Spain (footprint score of 24) (Figure 74). This is concerning given the high volume of imports from Spain in 2019.

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 34 below, with full details available in Appendix 1.

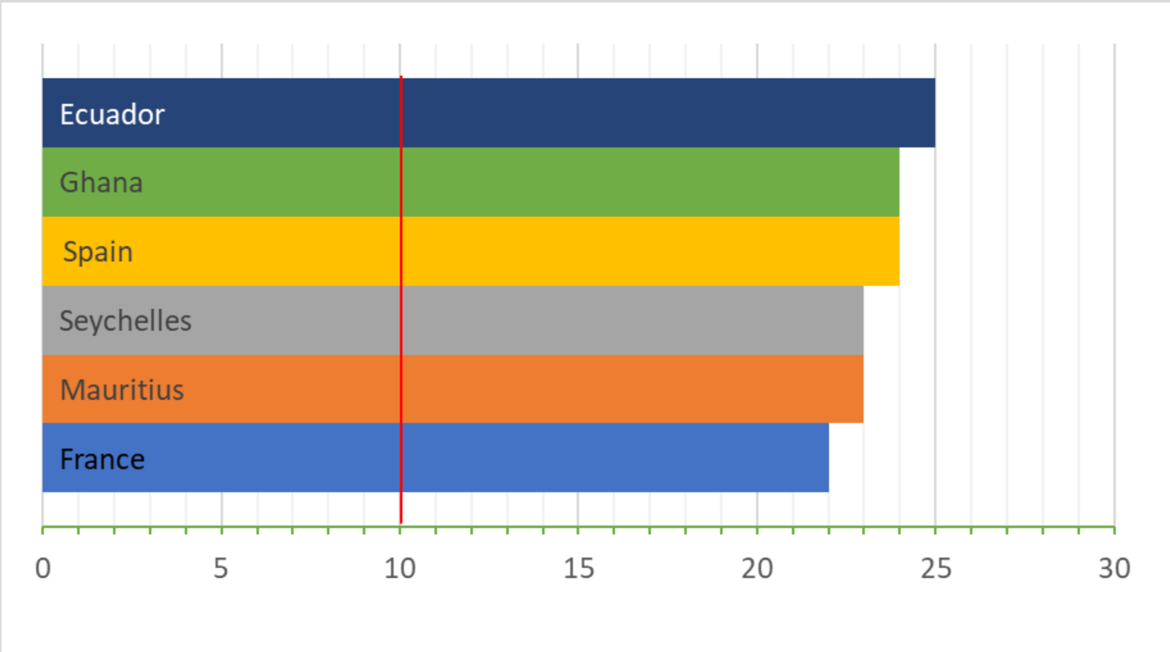


Figure 74: Total footprint for each of the UK's main yellowfin tuna supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 34: Risk assessment summary for main supply chains for yellowfin tuna consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	Mauritius	Spain	Ghana	Seychelles	France	Ecuador
Direct impact on resource (Env_1)	Indian Ocean stock remains overfished		ICCAT (2019) consider stock not overfished however SSB/SSB0 = 0.39	Indian Ocean stock remains overfished		Mixed views on stock status, however WWF estimate SSB/SSB0 = 0.18
Ecosystem impact (Env_2)	The use of FAD associated purse seines have the ability to catch juvenile yellowfin in addition to several other species of fish and marine mammals, sea turtles and sharks					
Climate change impact (Env_3)	An average score of 2 tonnes of CO2 per kg of fish is provided by 'The Seafood Carbon Emissions Tool'					
ETP impact (Env_4)	Bycatch of ETP species is an issue related to yellowfin purse seine fisheries, particularly where FADs are used					
Social concerns (Social_1)	Medium risk of modern Slavery	High risk of modern Slavery		Medium risk of modern Slavery		
Management effectiveness (Mgt_1)	Management is poor - reflected in the unsustainable		EU 'yellow IUU card' in 2021 due	Management is poor - reflected in the unsustainable		EU yellow card received by

	exploitation of the stock and failure to agree on an adequate rebuilding plan	to their inadequacy for combating IUU fishing, plus high bycatch risk	exploitation of the stock and failure to agree on an adequate rebuilding plan.		Ecuador in 2019 due to their shortfalls in relation to IUU management
Sustainability certification progress (Mgt_2)	Involved in a FIP or are undergoing MSC assessment, but are not MSC certified				
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator				
Rule of Law (Social_2)	External, country level indicator			External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator				External, country level indicator

8.5 Seafood resource: Albacore tuna

8.5.1 Supply chain overview

The UK is not a significant importer of albacore tuna, importing 148 tonnes in 2019, which represents only 0.1% of large pelagic imports. Countries that export to the UK include Denmark, Republic of Ireland, Spain, France, Malta, Greece, Germany and Portugal, two of which – Denmark and Germany – are likely to process / provide a trade route for the resource as opposed to produce. Although an intermediary in the supply chain, Denmark is the source for over 30% of the UK's albacore imports whereas the Republic of Ireland, as the highest producing country that exports to the UK (according to the trade data), accounts for just 14% (Figure 75).

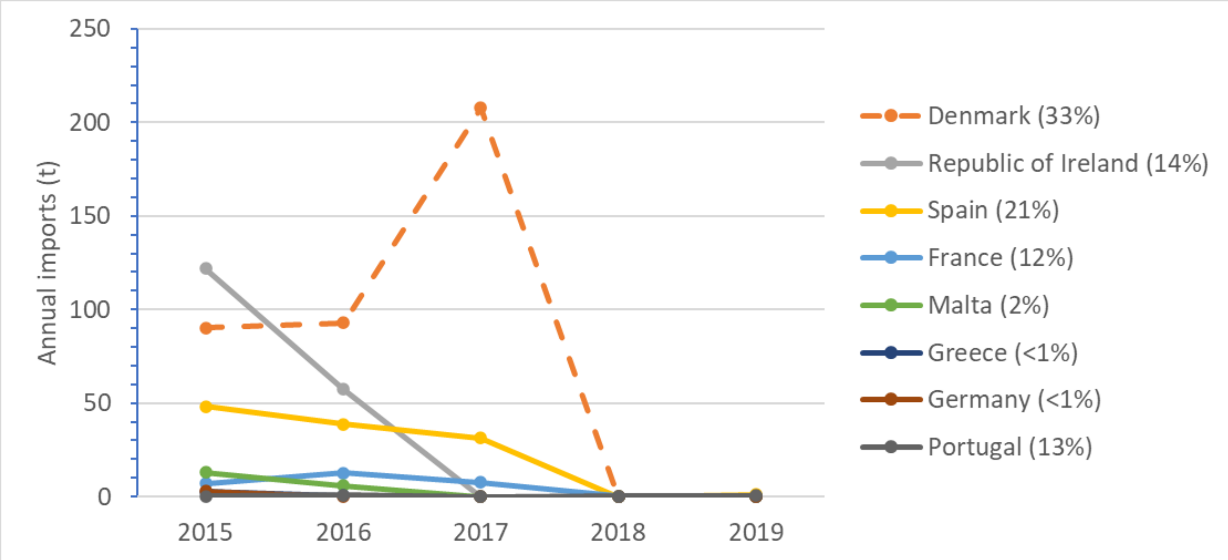


Figure 75: Volume (tonnes, t) of yellowfin tuna imported by the UK annually between 2015 and 2019. The Denmark and Germany are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Estimated consumption of albacore tuna in the UK in 2019 was just 2 tonnes[150], 60% of which was imported from Spain and another 24% from Portugal (Figure 76). However, it is believed that a consumption of 2 tonnes is unrealistic but the reason for this is beyond the scope of this study.

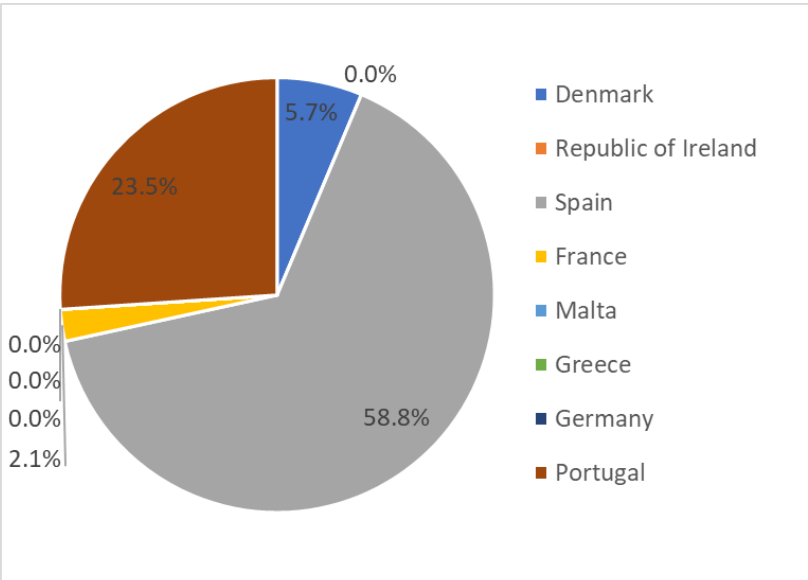


Figure 76: Percentage (%) contribution by the main countries from which albacore tuna is imported, to the UK's estimated albacore tuna consumption in 2019.

[150] *In fact, according to the data, consumption was -7 tonnes because UK production is reported as 1 tonnes, imports in 2019 were 2 tonnes and 10 tonnes were exported according to HMRC trade data. Assuming there are errors in one or more of these data points, consumption was assumed to be imports for the purposes of the analysis.*

8.5.2 Risk assessment and Footprint Summary

The average supply chain footprint for albacore is 20, the lowest of all large pelagic species imported into the UK, although still a medium footprint overall. Greece is associated with the highest supply chain footprint (medium score of 22), reducing to a footprint of 18 for the Republic of Ireland (Figure 77). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 35 below, with full details available in Appendix 1.

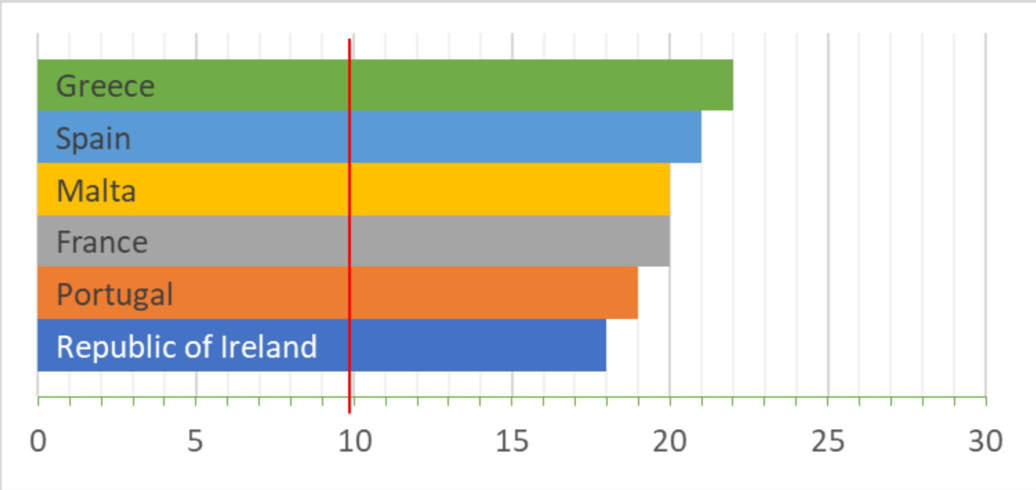


Figure 77: Total footprint for each of the UK's main albacore tuna supply chains (available score range: 10 – 30), excluding processing / trading countries

Table 35: Risk assessment summary for main supply chains for albacore tuna consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3)

<table>
<tr><th>Risk Indicator</th><th>Republic of Ireland</th><th>Spain</th><th>France</th><th>Malta</th><th>Greece</th><th>Portugal</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td colspan="6">Uncertainties over status of North Atlantic / Mediterranean stocks governed by ICCAT. SSB40 unknown (data limited)</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td colspan="6">Reasonable likelihood of instances of bycatch associated with traditional surface fisheries (troll and baitboat) and longlining, however data are scarce (data limited)</td></tr>
<tr><td>Climate change impact (Env_3)</td><td colspan="6">Combination of pelagic and surface gears associated with medium risk. Average score of 4.9 tonnes of CO_2 per kg of fish (‘low risk’) is provided by The Seafood Carbon Emissions Tool, but based only on longlines.</td></tr>
<tr><td>ETP impact (Env_4)</td><td colspan="6">Lack of data in relation to ETP impacts. But interactions with ETP species (including sharks, turtles and birds) reported within the limited MSC certification assessments (data limited)</td></tr>
<tr><td>Social concerns (Social_1)</td><td>Medium risk of modern slavery in fishing sector</td><td>High risk of modern slavery in fishing sector</td><td>Medium risk of modern slavery in fishing sector</td><td>No known concerns</td><td>Medium risk of modern slavery in fishing sector</td><td>Low risk of modern slavery in fishing sector</td></tr>
<tr><td>Management effectiveness (Mgt_1)</td><td colspan="6">Relatively unknown status of the stocks due to data uncertainties</td></tr>
<tr><td>Sustainability certification progress (Mgt_2)</td><td>Not known to be currently involved with a sustainability certification scheme</td><td>Partly MSC certified</td><td colspan="4">Not known to be currently involved with a sustainability certification scheme</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td>External, country level indicator</td><td colspan="5">External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td>External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td>External, country level indicator</td><td colspan="3">External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td></tr>
</table>

9. Seafood commodity – Molluscs

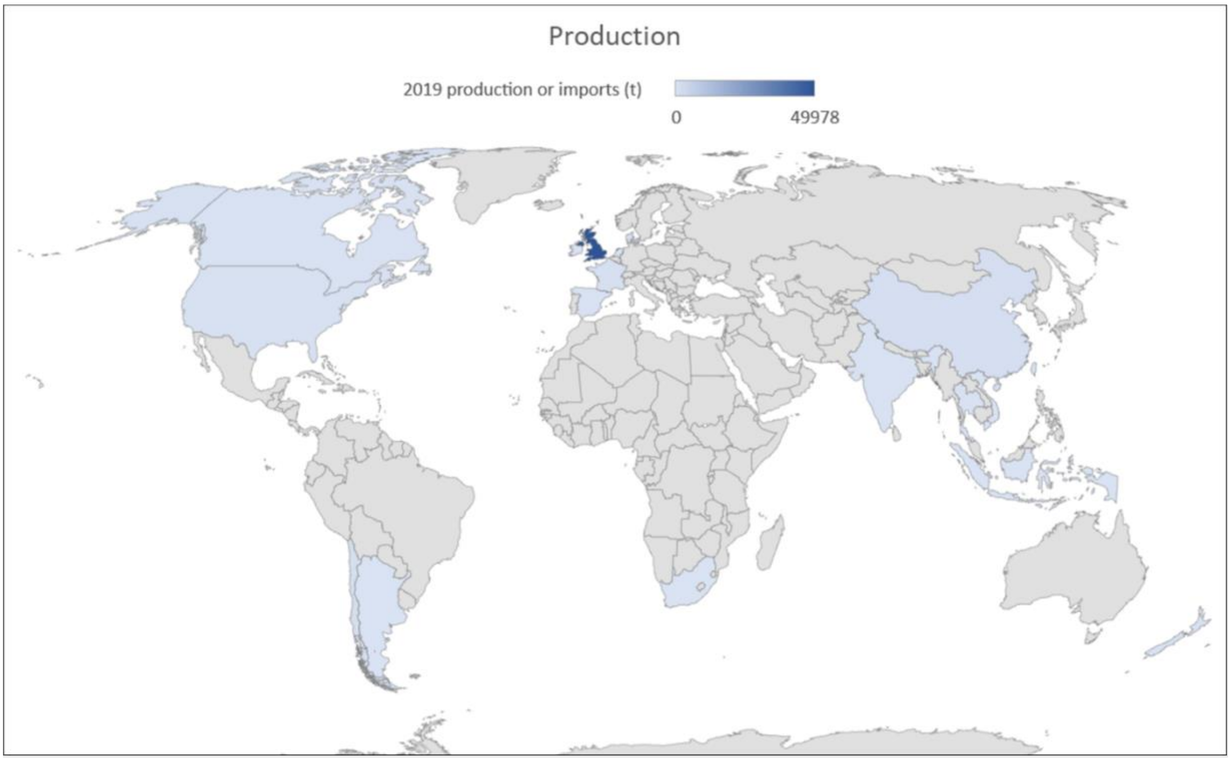
9.1 Summary of mollusc supply chains

Within the mollusc commodity category, five resources are considered in detail, three of which are predominantly imported from wild capture supply chains (Squid – *Loligo* spp., Squid – Shortfin squid, Scallops – mainly King scallops *Pecten maximus*) and two from aquaculture supply chains (Mussels – *Mytilus* spp, and *Perna* spp.). In 2019, around 59,000 tonnes of these molluscs were imported or produced in the UK. This accounted for 5.5% of overall 2019 imports of all resources investigated in this report.

Mytilus mussels contribute the largest share to UK supply in terms of imports with just over 4,000 tonnes imported mainly from four countries in 2019, however an additional 14,300 tonnes was supplied by the UK industry. Two countries in the *Perna* spp. supply chain – the Republic of Ireland and the Netherlands – are assumed to be intermediary (processing) countries, with the majority of the resource arriving from New Zealand (511 tonnes in 2019) (Figure 78).

Scallops are another important component of UK mollusc production, which greatly outweighs imports, with around 28,000 tonnes landed in the UK in 2019 and just over 1,100 tonnes imported.

Squid accounted for 6% (approximately 3,200 tonnes) of analysed mollusc imports in 2019, with a further 3,200 tonnes landed by the UK fleet into the UK[151].



[151] *A further 3,200 tonnes were landed outside the UK by the UK fleet*

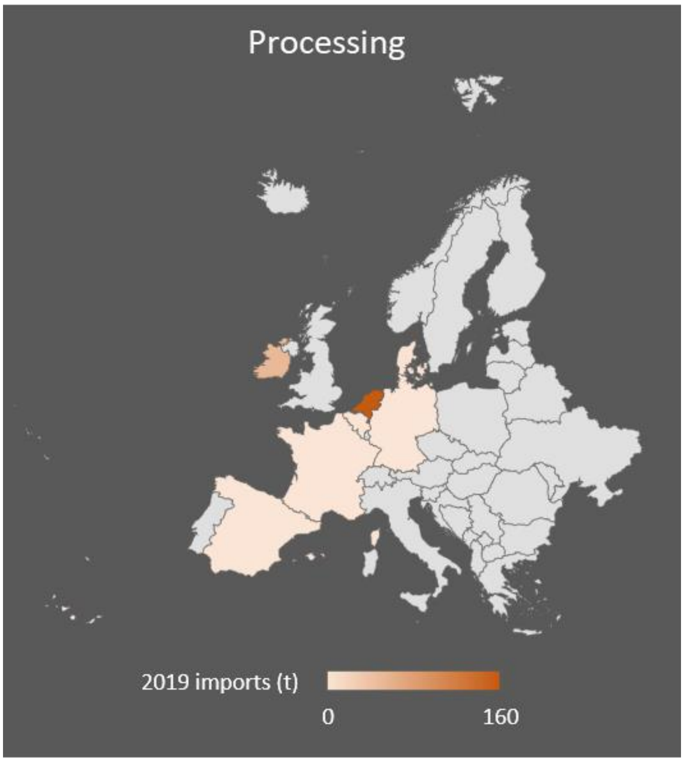


Figure 78: Maps showing source countries for mollusc seafood commodities (Scallops, Mussels (*Mytilus* spp. and *Perna* spp.), *Loligo*, Shortfin squid) consumed in the UK. Large (upper) map shows those countries which are primarily considered to be producers, whereas the lower map shows intermediary countries in the supply chains where mollusc products are largely processed rather than produced. Total (all mollusc resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

In 2020, based on value of retail sales, squid (calamari), scallops and mussels represented the 14th, 17th and 21st most popular category of frozen seafood purchased in the UK retail sector, respectively. A 120% and 356% increase in sales by volume (tonnes) of frozen squid and mussels, respectively, was observed between 2010 and 2020, whereas there was a 29% drop in volume of frozen scallops sold[152]. In terms of chilled seafood, it is only mussels that feature in the performance tables, although again a decreasing trend was seen over the last decade – 34% decline in multiple retail sales of chilled mussels[153]. For both frozen and chilled seafood statistics, the 'mixed seafood' category is however also likely to include most of the mollusc resources examined in this report.

Of the assessed mollusc resources that supply the UK market, shortfin squid and *Loligo* spp. had the highest overall supply chain footprint – a notable difference to the average footprint for mussels. Of all countries associated with the supply chains, China, Taiwan, Thailand and India had the highest footprints (24-25), whereas the Netherlands' and Denmark's mussel production received a very low score (footprint of 11) (Table 36 and Table 37).

[152] https://www.seafish.org/document/?id=d4a7cc42-0aec-42f0-91fd-f510a860ce46

[153] https://www.seafish.org/document/?id=19b3d61f-04ef-481e-affb-2abcda67dff0

Table 36: (a) Average footprint scores for each producing country in the UK's mollusc supply chains and (b) for each mollusc resource sub-category.

Producing country	Average Footprint
Netherlands	11.0
Denmark	11.0
New Zealand	12.0
Chile	15.0
Canada	16.0
France	16.0
United Kingdom	17.0
United States	19.0
Argentina	19.0
Spain	22.0
Indonesia	23.0
India	24.0
Thailand	24.0
China	25.0
Taiwan	25.0

Resource	Average Footprint
Mussels (*Perna* spp.)	12.0
Mussels (*Mytilus* spp.)	12.4
Scallops	17.8
Loligo	22.2
Shortfin squid	22.8

Table 37: Supply chain information, Risk assessment and Footprint for Molluscs commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Molluscs	Squid	Loligo	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	2	2	1	2	3	2	1	2	19	22.2	18.3
			43%	Asia and Oceania	Indian Ocean	India	Prod	Cap	2	2	2	3	2	3	3	2	2	3	24		
				North America	NW Atlantic	United States	Prod	Cap	2	3	3	2	1	2	2	2	1	3	21		
				Asia and Oceania	W Pacific, Indian	Thailand	Prod	Cap	2	2	2	2	3	3	3	2	2	3	24		
				Asia and Oceania	Indian Ocean/W	Indonesia	Prod	Cap	2	2	2	2	2	3	2	2	3	3	23		
				Asia and Oceania	W Pacific	Vietnam	Prod	Cap								3	2	3			
				European Union	N Atlantic	Spain	Prod	Cap								2	2	2			
				Sub-Saharan Africa	Indian Ocean/SE	South Africa	Prod	Cap								2	2	2			
				European Union	NE Atlantic	Netherlands	Prod	Cap								2	1	1			
				European Union	NE Atlantic	France	Prod	Cap								2	1	2			
				European Union	NE Atlantic	Republic of Irelanc	Prod	Cap								1	1	1			
		Shortfin squid	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	2	2	2	1	2	3	2	1	2	19	22.8	
			52%	Asia and Oceania	NW Pacific	China	Prod	Cap	2	2	2	2	3	3	3	3	2	3	25		
				Asia and Oceania	W Pacific	Taiwan	Prod	Cap	2	2	2	2	3	3	3	3	2	3	25		
				European Union	N Atlantic	Spain	Prod	Cap	2	2	2	2	3	2	3	2	2	2	22		
	Scallops	Scallops	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	3	2	1	1	2	2	2	1	2	18	17.8	
			100%	Latin America and Caribbear	S Atlantic	Argentina	Prod	Cap	2	3	2	1	1	1	2	2	3	2	19		
				North America	NW Atlantic	United States	Prod	Cap	1	3	2	2	1	1	1	2	1	3	17		
				European Union	NE Atlantic	France	Prod	Cap	2	3	2	1	1	2	3	2	1	2	19		
				North America	NW Atlantic	Canada	Prod	Cap	2	3	2	2	1	1	1	1	1	2	16		
				European Union		Netherlands	Process									2	1	1			
	Mussels	Mussels (Perna spp.)	15%	Asia and Oceania	SW Pacific	New Zealand	Prod	Aquac	1	1	1	1	1	1	2	1	1	2	12	12.0	
				European Union		Republic of Irelanc	Process									1	1	1			
				European Union		Netherlands	Process									1	1	1			
		Mussels (Mytilus spp.)	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Aquac	1	1	1	1	1	1	2	1	1	2	12	12.4	
			85%	Latin America and Caribbear	SE Pacific	Chile	Prod	Aquac	1	1	1	2	1	2	2	1	1	3	15		
				European Union	NE Atlantic	Denmark	Prod	Aquac	1	1	1	1	1	1	2	1	1	1	11		
				European Union	NE Atlantic	Netherlands	Prod	Aquac	1	1	1	1	1	1	2	1	1	1	11		
				European Union	NE Atlantic	France	Prod	Aquac	1	1	1	1	1	2	2	1	1	2	13		

9.2 Seafood resource: Scallops

9.2.1 Supply chain overview

Five countries are responsible for around 90% of the UK's imports of scallops (queen scallops *Aequipecten opercularis*, king scallops *Pecten maximus* and others - *Pecten* spp., *Chlamys* spp., *Placopecten* spp.): Argentina (prior to 2017), United States, France, Canada and the Netherlands. The average annual 'all scallop' imports for the period 2015-2019 was 1,831 tonnes, with average annual imports for each supply chain ranging from 82 tonnes (Netherlands) to 495 tonnes (Argentina). However, the former is considered to be an intermediary (processing / trade) country and the latter's imports are skewed by the relatively high imports in 2016 alone (Figure 79).

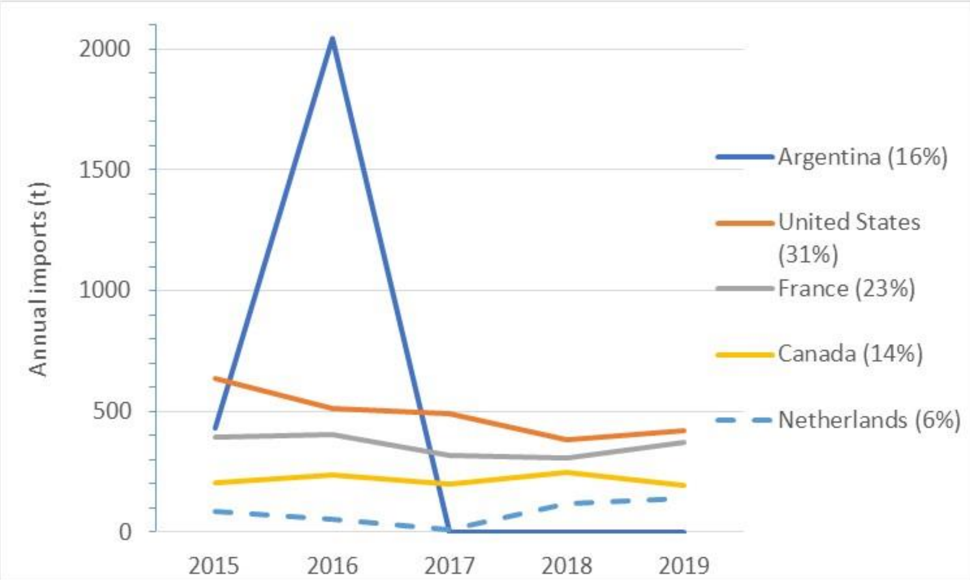


Figure 79: Volume (tonnes, t) of scallops imported by the UK annually between 2015 and 2019. The Netherlands is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Based on HMRC trade data, king scallops only represented around 3% on average of the UK's total scallop imports between 2015 and 2019. In contrast, the UK's domestic wild capture supply of king scallops was around 25,610 tonnes in 2019, with an additional 4 tonnes recorded as aquaculture production. The UK's harvest of king scallops was worth over £47 million in 2019, making it the fourth most valuable fishery, with 38% of those landings arising from the English Channel and just 3% recorded as collected by commercial hand diving. The scallop stocks are internationally exploited, primarily by the UK and France, with additional activity from the Republic of Ireland, the Netherlands and Belgium, so the total removals are significantly higher than these figures.

The UK queen scallop supply chain is comprised of imports and wild capture from UK waters, where UK production (3,569 tonnes in 2019) is again higher than that of imports (1,128 tonnes). Most UK queen scallop fisheries are active in the Irish Sea, in and around the waters of the Isle of Man, Welsh waters of Liverpool Bay and Cardigan Bay, the Clyde, off Shetland and the north Irish Sea. No UK queen scallop fisheries currently have third-party certification or are part of a FIP. The Isle of Man fishery's MSC certification was suspended in 2014 after a stock assessment report was published indicating that the biomass of queen scallops in the area was below the level at which recruitment was likely to be impaired. The Isle of Man Government's Department of Environment Food and Agriculture (DEFA) has chosen not to re-enter the Isle of Man queen Scallop trawl fishery into MSC assessment for a second term[154].

With around 6,800 tonnes of exports recorded in 2019, this leads to an estimated UK consumption of scallops (mainly king scallops) in 2019 of 22,500 tonnes which was almost entirely (95%) supplied by the UK's own production (Figure 80).

There are two main scallop fisheries within Argentinean waters – a small inshore fishery for the Tehuelche scallop, *Aequipecten tehuelchus* and the industrial northern Patagonia fishery for the Patagonian scallop, *Zygochlamys patagonica*. Catches in the order of 50,000 tonnes per year now rank the Patagonian fishery, which this assessment is based on, among the most important scallop fisheries in the world. Approximately 50% of the frozen-at-sea scallops are sold to European markets; an additional 40% are sold into the United States. Most of the remainder are sold to Canadian markets[155].

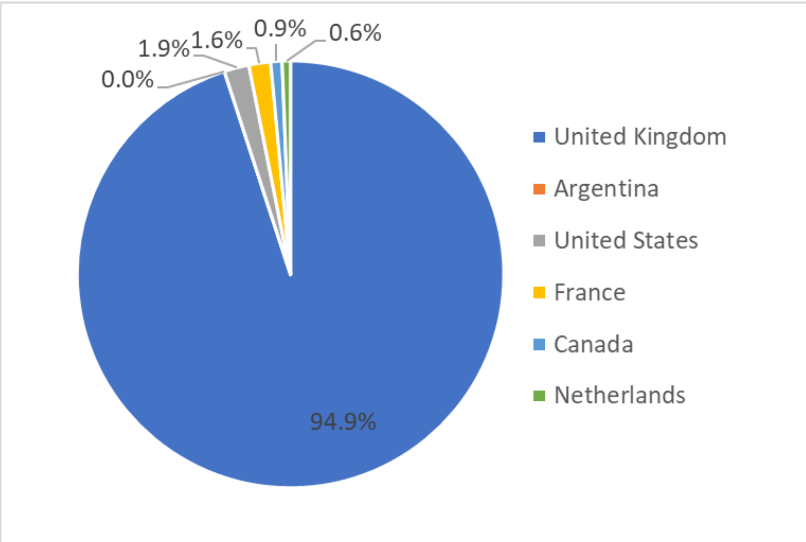


Figure 80: Percentage (%) contribution by the UK and the main countries from which scallops are imported, to the UK's estimated lobster consumption in 2019.

The primary Atlantic sea scallop (*Placopecten magellanicus*) fishery in the United States operates along the Atlantic coast from the Mid-Atlantic to the United States / Canada border. The United States sea scallop fishery is extremely important to the economy of the United States and is the largest wild scallop fishery in the world[156].

Canada's offshore Atlantic sea scallop fisheries are conducted on Georges Bank, Browns and German Banks, the Eastern Scotian Shelf and St. Pierre Bank. The offshore scallop fishery is one of the key commercial fisheries in the Maritimes Region, representing approximately 75% of all scallop landed value, and about 10% of the total landed value from all commercial fisheries in the region. The UK is one of the three most important European

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[154] https://fisheries.msc.org/en/fisheries/isle-of-man-queen-scallop-trawl/about/

[155] Gaspar Soria, J.M. (Lobo) Orensanz, Enrique M. Morsán, Ana M. Parma, Ricardo O. Amoroso, Chapter 25 - Scallops Biology, Fisheries, and management in Argentina, Editor(s): Sandra E. Shumway, G. Jay Parsons, Developments in Aquaculture and Fisheries Science, Elsevier, Volume 40, 2016, Pages 1019-1046. https://www.sciencedirect.com/science/article/pii/B9780444627100000250

[156] https://www.fisheries.noaa.gov/species/atlantic-sea-scallop

export markets for Canadian scallops, with most product exported in frozen, dried, salted or preserved in brine form[157].

French queen scallop fisheries are not as important or as well-developed as those for King scallops. The queen scallop fishery is sporadic and depends on good recruitment. The main ground is located in the Western Channel near the Channel Islands, but queen scallop is also sporadically caught in the Western part of the Bay of Brest and the Bay of Camaret[158].

9.2.2 Risk assessment and footprint summary

Supply chain footprints present little variability, with a range between 16 and 19, with the lowest footprints associated with the North American fisheries (Figure 81). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 38 below, with full details available in Appendix 1.

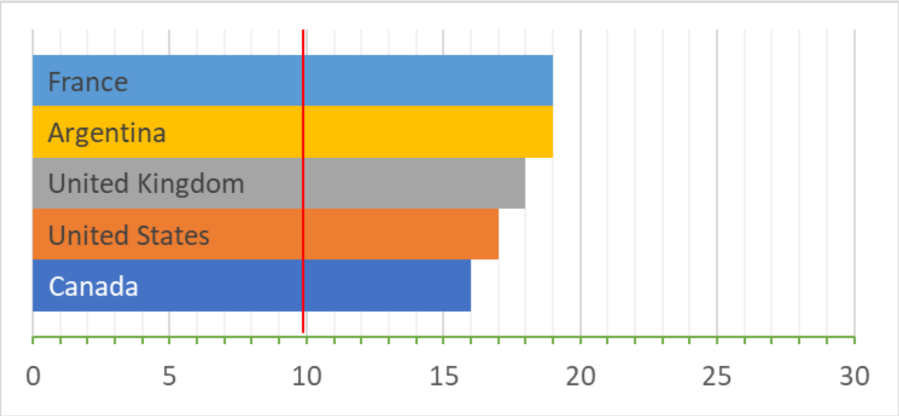

Figure 81: Total footprint for each of the UK's main scallop supply chains (available score range: 10 – 30), excluding processing / trading countries.

[157] https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/scallop-petoncle/2018/index-eng.html#toc1

[158] *Peter F. Duncan, Andrew R. Brand, Øivind Strand, Eric Foucher (2016), Chapter 19 - The European Scallop Fisheries for Pecten maximus, Aequipecten opercularis, Chlamys islandica, and Mimachlamys varia, Editor(s): Sandra E. Shumway, G. Jay Parsons, Developments in Aquaculture and Fisheries Science, Elsevier, Volume 40, 2016, Pages 781-858*

Table 38: Risk assessment summary for main supply chains for scallops consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Argentina	United States	France	Canada
Direct impact on resource (Env_1)	Variable stock status' and data limitations	Indications of potential decline in spawning stock biomass and risk of recruitment overfishing	Biomass and exploitation rate considered to be at sustainable levels	Variable stock status' and data limitations	
Ecosystem impact (Env_2)	Scallop dredging associated with high bycatch and damage to the seafloor (queen scallop dredges may be less damaging but risk remains)	Risk of habitat damage and bycatch through use of otter trawls	Scallop dredging associated with high bycatch and damage to the seafloor		
Climate change impact (Env_3)	Mixture of gear types / evidence and potential impact on blue carbon habitats				
ETP impact (Env_4)	ETP impact considered low		Incidental bycatch of Loggerhead sea turtles recorded	ETP impact considered low	Species listed as Endangered, Threatened or Special Concern by Committee on the Status of Endangered Wildlife in Canada have been caught by the fishery – impact may be low though
Social concerns (Social_1)	No known social concerns				

<table>
<tr><td>Management effectiveness (Mgt_1)</td><td>Mixture of management measures, improvements required</td><td colspan="2">Management of the fishery is considered largely effective</td><td>Mixture of management measures, improvements required</td><td>Extensively managed and regulated</td></tr>
<tr><td>Sustainability certification progress (Mgt_2)</td><td>Partially MSC certified / participating in FIPs</td><td>MSC certified, with conditions</td><td>MSC certified</td><td>No third-party certification or FIP</td><td>MSC certified</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td colspan="4">External, country level indicator</td><td>External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td>External, country level indicator</td><td>External, country level indicator</td><td colspan="3">External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td></tr>
</table>

9.3 Seafood resource: Mussels - *Mytilus* spp. and *Perna* spp.

9.3.1 Supply chain overview

According to Seafish[159], mussels represented 4% by volume (4000 tonnes) of the most popular farmed seafood in UK multiple retail in 2019, with a sales value of over £23 million, although this is less than the previous year (-12% by volume and -14.5% by value) and previous decade (-3% by volume and -13% by value).

There are three species in what is known as the blue mussel complex (*Mytilus edulis, Mytilus galloprovincialis* and *Mytilus trossulus*) and they show varying levels of hybridisation wherever they occur within overlapping geographical areas[160]. The UK for example farms *M. edulis, M. galloprovincialis* and their naturally occurring hybrids. Blue mussels have been eaten in Europe since 6,000 B.C. and are a staple of the European aquaculture scene. Production is found throughout Northern Europe with a variety of different methods employed. This includes longline or raft culture (hanging ropes upon which the mussels grow), bouchot culture (stakes placed in the seabed which uncover with the tides) and relaying or bottom culture (simply moving spat to specific areas of the seabed for future dredging when at market size).

Mussel production in Europe is divided between bottom culture and rope grown; northern countries, especially the Netherlands, concentrate on the former, whilst Spain and Italy the latter. Europe, including the UK, also imports significant quantities of farmed Chilean mussels. *Mytilus* spp. represented 85% on average of the UK's mussel imports for the period 2015-2019.

Chile farms a slightly different native species of mussel (*Mytilus chilensis*) commonly known as the Chilean mussel. This comprises 98% of the total production in the country. The main production system is longline. With the exception of 2019, Chile was the top source country for the UK's import of *Mytilus* spp. mussels (Figure 82).

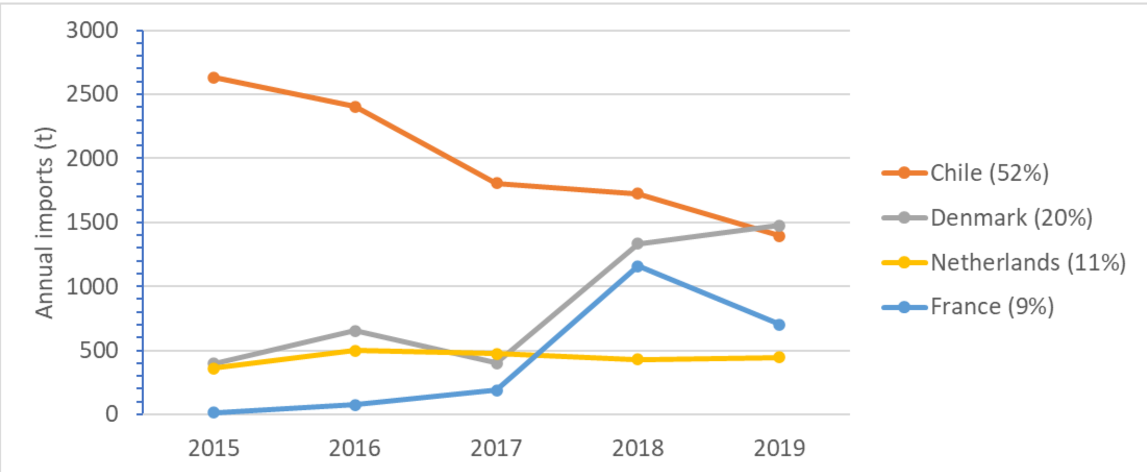

Figure 82: Volume (tonnes, t) of mussels (*Mytilus* spp.) imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

[159] https://www.seafish.org/document/?id=11052a6f-6c8e-423c-8d8c-1c4fa696a68e

[160] https://www.seafish.org/responsible-sourcing/aquaculture-farming-seafood/species-farmed-in-aquaculture/aquaculture-profiles/mussels/sources-quantities-and-cultivation-methods/

Between 31% (in 2019) and 74% (in 2015) of the UK's *Mytilus* spp. imports arrived from Chile, with an average of 52% (1,992 tonnes). Denmark's average contribution was 20% of imports over the time period (equivalent of 852 tonnes), compared to 11% for the Netherlands (442 tonnes) and 9% for France (429 tonnes). Whereas imports from Chile have decreased, Denmark and France's supply to the UK was higher in the most recent years assessed (Figure 82).

However, the UK's domestic production of mussels was estimated to have contributed approximately 71% of the UK's estimated consumption of 15,481 tonnes in 2019 with around 14,350 tonnes produced (~99% were farmed) and 3,400 tonnes exported. In 2019, imports from Chile and Denmark each contributed in the region of 9% of the UK's *Mytilus* spp. consumption (Figure 83).

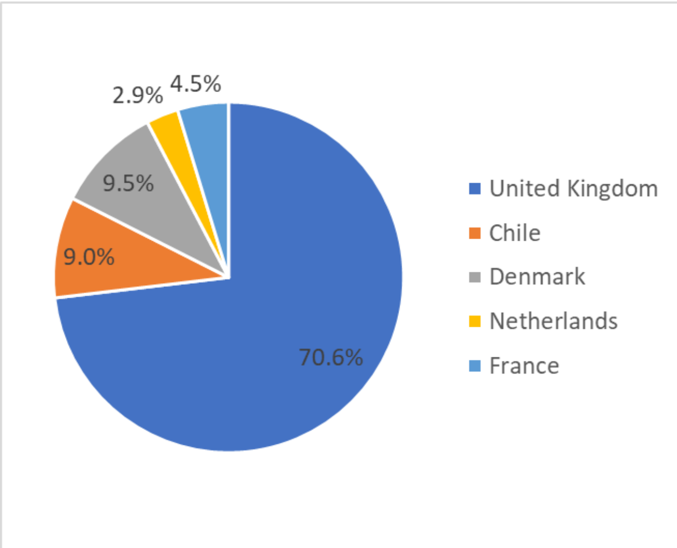

Figure 83: Percentage (%) contribution by the UK and the main countries from which mussels (*Mytilus* spp.) are imported, to the UK's estimated *Mytilus* spp. consumption in 2019.

Relatively small quantities of *Perna* spp., representing 15% of all mussel imports on average for the period 2015-2019, are shown as entering the UK from three sources, New Zealand, the Republic of Ireland and the Netherlands (Figure 84). Annual imports from New Zealand for the five-year period varies between an estimated 436 tonnes and 649 tonnes, with an average of 553 tonnes (78% of imports on average).

New Zealand produces the commercially important, green-lipped mussel (*Perna canaliculus*) and this is known to be sold in the UK both directly for human consumption and through a variety of processed, edible health products. The Republic of Ireland and the Netherlands do not produce any members of the *Perna* spp. of mussel and so it is assumed that these represent processing imports.

New Zealand represents 79% of the UK's estimated consumption of the resource in 2019 (645 tonnes), but when combined with *Mytilus* spp. this drops to around 3% of the UK's estimated total mussel consumption in 2019.

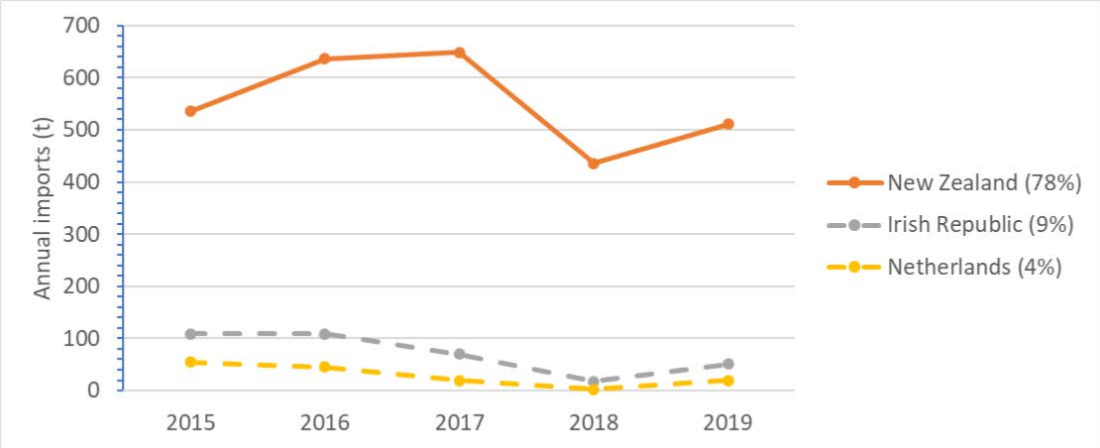

Figure 84: Volume (tonnes, t) of mussels (*Perna* spp.) imported by the UK annually between 2015 and 2019. The Republic of Ireland and the Netherlands are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

9.3.2 Risk assessment and footprint summary

The production of mussels is generally considered to be one of the most environmentally sustainable aquaculture practices that currently exist. They require no inputs and can help improve water quality through filtration from water column for food. This is reflected in the relatively low footprints of the UK's mussel production and supply chains (ranging from a very low score of 11 to 'low' score of 15) (Figure 85).

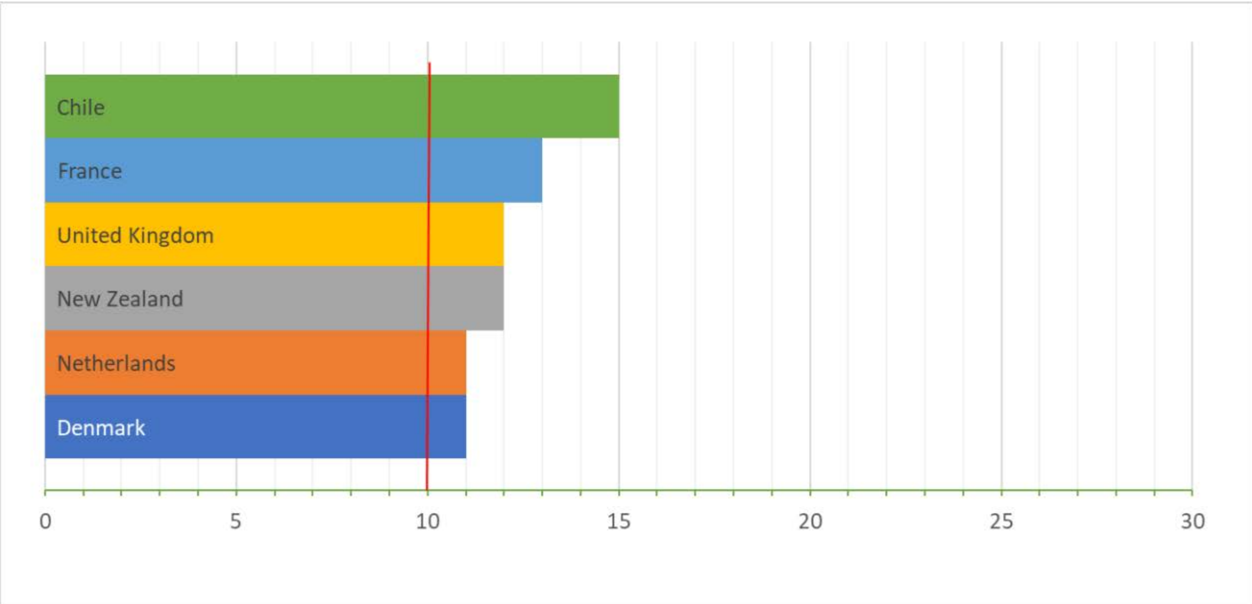

Figure 85: Total footprint for each of the UK's main mussel (*Mytilus* spp. and *Perna* spp.) supply chains (available score range: 10 – 30), excluding processing / trading countries.

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 39 below, with full details available in Appendix 1.

Table 39: Risk assessment summary for main supply chains for mussels (*Mytilus* spp. and *Perna* spp.) consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	New Zealand	United Kingdom	Chile	Denmark	Netherlands	France
Direct impact on resource (Env_1)	No evidence of negative interactions between farmed and wild mussel exists					
Ecosystem impact (Env_2)	Very limited environmental impacts (benefits may arise through removal of excess nutrients and phytoplankton)					
Climate change impact (Env_3)	Requires very little use of fossil fuels					
ETP impact (Env_4)	Interaction with ETP species are likely to be negligible / low risk		Potential interaction with ETP species – further information needed	Interaction with ETP species are likely to be negligible / low risk		
Social concerns (Social_1)	No specific social concerns					
Management effectiveness (Mgt_1)	Well-defined / developed management system		Management system lacking within the aquaculture space	Well-defined / developed management system		Management system is not well documented or understood
Sustainability certification progress (Mgt_2)	Partial third-party certification					
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator					
Rule of Law (Social_2)	External, country level indicator					
Labour Rights (Social_3)	External, country level indicator		External, country level indicator	External, country level indicator		External, country level indicator

9.4 Seafood resource: *Loligo* spp.

9.4.1 Supply chain overview

According to the HMRC trade data, ten countries are responsible for 90% of the UK's average annual imports (2015-2019) of *Loligo* spp. Those supply chains are: India (29%), US (16%), Thailand (16%), Indonesia (10%), Vietnam (4%), Spain (4%), South Africa (3%), The Netherlands (3%), France (2%) and the Republic of Ireland (2%) (Figure 86). However, the volume of imports associated with most of those countries is relatively low (e.g. <<100 tonnes). Therefore, the risk assessment is only undertaken for India, the United States, Thailand and Indonesia which collectively contribute just over 70% of imports on average and just over 56% of the UK's estimated consumption in 2019 of 1,926 tonnes (the UK's production accounted for 24%) and are typically associated with >200 tonnes of annual imports to the UK (which is still relatively low compared to the UK's >6,300 tonnes of landings in 2019, although around half of these catches were landed outside of the UK) (Figure 87).

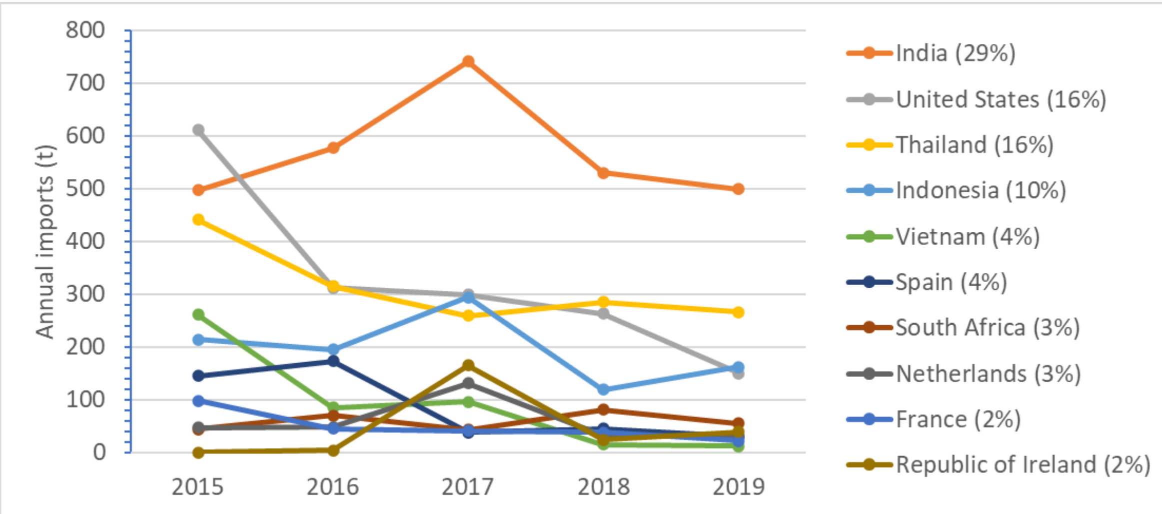

Figure 86: Volume (tonnes, t) of *Loligo* spp. imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Of around 30 cephalopod species in UK waters, three have significant commercial value as fishery target and bycatch species, namely common cuttlefish *Sepia officinalis* and two loliginid (longfin) squids, *Loligo forbesii* and *L. vulgaris*[161]. Longfin squid are typically caught by demersal trawlers and to a lesser extent demersal seines. There are also some small-scale handlining (jigging) fisheries in the south-west[162].

[161] http://randd.defra.gov.uk/Document.aspx?Document=13827_ME5311CephalopodsFinalReport.pdf

[162] https://www.cornwallgoodseafoodguide.org.uk/fish-guide/squid.php

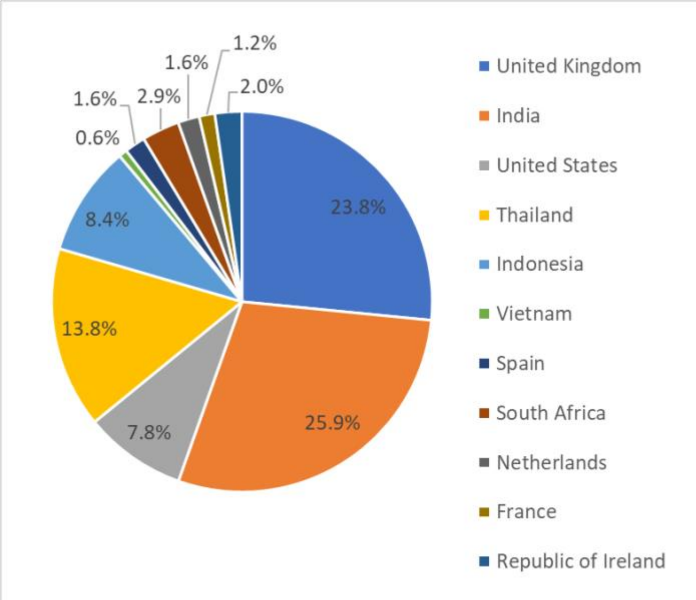

Figure 87: Percentage (%) contribution by the UK and the main countries from which *Loligo* spp. are imported, to the UK's estimated *Loligo* spp. consumption in 2019.

This assessment assumes that the Indian supply chain is dominated by the Indian squid (*Loligo duvauceli*) fishery along the west coast of India. *L. duvaucelii* is the most abundant squid species in Indian waters and the most common loliginid squid in Indo-Pacific waters. It is exploited by artisanal and commercial fisheries in India, Thailand, the Andaman Sea, Gulf of Aden, the Philippines, Malaysia, the Java Sea and appears in the commercial Hong Kong fishery, though India is likely to catch the largest proportion of Indian squid in the Indo-Pacific[163]. The assessment of Thailand's supply chain is also based on its wild capture of Indian squid, largely in the Indo- and West Pacific, as well as *Loligo chinensis* (Mitre squid).

Concerningly, little information is available for the Indonesian *Loligo chinensis* (Mitre squid) fishery as a whole, even though the UK has been the main export market since 2011[164].

Longfin squid (*Loligo pealeii*) are found from Newfoundland, Canada to the Gulf of Venezuela in the Caribbean Sea. Along the Atlantic Coast of the United States, they are most abundant and occur in commercial quantities from Southern Georges Bank to Cape Hatteras, North Carolina. The majority of landings come from Rhode Island, New York, New Jersey, and Massachusetts[165,166].

9.4.2 Risk assessment and Footprint Summary

The supply chain footprints associated with the UK's consumption of *Loligo* range from a 'medium' 19 for the UK and a 'high' 24 for Thailand and Indonesia (Figure 88). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 40 below, with full details available in Appendix 1.

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163 https://www.mcsuk.org/goodfishguide/species/indian-squid/

164 https://www.msc.org/what-we-are-doing/our-collective-impact/ocean-stewardship-fund/impact-projects/minimising-fishing-impacts-on-indonesian-squid-stocks-2021

165 https://fishchoice.com/buying-guide/longfin-squid

166 https://www.fishwatch.gov/profiles/longfin-squid

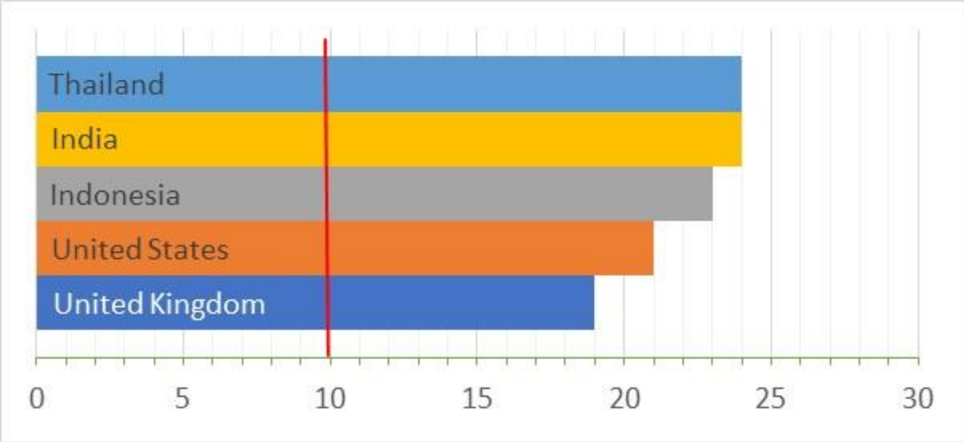

Figure 88: Total footprint for each of the UK's main Loligo supply chains (available score range: 10 – 30).

Table 40: Risk assessment summary for main supply chains for *Loligo* consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	India	United States	Thailand	Indonesia
Direct impact on resource (Env_1)	No stock assessments (*data limited*)		Biomass appears to fluctuate near or above target levels (*data limited*)	No stock assessments (*data limited*)	
Ecosystem impact (Env_2)	Small mesh demersal trawls and seines pose risk of habitat damage and bycatch (jigging considered low risk)	Mix of hook and line and otter trawl gear, although beach seines, drift gillnets, midwater trawls and seine nets also used. Risk of habitat damage and bycatch (except handlines).	Small mesh bottom trawls associated with habitat damage and high levels of bycatch	Demersal trawling poses risk of habitat damage and bycatch	Pole and line and lift net gear in use – but very little information available (*data limited*)
Climate change impact (Env_3)	Mixture of fishing methods		Dominance of bottom trawling	Mixture of fishing methods	
ETP impact (Env_4)	Threat to rare species of sharks and skates	Threat to turtles and marine mammals	Known interactions with protected, threatened and endangered species (cetaceans and turtles), although management & monitoring reduces risk	Turtle bycatch is an anticipated risk but *data limited*	Limited monitoring and information
Social concerns (Social_1)	No known social concerns	Medium risk of modern slavery in fishing sector	No known social concerns	High risk of modern slavery in fishing sector	Medium risk of modern slavery and forced labour in fishing sector
Management effectiveness (Mgt_1)	Limited management or monitoring	Lack of assessments and high exploitation rates	Largely effective but some improvements needed	Open access nature of the fishery, lack of monitoring, poor enforcement and limited management of issues such as bycatch	Limited management in place

Sustainability certification progress (Mgt_2)	No evidence of third-party certification progress		MSC certified, with conditions	No evidence of third-party certification progress	North Sumatra handline fishery has recently become involved in a FIP
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator				
Rule of Law (Social_2)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator			

9.5 Seafood resource: Shortfin squid

9.5.1 Supply chain overview

China is responsible for as much as 70% of the global shortfin squid catch, and its vessels sail as far as West Africa and Latin America. China is a key player in the Argentine shortfin squid fishery[167,168]. Recently, over one hundred Chinese flagged fishing vessels have been identified as active in the north-west Indian Ocean squid fishery[169]. Specific information on many of the stocks and fisheries is limited. Our assessment is mainly based on China's fishery for Argentine shortfin squid (*Ilex argentinus*). Furthermore, China is the source of the highest proportion of shortfin squid into the UK, and on average accounted for 74% of the resource's imports to the UK between 2015 – 2019 (average volume of 1,843 tonnes, with 1,242 tonnes imported from China in 2019). Although, this volume seems to have dropped from a peak in 2015 (Figure 89).

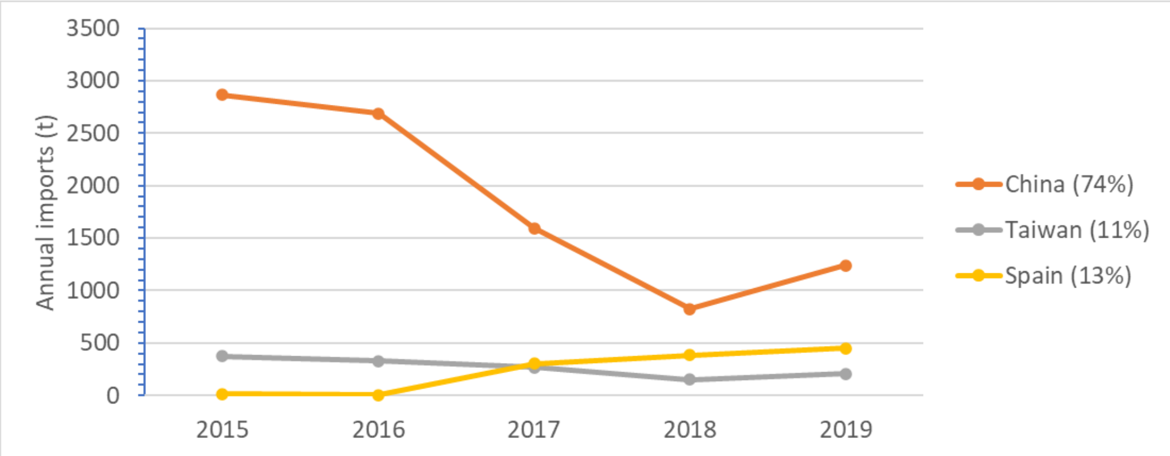

Figure 89: Volume (tonnes, t) of shortfin squid imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Taiwan and Spain are other key players in the Argentine shortfin squid fishery and therefore this assessment is largely based on that fishery, although both countries are likely to catch other shortfin squid species in other areas. Both countries contributed around 12% of the UK's annual imports of shortfin squid for the period 2015-2019, although Spain's contribution has increased over time whereas Taiwan's shows the opposite trend (Figure 89).

Three ommastrephid (shortfin) squids (*Todaropsis eblanae, Illex coindetii, Todarodes sagittatus*) are typically landed as bycatch by the UK fleet. The relatively low commercial value of ommastrephids and octopods in the UK means that landings may not accurately reflect catches[170]. In 2019, around 176 tonnes was landed by the UK fleet. The UK's estimated consumption of shortfin squid in 2019 was therefore 1,941 tonnes, meaning that China was responsible for around 64% of that consumption, with a further 23% arriving from Spain (Figure 90).

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[167] https://seafood.ocean.org/wp-content/uploads/2017/10/MBA_Seafood-Watch_Argentine-squid_Report.pdf

[168] https://phys.org/news/2021-06-china-squid-fishing-pacific-atlantic.html

[169] https://stopillegalfishing.com/news-articles/china-flagged-vessels-target-unregulated-north-west-indian-ocean-squid-fishery/

[170] http://randd.defra.gov.uk/Document.aspx?Document=13827_ME5311CephalopodsFinalReport.pdf

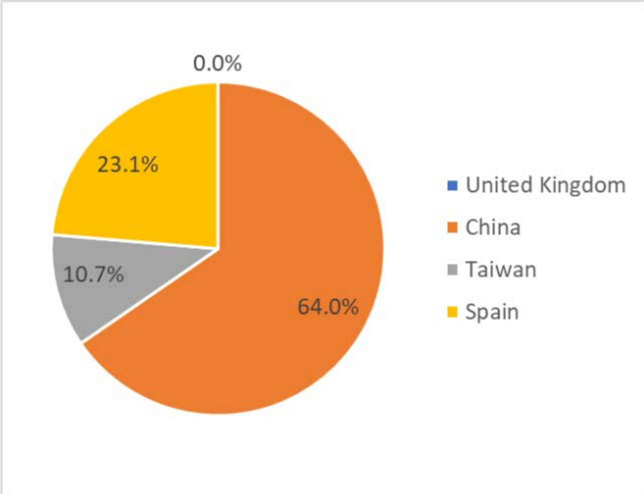

Figure 90: Percentage (%) contribution by the UK and the main countries from which shortfin squid are imported, to the UK's estimated shortfin squid consumption in 2019.

9.5.2 Risk assessment and footprint summary

The supply chain footprint for the UK is the lowest ('medium' footprint score of 19) when comparing all countries supplying the UK shortfin squid supply chain, whereas China and Taiwan rate the highest (both have a 'high' footprint score of 25**)** (Figure 91). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 41 below, with full details available in Appendix 1.

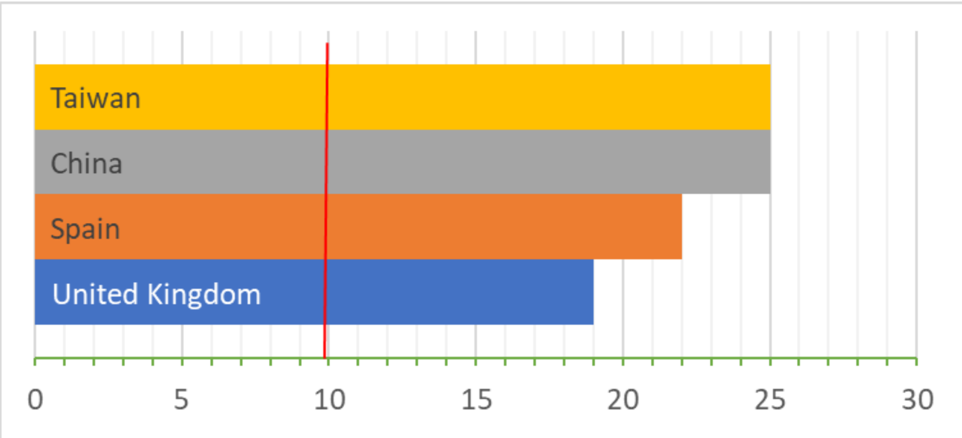

Figure 91: Total footprint for each of the UK's main shortfin squid supply chains (available score range: 10 – 30).

Table 41: Risk assessment summary for main supply chains for shortfin squid consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

<table>
<tr><th>Risk Indicator</th><th>United Kingdom</th><th>China</th><th>Taiwan</th><th>Spain</th></tr>
<tr><td>Direct impact on resource (Env_1)</td><td>No assessment of stock status (data limited) but environmental variation may be more significant than fishing pressure</td><td colspan="3">Stock status variable and may be at low level currently due to overfishing (data limited)</td></tr>
<tr><td>Ecosystem impact (Env_2)</td><td>Bycatch of bottom trawls which pose risk to the ecosystem through habitat damage and bycatch of target and non-target species</td><td colspan="3">Jigs and mid-water trawls avoid habitat damage, but large scale of removal of squid can cause ecosystem shifts</td></tr>
<tr><td>Climate change impact (Env_3)</td><td>Bycatch of trawl fisheries which generally have medium carbon footprint risk</td><td colspan="3">Mixed evidence – but more precautionary medium risk retained</td></tr>
<tr><td>ETP impact (Env_4)</td><td>Bycatch of trawl fisheries which generally have medium to high risk of ETP impact</td><td colspan="3">Likely that seabirds, some of which will be ETP species, are at risk</td></tr>
<tr><td>Social concerns (Social_1)</td><td>No known social concerns</td><td colspan="3">High risk of modern slavery in fishing industry</td></tr>
<tr><td>Management effectiveness (Mgt_1)</td><td>Limited management or monitoring of squid bycatches</td><td>Heavily subsidised and known for illegal fishing</td><td>Fleet operates extensively on the high seas and is known for illegal fishing activities</td><td>Significant challenges facing the effective management of high seas fishing</td></tr>
<tr><td>Sustainability certification progress (Mgt_2)</td><td colspan="4">No evidence of third-party certification progress</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td>External, country level indicator</td><td colspan="3">External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td></tr>
</table>

10. Seafood commodity – Small pelagics

10.1 Summary of small pelagics supply chains

In 2019, over 267,000 tonnes (21% of the seafood assessed in this report) of small pelagic resources, including mackerel (*Scomber scombrus, Scomber japonicus, Scomber australasicus*), herring (*Clupea harengus, Clupea pallasii*), sardines (European pilchard, *Sardina pilchardus* and 'other' sardine species, Sardinops spp., Sardinella spp., undefined) were imported to or produced by the UK. The majority of those imports or landings were comprised of mackerel (48%), while sardine constituted 33% and herring the lowest at 18% on average. Small pelagics consumed in the UK are derived from wild capture production.

Figure 92 shows the geographical distribution of small pelagic source countries for the UK supply chain. Northern Europe, and in particular, the UK, is a large producer of small pelagic species. However, Morocco, China and Thailand also contribute, but in comparatively small proportions. Latvia is the only country supplying small pelagics to the UK market which is thought to primarily be an intermediary country in the supply chain, i.e., a processor of the resource rather than a producer.

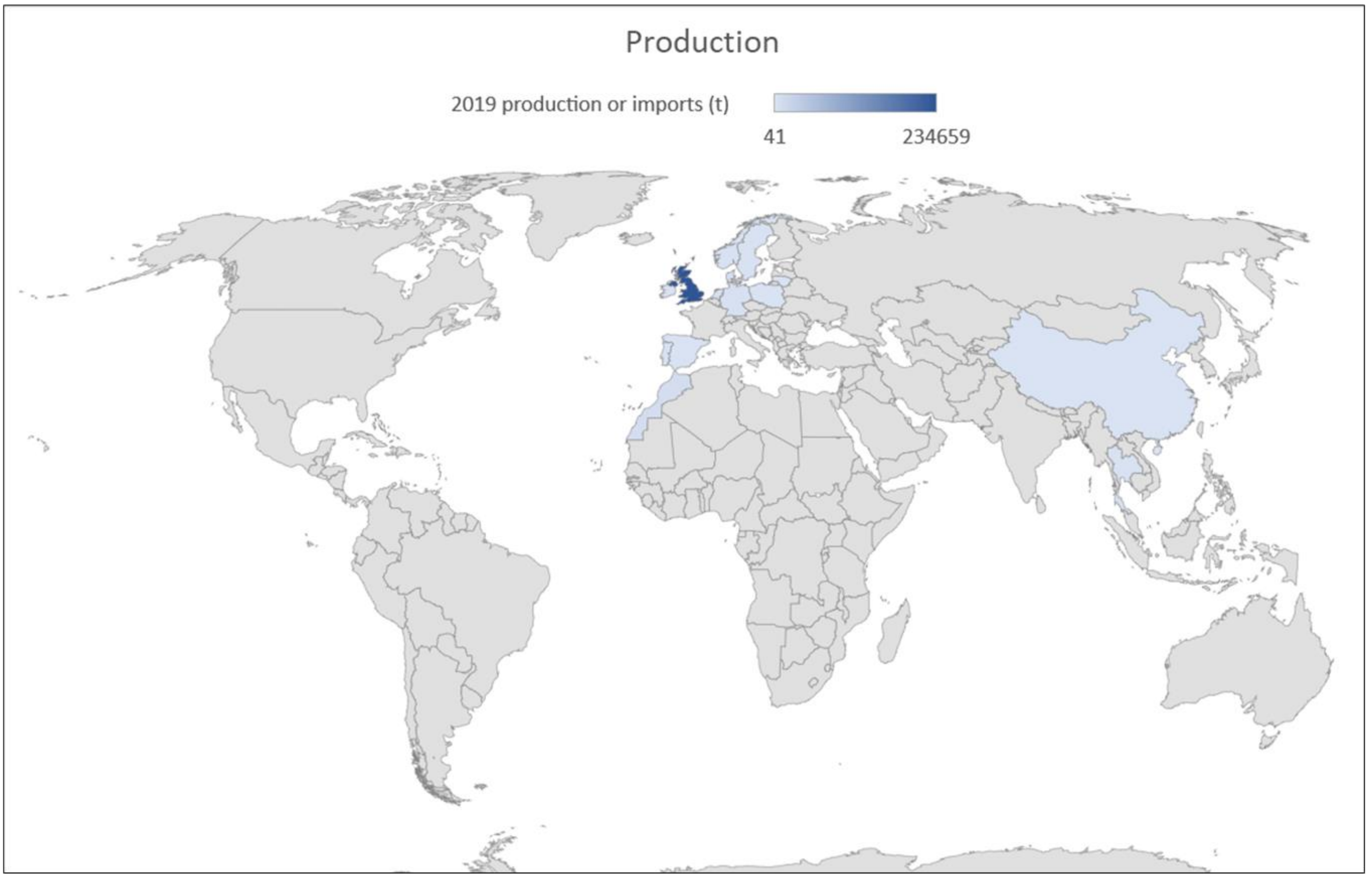

Figure 92: Map showing producing countries for small pelagic seafood commodities (Sardines, Herring and Mackerel) consumed in the UK. Latvia, considered to be a processing country in the UK supply chain for small pelagics, is not shown. Total (all small pelagic resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

Of those countries which produce small pelagics for the UK market, Sweden is considered to have the lowest supply chain footprint, while China and Thailand have the highest, with a notable difference between the two ends of the scale (Table 42). When considering individual resources as a whole, sardines had the highest footprint score whereas mackerel had the lowest, although the average is lower still (score of 13) without the Chinese supply chain (Table 43).

Table 42: (a) Average footprint scores for each producing country in the UK's small pelagics supply chains and (b) for each small pelagic resource sub-category.

Producing country	Average Footprint
Sweden	12.0
Denmark	13.0
Germany	13.3
Republic of Ireland	13.5
Netherlands	13.5
Norway	14.0
United Kingdom	14.7
Portugal	15.0
Morocco	16.0
Poland	16.0
Lithuania	16.0
Thailand	24.0
China	25.0

Resource	Average Footprint
Mackerel	14.4
Herring	14.6
Sardines (European pilchard, other)	17.0

Table 43: Supply chain information, Risk assessment and Footprint for Small pelagics commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Small pelagics	Mackerel	Mackerel	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	1	1	1	1	1	2	2	2	1	2	14	14.4	15.1
			100%	European Union	NE Atlantic	Denmark	Prod	Cap	1	1	1	1	1	2	2	1	1	1	12		
				European Union	NE Atlantic	Netherlands	Prod	Cap	1	1	1	1	1	2	2	2	1	1	13		
				European Union	NE Atlantic	Republic of Ireland	Prod	Cap	1	1	1	1	2	2	2	1	1	1	13		
				European Union	NE Atlantic	Germany	Prod	Cap	1	1	1	1	1	2	2	1	1	1	12		
				European Union		Latvia	Process									1	1	2			
				European Union	NE Atlantic	Sweden	Prod	Cap	1	1	1	1	1	2	2	1	1	1	12		
				European Union	N Atlantic	Portugal	Prod	Cap	1	1	1	1	1	2	2	2	1	2	14		
				Asia and Oceania	NW Pacific	China	Prod	Cap	3	2	1	2	3	3	3	3	2	3	25		
	Sardines	Sardines (European pilchard, other)	100%	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	1	1	1	1	2	2	2	1	2	15	17.0	
				Middle East and N Africa	N Atlantic	Morocco	Prod	Cap	1	1	1	1	2	2	2	2	2	2	16		
				Asia and Oceania	W Pacific, Indian	Thailand	Prod	Cap	2	2	2	2	3	3	3	2	2	3	24		
				European Union	N Atlantic	Portugal	Prod	Cap	2	1	1	1	1	2	3	2	1	2	16		
				European Union	N Atlantic	Germany	Prod	Cap	2	1	1	1	1	2	3	1	1	1	14		
	Herring	Herring	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	2	1	1	1	1	2	2	2	1	2	15	14.6	
			100%	European Union	NE Atlantic	Denmark	Prod	Cap	2	1	1	2	1	2	2	1	1	1	14		
				Western Europe exc EU	NE Atlantic	Norway	Prod	Cap	2	1	1	1	1	2	2	2	1	1	14		
				European Union	NE Atlantic	Germany	Prod	Cap	2	1	1	2	1	2	2	1	1	1	14		
				European Union	NE Atlantic	Poland	Prod	Cap	2	1	1	2	1	2	2	1	2	2	16		
				European Union	NE Atlantic	Netherlands	Prod	Cap	2	1	1	1	1	2	2	2	1	1	14		
				European Union	NE Atlantic	Republic of Ireland	Prod	Cap	2	1	1	1	2	2	2	1	1	1	14		
				European Union	NE Atlantic	Lithuania	Prod	Cap	2	1	1	2	1	2	2	2	1	2	16		

10.2 Seafood resource: Herring

10.2.1 Supply chain overview

In 2019, 4,565 tonnes of herring was imported into the UK from the seven countries collectively responsible for around 90% of the UK's annual imports for the period 2015-2019. On average for the period 2015-2019, Denmark contributed the largest proportion of imports (21%), although in recent years (2018 and 2019), the volume of herring imported from Denmark dropped substantially. Instead, Norway contributed the highest proportion of UK imports in 2019 (Figure 93).

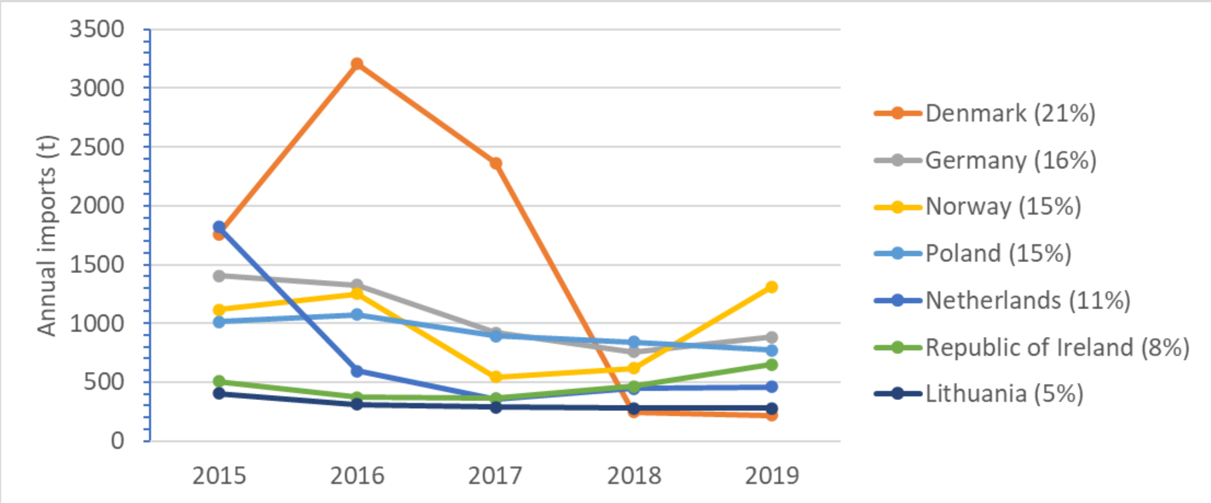

Figure 93: Volume (tonnes, t) of herring imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Imported volumes are small relative to UK landings however, which amounted to 75,459 tonnes in 2019 – although only 34,759 tonnes of these catches were landed in the UK, which reduces the estimated consumption figure significantly. Based on exports of around 34,000 tonnes, estimated consumption of herring in the UK in 2019 was around 6,000 tonnes. Just 11% of that consumption is provided by the UK fleet (because such a high proportion of catches are landed outside the UK). Instead, Norway contributed around 22% of the UK consumption in 2019, with the remaining consumed herring arriving through the other North Atlantic supply chains in relatively even proportions (Figure 94).

Based on data from HMRC, herring is largely prepared or preserved, whole or in pieces (tinned), but fresh or chilled and smoked are also popular forms of the product.

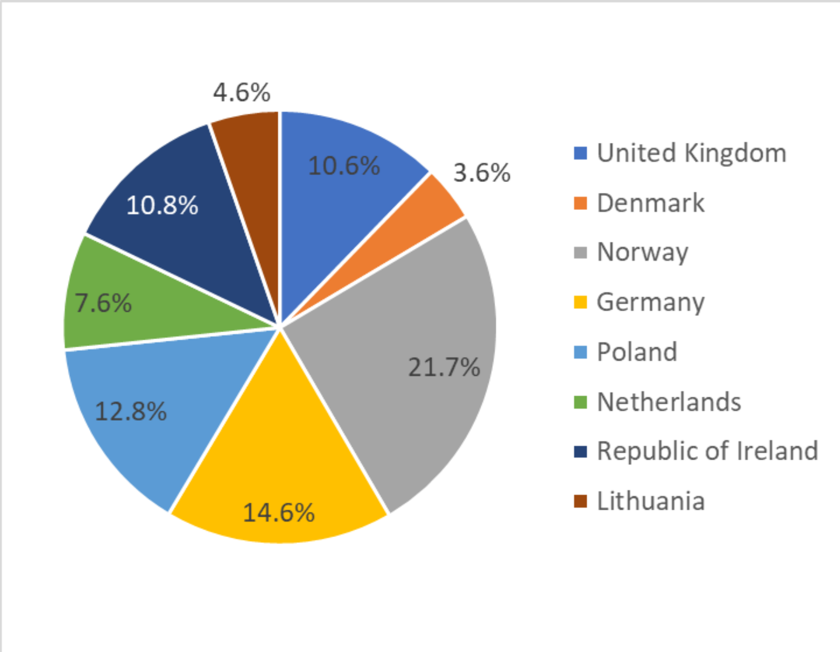

Figure 94: Percentage (%) contribution by the UK and the main countries from which herring is imported, to the UK's estimated swordfish consumption in 2019.

10.2.2 Risk assessment and footprint summary

There is little variation across the herring supply chains in terms of footprint, with scores ranging from a low 14 for 5 of the countries to a moderately-low 16 for Poland and Lithuania (Figure 95).

A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 44 below, with full details available in Appendix 1.

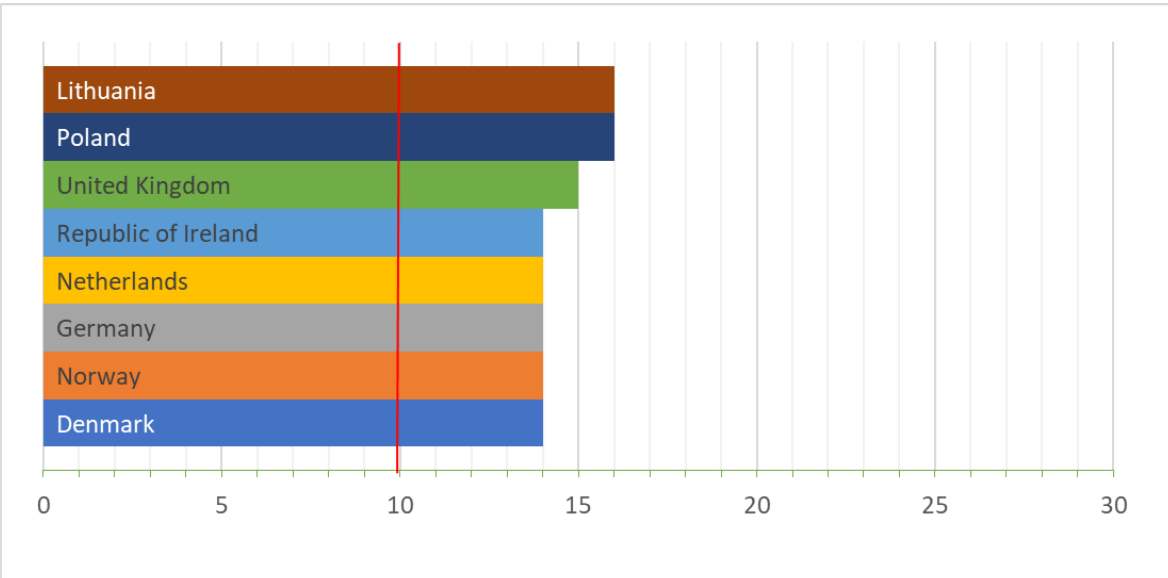

Figure 95: Total footprint for each of the UK’s main herring supply chains (available score range: 10 – 30).

Table 44: Risk assessment summary for main supply chains for herring consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Denmark	Norway	Germany	Poland	Netherlands	Republic of Ireland	Lithuania
Direct impact on resource (Env_1)	Status of herring populations is highly variable, with different nations fishing different populations in variable proportions							
Ecosystem impact (Env_2)	Pelagic trawls and seines have little contact with bottom habitats and are selective							
Climate change impact (Env_3)	Pelagic trawls for small species are associated with a relatively low carbon footprint							
ETP impact (Env_4)	Risk of ETP mortality is considered to be very low	Static nets in the Central Baltic pose a significant threat to the Critically Endangered Baltic harbour porpoise population	Risk of ETP mortality is considered to be very low	Static nets in the Central Baltic pose a significant threat to the Critically Endangered Baltic harbour porpoise population		Risk of ETP mortality is considered to be very low		Static nets in the Central Baltic pose a significant threat to the Critically Endangered Baltic harbour porpoise population
Social concerns (Social_1)	No known concerns						Recent media article on human trafficking	No known concerns
Management effectiveness (Mgt_1)	Variable status of the stocks, and variable status of agreements over development and implementation of management measures							

<table>
<tr><td>Sustainability certification progress (Mgt_2)</td><td colspan="8">Partial MSC certification or FIP progress for all nations</td></tr>
<tr><td>Fisheries Governance - IUU Fishing (Mgt_3)</td><td>External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td><td>External, country level indicator</td></tr>
<tr><td>Rule of Law (Social_2)</td><td colspan="4">External, country level indicator</td><td>External, country level indicator</td><td colspan="3">External, country level indicator</td></tr>
<tr><td>Labour Rights (Social_3)</td><td>External, country level indicator</td><td colspan="3">External, country level indicator</td><td>External, country level indicator</td><td colspan="2">External, country level indicator</td><td>External, country level indicator</td></tr>
</table>

10.3 Seafood resource: Mackerel

10.3.1 Supply chain overview

In 2019, the UK imported a total of 17,646 tonnes of Atlantic mackerel (*Scomber scombrus*), chub mackerel (*Scomber japonicus*), and Pacific mackerel (*Scomber australasicus*) from eight countries (average total imports 2015-2019: 16,453 tonnes). Of these countries, Latvia is the only country considered to be a processing nation as opposed to producing. Northern European countries will primarily be targeting Atlantic mackerel whereas China will likely be targeting chub and Pacific mackerel. On average (2015 – 2019), the UK imported the majority of mackerel from Denmark (33%), the Netherlands (24%) and the Republic of Ireland (11%), while the other supply chains each contributed <7% of annual imports (Figure 96).

Imports have been variable for Denmark, the Netherlands and Republic of Ireland between 2015 – 2019, whereas imports from Germany and Latvia have increased slightly, and imports have remained relatively constant, at a low level, from China (Figure 96). In 2017, there was a notable rise in imports from the Netherlands and Republic of Ireland.

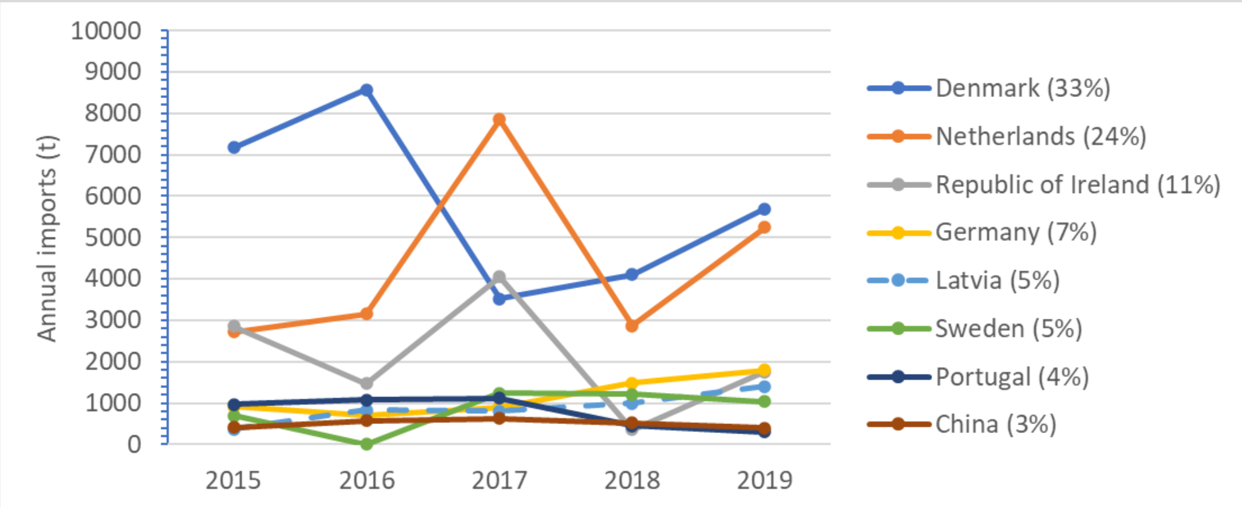

Figure 96: Volume (tonnes, t) of mackerel imported by the UK annually between 2015 and 2019. Latvia is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

However, the UK produces substantial volumes of Atlantic mackerel (152,147 tonnes in 2019), which far exceeds imported volumes to the UK. Once exports and non-UK landings were taken into account however, it is estimated that the UK contributed just 1% of domestic mackerel consumption in 2019, while countries such as Denmark and the Netherlands accounted for around 61% of UK mackerel consumption (Figure 97).

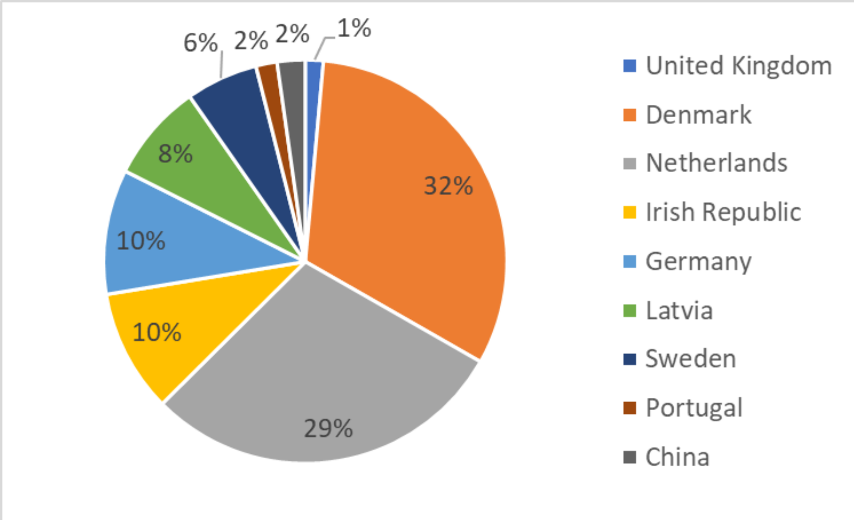

Figure 97: Percentage (%) contribution by the UK and the main countries from which mackerel is imported, to the UK's estimated mackerel consumption in 2019.

The majority of imported mackerel is preserved or prepared (around 43% of imports for the period 2015-2019), with another approximately 25% imported in fresh or chilled form and another quarter having been smoked.

10.3.2 Risk assessment and footprint summary

The majority of the UK's supply chains and its own production are associated with a low footprint score of 12 – 14. China's production of Pacific mackerel has a significantly greater footprint score (Figure 98). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 45 below, with full details available in Appendix 1.

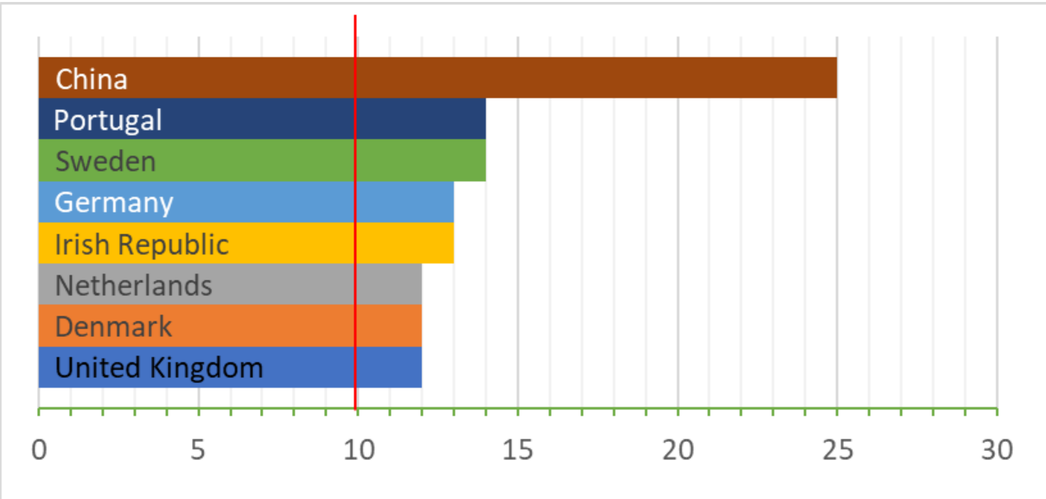

Figure 98: Total footprint for each of the UK's main mackerel tuna supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 45: Risk assessment summary for main supply chains for mackerel consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Denmark	Netherlands	Republic of Ireland	Germany	Sweden	Portugal	China
Direct impact on resource (Env_1)	Harvested sustainably, and at full reproductive capacity							Overfished
Ecosystem impact (Env_2)	Pelagic trawls and seines have little contact with bottom habitats and are selective							Absence of information (*data limited*)
Climate change impact (Env_3)	Pelagic trawls for small species are associated with a low carbon footprint							
ETP impact (Env_4)	Low concern for risk to ETP species							Absence of information (*data limited*)
Social concerns (Social_1)	No known social concerns			Recent media article on human trafficking	No known social concerns			Reports of forced labour onboard their flagged vessels
Management effectiveness (Mgt_1)	No long-term management strategy for North East Atlantic mackerel agreed by all parties involved in the mackerel fishery. No internationally agreed quota, recent catches have been substantially above scientific advice							Overfished and poor management
Sustainability certification progress (Mgt_2)	Lost MSC certification in 2019 as the stock had fallen below the precautionary threshold, and catches remained higher than advised by scientists. A FIP has recently been initiated between the UK, Iceland, Greenland, Russia, Norway, the Faroe Islands and the EU							Not known to be currently participating in any sustainability certification scheme
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator			External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator							External, country level indicator
Labour Rights (Social_3)	External, country level indicator	External, country level indicator					External, country level indicator	External, country level indicator

10.4 Seafood resource: Sardines

10.4.1 Supply chain overview

Sardines including *Sardinella sardinella* (European pilchards), *Sardinops* spp., *Sardinella* spp., and 'undefined', collectively contributed 12,619 tonnes to the UK market in 2019 and accounted for 32% of total small pelagic imports to the UK in 2019. Of this, Morocco supplied on average (2015 – 2019) 61% of imports, while Thailand and Portugal provided between 13% and 15% on average (Figure 99).

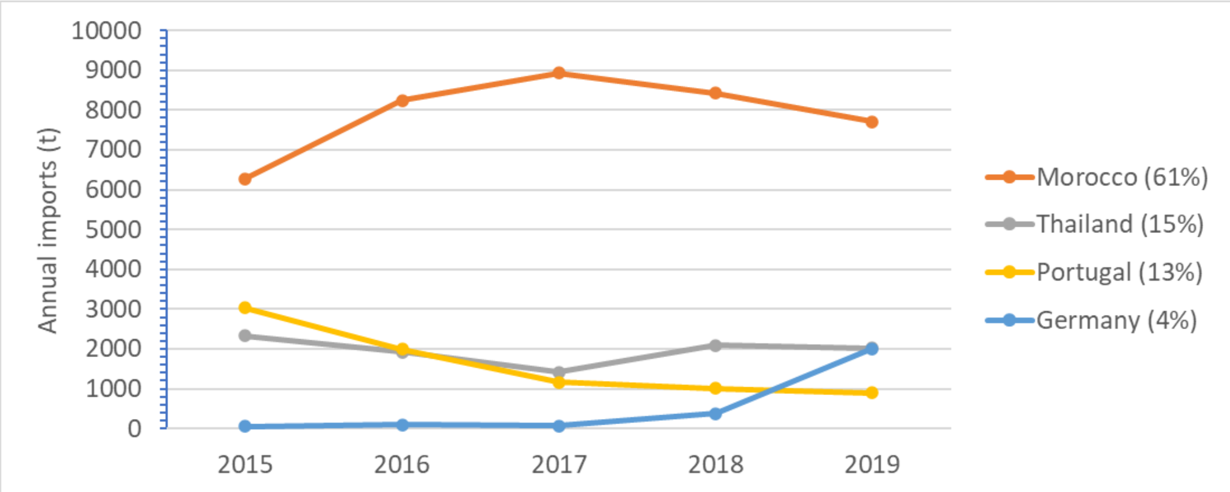

Figure 99: Volume (tonnes, t) of sardines imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Given the limited domestic supply relative to imports (around 7,000 tonnes were landed by the UK fleet in 2019 and approximately the same volume was exported according to HMRC trade data), the UK primarily consumed sardine sourced from Morocco (59%), and less so from Thailand (15%) and Germany (15%), with a total estimated consumption of 13,164 tonnes in 2019 (Figure 100). According to the HMRC data, the overwhelming majority of sardine consumed in the UK is prepared or preserved, whole or in pieces.

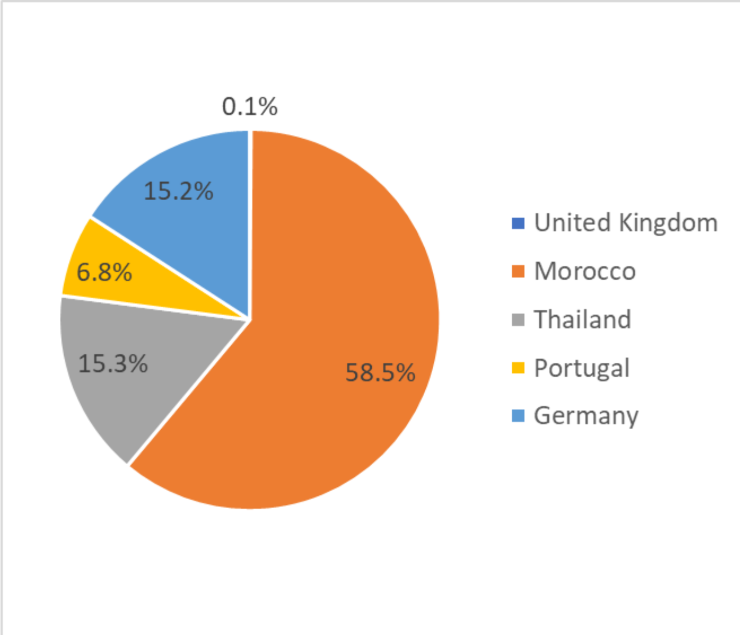

Figure 100: Percentage (%) contribution by the UK and the main countries from which sardines are imported, to the UK's estimated sardine consumption in 2019.

10.4.2 Risk assessment and footprint summary

The footprint for the UK's sardine supply chain is relatively low for Germany, the UK, Morocco and Portugal (footprint score of 14-16), whereas Thailand's supply of sardines to the UK is associated with a high footprint of 24 (Figure 101). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 46 below, with full details available in Appendix 1.

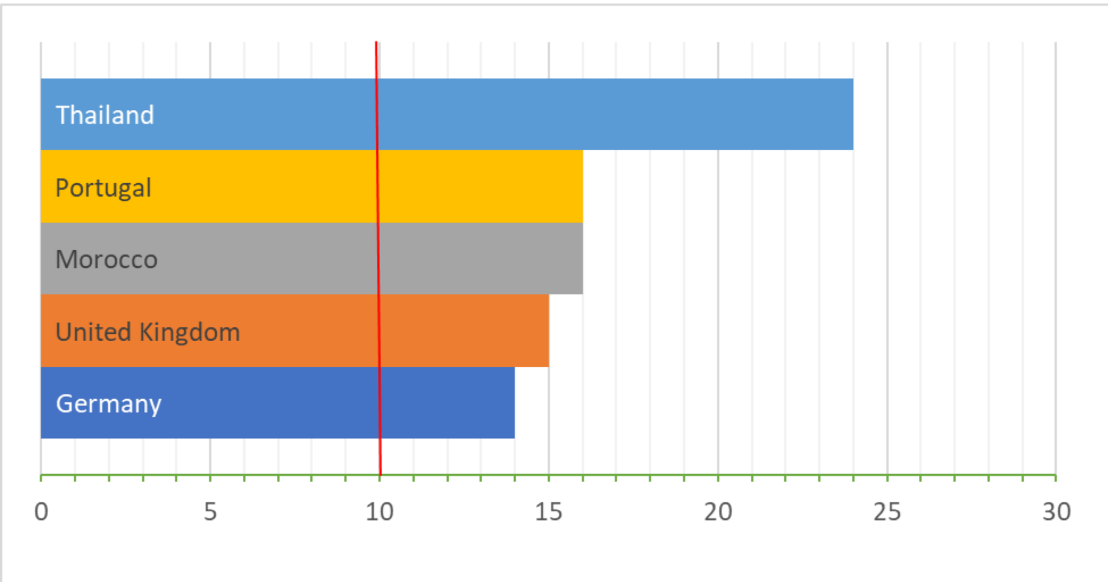

Figure 101: Total footprint for each of the UK's main sardine supply chains (available score range: 10 – 30), excluding processing / trading countries.

Table 46: Risk assessment summary for main supply chains for sardines consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Morocco	Thailand	Portugal	Germany
Direct impact on resource (Env_1)	Stock assessment is *data limited*	Stock is healthy and not fully exploited	Assessment data for Thai stocks in limited.	Fishing pressure is above MSY	Stock assessment is *data limited*
Ecosystem impact (Env_2)	Pelagic trawls and seines have little contact with bottom habitats and are selective		Gillnets and entangling nets have bycatch implications but minimal habitat damage	Pelagic trawls and seines have little contact with bottom habitats and are selective	
Climate change impact (Env_3)	Pelagic trawls for small species are associated with a low carbon footprint		Different gears in use result in a medium risk	Pelagic trawls for small species are associated with a low carbon footprint	
ETP impact (Env_4)	Selective capture method is low risk		Likely bycatch of ETP species occurs with the use of gillnets, however *data limited*	Selective capture method is low risk	
Social concerns (Social_1)	No specific concerns	Vulnerability to forced labour however *data limited*	High risk of modern slavery	No specific concerns	
Management effectiveness (Mgt_1)	Some localised limited management in place	Effective management of Northeast African stock in general however some issues to be resolved	Management in place not sufficient to ensure sustainable management of the stock	Regularly exceeding advised catch limits. Fishing pressure remains above sustainable limits	Some localised limited management in place
Sustainability certification progress (Mgt_2)	Partially MSC certified	Currently in stage five of a FIP	Not known to be working towards any sustainability certification		

Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator				External, country level indicator
Rule of Law (Social_2)	External, country level indicator	External, country level indicator		External, country level indicator	
Labour Rights (Social_3)	External, country level indicator		External, country level indicator	External, country level indicator	External, country level indicator

11. Seafood commodity – Farmed whitefish

11.1 Summary of farmed whitefish supply chains

Over the past 40 years there has been a significant change in the type of seafood eaten in the UK, with a shift away from traditional wild caught white fish species like cod and haddock, towards farmed seafood species such as salmon and warm-water prawns. More recently, some farmed 'white fish' species, catfish (basa or pangasius), sea bass and sea bream, have become popular alternatives to the traditional white fish species[171]. Sea bass and basa feature in the top five most popular farmed seafood species in UK multiple retail[172] (representing 4% and 7%, respectively, by volume of purchased farmed seafood in 2019), alongside salmon (59%), warm-water prawns (22%) and trout (2%). In 2019, sea bream represented 1% by volume of top farmed species.

In 2019, around 26,500 tonnes of predominantly farmed sea bass, sea bream and catfish were imported into the UK, with the majority (around 90%) arriving from the producing nations of Turkey, Greece, Vietnam and to a lesser extent Morocco, as well as from the Netherlands and Germany where the product is processed. Pangasius, and its producing country Vietnam, represented close to 60% of those aquaculture imports, with a further 28% of 'farmed whitefish' imports comprised of sea bass (Figure 102).

In addition, the UK caught around 400 tonnes of sea bass in UK waters in 2019, contributing an estimated 1.5% of the UK's consumed sea bass. Therefore, within this commodity category, there is consideration of both farmed and wild caught sea bass for completion.

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[171] https://www.seafish.org/document/?id=11052a6f-6c8e-423c-8d8c-1c4fa696a68e

[172] *'Multiple retail' used within Seafish market insight reports refers to retailers with multiple outlets i.e. major supermarket chains.*

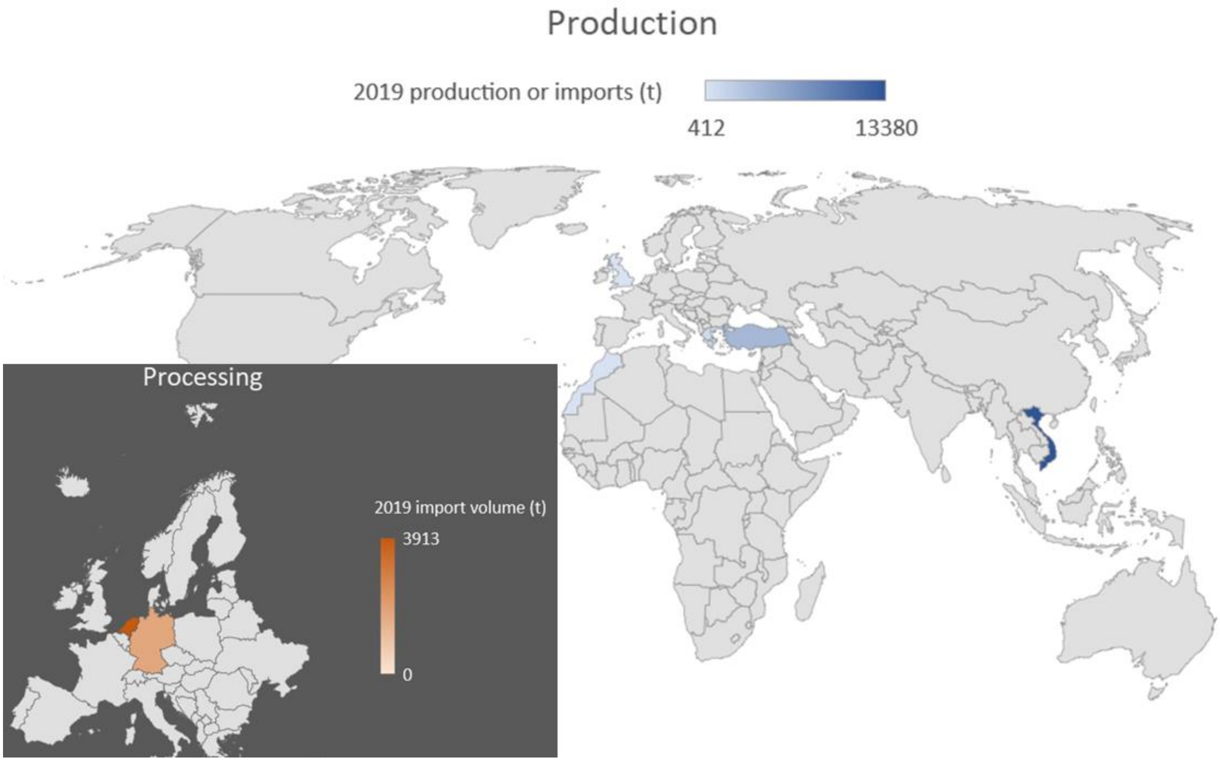

Figure 102: Map showing source countries for farmed whitefish seafood commodities (Sea bass, Sea bream, Catfish) consumed in the UK. Large map shows those countries which are primarily considered to be producers, whereas the inset map shows intermediary countries in the supply chains where bass, bream and catfish products are largely processed rather than produced. Total (all farmed whitefish resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scales.

The estimated footprints for the farmed whitefish supply chains fall within the ‘medium’ range of 19 to 21, with Turkey and Greece’s supply of bream and bass to the UK considered to be the lowest risk and the UK’s wild capture production of sea bass the highest. There is however, very little difference in the footprint of the three resources (Table 47 and Table 48).

Table 47: (a) Average footprint scores for each producing country in the UK’s farmed whitefish supply chains and (b) for each farmed whitefish resource sub-category.

Producing country	Average Footprint
Greece	19.0
Turkey	19.0
Morocco	20.0
Vietnam	20.0
United Kingdom	21.0

Resource	Average Footprint
Sea bream	19.3
European sea bass	19.7
Catfish	20.0

Table 48: Supply chain information, Risk assessment and Footprint for Farmed whitefish commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Farmed whitefish	Sea bass	European sea bass	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	3	2	2	3	1	2	3	2	1	2	21	19.7	19.6
			100%	European Union		Netherlands	Process									2	1	1			
				Western Europe exc EU	Mediterranean	Turkey	Prod	Aquac	1	2	2	2	1	2	2	2	2	3	19		
				European Union	Mediterranean	Greece	Prod	Aquac	1	2	2	2	1	2	2	2	2	3	19		
				European Union		Germany	Process									1	1	1			
	Sea bream	Sea bream	100%	Western Europe exc EU	Mediterranean	Turkey	Prod	Aquac	1	2	2	2	1	2	2	2	2	3	19	19.3	
				European Union		Netherlands	Process									2	1	1			
				European Union	Mediterranean	Greece	Prod	Aquac	1	2	2	2	1	2	2	2	2	3	19		
				Middle East and N Africa	N Atlantic	Morocco	Prod		1	2	2	2	2	2	3	2	2	2	20		
				European Union		Germany	Process	Aquac								1	1	1			
				Western Europe exc EU		Faroe Islands	Prod									1	1	1			
	Catfish	Catfish	100%	Asia and Oceania	W Pacific	Vietnam	Prod	Aquac	2	2	3	1	1	2	1	3	2	3	20	20.0	
				European Union		Germany	Process									1	1	1			

11.2 Seafood resource: European sea bass

11.2.1 Supply chain overview

In 2019, the UK imported a total of 7,048 tonnes of European sea bass (*Dicentrachus labrax*) from four countries, which collectively accounted for 95% of average annual imports (average total imports 2015-2019: 6,850 tonnes). Of these, two (the Netherlands and Germany) are considered to primarily be intermediaries in the supply chain (Figure 103).

The production of sea bass represents a major European aquaculture industry, with Greece and Turkey being the two main global producers (70% of global production). The UK is a significant consumer of farmed sea bass (but consumption is still low compared to Spain and France). Sea bass is grown in cage systems along the coast of both Turkey and Greece. It is often grown in association with European sea bream (grown on the same farms at the same time but in separate cages). In Turkey, sea bass is the dominant production species while in Greece this changes to sea bream. Imports of sea bass from Turkey have increased during the period 2015-2019, whereas there has been a slight decline in imports from Greece (Figure 103).

The majority (~90%) of sea bass enters the UK as fresh or chilled product rather than frozen. In 2020, sea bass represented 3.6% (value of £79 million) of the UK chilled seafood sector, having grown over the long-term (+178% over past decade)[173], fetching an average price of £15.92 per kg in 2019[174].

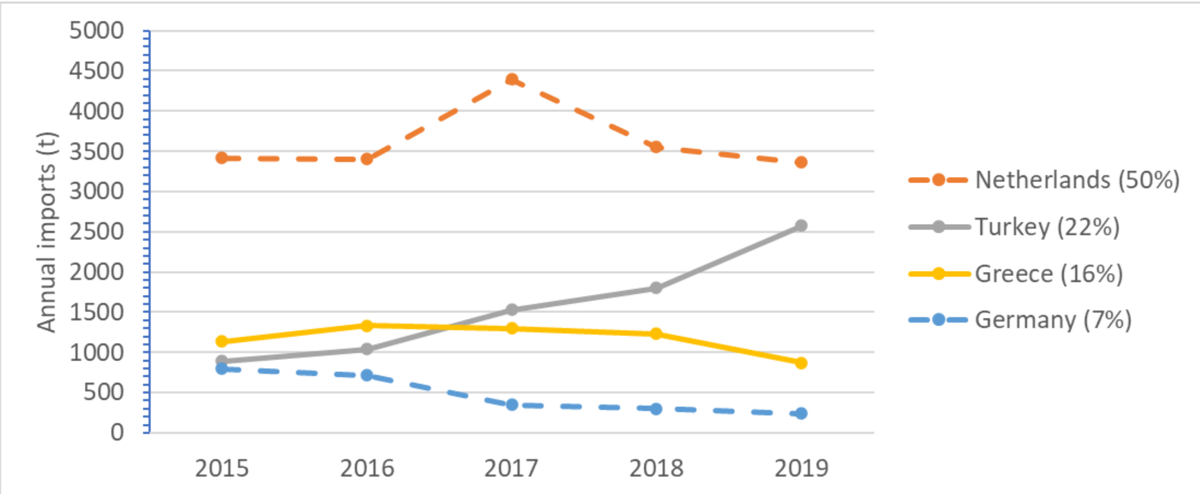

Figure 103: Volume (tonnes, t) of European sea bass imported by the UK annually between 2015 and 2019. The Netherlands and Germany are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

Sea bass is also a target and bycatch species for the UK fishing fleet (and other fleets fishing in UK and European waters, particularly France, Spain and Portugal), as well as recreational fishers. Wild-capture production of sea bass by the UK fishing fleet was estimated to represent just 1.5% of the UK's total bass consumption (estimated as 7,652

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173 https://www.seafish.org/document/?id=19b3d61f-04ef-481e-affb-2abcda67dff0

174 https://www.seafish.org/document/?id=11052a6f-6c8e-423c-8d8c-1c4fa696a68e

tonnes) in 2019, whereas farmed sea bass arriving directly from Greece and Turkey was responsible for around 78% of that consumption (Figure 104).

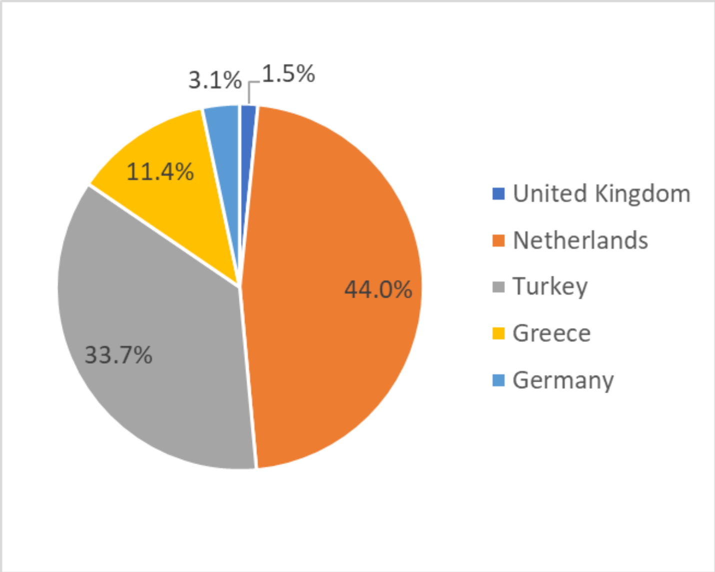

Figure 104: Percentage (%) contribution by the UK and the main countries from which European sea bass is imported, to the UK's estimated European sea bass consumption in 2019. Please note the UK data is wild-capture volume.

11.2.2 Risk assessment and footprint summary

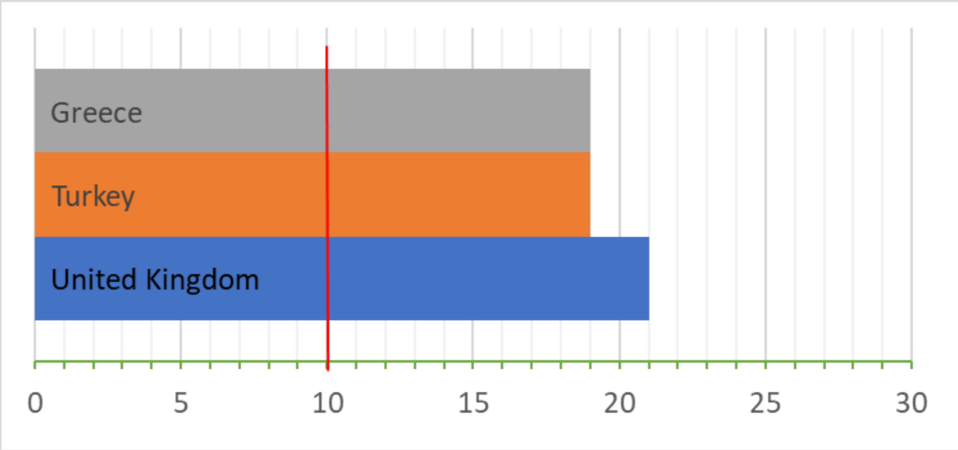

Figure 105: Total footprint for each of the UK's main European sea bass supply chains (available score range: 10 – 30), excluding processing / trading countries.

The footprint of the UK's farmed sea bass supply chains is lower ('medium' footprint score of 19 for both Turkey and Greece) than that of wild-capture (UK produced) sea bass (footprint score of 21) (Figure 105). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 49 below, with full details available in Appendix 1.

Table 49: Risk assessment summary for main supply chains for European sea bass consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Turkey	Greece
Direct impact on resource (Env_1)	Although some areas are data limited, stock status variable with evidence of decline in certain areas	Not known to have any direct or indirect impact on naturally occurring European sea bass in the Mediterranean	
Ecosystem impact (Env_2)	Hook and line (longlines and handlines), demersal seine nets and otter trawls and fixed gillnets – risk of habitat damage and bycatch from latter gear types	Some evidence of environmental degradation	
Climate change impact (Env_3)	Mixture of gear	The farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method	
ETP impact (Env_4)	Pair trawls and demersal set gillnets, in particular are associated with large bycatches of ETP species such as harbour porpoise and common dolphin	Although interactions do exist with ETP species they are not considered significant and are managed to some degree	
Social concerns (Social_1)	No specific social concerns exist		
Management effectiveness (Mgt_1)	Overfishing, discarding and illegal targeting of sea bass is known to be occurring.	Concerns still exist around Turkish production, particularly lack of transparency.	System still lacks some vital components to consider it fully effective.
Sustainability certification progress (Mgt_2)	No known progress	Largely covered by third party certification standards, particularly in reference to sales to the UK, however not all are ASC certified	
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator		
Rule of Law (Social_2)	External, country level indicator	External, country level indicator	
Labour Rights (Social_3)	External, country level indicator	External, country level indicator	

11.3 Seafood resource: Sea bream

11.3.1 Supply chain overview

The UK imported just over 3,800 tonnes of bream in 2019 (annual average of 3,740 tonnes in 2015-2019), comprised mainly of gilthead sea bream (*Sparus aurata*) (74% on average) with the remainder of bream imports recorded in the HMRC trade data as a mix of *Dentex dentex*, *Pagellus* spp., *Sparidae* spp., and 'Ray's bream' (*Brama* spp.). Six countries were responsible for around 93% of these imports on average – Turkey, Greece and Morocco, along with the Netherlands, Germany and the Faroe Islands (Figure 106). The Netherlands and Germany are known intermediaries in the UK's supply chain (for processing / trade).

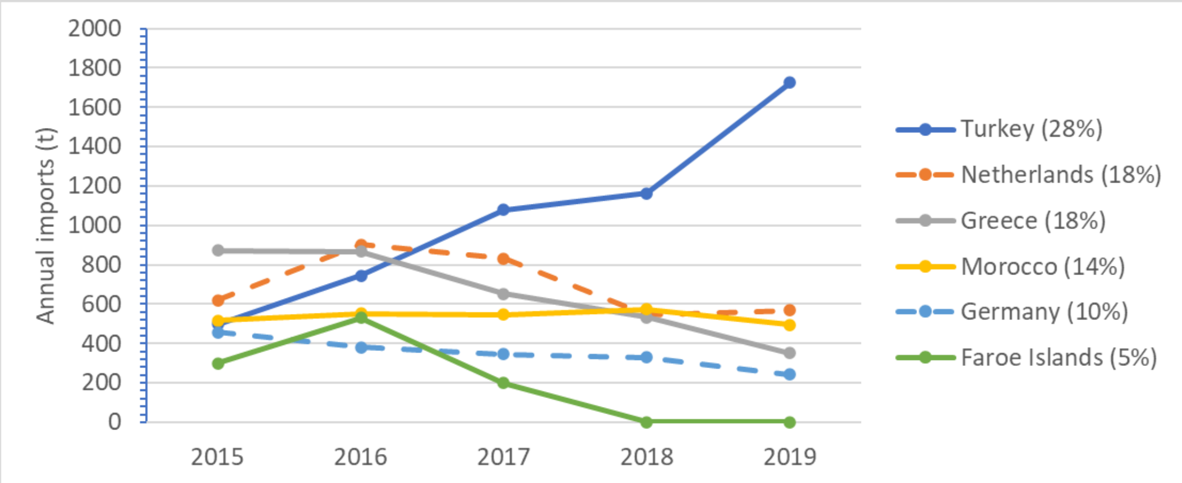

Figure 106: Volume (tonnes, t) of sea bream imported by the UK annually between 2015 and 2019. The Netherlands and Germany are assumed to be intermediary countries, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

The production of gilthead sea bream (*Sparus aurata*) represents a major aquaculture industry with Greece and Turkey being the two main global producers (70% of global production). The UK is a relatively minor consumer for farmed sea bream (compared to Spain and France). Sea bream is grown in cage systems along the coast of both Turkey and Greece, as well as other countries in Europe, such as Spain and France. It is often grown in association with European sea bass (grown on the same farms at the same time but in separate cages). In Greece, sea bream is the dominant production species while in Turkey this changes to sea bass.

Sea bream arriving in the UK from Turkey represents 28% of average annual (2015-2019) import volume and 50% of the UK's estimated consumption (3,438 tonnes) in 2019, compared to 18% of imports and 10% of consumption for Greece (Figure 106 and Figure 107). These figures are likely to be higher however, if it were possible to account for the product arriving in the UK via the Netherlands or Germany.

Alongside gilthead sea bream, a small quantity of 'other' bream species also enters the UK from Turkey. These species are produced in very small quantities in the same cage farming systems as gilthead sea bream and European sea bass. Morocco dominates import volumes on these 'other' bream species (assuming imports have been recorded under the correct codes in the HMRC trade data), however (over 61% of annual imports of 'other' bream on average 2015-19).

The Faroe Islands were a relatively important player prior to 2018 (Figure 106). Whilst salmon farming by the Faroe Islands is well documented, information on bream aquaculture could not be found, suggesting that it only occurs on a small scale, if at all, which would be our expectation given the environmental conditions are not suited to such species. The Faroe Islands is also not known as a processing centre for UK importers and so it is not clear why it features within the trade data for bream. However, in the absence of an explanation, it has been assumed that this represents a processing product only. The consequences of that assumption being incorrect are minimal given the relatively low importance of the supply chain (in fact, there were no imports in 2018 or 2019,Figure 107). Further, if production is taking place, or has done previously, it is assumed it would be through a RAS system which is a relatively low risk method compared to cage farming systems.

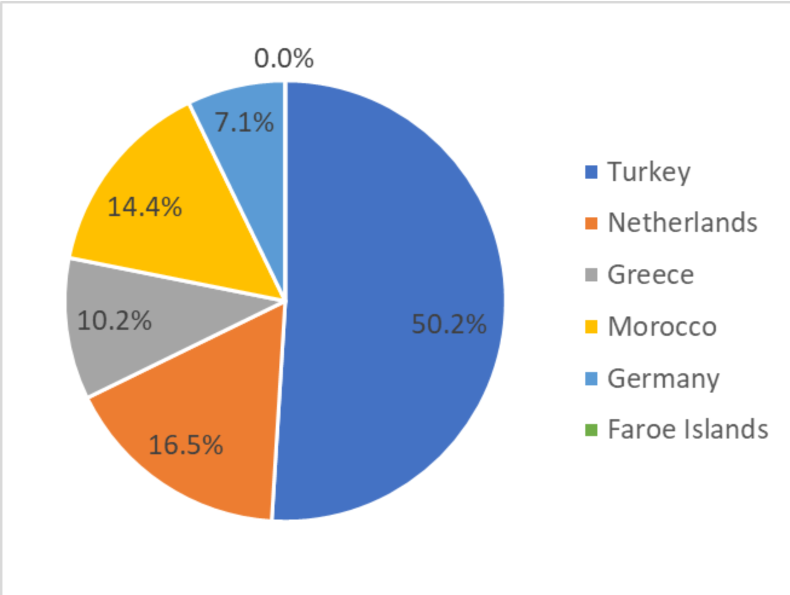

Figure 107: Percentage (%) contribution by the UK and the main countries from which sea bream is imported, to the UK's estimated bream consumption in 2019.

11.3.2 Risk assessment and footprint summary

The lowest footprint score of 19 is associated with the supply chains from Turkey and Greece and the highest score of 20 (all within the 'medium' category, however) arises from Morocco's supply of sea bream to the UK (Figure 108). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 50 below, with full details available in Appendix 1.

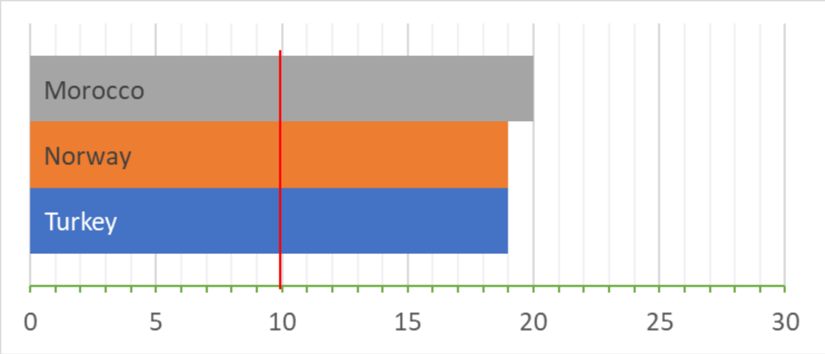

Figure 108: Total footprint for each of the UK's main sea bream supply chains (available score range: 10 – 30), excluding processing / trading countries (and the Faroe Islands due to lack of imports in recent years).

Table 50: Risk assessment summary for main supply chains for sea bream consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	Turkey	Greece	Morocco
Direct impact on resource (Env_1)	Cage farming is not known to have any direct or indirect impact on naturally occurring sea bream		
Ecosystem impact (Env_2)	Some evidence of environmental degradation through cage farming		
Climate change impact (Env_3)	The farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method		
ETP impact (Env_4)	Although interactions do exist with ETP species they are not considered highly significant and are managed to some degree		
Social concerns (Social_1)	Although noted that Turkish wages remain significantly lower than those found in Greece no specific social concerns exist in the cage farmed production of sea bream		Concerns have been raised about human rights issues in the country on a more generic level
Management effectiveness (Mgt_1)	Management system is seen as effective but could still benefit from improvement		Legislation is in place which covers the main areas but is likely to need strengthening as and when the sector grows
Sustainability certification progress (Mgt_2)	Largely covered by third party certification standards, particularly in reference to sales to the UK, however not all are ASC certified		No certification against any known standard
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator		
Rule of Law (Social_2)	External, country level indicator		
Labour Rights (Social_3)	External, country level indicator		External, country level indicator

11.4 Seafood resource: Catfish

11.4.1 Supply chain overview

Pangasius (commonly, *Pangasius hypophthalmus*) refers to a member of the catfish family found naturally in southern Asia which are produced in aquaculture production systems. In the UK they are often referred to a 'Vietnamese river cobbler' or 'basa'.

Pangasius is produced in pond and cage systems and grows very well in high densities, making it ideal for aquaculture. The epicentre for production has been the Mekong Delta in Vietnam, which has seen increases in production of 35% per year since the turn of the century[175]. Indeed, in the UK, the only reported source of farmed Pangasius is from Vietnam. This is not surprising since the country is known to be responsible for around 70-80% of global pangasius production. This increase has also seen a movement away from more traditional production methods (often in ponds or cages attached to individual houses) to bigger more industrial methods using large pond systems.

It is these large commercial operations which now dominate the export market and the supply to the UK and are therefore the focus of this assessment (i.e. pond farming and not cage farming is assessed here).

In 2015-2019, the UK imported between around 11,200 tonnes and 13,380 tonnes of catfish (*Pangasius* spp., *Silurus* spp., *Clarias* spp. and *Ictalurus* spp.) from Vietnam, representing 83-88% of annual catfish imports (average of 12,500 tonnes or 86% across the time period). A further 317 to 1,489 tonnes were received from Germany, a processing / trading stop, contributing on average another 6% of annual imports. Unsurprisingly, the majority (around 92%) of catfish imports are comprised of frozen product and product arriving from Vietnam directly accounted for around 92% of the UK's estimated consumption of 14,549 tonnes in 2019 (Figure 109 and Figure 110)

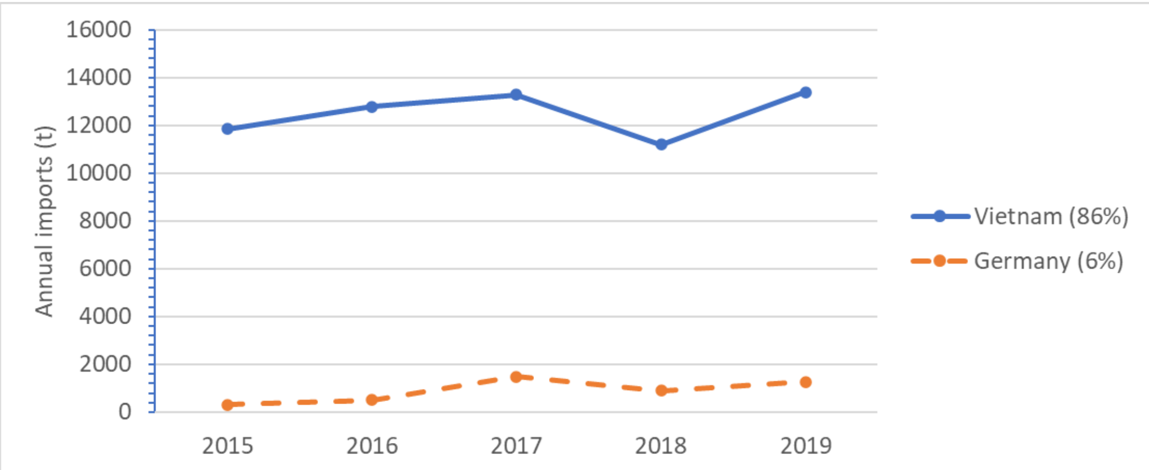

Figure 109: Volume (tonnes, t) of Pangasius (catfish) imported by the UK annually between 2015 and 2019. Germany is assumed to be an intermediary country, where product is processed / traded. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

[175] *Anh, P. T. et al. (2018): https://www.tandfonline.com/doi/pdf/10.1080/13657305.2017.1399296*

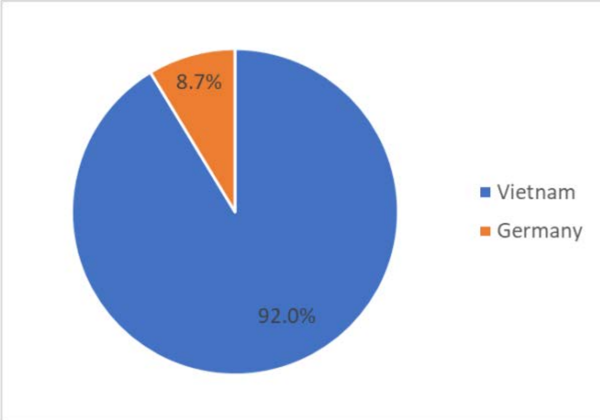

Figure 110: Percentage (%) contribution by the UK and the main countries from which Atlantic cod is imported, to the UK's estimated Atlantic cod consumption in 2019.

11.4.2 Risk assessment and footprint summary

Vietnam's supply of catfish to the UK is associated with a medium footprint score of 20. A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 51 below, with full details available in Appendix 1.

Table 51: Risk assessment summary for main supply chains for Pangasius (catfish) consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	Vietnam
Direct impact on resource (Env_1)	Escapes are not likely to be common occurrences, however impacts are not yet known (*data limited*)
Ecosystem impact (Env_2)	Some evidence of habitat degradation, habitat alteration resulting from pond construction, use of antibiotics
Climate change impact (Env_3)	High CO2 emissions related to the specific farming conditions (aeration and mechanical equipment is commonly used)
ETP impact (Env_4)	ETP interactions are likely to be limited
Social concerns (Social_1)	Concerns existed in past, but most major commercial companies supplying UK have undergone ASC assessment – includes social certification
Management effectiveness (Mgt_1)	Concerns remain around lack of use of EIAs in farm licensing, antibiotic use and regulatory control of outputs
Sustainability certification progress (Mgt_2)	Largely covered by ASC certification standards
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator
Rule of Law (Social_2)	External, country level indicator
Labour Rights (Social_3)	External, country level indicator

12. Seafood commodity – Flatfish

12.1 Summary of flatfish supply chains

A variety of 'flatfish' species are consumed in the UK, including for example brill (*Scophthalmus rhombus*), common dab (*Limanda limanda*), megrim (*Lepidorhombus whiffiagonis*), turbot (*Psetta maxima*), European flounder (*Platichthys flesus*) – and the two focus resources here, sole (comprised of two species, the first commonly known as Dover sole, *Solea solea* and second, lemon sole *Microstomus kitt*) and European plaice (*Pleuronectes platessa*).

For both resources, the UK's national production provides a large proportion of our annual consumption (around 63% and 78% in 2019 for sole and plaice, respectively). Imports are derived from countries in Northern Europe, predominantly Iceland (61% of sole imports – largely lemon sole - and 58% of plaice imports on average 2015-19), followed by the Netherlands for both resources (8% of imports for sole, 34% for plaice) and to a lesser extent, Denmark and the Faroe Islands for sole (Figure 111).

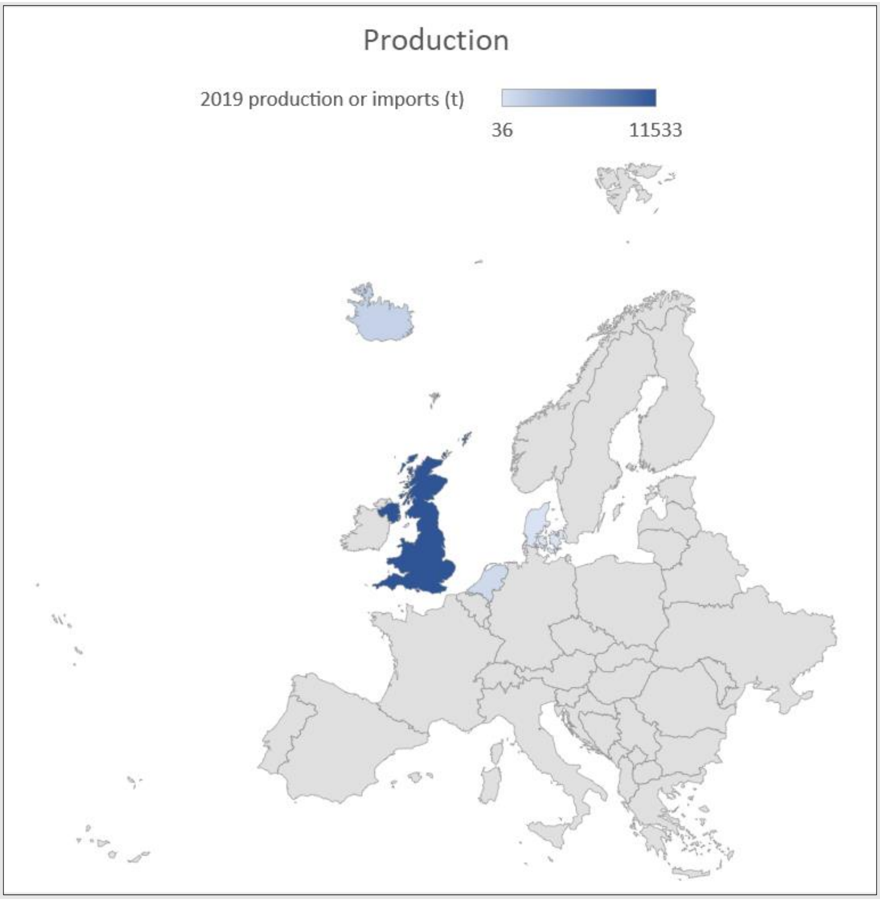

Figure 111: Map showing source countries for flatfish seafood commodities (Sole, Plaice) consumed in the UK. Total (all flatfish resources) annual import (or production for the UK) volumes (tonnes) in 2019 are shown by the colour scale.

A range of footprint scores (all within the 'low' to 'medium' categories) were estimated for the countries involved in the UK's main flatfish supply chains, with Iceland scoring the lowest and the Netherlands the highest on average (Table 52). The UK's own domestic production of flatfish was associated with a relatively high footprint score. Both resources were similar when considering the average footprint associated with their supply to the UK (Table 52 and Table 53).

Table 52: (a) Average footprint scores for each producing country in the UK's flatfish supply chains and (b) for each flatfish resource sub-category.

Producing country	Average Footprint
Iceland	14.5
Denmark	16.0
Faroe Islands	17.0
United Kingdom	17.5
Netherlands	19.5

Resource	Average Footprint
Plaice	16.7
Sole	17.2

Table 53: Supply chain information, Risk assessment and Footprint for Flatfish commodity category and resources that form that category. For details of the scores, see resource subcategory chapters and Appendix 1 below. Coloured cells contain Risk assessment scores for each production (not processing / trade) supply chain associated with each resource. Risk assessment is based on 10 indicators of ecological, social and governance risk. Scores are low (green=1), medium (amber=2) or high (red=3) risk. Cells with medium (=2) scores and shading indicate where there was limited information or evidence. Footprint for each supply chain is provided in blue (sum of all Risk Indicator scores). The average footprint score for each resource and the commodity is provided.

Commodity category	Resource category	Resource	Proportion of imports of resource category	Continent (of supplier)	Oceanic region (of production)	Country (supplier)	Production or Processing?	Wild capture or Aquaculture?	Direct impact on resource (Env_1)	Ecosystem impact (Env_2)	Climate change impact (Env_3)	ETP impact (Env_4)	Social concerns (Social_1)	Management effectiveness (Mgt_1)	Sustainability certification progress (Mgt_2)	Fisheries Governance - IUU Fishing (Mgt_3)	Rule of Law (Social_2)	Labour Rights (Social_3)	Supply Chain Footprint	Average Footprint - Resource	Average Footprint - Commodity
Flatfish	Plaice	Plaice	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	1	2	2	2	1	2	2	2	1	2	17	**16.7**	**17.0**
			100%	Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	1	2	2	2	1	1	2	1	1	1	14		
				European Union	NE Atlantic	Netherlands	Prod	Cap	1	3	3	2	1	2	3	2	1	1	19		
	Sole	Sole	NA	Western Europe exc EU	NE Atlantic	United Kingdom	Prod	Cap	1	2	2	2	1	2	3	2	1	2	18	**17.2**	
			100%	Western Europe exc EU	NE Atlantic	Iceland	Prod	Cap	2	2	2	2	1	1	2	1	1	1	15		
				European Union	NE Atlantic	Netherlands	Prod	Cap	2	3	3	2	1	2	3	2	1	1	20		
				European Union	NE Atlantic	Denmark	Prod	Cap	1	2	2	2	1	2	3	1	1	1	16		
				Western Europe exc EU	NE Atlantic	Faroe Islands	Prod	Cap	2	2	2	2	1	2	3	1	1	1	17		

12.2 Seafood resource: Sole

12.2.1 Supply chain overview

The UK derives the majority (61% on average) of its imported sole from Iceland (mainly lemon sole) with an average of 216 tonnes imported annually between 2015 and 2019, although volumes have decreased in recent years (Figure 112). An additional 36 to 79 tonnes were imported from the other three main supply countries – the Netherlands (mainly Dover sole), Denmark and the Faroe Islands (mainly lemon sole) in 2019, which on average (2015-19) contribute 15%, 12% and 7% of the UK's imports, respectively.

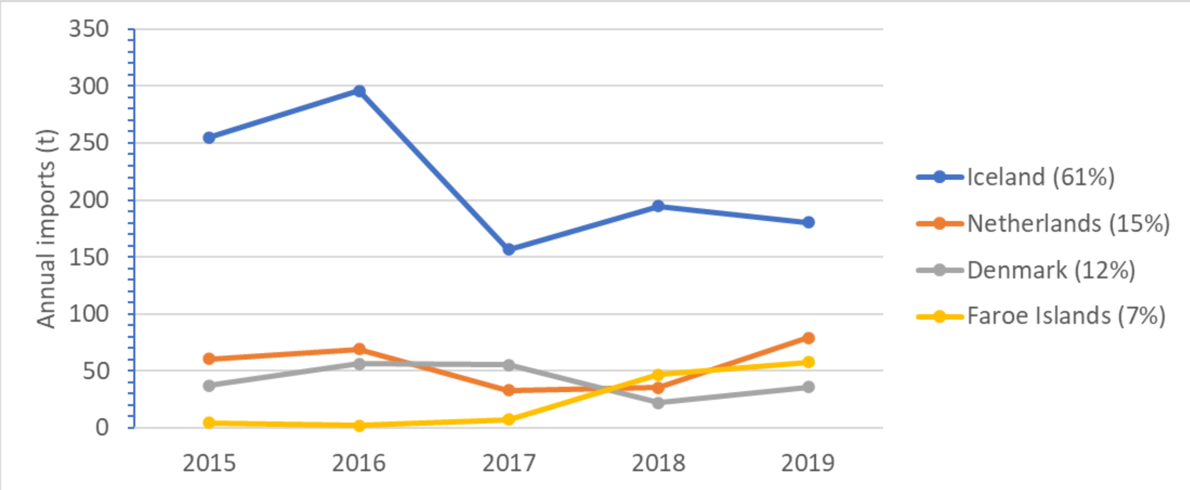

Figure 112: Volume (tonnes, t) of sole imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

However, the UK's fleet landed 1,567 tonnes of Dover sole into the UK in 2019 which accounted for around 55% of the UK's estimated sole consumption of 856 tonnes that year, compared to 21% for Iceland and 4-9% for the other three main source countries (Figure 113).

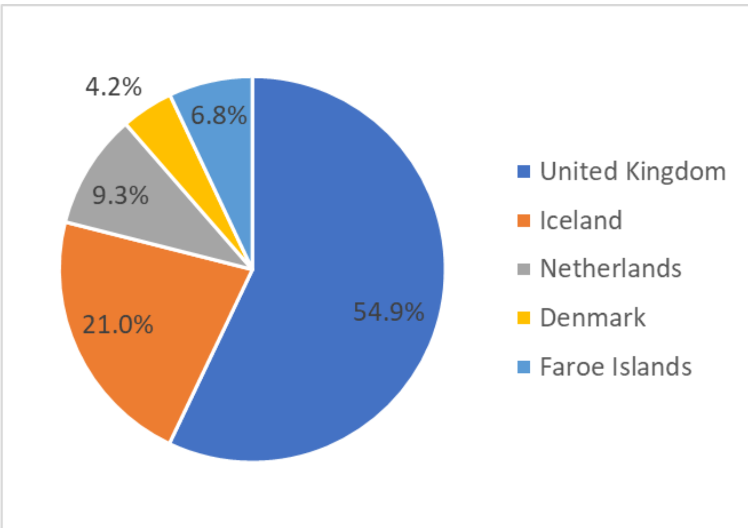

Figure 113: Percentage (%) contribution by the UK and the main countries from which sole is imported, to the UK's estimated sole consumption in 2019.

12.2.2 Risk assessment and footprint summary

The UK's sole production and supply is associated with a range of 'low' (Iceland, Denmark – 15 and 16, respectively) to 'medium' (Faroe Islands, UK, Netherlands – 17 to 20) ecological and social footprints (Figure 114). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 54 below, with full details available in Appendix 1.

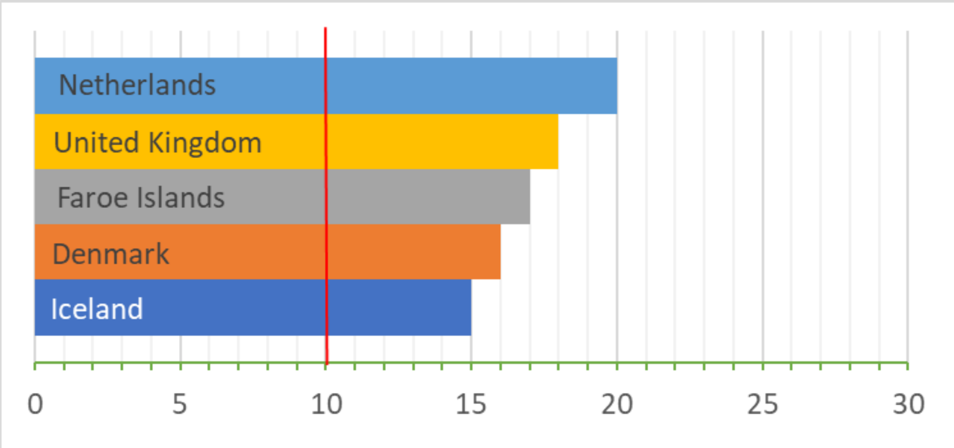

Figure 114: Total footprint for each of the UK's main sole supply chains (available score range: 10 – 30).

Table 54: Risk assessment summary for main supply chains for sole consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Iceland	Netherlands	Denmark	Faroe Islands
Direct impact on resource (Env_1)	Stock size and exploitation rate considered sustainable for main stocks	*Data limited* and MSY reference points are undefined	Fishing mortality above Fmsy in North Sea	Stock size and exploitation rate considered sustainable for main stocks	No assessment of the stock status in Faroe Islands waters(*data limited*)
Ecosystem impact (Env_2)	Mixture of demersal fishing gear (beam trawls, otter trawls, trammel / gill nets). Variable levels of physical and biological impacts on seafloor. Bycatch of undersized demersal species.	Main gear is demersal seines, although also bottom trawls and Nephrops trawls. Risk of habitat damage and bycatch.	Risk of habitat damage and bycatch through beam trawlers and pulse trawlers, plus seine nets, set gill nets and otter trawls used by fishery	Bycatch of depleted Kattegat cod and bottom habitat damage due to main gears (bottom trawls)	Assumed fishery uses bottom trawls (*data limited*)
Climate change impact (Env_3)	Mixture of gear types. High risk CO_2 per kg of fish data is variable and for bottom trawls only.		Dominance of beam trawler activity results in a high carbon footprint	Mixture of gear types (assumed for Faroe Islands). High risk CO_2 per kg of fish data is variable and for bottom trawls only.	
ETP impact (Env_4)	Gill nets and fixed nets can result in bycatch of cetaceans and sharks and damage to seabed features	Interaction between the fishery and most ETP species considered to be low, however *data limitations* reduce confidence	There is lack of confidence over the potential population level impacts of interactions with ETP species	Risk of bycatch of cetaceans, elasmobranchs and seabirds	*Data limited*
Social concerns (Social_1)	No known social impacts				
Management effectiveness (Mgt_1)	Scope for improvements	Generally considered to be effective	Scope for improvements		*Data limited*
Sustainability certification	No third-party certification or FIP progress	MSC certified, with conditions	Fishery partially MSC certified. In 2019, WWF as part of an NGO consortium submitted objections		No known progress

progress (Mgt_2)			to the certification of the fishery which were not withdrawn	
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator			
Labour Rights (Social_3)	External, country level indicator	External, country level indicator		

12.3 Seafood resource: Plaice

12.3.1 Supply chain overview

In 2019, the UK imported just over 2,200 tonnes of European plaice (*Pleuronectes platessa*), with around 92% of the supply derived from Iceland (average contribution across the period 2015-19 was 58%) and the Netherlands (average contribution 34%), which have consistently dominated the UK's supply of imported plaice (Figure 115). Imports in 2019 were lower than the average for the 5-year time period (3,500 tonnes), as can be seen by the decreasing import volumes for both countries in recent years (Figure 115).

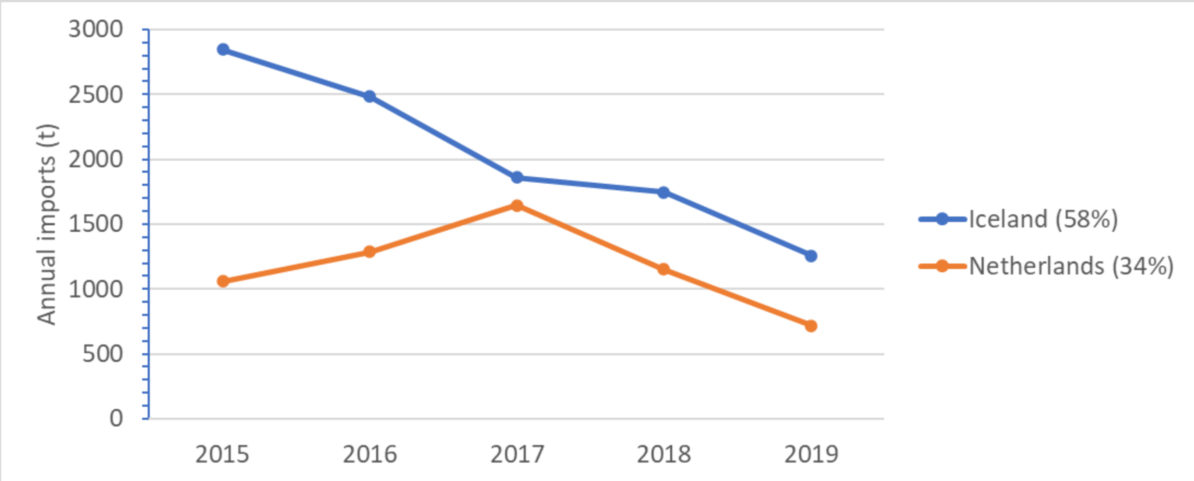

Figure 115: Volume (tonnes, t) of plaice imported by the UK annually between 2015 and 2019. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

However, the UK fleet landed around 9,800 tonnes of plaice in 2019 – although only 3,900 tonnes of this into the UK - providing approximately 49% of the UK's estimated plaice consumption (4,296 tonnes) in 2019, compared to 29% by Iceland and 17% by the Netherlands (Figure 116).

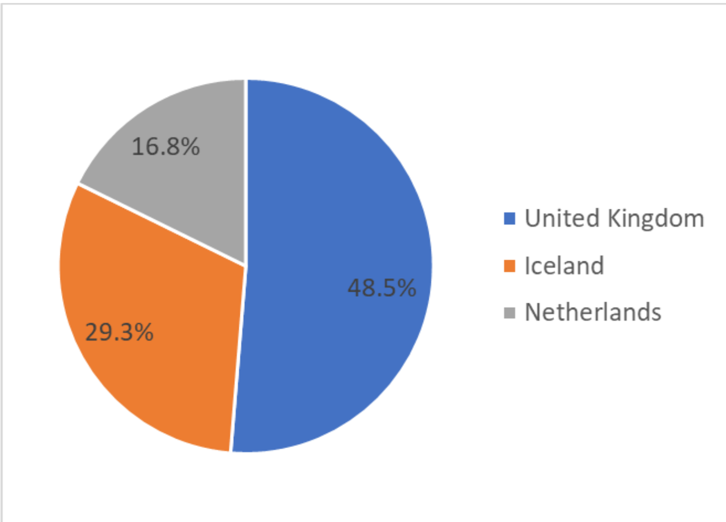

Figure 116: Percentage (%) contribution by the UK and the main countries from which plaice is imported, to the UK's estimated plaice consumption in 2019.

12.3.2 Risk assessment and footprint summary

The footprint of the UK's wild capture production of plaice is higher ('medium' footprint score of 17) than that of Iceland ('low' footprint score of 14), with the Netherland's production having the highest footprint overall ('medium' score of 19) (Figure 117). A summary of the key contributing factors to the risk assessment and footprint scores is provided in Table 55 below, with full details available in Appendix 1.

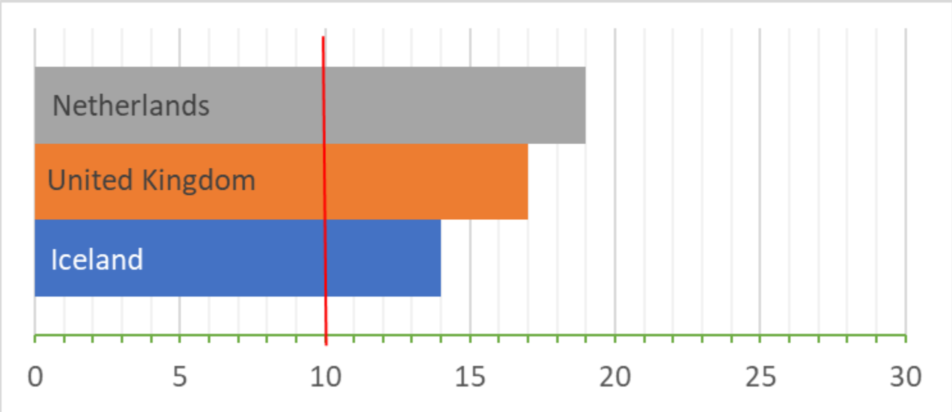

Figure 117: Total footprint for each of the UK's main plaice supply chains (available score range: 10 – 30).

Table 55: Risk assessment summary for main supply chains for plaice consumed in the UK (see Appendix 1 for details). Where present, green cells represent a low risk score (=1), amber cells represent a medium risk score (=2) and red cells represent a high risk score (=3).

Risk Indicator	United Kingdom	Iceland	Netherlands
Direct impact on resource (Env_1)	Target stocks are considered to be healthy and not overfished		
Ecosystem impact (Env_2)	Demersal fishing gear (beam trawls, otter trawls, seine nets) causes variable levels of potential physical and biological impacts on seafloor	Otter trawls and Danish seines are main gear types. Risk of habitat damage and bycatch.	Beam trawlers or pulse trawlers, along with seine nets, set gill nets and otter trawls - risk of habitat damage and bycatch or mortality of non-target species
Climate change impact (Env_3)	Mixture of gear types. High risk CO2 per kg of fish data is variable and for bottom trawls only.		Dominance of beam trawls result in high carbon footprint
ETP impact (Env_4)	High risk of interactions with endangered elasmobranchs in southwest, but lower elsewhere	Potential interactions between gear and seals	Potential interactions with elasmobranchs
Social concerns (Social_1)	No known social concerns		
Management effectiveness (Mgt_1)	Scope for improvement	Generally considered to be effective	Scope for improvement
Sustainability certification progress (Mgt_2)	Partial MSC and FIP coverage	MSC certified, with conditions	Fishery partially MSC certified. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery which were not withdrawn
Fisheries Governance - IUU Fishing (Mgt_3)	External, country level indicator	External, country level indicator	External, country level indicator
Rule of Law (Social_2)	External, country level indicator		
Labour Rights (Social_3)	External, country level indicator	External, country level indicator	

13. Case study – ETP species interactions

Seafood production can not only have negative impacts on target species populations, but also direct and indirect effects on species that occupy the same habitats. One of the most prevalent direct impacts is the incidental capture of species that are not targeted by fisheries, commonly known as bycatch[176]. Many species of marine life are bycatch in fisheries and often discarded dead or dying. Moreover, less direct impacts of fisheries can include depleting a species' food source, destroying its habitat, and discarded fishing gear leading to ghost fishing. In terms of aquaculture, marine wildlife can be threatened by direct loss of habitat, competition with the escaped farmed animals and spread of diseases from aquaculture farms.

Marine wildlife have varying susceptibility to impacts of fishing and aquaculture activities depending on their biology, population health and other factors, and some need more protection than others. For example, sharks, skates, rays and chimaeras, collectively known as chondrichthyan fishes, are generally late to mature and reproduce few young, among other factors, making them highly vulnerable to the effects of climate change, habitat destruction and fishing. This is what has led to the 32% of Chondrichthyes species being classified as 'Threatened' (i.e. 'Critically Endangered', 'Endangered', or 'Vulnerable') by the International Union for Conservation of Nature (IUCN) Red List[177].

The fisheries and farms that are the sources of seafood supply chains in the UK could impact marine wildlife around the world. Many of these may be considered vulnerable, endangered, threatened with extinction, or similar. This case study aims to estimate the number of non-target Endangered, Threatened or Protected (ETP) species that have been and could be impacted by fisheries and farms associated with the UK's seafood supply chains.

13.1 Analysis of the UK's seafood supply chains' impacts on vulnerable species

Publicly available information on ETP species associated with the wild and farmed seafood supply chains, that link to the UK's seafood consumption, included in this report were analysed. For wild fisheries, this includes ETP species lists from Marine Stewardship Council (MSC) certified fishery reports, Fishery Improvement Project (FIP) reports, and protected species included in the International Council for the Exploration of the Sea (ICES) Working Group on Bycatch of Protected Species (WGBYC). For farmed species, we used Aquaculture Stewardship Council (ASC) ETP species lists. In total, ETP lists for close to 200 reports were included in this analysis.

Data were therefore not available for all supply chains (ETP interaction data were unavailable for around 40% of the 157 supply chains) meaning the analysis is likely to be an underrepresentation of the potential impact of the UK seafood consumption on ETP species.

The ETP species were then split into the groups listed in Table 56.

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[176] https://www.worldwildlife.org/threats/bycatch

[177] http://www.iucnssg.org/news#:~:text=In%20this%20new%20global%20analysis,Endangered%2C%20Endangered%2C%20or%20Vulnerable

Table 56: Groups of species and examples of those that are part of these groups. 'Groups' were determined based on which species were prevalent in the analysis. The general term 'Groups' is used here as not all follow the same level of scientific classification of species (e.g., class, super class, phylum).

Group	Description and examples
Birds	All
Non-cartilaginous fish	Bony fish, jawless fish
Cartilaginous fish	Elasmobranchs (sharks, skates, rays, sawfish), holocephalans (chimaeras)
Aquatic mammals	Whales, dolphins, porpoises, seals, otters, sea lions, etc.
Terrestrial mammals	Monkeys, cats, foxes, bats, etc.
Molluscs	Snails, clams, etc.
Reptiles	Turtles, snakes, crocodiles, etc.
Arthropods	Crabs, lobsters, horseshoe crabs, etc.
Amphibians	Frogs, caecilians, etc.

The MSC defines ETP species as '*Species recognised by national legislation and / or binding international agreements to which the jurisdictions controlling the fishery under assessment are party*'[178]. Agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Migratory Species (CMS) and the International Union for Conservation of Nature (IUCN) are typically used to designate ETP species. The term ETP species is commonly used in fisheries and not specific to just MSC.

In this report, a wider definition of ETP species was applied as part of a precautionary approach to assessing risks. This includes those species that are designated as 'Near Threatened', 'Vulnerable' or 'Data Deficient' under the IUCN Red List or an equivalent category in a different list.

The ETP species lists included in this analysis are those for which there are recorded interactions with fisheries associated with the supply chain, or where there is considered to be a risk of the ETP species interacting with a fishery of relevance. Interactions generally include past and current incidents of events such as bycatch or entanglement. A species is considered as interacting if at least one instance of interaction is recorded. Those at risk of interaction include particular species that have been observed in, or are known to inhabit, the area of the fishery or farm, or for instance have direct interactions with different fisheries or farms in the same area.

13.2 Results

13.2.1 All supply chains (wild capture and aquaculture)

It is estimated that a staggering 528 ETP species are at risk of interacting with fisheries and farms associated with the UK's global seafood supply chains, and 253 of these have recorded interactions. In other words, close to half of all the recorded species have had at least one reported direct interaction with a fishery or farm (Figure 118) (Appendix 3).

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[178] *https://www.msc.org/docs/default-source/default-document-library/for-business/program-documents/fisheries-program-documents/msc-fisheries-standard-v2-01.pdf?sfvrsn=8ecb3272_19*

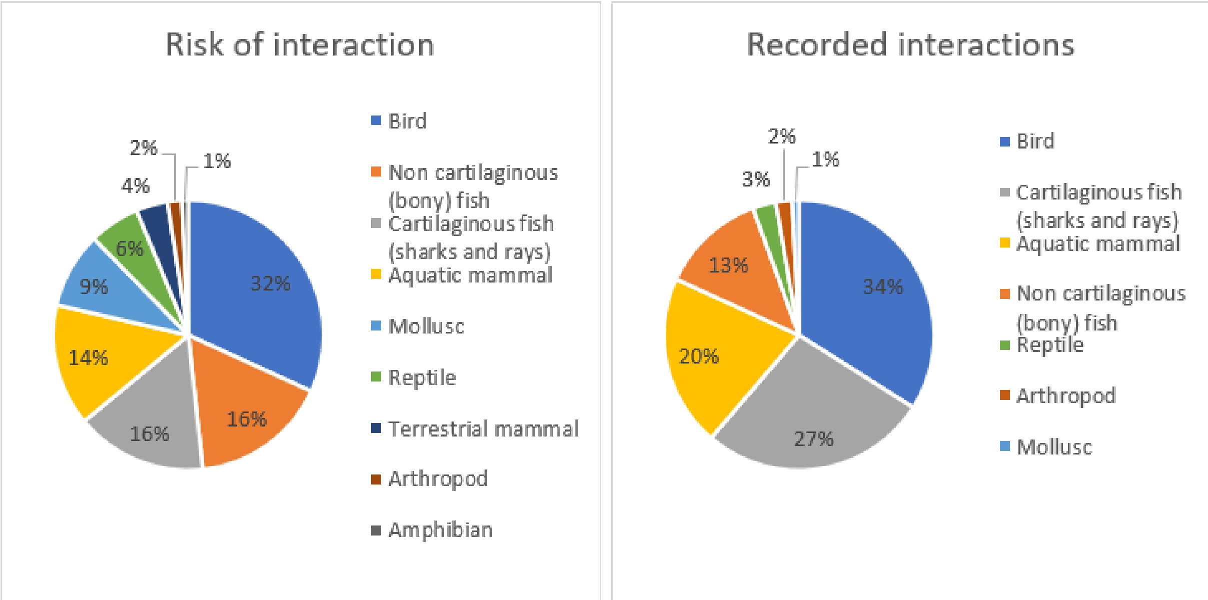


Figure 118: Percentage of all species recorded as (left) at risk of interacting or (right) having had interacted with UK's seafood consumption by species group. Note that data was not available for all supply chains included in this report.

Table 57: Number of species recorded as (a) at risk of interacting or (b) having had interacted with UK's seafood consumption by species group. Note that data was not available for all supply chains included in this report.

Group	(a) Number of species at risk of interaction	(b) Number of species with recorded interactions
Bird	168	86
Non-cartilaginous fish / bony fish	87	32
Cartilaginous fish	83	69
Aquatic mammal	77	52
Mollusc	48	2
Reptile	32	7
Terrestrial mammal	20	0
Arthropod	9	5
Amphibian	4	0
Total	528	253

Birds have the highest number of species recorded both at risk of and having interacted with fisheries and farms. Non-cartilaginous fish or bony fish, cartilaginous fish (shark, skate & ray), and aquatic mammals also make up large proportions of vulnerable species. All four groups equate to 78% of species at risk of interaction and 94% of recorded interactions (Table 57).

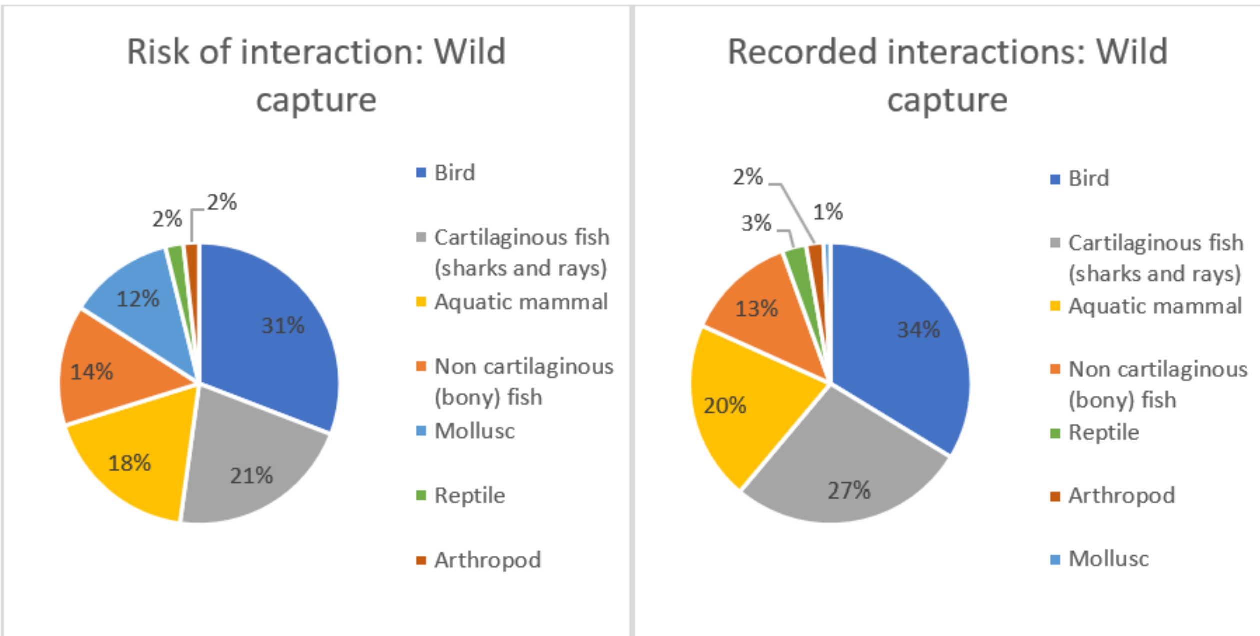
As this analysis is based solely on published information and therefore data are not available for all supply chains, these are considered to be very conservative estimates. In reality, the number of ETP species interacting with fisheries and farms in the UK's seafood supply chains may be much higher.

13.2.2 Wild capture versus aquaculture production

Wild capture fisheries were at risk of interacting, and had recorded interactions, with far more ETP species than those of aquaculture farms. In fact, 252 of 389 species (65%) deemed at risk of interaction have had at least one recorded interaction with fisheries compared to 10 of 188 (5%) for farms (Table 58, with group level percentages also displayed inFigure 119).

Table 58: Number of species recorded as (a) at risk of interacting (b) having had interacted with wild capture fisheries at least once, (c) at risk of interacting with and (d) having had interacted with aquaculture farms at least once, categorised by group. It should be noted that some species are listed as at risk of interaction and recorded as having had an interaction with both fisheries and farms. Data was not available for all supply chains included in this report.

	Wild capture fisheries		Aquaculture farms	
Group	**(a) Number of species at risk of interaction**	**(b) Number of species with recorded interactions**	**(c) Number of species at risk of interaction**	**(d) Number of species at risk of interaction**
Bird	120	85	70	8
Cartilaginous fish	83	69	2	0
Aquatic mammal	70	52	23	2
Non-cartilaginous fish	54	32	39	0
Mollusc	47	2	1	0
Reptile	8	7	27	0
Arthropod	7	5	2	0
Terrestrial mammal	0	0	20	0
Amphibian	0	0	4	0
Total	**389**	**252**	**188**	**10**



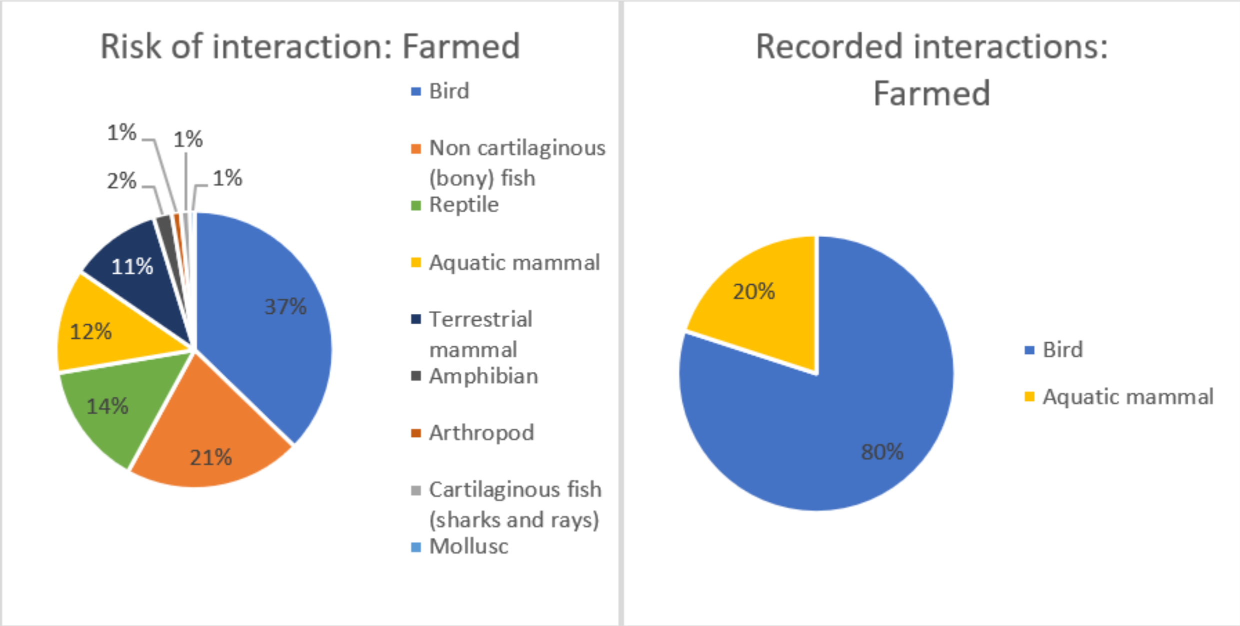


Figure 119: Percentage of species recorded as (top left) at risk of interacting (top right) having had interacted with wild capture fisheries at least once, (bottom left) at risk of interacting with and (bottom right) having had interacted with aquaculture farms at least once, categorised by group. Data was not available for all supply chains included in this report.

Birds are the most affected group for both wild capture fisheries and farms. Farms have recorded interactions with only two species groups, while fisheries have interactions with eight species groups (Table 58).

The majority (80%) of production supply chains included in this report are of wild-caught origin and so this is likely to be a factor in the much higher number of ETP species associated with these supply chains. Furthermore, given that availability of data from certified wild-caught fisheries was higher than certified farms, it could also affect the outcomes of the analysis. However, wild fisheries in general have a much higher risk of interacting with ETP species compared to farms as they are mobile and therefore cover a significantly larger spatial area, meaning they are more susceptible to interaction with non-target species, some of which will be ETP. Therefore, it is expected that supply chains with wild fishery sources are associated with a much higher number of ETP species interactions compared to that of aquaculture production.

13.2.3 Wild capture fisheries and aquaculture in the UK

In the UK, it is estimated that at least 150 ETP species interact with fisheries and farms. Of these, just over a third (38%) of species have recorded interactions (Figure 120).

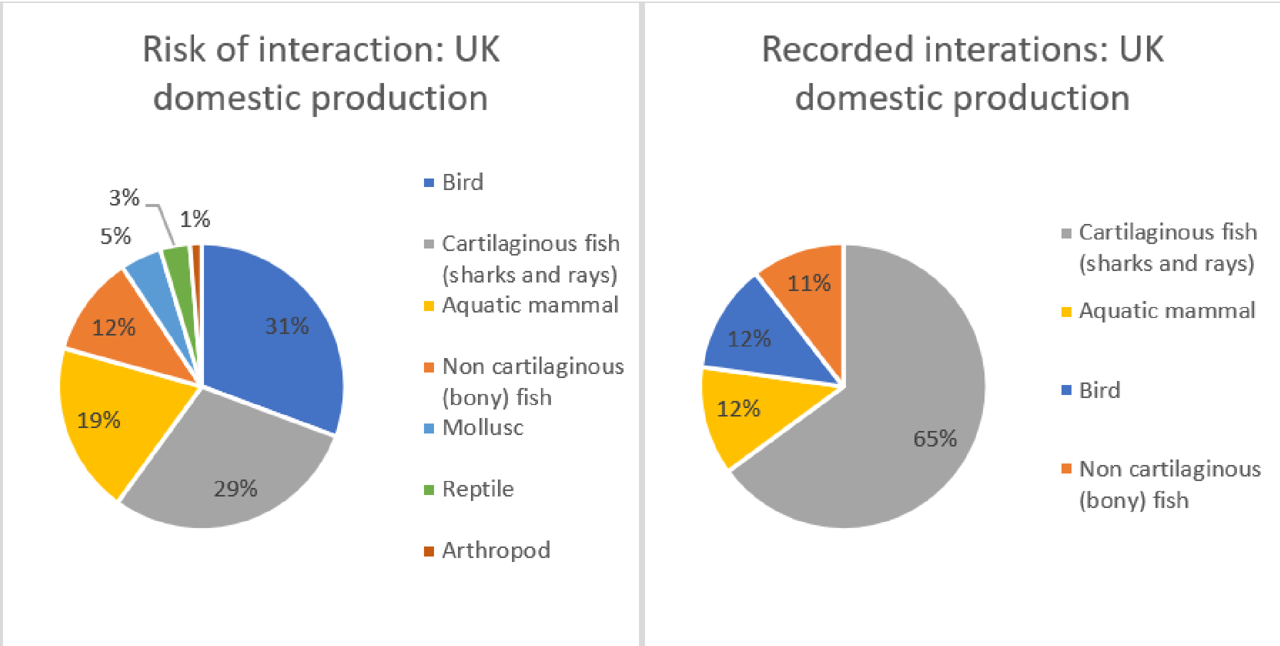


Figure 120: Pie charts of all species recorded as (left) at risk of interacting with a fishery or farm in the UK, or (right) having had interacted with a fishery or farm in the UK at least once, categorised by group. Note that data was not available for all UK supply chains included in this report.

As consistent with the analysis of all supply chains, birds make up the highest number of species considered to be at risk of interaction. However, the majority of interacting species are cartilaginous fish (i.e. sharks, skates, rays, etc.), comprising 61% of those species with recorded interactions with UK fisheries and farms (interactions have been recorded for around 85% of all cartilaginous species considered to be at risk of interaction, compared to 15% for birds) (Table 59).

Table 59: Number of species recorded as at risk of interacting with a fishery or farm in the UK or having had interacted with a fishery or farm in the UK at least once, categorised by group. Note that the count of ETP species at risk of interaction include those with recorded interactions.

Group	Number of species at risk of interaction	Number of species with recorded interactions
Bird	46	7
Cartilaginous fish	44	37
Aquatic mammal	29	7
Non-cartilaginous fish	17	6
Mollusc	7	0
Reptile	5	0
Arthropod	2	0
Total	**150**	**57**

A new report by MacLennan et. al (2021)[179] found that approximately half of Scottish creel fishermen (crab, European lobster, Norwegian lobster or Nephrops) have reported at least one entanglement in the past 10 years. The majority of species reported entangled are cetaceans (e.g. minke whale) and aquatic mammals (e.g. grey seal), as well as a few cartilaginous fish (e.g. basking shark, porbeagle shark). Including results from this report alone would inflate our estimates to 152 ETP species at risk of interaction and 67 ETP species (44%) with recorded interactions.

13.3 Key Limitations in the ETP case study

There are several limitations associated with this analysis, the primary one being an overall lack of reliable information on ETP species that may be impacted by fishing and fish farming activities. This information is not available, particular in some regions like Asia Pacific or Indian Ocean – either at all or within the public domain - for every supply chain considered in this report, leading to results that are more representative of certain supply chains. Data gaps and limitations are largely due to (i) weak or lacking legislative or regulatory requirements for bycatch monitoring, reporting and mitigation, and / or (ii) poor monitoring and reporting and / or (iii) no or limited progress towards sustainable certification. As such, certification reports have become the major sources of information for ETP species interactions in this report. As a result, it is likely that there are geographical biases in the assessment of ETP interactions, with greater information availability in the North Atlantic compared to the Indian and Pacific Ocean. For example, it is found that ETP species interactions on some squid and crab supply chains in Asia Pacific and Indian Ocean tended to be lacking due to the limited progress towards MSC certification and the generally low levels of monitoring in place.

Secondly, where data and information are available from MSC or ASC assessments or FIP reports, there are inconsistencies in the levels of information provided and what is considered an interaction risk. For example, one MSC assessment may list all ETP species in the Baltic Sea as at risk of interaction with the fishery while another may list only those that have interacted with the fishery in the recent past, according to available data. Furthermore, the quality of information on ETP species can vary greatly. Some assessments list ‘all cetaceans’ as at risk of interaction or that a ‘sea gull’ was entangled in a net, whereas others provide detailed species level evidence and analysis. Importantly, there is also a non-standardised, and often subjective, approach to determination of the risk of impact to the ETP species population of any assessed interaction(s) – whether that interaction risk is assumed (e.g. based on spatial overlap of the fishery and ETP species) or supported by bycatch records. A key consideration that tends to be lacking in such as assessment is the cumulative impact of all fisheries (certified or not) on the ETP species population, for example. Moreover, information varies greatly between supply chains associated with the same oceanic region, for example US fisheries compared to those of Russia.

As this report uses a more inclusive definition of ETP and took an overall precautionary approach for our analysis, we included all interactions noted in the literature, whether that be direct capture or entanglement or 1 versus 100,000 interactions with a fishery – and regardless of an assessments’ conclusion over the likely impact on the ETP species’ population. This means there was no deliberate attempt to assess or quantify the scale of

[179] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

impact of such interactions – but rather seek to document the potential breadth of influence of the UK's seafood consumption on non-target ETP species across the world.

14. Case study – UK seafood regulations and stakeholders

The UK seafood supply chain is relatively well developed and has changed little (in terms of major players) in the past few decades. A map of the key stakeholders in the UK's supply of seafood is provided in Figure 121. A brief description of the main roles and responsibilities for each actor is given and as far as possible they have been grouped according to their primary function. Collectively these stakeholders, with others that have not been included due to their more limited roles, influence the UK's supply of consumable seafood products including production, importation and exportation, research and monitoring, regulation and social, ecological and economic impacts.

A number of legislations and guidelines are in place to regulate how seafood is imported and marketed in the UK. The management authorities in the UK on seafood production, consumption and trade are the Department for Environment, Food & Rural Affairs (Defra),the Department of International Trade, the Food Standards Agency (FSA) and equivalent devolved authorities in Scotland, Wales and Northern Ireland (see Figure 121). An overview of these regulations, along with some key gaps, is provided below.

Two major sectors dominate the supply chain throughout the country, namely the retail (supermarket) and foodservice sectors. Around 70-80% of the seafood sold in the UK is supplied by these two sectors, which are discussed in further detail below.

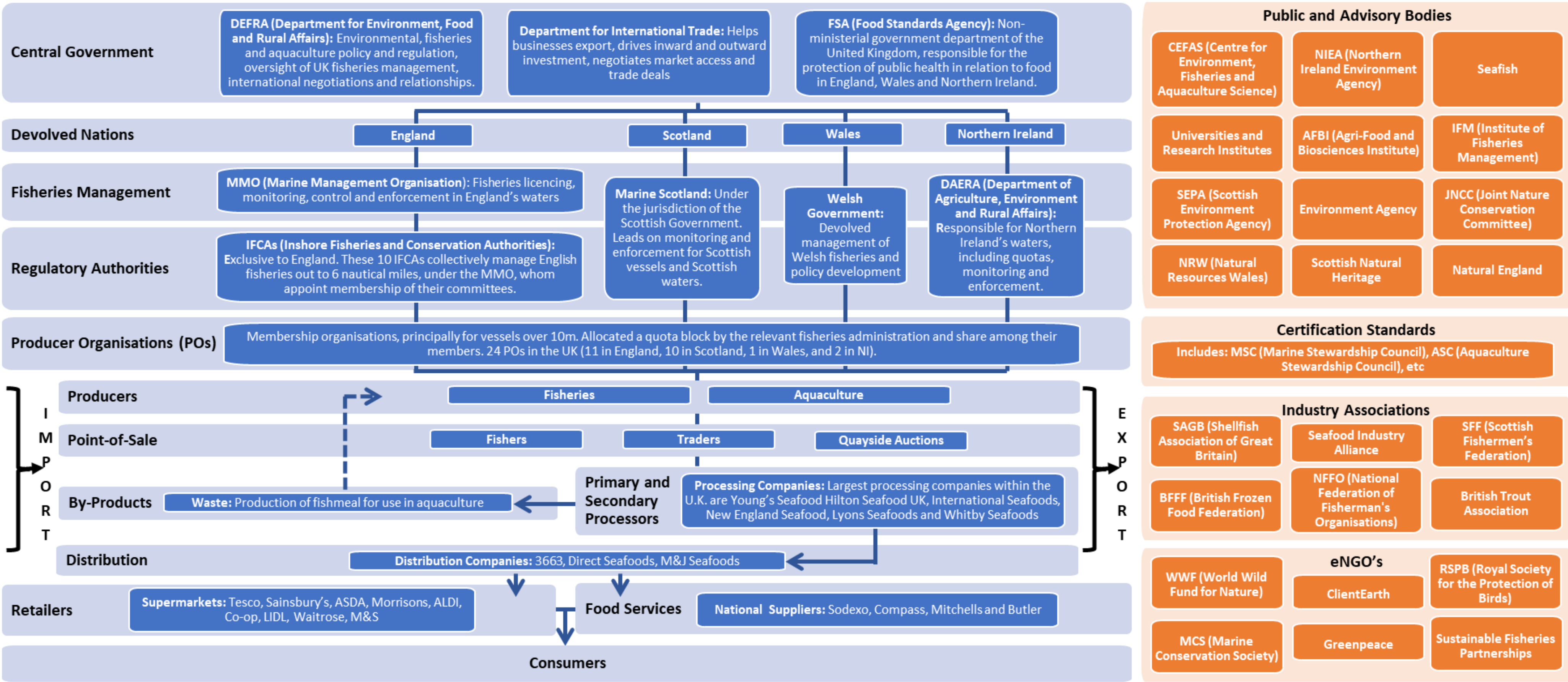


Figure 121: Stakeholder map for UK's seafood supply chain.

14.1 Regulations and policies of the UK seafood production, consumption and trade

14.1.1 Food Laws - Seafood labelling and traceability

Historically seafood regulations have mainly focused on food safety, labelling and traceability. It should be noted that it is not until the last decade when demands on increasing the transparency of the environmental and social sustainability of seafood products have arisen. Key regulations that link to traceability and labelling of seafood products include the Food Information to Consumers Regulation 2011[180], the Fish Labelling Regulations 2014[181] and the Control Regulation 1224/2009[182].

The Food Information to Consumer Regulation 2011 requires all pre-packaged food (including seafood) to include the name, a list of ingredients, country of origin, health claim, nutrition and other general information such as use-by or best before date, storage conditions, the name and address of the manufacturer / packer, etc. The Fish Labelling Regulation 2014 requires additional information such as production methods and catch areas to be provided to consumers. The Production method is expressed as '… caught …' or '… caught in freshwater …' or '… farmed …' or '… cultivated …' to demonstrate whether the seafood products are wild caught or farmed. The catch area information is expressed at the level of UN FAO areas (e.g., example FAO area 27 - North-East Atlantic). This information is thereby limited in detail and arguably accessibility.

The Control Regulation 1224/2009 requires wild-caught and farmed seafood products which are produced within the EU (and UK) to provide traceability and labelling information on the scientific name, catch area, production method, date of catch (wild-caught) and production (farmed), FAO alpha-3 code, name of fishing vessel or aquaculture unit and other information such as commercial designation, information on the supplier and whether the products have been previously frozen or not. However, there are some exemptions for seafood products to follow these traceability requirements including:

- Seafood products with a tariff code of CN1604 (prepared or preserved fish products like canned tuna, caviar and caviar substitutes) and CN1605 (prepared or preserved invertebrates like canned crabs, oyster and mussels);
- Imported seafood products under the IUU Regulation (Council Regulation 1005/2008), and;
- Ornamental fish and seafood products that are farmed or caught in freshwater.

In summary, current regulations require UK seafood traders (e.g. producers, suppliers and retailers) to ensure some level of traceability along the supply chain and provide basic information to consumers such as species name, production method and area of fishing or production. However, there is no legal requirement that an indicator of sustainability performance of the UK's seafood products be provided to consumers through seafood labelling.

[180] https://www.legislation.gov.uk/uksi/2014/1855/made

[181] https://www.legislation.gov.uk/uksi/2014/3104/contents/made

[182] https://www.legislation.gov.uk/eur/2009/1224/contents

Additionally, exemptions create loopholes so that not all seafood products need to provide the same level of information to the public. The potential mislabelling issue is particularly risky for seafood that has been processed multiple times and their forms have significantly changed (e.g. breaded fish fingers or surimi). See details in the Case Study on the processing countries in Section 15.

14.1.2 Domestic UK seafood production (fisheries and aquaculture)

Until 2020, seafood production (i.e. wild-caught fisheries and aquaculture) in the UK was under the regulation of the EU Common Fishery Policy (CFP) (Regulation 1380/2013)[183], ratified by a number of legislations, including the Sea Fisheries (Shell fish) Act 1967[184], Sea Fish (Conservation) Act 1967[185] and Fisheries Act (1981)[186] in England and their equivalents for the devolved administrations.

With the UK withdrawal from the EU and new status as an independent coastal state, a new UK Fisheries Act was passed in 2020 to replace the EU CFP.

The UK Fisheries Act (2020)[187] sets out the rules of seafood production in the UK with eight objectives that can be summarised as follows:

1. Sustainability objective – fish and aquaculture activities are environmentally sustainable, have economic, social and employment benefits, and contribute to the availability of food supplies; and do not overexploit marine stocks.
2. Precautionary objective – fisheries management applies the precautionary approach and populations of targeted species are managed above Bmsy.
3. Ecosystem objective – using an ecosystem-based approach to manage fishing and aquaculture activities so that any negative impacts are minimised or reversed; and incidental catch of sensitive species are minimised or eliminated.
4. Scientific evidence objective – scientific data are collected, shared and utilised for the management of fishing and aquaculture activities.
5. Bycatch objective – catching of undersized or other bycatch fish are minimised or avoided and recorded; landing of bycatch does not create an incentive to catch undersized fish.
6. Equal access objective – UK fishing boats have equal access to UK waters regardless of their home ports and ownerships.
7. National benefit objective – fishing activities will bring social and economic benefits to the UK.
8. Climate objective – fishing and aquaculture activities adapt to climate change and their negative impacts on climate change are minimised.

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[183] https://www.legislation.gov.uk/eur/2013/1380/contents

[184] https://www.legislation.gov.uk/ukpga/1967/83/contents

[185] https://www.legislation.gov.uk/ukpga/1967/84

[186] https://www.legislation.gov.uk/ukpga/1981/29/contents

[187] https://www.legislation.gov.uk/ukpga/2020/22/contents/enacted

However, the Act does not provide full details on how these objectives will be achieved nor the targets for these objectives[188]. To meet the objectives of the Fisheries Act, a Joint Fisheries Statement (JFS) will be produced by the four national fisheries policy authorities in England, Scotland, Wales and Northern Ireland. It is required that the JFS be produced within two years of the Fisheries Act being passed.

The JFS must be reviewed once every six years although it can be amended or replaced at any time, where necessary. Furthermore, the implementation and effectiveness of the JFS must be reported every three years.

At the time of writing this report, a consultation on the draft JFS had just been launched[189], with the timeline for publication of the final JFS stated as November 2022. It is therefore premature to determine whether the Fisheries Act is an effective regulation to ensure the ecological, social and economic sustainability or to minimise the footprint of UK's domestic seafood production. It should be noted that the Fisheries Act was criticised due to its lack of ambition to set real sustainable stock targets to end overfishing and failure to include remote electronic monitoring (such as on-board cameras) to achieve fully documented fisheries in the UK[190].

Of particular concern is that in May 2022 the Office of Environmental Protection (OEP) called for urgent action by the UK government to restore the fish stock levels and to protect the marine habitat from indiscriminate fishing gears[191]. Additionally, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) reported that in 2020 only 34% of UK's Total Allowable Catches (TACs) were consistent with the ICES scientific advice[192]. To achieve the Good Environmental Status (GES) for the UK Marine Strategy and meet the ambitions of the UK 25 Year Environment Plan, more must be done to address these issues.

Regulations of aquaculture or farmed seafood in the UK are more complicated. While the Fishery Act 2020 covers aquaculture, most regulations and management of aquaculture in the UK are under devolved administrations in England, Scotland, Wales and Scotland since fish or shellfish farms are location specific. There are a number of national and devolved legislations such as the Sea Fisheries (Shell fish) Act 1967[193] (England and Wales), the Aquaculture & Fisheries (Scotland) Act 2013[194], and the Fisheries Act (Northern Ireland) 1966[195] which set rules on how farmed seafood species are produced in the UK.

As there is a wide range of farmed seafood from land-based trout farms, inshore fish cages for salmon to rope-grown or seabed grown mussels or oysters, additional regulations - 'several' or

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[188] https://www.fisheriesappg.org/blog/2020/12/16/the-fisheries-act-2020-what-you-need-to-know

[189] https://www.gov.uk/government/consultations/draft-joint-fisheries-statement-jfs

[190] https://www.sustainableseafoodcoalition.org/fisheries-bill/

[191] https://www.theoep.org.uk/taking-stock

[192] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1061261/Assessing_negotiated_catch_limits_2020_to_2022.pdf

[193] https://www.legislation.gov.uk/ukpga/1967/83/contents

[194] https://www.legislation.gov.uk/asp/2013/7/contents

[195] https://www.legislation.gov.uk/apni/1966/17

‘regulating’ orders, are also applied to manage the farming activities such as licensing, water quality, feed, animal welfare, etc. Some further key regulations applicable to the aquaculture sector in the UK are listed in Table 60. As these regulations are beyond the scope of this report, they will not be discussed further here.

Table 60: Additional regulations applicable to the aquaculture sector in the UK.

Regulation	Main Purpose
Aquatic Animal Health (England and Wales) regulations 2009[196]	To authorise an aquaculture production business in England and Wales.
Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011[197]	To manage the use of alien and locally absent species in aquaculture.
Marine (Scotland) Act 2010[198]	To manage Marine Licence, navigational risk or discharge from boat.
Aquatic Animal Health (Scotland) Regulations 2009[199]	To authorise an aquaculture production business in Scotland.
Animal Health and Welfare (Scotland) Act 2006[200]	To manage the health and welfare of animals in Scotland.
Aquatic Animal Health Regulations (Northern Ireland) 2009[201]	To manage the health of aquatic animals in Northern Ireland.
The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations (Northern Ireland) 2007[202]	Environmental Impact Assessment for fish farming.

Being the most valuable aquaculture species in the UK, there is an ambition to further expand the production of farmed salmon. However, concerns that the current regulations are not adequate to protect the marine environment in Scotland have been raised[203].

14.1.3 International seafood trade

Although a significant amount of seafood is imported into the UK each year, there are no national laws or regulations to ensure due diligence for imported seafood, for example, to ensure it is sourced from well-managed fisheries or farms that do not cause negative impacts (e.g. overfishing, catching of endangered species or pollution) on the marine environment or local communities. In other words. there is no legal requirement for imported seafood to meet

196 https://www.legislation.gov.uk/uksi/2009/463/contents

197 https://www.legislation.gov.uk/uksi/2011/2292/contents

198 https://www.legislation.gov.uk/asp/2010/5/contents

199 https://www.legislation.gov.uk/ssi/2009/85/contents

200 https://www.legislation.gov.uk/asp/2006/11/contents

201 https://www.legislation.gov.uk/nisr/2009/129/contents/made

202 https://www.legislation.gov.uk/nisr/2007/23/contents/made

203 https://www.scotlink.org/files/documents/LINK_ECCLR_Salmon-Aquaculture-inquiry_Written-Evidence-Feb-2018.pdf

any minimum standard that is equivalent to the UK Fisheries Act (2020) (or previous equivalents or current complementary legislations).

As the UK Fisheries Act aims to help the UK become a leader in sustainable seafood production, efforts should be made to ensure fishers and fish farmers in the UK are not undercut by imports of seafood produced to lower environmental and animal welfare standards. Indeed, it has been reported that 74% of UK's public said that food produced in countries with lower standards should not be available in the UK[204].

The UK Fisheries Act has set sustainability objectives for UK seafood production and imported seafood should at least meet similar requirements. As a net importer of seafood, it is particularly important for the UK Government to create a level playing field so that shared global resources like seafood are sustainably managed, at home and overseas. There are calls for the UK Government to develop core environmental standards for food production[205] to address nature and climate crises.

As an example, the import Provision[206] of the Marine Mammal Protection Act (MMPA) in the United States ensures seafood imported from foreign countries has comparable standards that are equivalent to the requirements for the United States' domestic seafood production in reducing the bycatch of marine mammals[207].

Nevertheless, the transposed EU IUU Regulation (Council Regulation 1005/2008)[208] provides a certain level of assurance to prevent, deter and eliminate imported seafood from entering the UK through illegal, unreported and unregulated (IUU) fishing activities. The EU IUU Regulation has been enforced since 2010 and was retained in UK law in 2020 through the European Union (Withdrawal) Act of 2018. Specifically, the regulation aims to ensure:

- Only verified legal marine fisheries products can be imported to the UK from a competent flag state or export countries via catch certificate scheme.
- The updating of the IUU vessel list based on the IUU vessels identified by FAO Regional Fisheries Management Organisations.
- The possibility of blacklisting countries from exporting fisheries products to the UK if they allow illegal fishing activities.
- A substantial penalty will be issued to any UK operators who fish illegally anywhere in the world regardless of flag state.

The EU IUU Regulation, particularly the blacklisting system, has been considered an effective tool for the EU to encourage exporting countries of seafood to improve their fisheries management. However, it has also been criticised due to lack of transparency on the criteria of blacklisting by the European Commission. Furthermore, while there are some estimates of IUU

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[204] https://www.itv.com/news/2020-06-25/majority-of-britons-oppose-weakening-of-food-standards-under-uk-us-trade-deal

[205] https://www.wwf.org.uk/updates/environmental-standards-food-trade

[206] https://www.fisheries.noaa.gov/foreign/marine-mammal-protection/noaa-fisheries-establishes-international-marine-mammal-bycatch-criteria-us-imports

[207] https://www.wwf.org.uk/sites/default/files/2021-03/MMPA%20Briefing%20final%20draft_0.pdf

[208] https://www.legislation.gov.uk/eur/2008/1005/contents

fishing at global and EU levels, it is not clear in what quantities IUU seafood products have entered the UK annually. The UK government is reviewing its IUU strategy after leaving the EU and so it remains to be seen how effective any future amendments to the transposed regulation will be.

In addition, unlike those 'Forest Risky Commodities' (FRC) like palm oil and soy that are now covered in the recently passed Environment Act 2021, that requires companies to conduct due diligence on their supply chains to avoid illegal importation of these FRC commodities, there is no similar requirements for imported seafood, apart from the Catch Certificates issued by the exporting countries[209].

The potential risk is that the UK actually goes backwards on progress against IUU made through the EU system. This report highlights that the UK Government needs to secure better monitored, controlled and regulated fisheries for the UK's seafood supply chain network.

14.2 The UK's Retail Sector

The UK supermarket sector is the dominant retail outlet type in the country and therefore is the primary consideration here. The Sustainable Food Trust[210] estimated that 74% of all UK food shopping in 2019 was completed in the UK supermarket sector (including online sales and discount stores). The other major player is local convenience stores, but this does not necessarily apply for seafood products (which tend not to be sold in smaller convenience stores). Furthermore, the small convenience stores are becoming more and more dominated by the major supermarket brands.

As an illustration of how the shopping sector has changed, the same Sustainable Food Trust report estimated that fishmonger numbers in the UK have fallen from 8,000 in 1940 to around 950 in 2019. Most UK consumers will buy fish products from a supermarket outlet (in store or increasingly, on-line).

The UK supermarket sector had also remained relatively unchanged until recently with the introduction of the German discounters in the sector (i.e. Aldi and Lidl) which have taken a significant share from the traditional retailers. The UK supermarket split by market share (across Chilled, Frozen and Ambient) is set out in Figure 122below[211].

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[209] https://www.gov.uk/guidance/importing-or-moving-fish-to-the-uk

[210] https://sustainablefoodtrust.org/articles/we-still-need-alternatives-to-supermarkets-perhaps-now-more-than-ever/

[211] https://nielseniq.com/global/en/solutions/homescan/

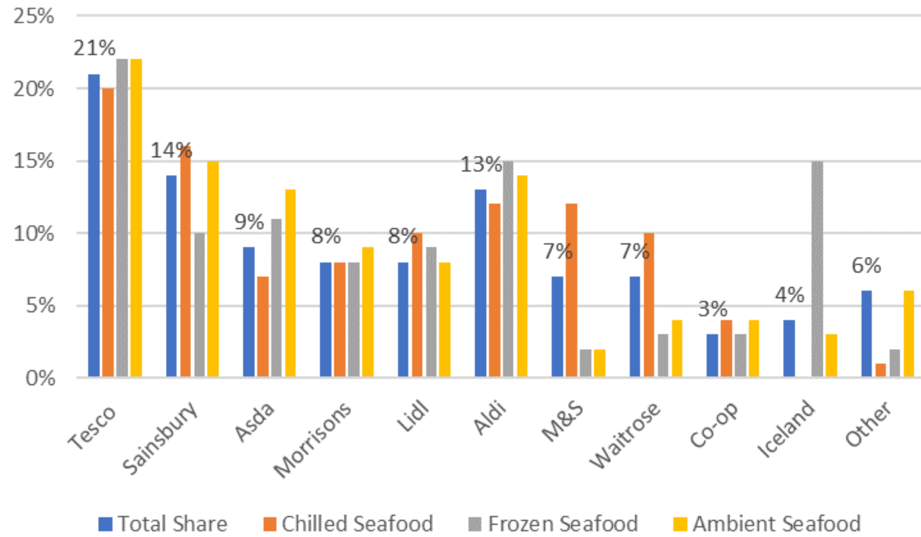

Figure 122: UK supermarket split by market share (in total (blue) with percentage and across Chilled, Frozen and Ambient).

The UK supermarket scene remains dominated by the 'big four' of Tesco, Sainsburys, Asda and Morrisons (52% of market share). At the higher end, the likes of M&S, Waitrose and Co-Op can be seen to have a significant portion of the chilled seafood sector (26%), when compared to the larger more traditional supermarkets. Iceland mainly focuses on frozen products including seafood.

The UK seafood supply chain to the supermarket sector in the UK is quite small and focused on a few major processing companies. While some companies have maintained long-term links with supermarkets, it is also common for contracts to change quite regularly between supermarkets and processors (often on a yearly basis) in what is a very competitive market. The main processing suppliers in the UK are Young's Seafood Group Ltd., Hilton Seafood UK, New England Seafood International (NESI), Nippon Suisan Kaisha Ltd., and Lyons Seafoods.

14.2.1 How do sustainable sourcing policies work in the retail sector?

In the UK, all supermarkets have a seafood specific sustainable sourcing policy in place which sets out the key parameters they have for the supply of fish and seafood products. However, the supermarkets are generally not responsible for the direct purchasing of seafood products themselves. Instead, this is completed by the processors (as above) who work on behalf of the supermarket through an agreed contract.

Processors are required to tender for the supply of products to most supermarkets and part of this tender will be requirements on sustainability of the products received. This will include any specifications on certification requirements for products. These tenders can be product or range specific and cover one to ten years (it depends on the retailer's approach).

The supermarkets will ensure that they 'approve' the supplies that the processor has selected, and in many cases, this is specifically set out by the retailer in the tendering process (for example, cod from Iceland and Norway). On this basis, it is the processors that have been playing an important role to help drive the sustainability credentials of the products that supermarkets stock.

In recent years, a move towards precompetitive sustainability platforms has become more prominent with the Sustainable Seafood Coalition (SSC) being a case in point. The SSC[212] is a membership-based partnership of UK business, and was originally set up in 2011 with the aim of promoting a more industry wide approach to sourcing sustainable seafood. In the UK retail sector, almost all the major supermarkets and many suppliers are members of the SSC.

By signing up to the SSC, a member commits to completing a regular risk assessment on its seafood supply chain. The member should then put actions in place to reduce the issues associated with high-risk fisheries, often through the commencement of Fishery Improvement Plans (FIPs), for example. In cases when the fishery cannot or will not move to a lower risk rating, the member is required to action which could include delisting of the fishery from sourcing. The SSC supports the systems already in place for most of the retailers and provides another level of scrutiny while also providing a more 'joined-up' approach to sustainable sourcing.

A few key observed patterns can be seen in the sustainable sourcing policies of the UK's main supermarket retailers and their suppliers (i.e. processors):

1. All retailers discussed now require most farmed products to be certified by either the ASC, Global GAP or BAP. For some these commitments cover all products, while for others it is only the own-brands which are covered. On this basis, it is becoming increasingly rare to find aquaculture products on the UK supermarket shelves which are not covered by a third-party certification scheme.
2. For wild-caught fish, the policies are less consistent. In some cases, commitments have been made on sourcing (mainly around 100% MSC certification) which have been amended and extended.
3. In general, all retailers operate a risk-based approach but from here the approaches vary. Some are committed to 100% third-party certified for all products by a certain year, some to 100% own-brand certified and others to a more generic 'responsibly caught' requirement.
4. All retailers have introduced a specific 'tuna policy', with many requiring tuna to be sourced from Fish Aggregating Device (FAD) free[213], pole & line or MSC certified fisheries. However, for some this covers own brand products only.
5. Generally, with some retailers, the policies in place may suggest an approach which aims to improve a current supply chain as best as possible, resulting sometimes in only minor changes to policies than a simply stopping sourcing approach.
6. Many retailers have also other joined precompetitive sustainability platforms, such as the Global Tuna Alliance[214] (GTA) and North Atlantic Pelagic Advocacy (NAPA) Group[215], to help provide a more joined up approach to sustainability within the industry. This is likely to continue as a growing trend.

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[212] https://www.sustainableseafoodcoalition.org/

[213] For a discussion of the impacts and benefits of FADs in the global tuna industry, see: https://www.wwf.org.uk/sites/default/files/publications/Mar17/Tuna%20fisheries%20FADs%20report%20-%20MRAG_WWF.pdf

[214] Global Tuna Alliance: https://www.globaltunaalliance.com/

[215] NAPA: https://www.seafish.org/responsible-sourcing/uk-fisheries-management-and-supply-chain-initiatives/north-atlantic-pelagic-advocacy-group/

7. Finally, the carbon footprint of the UK seafood supply is almost non-existent in most retailers' policies with little consideration of potential blue carbon impact, food miles, green credentials and Scope 3 emissions of the farming or fishing method.

14.3 The UK's Foodservice Sector

The foodservice sector in the UK includes the supply of a large majority of pubs, restaurants and catering companies (the contract sector). The sector itself is worth £57 billion and is said to be the fourth largest employer in the UK. The UK supply chain for seafood is dominated by a few very large suppliers who provide the majority of product to all settings.

The UK has a very strong catering sector which is used by private and public companies alike for their catering needs. Within this sector, four significant catering companies exist all of which compete for individual or group contracts on a regular basis[216]: Compass Group, Sodexo, Arramark and Baxter Storey.

All of the four catering companies above are predominantly supplied by the same fish suppliers. This is vital to their business model as it allows them to negotiate on price through significant volume purchasing agreements (i.e. by buying all fish products from limited suppliers they are able to produce a significant economies of scale). The two major food service processors / suppliers for these companies are Brakes Bros and M&J Seafood, and Bidvest & Seafood Holdings Ltd.

Within the UK, most of the fresh and frozen seafood products that are supplied to the UK food service sector are from the two companies listed above. As a result, they are significant players in the UK fish purchasing sector. Both receive seafood either directly from source or in many cases through sub-contracted processors, which tend to be the same as those set out for the retail sector (two completely separate supply chains do not exist but tend to be the same at the point of entry and then split). For fresh seafood products, the supply tends to be more direct, while for frozen it is more common for it to be provided through the retail processor path. The main role of the companies is to take the raw material and prepare and distribute it accordingly. For fresh fish, this can be incredibly time consuming, with each consumer wanting a slightly different product form or type (little conformity exists across the buyers).

The sustainability policies set out by the food service sector are comparatively not as developed as those for the retail sector. This is mainly due to far less public scrutiny than is often seen for the supermarket sector, but also because of a much wider diversity within the businesses (they are catering for large high catering sites right down to a small café). It is also true that the fresh foodservice sector tends to supply a greater volume of UK caught fish from often smaller fisheries. For these, it is not as easy to apply blanket requirements (such as third-party certification). Nevertheless, some companies have also signed up to SSC as members. A few general observations are summarised here:

1. Similar to retailers, the foodservice services providers also operate a risk-based approach and some are SSC members.

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[216] *It is noted that a vast number of foodservice companies exist in the UK. However, the four mentioned here control around 85-90% of the market and so are clearly the most important for this discussion.*

2. Owing to a greater use of UK produced seafood, most foodservice's sustainability polices are based around the MCS Good Fish Guide[217] ratings system which covers a wide range of UK seafood species.
3. No supplier makes specific commitments (i.e., 100%) about only supplying wild fish from MSC or ASC certifications sources.
4. All have some commitments relating to social requirements, although these are quite loosely formed.
5. None have any requirements specific around carbon footprint requirements for seafood supply chains.

[217] *https://www.mcsuk.org/goodfishguide/*

15. Case study – Processing countries of the UK seafood supply chain

15.1 Overview

The UK is very much a market which focuses on processed products, with few UK consumers interested in whole fish traditionally. After seafood is harvested, it is transported and packed for distribution to processing plants or wholesalers. Seafood processors convert the whole animal into other product forms such as fresh fish fillets, frozen, canned or smoked products. Some of these products then might be converted by secondary processors to ready meals such as boil in the bag fish fillets with butter or sauce. Wholesalers and foodservice distributors then receive both raw and processed products and distribute them to retail stores and restaurants. The infographic below summarises the process in the context of the seafood supply chain (Figure 123).

Seafood products available in the UK are often processed multiple times in this way. Seafood processors or processing countries are positioned half-way between harvesters (wild-catch fish and aquaculture) and consumers in long, complex and transnational supply chains, and handle most of the fish produced globally.

Think tank Planet Tracker identified in a 2020 report[218] that >4,600 companies process seafood globally, more than one-third headquartered either in China or Japan. Twelve countries have more than a hundred companies (Figure 124), accounting for three-quarters of the total number of companies globally. These individual companies are ultimately owned by 4,000 different entities.

[218] https://planet-tracker.org/tracker-programmes/oceans/seafood/#traceable-returns

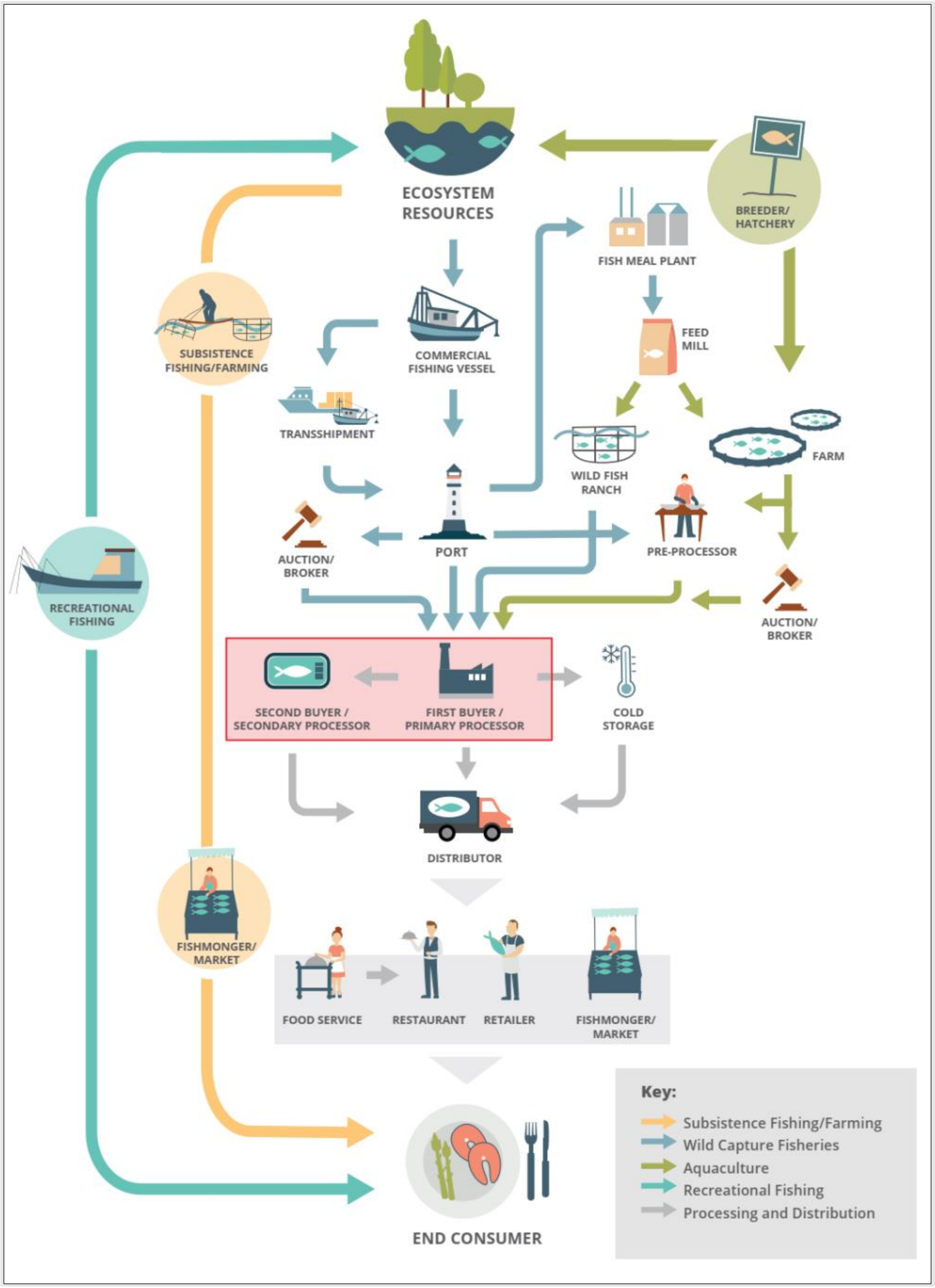

Figure 123: Seafood Processing (highlighted in red) in the Context of the Seafood Supply Chain (Diagram courtesy of FishWise (2018), Advancing Traceability in the Seafood Industry). Image taken directly from Planet Tracker report[219]

[219] *https://planet-tracker.org/wp-content/uploads/2021/08/5.-Traceable-Returns.pdf*

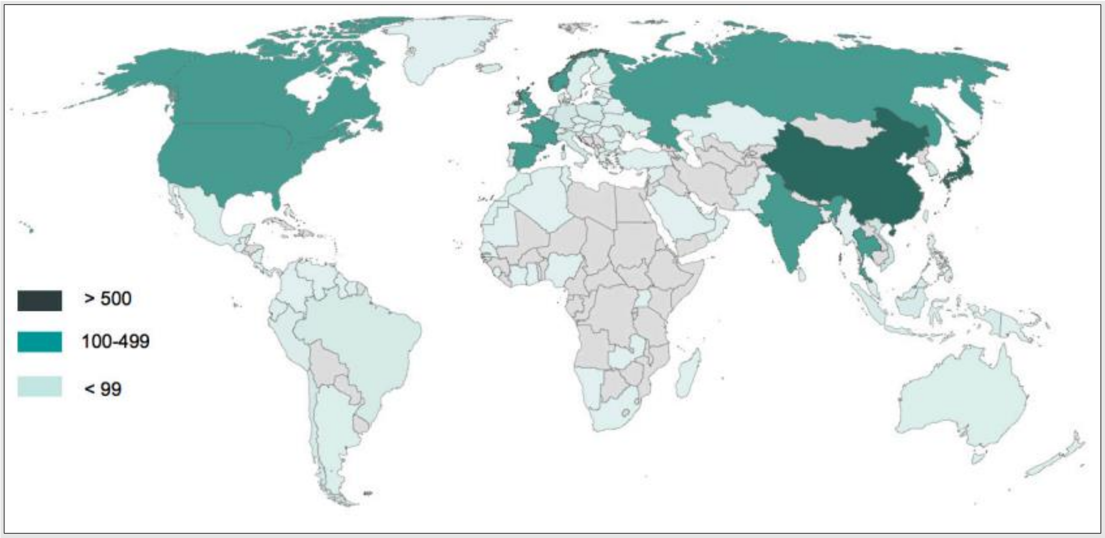

Figure 124: Number of Seafood Processing Companies by Country. Image taken directly from Planet Tracker report. Source: FactSet 2020.

15.2 Findings from this report

At least 16% (80,794 tonnes) of the 509,448 tonnes of focus commodities (see Sections 5-12 of the report) that were imported into the UK by the main source countries in 2019, arrived from an intermediary country[220]. For the purposes of this discussion, it is assumed that those countries represent processing steps in the supply chains. However, some may instead represent trade routes e.g. where the product is transported from the source (producing) country to its final destination via one or more countries, for the purposes of onward transportation. Some intermediary countries may represent both processing and trade routes for a given seafood resource. The resource may also have been produced in relatively small quantities by the intermediary country itself. A key limitation of the HMRC trade data, and other data sources related to seafood supply chains, is the inability to trace resources to their origin.

Figure 125 shows the UK's seafood imports assessed in this report which are assumed to have arrived from a processing (or trading) country, broken down by commodity. This indicates that wild caught and farmed whitefish are the commodities imported in the greatest proportions from a processing (or trading), rather than a producing country. As shown in Figure 126, the main processing country in the UK seafood supply chain by far is China (accounting for 66% or 53,613 tonnes of 2019 imports that are assumed to have arrived from an intermediary country).

[220] *Had Atlantic salmon imports from Sweden not been fully reassigned to Norway on the assumption it was the source country, this figure would be higher and Sweden would be viewed as the second main source of imports from an intermediary country, after China.*

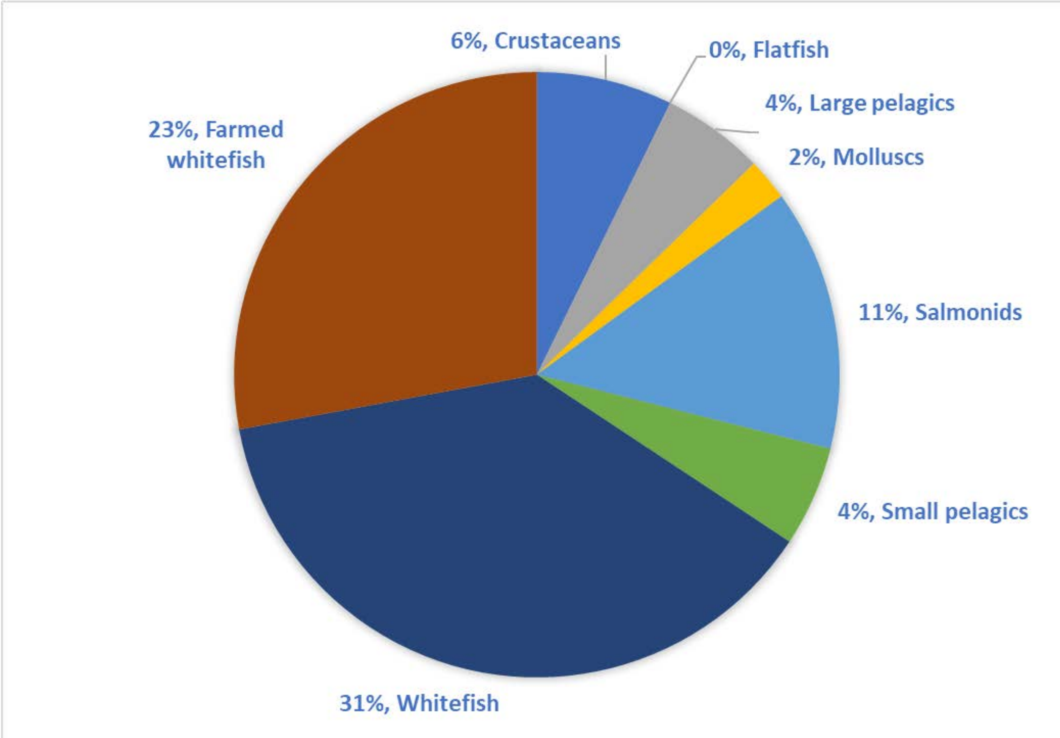

Figure 125: In 2019, around 16% (80,794 tonnes) of assessed UK seafood imports are assumed to have arrived from intermediary (processing / trading) countries, rather than from the producing country. Pie chart shows the proportion (%) of these processed / traded resources represented by each commodity category.

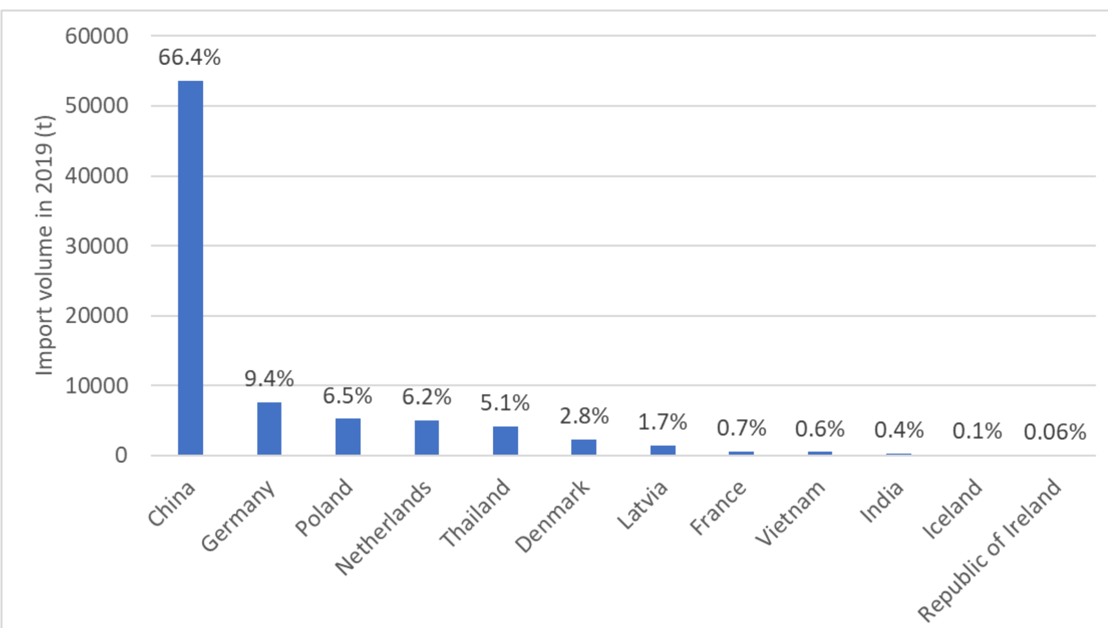

Figure 126: Total volume (tonnes) of imports in 2019 from each country identified as an intermediary (processing/trading) in the assessed UK seafood supply chains. The proportion (%) of those total imports (80,794 tonnes) associated with each assumed intermediary country is also shown.

Figure 127 provides a breakdown of the imports from the main processing / trading countries involved in the UK's seafood supply chain. Between 2015 and 2019, Alaskan pollock and Atlantic cod dominated China's supply of processed fish to the UK. Alaskan pollock is also an important export product for both Germany and Poland's supply of processed seafood to the UK market, along with Atlantic salmon for Germany and Pacific salmon for Poland. For Sweden (not shown), 100% of processed exports to the UK were Atlantic salmon (assumed to have originated in Norway). Sea bass and sea bream, presumably produced in Turkey and / or Greece (see Section 11), make up a significant proportion (~78%) of processed fish exports from the Netherlands to the UK, along with warm-water prawns (~17%).

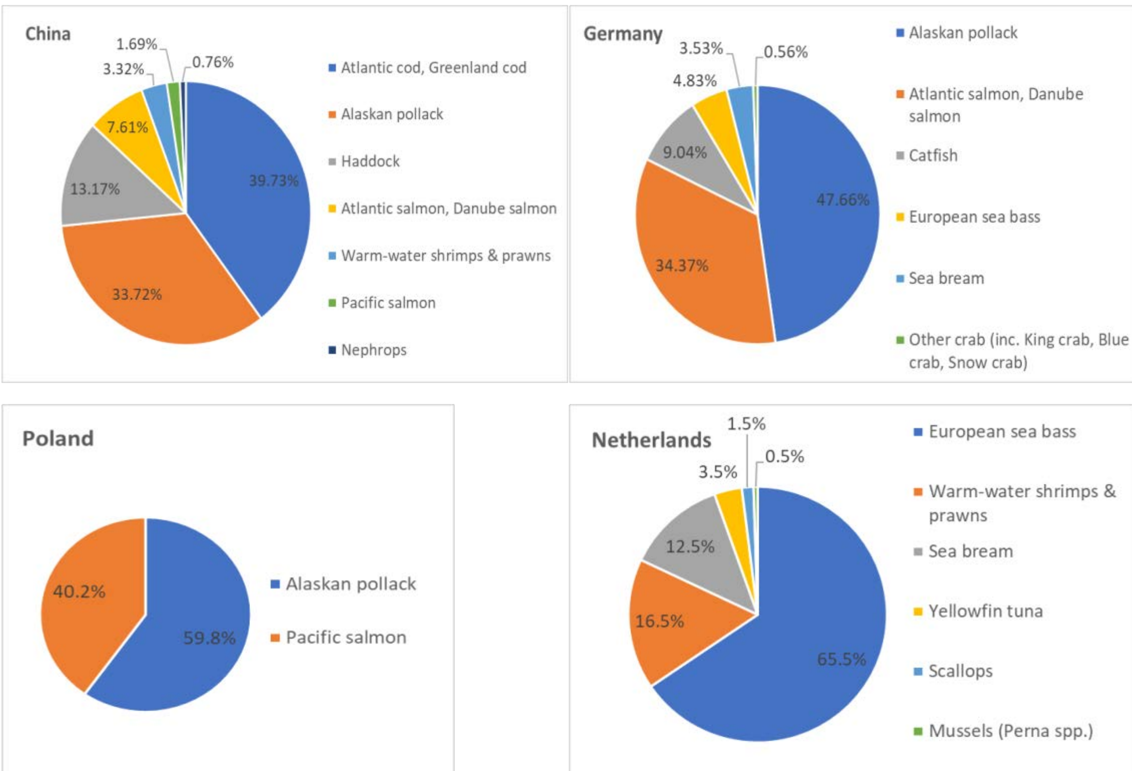

Figure 127: Average annual percentage (%) composition between 2015-2019 of processed imports from four main processing supply countries. Sweden is not shown as 100% of processed imports are Atlantic salmon.

Table 61 shows that China typically dominates the UK's imports of Alaskan pollock (46%)[221] and 51% of the European sea bass imported by the UK arrives from the Netherlands, with both countries thereby making significant contributions to the UK's consumption of these species (54% and 44% in 2019, respectively). Other key contributions from processing countries include sea bream from the Netherlands, Atlantic cod from China, 'other' crabs from Denmark and Norway lobster from Vietnam.

Between 2015 and 2019, an average of 40% of the UK's imported Atlantic salmon arrived from Sweden, contributing around a quarter of the UK's consumed salmon in 2019. This finding was

[221] *China also dominates the UK's imports of Pacific cod (>50%), however those imports are assumed to have originated from the US and Russia for the purposes of the assessment*

unexpected given that Sweden’s production of salmon is relatively low compared to other Northern European countries (such as Norway, the Faroe Islands and the UK). There is some conjecture that retailer like Ikea may be a key driver of this finding e.g. “*IKEA Food Services AB has become one of the largest vendors of responsibly sourced seafood in the world*” [222], an interesting link in the supply chain that warrants further investigation. However, it is assumed for the assessment that the salmon arriving from Sweden is farmed in Norway (Sweden therefore does not feature in Table 61).

[222] https://about.ikea.com/en/sustainability/responsible-sourcing/seafood-you-can-feel-good-about

Table 61: Processed resource breakdown for top 10 processing countries for UK seafood supply chains in 2019.

Processing country	Resource	Imports in 2019 (t)	Average % of total imports 2015-2019	% of UK consumption in 2019
China	Alaskan pollack	20360	46%	54%
	Atlantic cod, Greenland cod	21214	18%	19%
	Atlantic salmon, Danube salmon	3816	5%	3%
	Haddock	6494	13%	8%
	Nephrops	19	15%	0%
	Pacific salmon	854	5%	7%
	Warm-water shrimps & prawns	856	3%	2%
Denmark	European lobster, American lobster	96	5%	3%
	Other crab (inc. King crab, Blue crab, Snow crab)	579	30%	28%
	Pacific cod, Greenland cod	470	8%	9%
	Albacore tuna	0.11	33%	6%
	Warm-water shrimps & prawns	1121	2%	2%
France	Pacific salmon	557	5%	5%
Germany	Alaskan pollack	3162	15%	8%
	Atlantic salmon, Danube salmon	2684	5%	2%
	Catfish	1269	6%	9%
	European sea bass	237	7%	3%
	Sea bream	244	9%	7%
	Other crab (inc. King crab, Blue crab, Snow crab)	30	3%	1%
India	Norway lobster	329	13%	1%
Latvia	Mackerel	1408	5%	7%
Netherlands	European sea bass	3363	51%	44%
	Sea bream	567	24%	19%
	Mussels (Perna spp.)	19	4%	3%
	Scallops inc. Queen scallops	141	6%	12%
	Warm-water shrimps & prawns	921	2%	2%
	Yellowfin tuna	17	3%	0%
Poland	Alaskan pollack	3326	7%	9%
	Pacific salmon	1911	11%	16%
Republic of Ireland	Mussels (Perna spp.)	51	9%	8%
Thailand	Skipjack tuna (or Stripe-bellied bonito)	4033	7%	4%
	Yellowfin tuna	89	2%	1%
Vietnam	Norway lobster	484	24%	2%

15.3 Key risks associated with seafood processing in supply chains

Given these complexities in international supply chains, it is no surprise that issues now commonly highlighted include mislabeling of products, a lack of traceability, carbon footprint, and uncertainty around other issues associated with buying seafood products (such as lack of information on supply chain contribution to other social and environmental issues).

15.3.1 Labelling

A Guardian Seascape analysis[223] of 44 recent studies of over 9,000 seafood samples from restaurants, fishmongers and supermarkets in more than 30 countries found that 36% were mislabeled. Using DNA analysis techniques to identify true species, in a comparison of sales of fish labelled ‘snapper’ by various retailers in Canada, the United States, the UK, Singapore, Australia and New Zealand, mislabeling was found in ~40% of fish tested. The UK and Canada had the highest rates of mislabeling in that study at 55%, followed by the United States at 38%. Another study in 2018[224] found up to 60% of premium Chinese cod fillet products in China were mislabelled and were other species of fish such as pollock. In a separate study on Chinese processing sector traceability, it was reported that many instances of miscoding by species of imported raw materials were observed, in some cases exacerbated by the lack of definition in the existing coding system[225]. With potentially up to 37% of such products being imported into the UK from China, this is cause for concern. Though it must be noted that the proportion imported from China may reduce over time, given incomes are rising in China[226] and the advantage to UK exporters of low-cost labour may be a thing of the past. It is likely that exported processing capacity will either shift to other countries who can supply low-cost labour, or we will see increases in consumer prices.

There also appears to be a lack of detail when it comes to UK minimum requirements for seafood labelling. According to the latest government guidance[227], the only requirement related to processing is as follows: “*whether the fisheries products have been previously frozen or not*”. Some details are often provided on whether the product has been processed in the UK, but this is not listed as a requirement. According to information provided by Seafish[228,229], the only labelling requirements related to processing include: declaration of any treatments (incl. mincing, freezing, defrosting and smoking), details on water uptake and addition of processing aids. It is important to note that detail on where the product has been processed along the supply chain is not required to be provided and data on such details are not included alongside UK trade data. There is however a requirement to specify the origin of the product.

15.3.2 Carbon footprint

Primary production (such as fishing or aquaculture) is typically the dominant contributor to greenhouse gas (GHG) emissions associated with seafood products, whereas processing and packaging generally make very small contributions to overall emissions (often under 10% of the total), except in instances in which emission intensive materials are used (such as metals), or

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[223] https://www.theguardian.com/environment/2021/mar/15/revealed-seafood-happening-on-a-vast-global-scale

[224] *Xiong, Yao, Ying, Lu, Guardone, Armani, Guidi, Xiong (2018). Multiple fish species identified from China’s roasted Xue Yu fillet products using DNA and mini-DNA barcoding: Implications on human health and marine sustainability*

[225] https://www.traffic.org/site/assets/files/5938/understanding-chinas-fish-trade.pdf

[226] https://www.seafoodsource.com/news/supply-trade/new-report-chinas-seafood-processing-sector-in-decline

[227] https://www.gov.uk/government/publications/how-to-trace-weigh-and-distribute-fish-products/traceability-and-labelling-information

[228] https://www.seafish.org/document?id=77851378-15b8-4d6c-ba7b-ea1e31656e86

[229] https://www.seafish.org/trade-and-regulation/seafood-traceability-and-labelling-regulations/general-food-labelling-requirements/ *and* https://www.seafish.org/trade-and-regulation/seafood-traceability-and-labelling-regulations/the-fish-labelling-regulations/

where cooking is involved. Further, according to Seafish in 2014[230], the emission stages within the seafood supply chain differ most significantly between the fishing stage of capture fisheries and the production stage of aquaculture systems.

However, seafood is one of the most traded food commodities globally and the UK imports most of the seafood it consumes. This report has shown that a notable quantity of the seafood the UK imports arrives from processing hubs, and / or via at least one trade route 'steppingstone', which adds significant 'food miles' to a given seafood resource. Transport therefore plays an important role, especially when fresh products are transported over short or long distances by air, or frozen products are transported over long distances. If the carbon footprint of seafood consumption is considered a priority by consumers, retailers, government etc, then it is important that both the distance and the mode of transport are considered at all stages of the processing chain, and duly incorporated into policies around reducing carbon footprint.

For example, 10% of total emissions for processing may appear an underestimate when cod is considered. Planet Tracker undertook an examination[231] of the food (nautical) miles for cod imports which suggested that transport prices are inefficient: "*From Peterhead to the fisheries in the North Sea is approximately 50 nautical miles (96km), while the sea trip from China to the UK is 11,866 nautical miles (21,976km). This suggested that the role of subsidies in both fishing and transport are increasing the carbon intensity of the UK food budget. The reported £437 million trade deficit in British cod supply could be down to price, size or quality. Cod which originates from China costed 13.6% less per kilogram than the EU 27 average in 2019.The largest price differential is between cod imported from the largest importer, Iceland, and the UK's exported fish – with the imports into the UK costing 38% more than the same species exported from the UK. The average price of UK exports of cod to all global partners is lower than the import price from Iceland, China and the EU*".

UK government policy specifically relating to the carbon footprint of imported seafood could also not be found, although Seafish noted that: *"The UK governments commitment to reduce GHG emissions places the onus on businesses to understand the GHG emissions of their supply chains and take appropriate action. The purpose is to improve supply chain practices, make product declarations or simply to address misperceptions of industry practice".*

Life Cycle Assessment (LCA) is an approach that evaluates all stages of a product's life cycle and is the accepted analytical framework for assessing environmental impacts and GHG emissions. It is used to measure GHG emissions across all activities in the product life cycle and can identify those activities which contribute most, often referred to as 'hot spots'. LCA results could not be found for cod imported to the UK from China, but it is an approach that could be incorporated into company sourcing policies and practices to inform carbon footprint assessments specific to supply chains.

With regards to the issue of food miles specifically in the seafood supply chain, it is clear that this is a significant area for future development in the UK. The UK's supply chain remains heavily reliant on the processing sector in China and this can add significant food miles (with

[230] https://www.seafish.org/document/?id=B131396D-7D7C-4538-9212-D70D0B3A7980

[231] https://planet-tracker.org/cod-astrophe-unsustainable-uk-cod-exports-face-demand-side-squeeze/

product often caught locally to the UK being sent to China before returning). One reason for this is economical in that it is cheaper to complete this process than to source more expensive alternative processing sectors nearer to home. However, with a growing focus on the UK carbon footprint, it is not evident that the full cost of this practice is being taken into account.

One alternative may be for the UK government to help investment and development in closer 'low-cost' processing alternatives (for example Africa), which could then be used by the sector in the future. This would allow the processing costs to remain low but also develop sectors closer to the UK and so reduce the carbon footprint relative to the existing Asian dominated processing sector. The alternative (likely to be highly preferable from a carbon footprint perspective) is to have all processing in the UK or in nearby European countries. However, this is likely to increase costs and subsequently prices for the consumers. The potential for post Brexit investment in UK processing infrastructure, which could also act as a processing option for EU Member States, could however become an ambition for the UK seafood industry, including as mitigation against consumer price increases.

15.3.3 Other social and environmental issues

Previously the industry's traceability focus has primarily been on food safety concerns. The increase in media coverage on the environmental, social, and legal issues associated with seafood production has led to shareholder concerns, a potential impact on brand value and challenges to the corporate sustainability initiatives of companies. With a lack of traceability in the UK seafood supply chain, particularly in the complex transnational processing sectors, issues with workers' rights and environmental pollution in seafood processing locations overseas may well have links to seafood products sold in the UK. Planet Tracker also reported that globally, the seafood processing industry is low margin (3% on average) and not cash generative[232] which may further exacerbate issues such as minimum wage violations.

[232] *https://planet-tracker.org/wp-content/uploads/2021/08/5.-Traceable-Returns.pdf*

16. Case study – Fishmeal, feed and oils

Aquaculture systems are split into fed aquaculture (farmed fish / crustacean fed using commercial / farm-made aquafeed) and unfed aquaculture (mainly molluscs: oysters, clams and mussels, where no external feed inputs are used). The most widely sold farmed seafood species in UK supermarkets are carnivorous or omnivorous fish, such as salmon, sea bass, sea bream and trout. For example, the diet of an omnivorous commercially farmed salmon contains 14.5–25% fishmeal and 10–15% fish oil, alongside other plant-based ingredients such as vegetable oils, soy and wheat[233]. About two thirds of fishmeal and fish oil (FMFO) is made from wild fish caught specifically for aquafeed and the other third comprises trimmings and by-products (e.g. offal) of fish caught for human consumption.

Annually, around 15 million tonnes of wild fish from around the globe is used to produce FMFO, making up nearly 20% of the world's total catch. While almost 70% of all landed forage fish are processed into FMFO, 90% of this catch could instead be used for direct human consumption rather than as FMFO[233]. Notably however, the use of FMFO has been decreasing over the last few decades.

The ecosystem impacts of FMFO fisheries are complex and largely poorly documented. One exception is sandeels, which are commonly used in FMFO but are an essential component of the North Sea ecosystem, supporting populations of other fish, mammals and seabirds. Localised overfishing, primarily for the FMFO industry, has led to depletion of subpopulations of North Sea sandeels and climate change is likely to put further pressure on sandeel populations and the animals depending on them in the future. Whilst Denmark controls more than 90% of the quota for sandeels in UK waters, the catch of which is largely destined for processing into fishmeal, shared management of the sandeel fishery on the Dogger Bank may become an increasingly contentious issue now that the UK has left the EU[234].

The Marine Ingredients Organisation (IFFO) estimated in 2007 that for every 1 kg of wild fish used, 4.5 kg of farmed fish is produced[235]. However, in light of global food security and the debate on ethical use of wild caught fisheries for aquaculture, FMFO are gradually being considered as a strategic ingredient to be used efficiently and replaced where possible[236]. For example, FMFO are increasingly used selectively (in small quantities) at specific stages of production, such as for hatchery, broodstock and finishing diets, and the incorporation of FMFO in grower diets (in large quantities) is decreasing. FMFO share in grower diets for farmed Atlantic salmon is now less than 10%[244]. The ratio of wild fish input (via feed) to total farmed fish output fell by more than one third between 1995 and 2007[237]. The ratio has continuously reduced.

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[233] https://www.fishingthefeed.com/wp-content/uploads/2020/03/Caught_Out_Report_FINAL.pdf

[234] Guille, H., Gilmour, C., Willsteed, E. 2021. UK Fisheries Audit. Report produced by MEP for Oceana: https://europe.oceana.org/en/publications/reports/uk-fisheries-audit

[235] https://www.iffo.com/fish-fish-out-fifo-ratios-conversion-wild-feed

[236] https://www.seafish.org/document/?id=D31C2582-7608-4BD2-B394-FC51900C1279

[237] Naylor, R.L., et al, 2009. *Feeding aquaculture in an era of finite resources. Proceedings of the National Academy of Sciences. 106 (36), pp15103-15110*

A continuing decrease in FMFO in aquafeeds is predicted as feed companies develop formulations which increasingly reduce these marine ingredients, replacing them with fishery and aquaculture processing by-product or trimmings (predicted to reach 49% by 2022)[244,238,239] and plant-based protein alternatives. Whilst plant-based protein alternatives reduce dependency on FMFO, they may present other environmental impacts such as risk of habitat conversion (e.g. deforestation in the case of soy), and can compete with food for people. There is a need to reduce the reliance on FMFO in aquafeeds, whilst at the same time avoiding the introduction of other negative impacts through the inclusion of plant-based protein alternatives.

It nevertheless remains important to ensure that products such as FMFO used to manufacture aquafeed come from legal, reported and regulated fisheries. If feed ingredients originate from IUU fishing activities, this not only places pressure on ecosystems but reduces food security in countries reliant on pelagic fish for protein (as reported in the Gambia, India and Vietnam)[240].

There are various ways FMFO products can demonstrate their sourcing adheres to the FAO Code of Conduct for Responsible Fisheries, including the Marine Stewardship Council (MSC), Aquaculture Stewardship Council (ASC), the MarinTrust[241] (formally IFFO RS), and other resources such as FishSource[242] and Fishery Progress[243] which provide analysis without a certification or approval rating. In 2018, Seafish[244] presented a list of feed grade fish stocks used to produce FMFO products in the UK (Table 62).

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238 https://www.food.gov.uk/business-guidance/animal-feed-legislation

239 https://www.iffo.com/system/files/downloads/Report%20IoA%20IFFO%20project%20Final_0.pdf

240 Changing Markets Foundation (2019) Fishing for catastrophe: How global aquaculture supply chains are leading to the destruction of wild fish stocks and depriving people of food in India, Vietnam and The Gambia

241 https://www.marin-trust.com/

242 https://www.fishsource.org/

243 https://fisheryprogress.org/

244 https://www.seafish.org/document?id=1b08b6d5-75d9-4179-9094-840195ceee4b

Table 62: List of feed grade fish stocks used to produce FMFO products in the UK, approximate quantities they are used in and the estimated status of the fish stock(s) (in 2017). From Seafish (2018)[244].

Trade Sources:	% of FM used in UK 2007	2011	2013	How stock is used	Estimated status of fish stocks in 2017
EUROPE AND THE ANTARTIC – *Source ICES and FishSource*					
Sandeel *Ammodytidae*	Less than 3%	8%	2.2%	Not used for human consumption (HC)	**Main North Sea:** Adult stock is large enough for optimal use in the long term. Improvement in Spawning Stock Biomass (SSB) in 2015, 2016 and 2017. Uncertain recruitment in 2016.
Sprat *Sprattus Sprattus*	3%	8%	1.1%	Potential uses for HC but mainly used for fishmeal (FM).	**North Sea:** Adult stock size is large enough and fishing pressure is low enough to ensure a sufficient amount of offspring can be produced. Recruitment increased in 2016.
Capelin *Mallotus villosus*	Less than 1%	2%	5.3%	Roe used for HC. Frozen capelin for specific limited markets. Mainly used for FM.	**Barents Sea:** Estimated that 2016 year class at age 1 is below long-term average but above 2014 and 2015. **Icelandic:** Likelihood that SSB is above the precautionary limits of 150,000 t.
Norway pout	Less than 1%	2%	2.0%	Not used for HC.	SSB is above precautionary levels in 2017. Recruitment is variable (high in 2014 and 2016) and below average in 2015 and 2017.
Blue Whiting *Micromesistius Poutassou*	21%	1%	3.6%	Mainly used for FM. Limited use for HC due to processing difficulties.	SSB has increased from 2010 and is above the MSY biomass trigger. Recruitment in 2017 is estimated to be low, following a period of high recruitments.
Herring *Clupea harengus*	3%	1%	0.2%	Primarily HC, but non-food grade fish and trimmings may be used for FM.	**Icelandic:** Indications of poor recruitment and fishing pressure has been increasing. **Norwegian:** Stock is declining and estimated below MSY biomass trigger in 2017.
Mackerel *Scomber scombrus*	n/a	n/a	4.1%	Primarily HC, but non-food grade fish and trimmings may be used for FM.	**NEA:** Various surveys give contradictory evidence. SSB is estimated to have decreased from 2016 to 2017.
Boar fish *Capros aper*	n/a	n/a	5.9%	Currently for FM but HC market underway.	Stock status is currently unknown. Stock has declined sharply since the peak in 2010–2013 and is currently at a historic low.
Krill	n/a	n/a	1.1%	Mostly used for FM.	No recent stock assessment for *Euphausia superba*.
Trimmings	**38%**	**35%**	**50%**	**Generally small pelagic species (e.g mackerel, capelin, herring) and trimmings from the white fish processing sector (e.g. cod).**	
SOUTH AMERICA/GULF – *Source FishSource*					
Anchovy *Engraulis ringens*	28%	38%	19.6 %	Very small amount used for HC. Majority used for FM.	2017 estimates show SSB to be above the limit biomass reference point but below the optimal biomass level. Surveys show the ability of this stock to recover rapidly.
Jack mackerel *Trachurus murphyi*	1%	3%		50% of Chilean jack mackerel used for HC and 50% for FM.	The stock shows a continued recovery since the time-series low in 2010. Recruitment in the most recent years shows signs of stronger incoming year-classes but the information is uncertain.
Sardine *Strangomera bentincki*	Less than 1%	1%	4.2%	Used for HC and FM	Recruitment has been low in the 2015-2016 biological year, but it is estimated above historical levels in 2017. Fishing mortality is showing a decreasing trend since 2005.
Gulf Menhaden *Brevoortia patronus*	n/a	1%	0.6%	Mostly used for FM and FO.	The stock is not overfished and overfishing is not occurring. Population fecundity well above benchmarks/fishing mortality well below benchmarks. Stock appears in very good shape.

According to Seafish[245] "*around 1.9 million tonnes of food meal production is certified as either MarinTrust or MSC – representing about 40% of global production. Most of this comes from South America, but Europe and North America are providing significant volumes, and North Africa currently has certified production. Currently there is no certified fish meal product produced in China and only very small quantities (less than 10,000 tonnes) are produced in the rest of Asia (and this is from by-products). Given Asia produces around 1.5 million tonnes of fish meal, there is obviously considerable room for improvement, in both fisheries management and certification uptake*[246]".

Aquaculture certification schemes, such as the Aquaculture Stewardship Council (ASC), also require that fish products used in feeds are not on the International Union for Conservation of Nature (IUCN) red list of threatened species or the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list of endangered species. However, transparency issues around FMFO sourcing still exist, for example including lack of information on full catch profiles of the fisheries supplying the feed components, or documentation of each step in the processing chain before use in the aquaculture system.

Plant-based alternatives to FMFO, such as soy, bring their own sustainability challenges. In 2019, it was reported that the salmon farming industry in Scotland alone uses around 50,000 tonnes of soya protein concentrate, which has considerable implications for the reliance of the industry on overseas land and other resource use, and deforestation and habitat conversion risks in biomes like the Brazilian Cerrado[247,248].

Some industry groups, such as Feedback Global, have recommended that salmon farming should be limited to that which is possible using FMFO made from unavoidable fishery by-products alone[249]. Any edible fish should be destined for direct human consumption, not salmon feed. Based on current available figures, this means that the Scottish salmon industry would need to shrink by at least two thirds. Another recommendation included to develop feed formulations that replace human-edible plant-based ingredients such as wheat, soya and peas, as well as cultivated insect protein, with unavoidable by-products of the food industry, as is already achieved in some chicken farms[250].

Transparency in the sector is key as currently there are doubts as to whether fishery 'by-products' truly are waste products and are not themselves exerting further pressure on wild-fish populations. As shown by Changing Markets' on-the-ground investigations[240], juvenile fish and fish fit for human consumption are frequently misclassified as 'trash fish' and diverted to FMFO processing[233].

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245 https://www.seafish.org/responsible-sourcing/aquaculture-farming-seafood/species-farmed-in-aquaculture/aquaculture-profiles/white-leg-prawn/feed/

246 https://www.seafish.org/responsible-sourcing/aquaculture-farming-seafood/species-farmed-in-aquaculture/aquaculture-profiles/rainbow-trout/feed/

247 Shepherd, C., Jonathan, O. M. and Tocher, D.R. (2017) Future availability of raw materials for salmon feeds and supply chain implications: The case of Scottish farmed salmon. Aquaculture, 467 (January): 49–62. https://doi.org/10.1016/j.aquaculture.2016.08.021.

248 https://www.wwf.org.uk/riskybusiness

249 https://feedbackglobal.org/wp-content/uploads/2020/06/Feedback_On-the-Hook_June-2020_LoRes.pdf

250 https://feedbackglobal.org/wp-content/uploads/2020/06/Feedback_Off-the-Menu_June-2020_LoRes.pdf

While the aquafeed sector itself is quite concentrated involving a small number of large corporations, the supply chain can involve as many as eight different stages including: fishery, FMFO plant, aquafeed producer, aquaculture farms, seafood processor, distributor, retailer and many 'middlemen'. Many prawn farms in Southeast Asia, India and China are very disaggregated, family-operated production units serviced by an informal network of traders and brokers who in turn, supply hundreds of processors. Alternatively, some companies have a highly integrated value chain, with operations across FMFO production, feed manufacturing, fish farming and distribution.

Retailers currently rely on assurances of sustainability from seafood processors and aquaculture and aquafeed producers, who in turn may be covered by certification schemes for marine products, such as Global GAP, the ASC or the MarinTrust. However, supply chain research by Changing Markets Foundation in 2019[240] revealed the globalised nature of FMFO and the aquafeed trade, and enabled links to be made between consumption of farmed fish and seafood in the Global North and extractive and unsustainable reduction fisheries in the Global South. Their findings also indicated that aquafeed producers' assurances of responsible supply were dubious and any sustainability claims made by retailers regarding their farmed-seafood supply chain should be closely scrutinised.

Such complexity, limited transparency and lack of corporate accountability across the sector restricts external scrutiny and in turn, is likely to mask the full scale of social and environmental problems in aquaculture supply chains.

Here, a descriptive case study approach is taken to the consideration of FMFO as a key component of the UK's global seafood consumption footprint, rather than the detailed commodity / resource-based analysis used in the rest of the report, due to the significant data limitations. Within the HMRC trade data, two codes relate to FMFO: '*Fats and oils of fish or marine mammals*' (1503) and '*Flours, meals and pellets, of meat or meat offal, of fish or of crustaceans, molluscs or other aquatic invertebrates, unfit for human consumption*' (2301). Both were excluded from the analyses on the basis that the former product could not be attributed to a specific purpose, i.e. human consumption or use in animal feed, and neither could be associated with any specific fish species nor could it be confirmed that the product was used specifically by the aquaculture industry. For code 2301 (Flours, meals or pellets), total imports have risen steadily from around 58,200 tonnes in 2015 to 105,660 tonnes in 2019, with the largest increase seen for Norway as a source country (Figure 128). Norway, along with the Republic of Ireland, Iceland, Denmark, the Faroe Islands, Germany and Spain were collectively responsible for around 90% of the UK's annual imports of the product, on average between 2015 and 2019. According to the trade data, the UK exported around 31,655 tonnes of the same category of product in 2019.

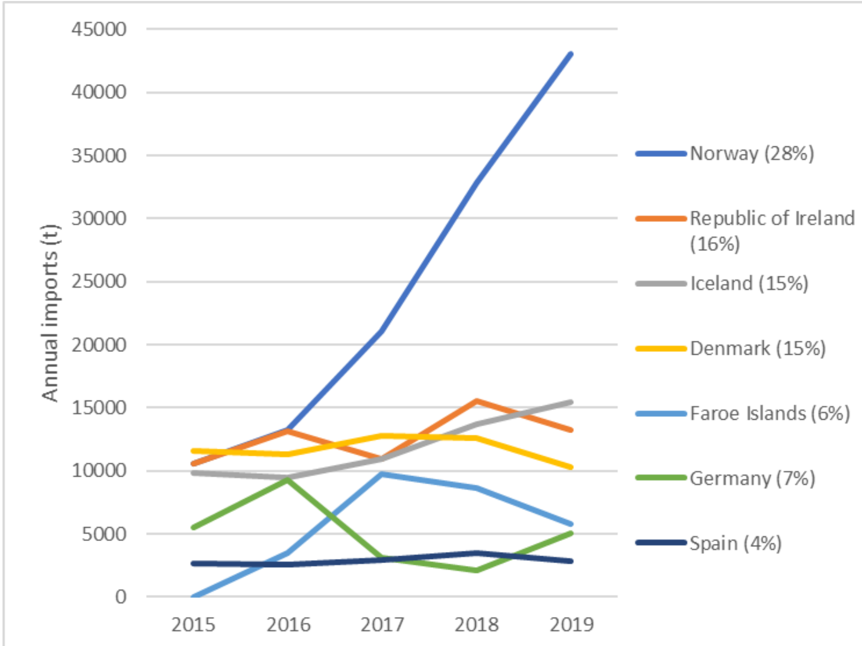

Figure 128: Annual (2015-2109) imports (tonnes) of 'Flours, meals and pellets, of meat or meat offal, of fish or of crustaceans, molluscs or other aquatic invertebrates, unfit for human consumption' from the top source countries, collectively responsible for ~90% of UK imports, on average for the period. Percentages in legend show average annual % contribution to UK's imports for period 2015-2019.

16.1 Atlantic salmon

Farmed salmon is fed on a carefully calibrated diet, including plant-based ingredients such as soya, wheat and pea protein, and marine ingredients that mimic the carnivorous diets of wild salmon: fishmeal and fish oil produced from wild-caught fish. Along with global trends, a reduction in the reliance on FMFO in salmon feed is also reported. In 1990, 90% of the ingredients in Norwegian salmon feed were of marine origin whereas in 2013 it was only around 30%[251], and this trend is set to continue for a number of farmed species including trout[252].

For UK salmon aquaculture, Feedback Global (2020) produced a report[253] exploring the sources of wild fish used in Scottish salmon feed, based on industry data, which vary from the Peruvian anchoveta fishery to menhaden from the United States, and large volumes of fish from European waters, such as capelin, herring, sprat and blue whiting. The six largest salmon companies operating in Scotland were contacted for information on the composition of their feed including the species and quantities of fish used, details on the fisheries and certification status, the proportion of marine ingredients sourced from by-products and the Forage Fish Dependency Ratio (FFDR). The wide variance in the level of detail received from companies indicates that, overall, there is insufficient data and information to verify the industry's claims that they are

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[251] *Ytrestøyl, T., Aas, T.S., and Åsgård, T., 2015. Utilisation of feed resources in production of Atlantic salmon (Salmo salar) in Norway. Aquaculture. 448, pp365–374*

[252] *https://www.seafish.org/responsible-sourcing/aquaculture-farming-seafood/species-farmed-in-aquaculture/aquaculture-profiles/rainbow-trout/feed/*

[253] *https://feedbackglobal.org/wp-content/uploads/2020/06/Feedback_On-the-Hook_June-2020_LoRes.pdf*

providing a sustainable source of protein and avoiding placing an excessive burden on wild fish populations. It is also concluded that the salmon farming industry is over-reliant on general statements as a means of demonstrating sustainability. In the absence of comprehensive, transparent, industry-wide data, readers should be highly sceptical of the UK salmon industry's sustainable-sourcing claims[253].

Feedback Global produced a subsequent report which estimated proportions of wild-caught fish in salmon feed based on the data from 3 major feed producers[253] (Figure 129).

Anchoveta and anchovy	*14.6%*
Sardine and sardinella	*13.4%*
Capelin	*6.9%*
Menhaden	*10.5%*
Lesser sand eel	*7.9%*
Blue whiting	*27.6%*
Sprat	*6.5%*
Herring	*4.8%*
Other	*7.8%*
TOTAL	*100%*

Figure 129: Estimated proportions of species of wild-caught fish in the production of fishmeal and fish oil based on MOWI, Biomar and EWOS Cargill data[253]

While this study also considers salmon farming in the Faroe Islands, Denmark and Iceland, the feed requirements are presumed to be similar to those in UK salmon aquaculture.

16.2 Trout

Rainbow trout have similar feed requirements to Atlantic salmon, so the above text is applicable. Trout farming systems are likely to be similar in the countries considered in this study (UK, Sweden, Netherlands, the Republic of Ireland, Denmark, Norway and France) although it is noted that lower Feed Conversion Ratios (FCRs[254]) (lower than the reported global average of 1.25 reported in 2008[255]) have been achieved in land-based trout farms in Denmark where according to the Danish environmental legislations, FCR must not exceed 1.023.

16.3 Warm-water prawns

European retailers import significant volumes of warm-water prawns from Central America and Asia. After Ecuador, India and Vietnam are major suppliers to the EU market. In 2017, India accounted for 18% of the total volume of this species' imports into the EU, and Vietnam accounted for 12%. Imports from India and Vietnam are mostly destined for the UK, the

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[254] Feed conversion ratio (FCR) is a way of describing efficiency in terms of how much feed is required to produce 1 kg of fish. If an FCR is around 1.2, this means that to produce 1 kg of farmed fish, you need around 1.2 kg of feed.

[255] Tacon, A. G. J. & Metian, M., 2008. Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. Aquaculture, 285: 146-158

Netherlands and Belgium. Supply chain research by Changing Markets Foundation in 2019[240] demonstrated the complex and opaque supply chains bringing warm-water prawns to Europe. Traceability is a particular concern for farmed prawns in the regions investigated which included India and Vietnam. Both farms and FMFO producers were disaggregated, distributed among hundreds of companies and smallholdings with little regulatory oversight. Small farms typically sell to a bigger market player that aggregates supply for export to global markets, which complicates traceability of farmed-seafood products and the origin of FMFO and aquafeed used to cultivate them. Analysis of packaging from a range of farmed seafood available in supermarkets revealed several supply-chain connections, enabling links to be made between farmed prawns available to European consumers with irresponsible fisheries and FMFO production in India and Vietnam.

For Vietnam the report[240] states: "*In Vietnam, where there is widespread illegal, unregulated and unreported (IUU) fishing, threats to the marine ecosystem, FMFO plant pollution, unsustainable fishing techniques and use of mixed species – FMFO is produced for markets in Western Europe, the US, China, Japan and Australia"*

For India, the report states: "*In India, where crashing fish stocks, indiscriminate use of species (including reef species), catching of juvenile fish, wastewater contamination, human health, workers rights issues and food-security issues were discovered…, with export markets including the US, Europe, China, Japan, Taiwan, Thailand and Vietnam*."

16.4 Sea bass and sea bream

Sea bass feeds now contain approximately 15-20% fish meal and 2-5% fish oil[256]. Over the last 10 years or more, the inclusion of marine ingredients in sea bass feeds has declined, and this is a trend set to continue.

The Monterey Bay Aquarium's 2019 Seafood Watch Assessment for Gilthead sea bream produced in marine net pens in the EU, and European sea bass produced in marine net pens in Turkey[257], rated 'Feed' a yellow rating (<6/10). The scoring justifications were as follows:

Recent years have seen the vegetable protein component of feed increase while marine inputs have decreased; in addition to this, a greater percentage of these marine inputs are sourced from by-products. According to a recent article in International Aquafeed magazine, Mediterranean companies use between 1.8 and 2.2kg of feed to produce one kg of seabream (of 400g harvest weight) although there are differences between farmers using commercial diets and some, particularly in Greece and Turkey, producing their own feeds via toll milling.

There is a range of fishmeal (16-17%) and oil (10%) inclusions in sea bass and sea bream feeds applied in EU and Turkey farms. The sustainability of the sources of wild fish (which are listed in full on page 111 of the report) were overall assessed to be sustainable, although there were some concerns over Atlantic mackerel caught in the NE Atlantic, Atlantic chub mackerel

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[256] https://www.seafish.org/responsible-sourcing/aquaculture-farming-seafood/species-farmed-in-aquaculture/aquaculture-profiles/european-sea-bass/feed/

[257] https://www.seafoodwatch.org/recommendation/bream/red-bream-gilthead-bream-turkey-marine-net-pen?species=369

caught in Spain / Portugal, European pilchard caught in Morocco / Mauritania and European sprat caught in Denmark.

Nevertheless, it is reported that there are concerns on the sustainability of the use of European anchovies as feed from the Black Sea for the sea bass and sea bream farming in Turkey[258].

16.5 Catfish

Pangasius is now one of Vietnam's most important export crops by volume and value; the United States and Europe are both important markets and Vietnam exports pangasius to over 145 countries.

The Monterey Bay Aquarium's 2021 Seafood Watch Assessment for Pangasius produced in ponds in Vietnam[259], rated 'Feed' a green rating (7.6/10). The scoring justifications were as follows:

The majority of Vietnamese pangasius are fed commercial feeds utilizing low inclusion levels of fishmeal and fish oil whereas terrestrial crop ingredients constitute the bulk of the feed. A Feed Conversion Ratio (FCR) value of 1.6 is considered average, and with low fishmeal inclusion and zero fish oil, the "fish in: fish out" (FIFO) ratio is less than 1 (0.36). However, data on the source of fishmeal used in pangasius feeds in Vietnam is scarce and feed mills are likely to include trash fish of unknown (but likely poor) sustainability in addition to better-known international sources such as Peruvian anchovy and Chilean salmon byproducts. There is a substantial loss of edible protein (60%) in the conversion of feed to harvested pangasius, however, with low use of marine ingredients and high levels of crop ingredients forming the bulk of the feed, the overall feed score is considered good.

[258] *Sea Bass and Sea Bream Supply Chain Study: from Turkey to Europe: https://wwfint.awsassets.panda.org/downloads/wwf_fishforwardprojectsbsb_2021_v5.pdf*

[259] *https://www.seafoodwatch.org/recommendation/catfish/red-sutchi-catfish-vietnam-ponds?species=243*

17. Limitations to the analysis of the UK's seafood supply chains

17.1 The UK's marine resource footprint is globally extensive but poorly understood

HMRC trade data were used for this study to establish and analyse the UK's seafood sourcing geographical footprint. This data is publicly available but is collected for the purpose of ensuring relevant import tax duties are paid. Unsurprisingly, the data is not sufficient to allow the user to accurately determine the geographical source of fish products entering the country since it reports the country of dispatch and not the raw material sourcing location, nor other intermediary steps in the supply chain. This results in a significant number of imports being reported from known processing or trade hubs, including China, Denmark and the Netherlands. While this data provides important information, it also highlights the fact that the UK does not have an accurate data source for the reporting of provenance of seafood products.

Furthermore, the UK has a system for tracking product forms and types which is based on the EU Commodity Coding system (referred to as Integrated Tariff of the European Union (TARIC)). These codes are composed of a ten-digit number (although this is increased to fourteen for certain products). For fish and crustaceans, the TARIC codes largely fall under Chapter 3 (Fish and crustaceans, molluscs and other aquatic invertebrates), meaning all will start with a 03. Below this, products are further split between 0301 (live fish), 0302 (whole fresh fish), 0303 (whole frozen fish), 0304 (fresh or frozen processed fish (fillets etc…), 0306 (crustaceans in any state), 0307 (molluscs in any states) and 0308 (aquatic invertebrates in any state).

From here the system is further split down by species. For example, under 0303 (whole fresh fish), you then have 0302 11 (salmonidae), 0302 21 (flatfish), 0302 31 (tuna), etc. However, these species level headings have many exceptions and do not cover all relevant families and species. This can make choosing the correct TARIC code confusing and leads to mistakes being made regularly. For example, during this study, we have seen countries importing species that are neither caught, farmed or processed in that country and can then only assume that those data, to an unquantifiable extent, represent unintentional mis-reporting due to the complexity of the system (as well as known issues with deliberate misreporting).

The UK is a net importer of seafood, with imports from all continents and most coastal nations, amounting to over 720,000 tonnes in 2019 (valued at £3.5 billion). However, this figure is again likely to be underestimated, in part because seafood is also imported in other forms (for both human and non-human consumption) that are not readily quantifiable in the trade data.

Furthermore, this report has highlighted that there is a lack of data to allow full traceability and transparency of marine resource supply chains for imports from overseas. Moreover, assessing the social and environmental footprints of that supply is extremely challenging. Ultimately, the ecological, social and governance risks associated with wild capture and aquaculture production tend to vary considerably between, for example, fishing activities (and even vessels associated with an activity) and production systems (and operations), and thereby within the producing country, as well as between processing facilities and countries - between which seafood products may move in multiple steps during the journey from 'ocean to plate'. It is however not possible to trace the majority of the UK's seafood imports back through processing or trade intermediaries in the supply chain, or even to the specific point of production, and therefore it is not possible to assess the full extent of risks associated with the supply chain. Addressing these gaps will need to be one of the priority steps in reducing the overseas impacts of UK marine resource use[260].

17.2 The UK's domestic footprint on marine resources is significant but there are gaps in understanding its full impacts

The UK's fishing fleet was responsible for the removal of at least 622,000 tonnes of fish and shellfish in 2019, with much of the retained catch exported across the world; nearly 452,000 tonnes of seafood was recorded in trade data in 2019 as being distributed across the globe from the UK. However, significantly more fauna biomass was affected by UK capture fisheries through bycatch, discards, habitat damage and production of aquaculture and animal feed. The extent of this impact remains unquantified, in part due to poor reporting of unwanted and unretained catch.

One of the ways to address fraudulent data entry is to evidence catch with use of Remote Electronic Monitoring systems, with cameras that can be used to cross check logbook entries and support blockchain entries. Having such technology onboard disincentivises fraudulent activities elsewhere in the catching process and can be used to evidence good practice.

As for aquaculture, the source of fishmeal in the UK supply chain is clearly not well understood and often covered by rather generic statements around 'sustainable sources', etc. Very little public information is available on how and where fishmeal and oil are being sourced and it appears that this can vary greatly depending on availability of supplies at certain times of the year. There is clearly a need for continuing focus on this sector in the future.

17.3 Challenge of country specific supply chain analysis

This study attempts to conduct supply chain analyses at country level based on the most popular commodities involved, but in practice this is extremely challenging as within one country multiple different supply chains exist. A good example would be the provision of shrimp from Vietnam. Warm-water shrimp and prawns in Vietnam are produced in organic extensive systems, polyculture systems, highly intensive systems and across a wide range of standards in between. All of these production systems vary greatly in both environmental and social performance and scoring could be dramatically different between them.

This study attempted to use available expert knowledge in assessing which form of production is most representative for imports to the UK. The time and resources to complete a task to exam all possible supply chains for UK's seafood consumption is far beyond the ability of this report. Nevertheless, in most cases, UK retailers are insistent on the supply of products from the better performing sources (often third-party certified for example).

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[260] https://www.wwf.org.uk/what-we-do/uk-global-footprint

It is therefore important to state that with the limitation mentioned above, it is likely not possible for the UK to make simple sourcing decisions on a country-by-country basis, since the range of supply options within that country can be so varied.

18. Recommendations

18.1 Recommendations for the UK governments

Since the majority of the seafood consumed in the UK is imported, the UK and devolved governments have to ensure we do not export negative environmental and social risks to other countries because of our demand seafood. Equally there is an urgent need to ensure our domestic seafood production (wild capture fisheries and aquaculture) are environmentally and socially sustainable. Therefore, the UK and devolved governments should:

Set meaningful and measurable sustainability targets for UK domestic seafood production

The UK has become an independent coastal state and the newly passed Fisheries Act (2020) sets eight objectives to manage our domestic seafood production. The UK and devolved governments must ensure meaningful targets are set in the coming Joint Fisheries Statement.

Given that the UK only consumes 30% of its own seafood production, there is room to increase its self-sufficiency rate in seafood consumption. However, the UK must reduce the footprint of its domestic fisheries and aquaculture production, to provide confidence to the UK public to purchase locally produced seafood.

The UK seafood production policies need to ensure:

1. There are healthy stocks of fish that are fished at a Maximum Sustainable Yield (MSY) with at least Spawning Stock Biomass (SSB) of 40% unfished stock (i.e. SSB40) together with the fishing mortality at less than 1 (F/Fmsy <1) and catch quotas are set based on the best available evidence and science.
2. Bycatch of ETP species will be minimised and ultimately eliminated through a strengthened UK's Bycatch Mitigation Initiative, better data collection with Remote Electronic Monitoring (with onboard cameras) and innovation of fishing gears.
3. Seafood production supports the Climate objectives of the Fisheries Act to contribute to the UK's Net Zero target through decarbonising fleets, protecting the UK's blue carbon ecosystems and reducing greenhouse emissions of feed.
4. Support is provided to fishers and fish farmers to transition to sustainable practices.

Develop core environmental standards for imported seafood

Given that 81% of UK's seafood demand is fulfilled through international trade, urgent actions are required by the UK and devolved governments to minimise our environmental impacts on global marine habitats and species. UK seafood sourcing should ensure that populations of endangered, threatened or protected (ETP) species are not declining and that fish stocks are not overfished, amongst other issues.

The UK's new independent trade status has provided a once in a generation opportunity for seafood supply chains to join the farming supply chains in developing national core environmental standards to deliver a strong sustainable food strategy, and to ensure the UK's seafood demand is improving standards of production at home and overseas. The US Marine

Mammal Protection Act (1972) provides an example of how this can be done in the context of protecting marine mammals from the impacts of fishing.

Additionally, the UK and devolved governments should improve consumer labelling requirements and provide increased transparency of seafood sustainability to allow consumers to make informed decisions in their seafood purchasing.

Strengthen IUU regulations including due diligence

The UK Government has committed to continue its adoption of the EU IUU regulations to prevent, deter and eliminate imported seafood from entering the UK through Illegal, Unreported and Unregulated (IUU) fishing activities. The EU IUU regulations and its 'carding' process are recognised as powerful tools to not only prevent illegal fisheries products from entering the European market, but also helping improve fisheries management in many seafood producer countries.

As such, the UK governments should strengthen the IUU regulations to:

1. Seek collaboration with other key consumer countries and regions like the EU, the United States and Japan to reduce global IUU fishing activities and improve traceability.
2. Develop due diligence requirements for imported seafood (similar to deforestation risk commodities in the Environment Act) to mandate annual reporting and increase transparency for UK businesses.

Strengthen the UK's role in international fisheries management and trade forums

Apart from ensuring domestic seafood production is sustainable, there is an obligation for the UK to be a responsible global citizen. As a newly independent coastal state following Brexit, the UK has the opportunity to demonstrate its global leadership in international fisheries management forums, like Regional Fisheries Management Organisation (RFMOs) for tuna (e.g. Indian Ocean Tuna Commission (IOTC) and International Commission for the Conservation of Atlantic Tunas regional (ICCAT)) and whitefish (e.g. North-East Atlantic Fisheries Commission (NEAFC)) to ensure fish stocks are healthy, ETP species' bycatch is minimised and ultimately eliminated and human welfare is safeguarded.

The UK should further its influence in the World Trade Organization (WTO) to support the inclusion of seafood supply chains in the development of international environment standards and the proposed *Codex Planetarius.* The UK governments should also support the WTO in ending harmful subsidies in seafood production.

Support lower income countries and UK producers to reduce seafood footprint risks

This report identifies that nearly half of the key producer countries of the UK's seafood consumption are lower income countries and many are tropical coastal states in Asia, Africa and Latin America. Furthermore, the average footprint scores of these countries are higher than countries in North America and Europe, implying support will be needed to improve the sustainability of their seafood production.

There is an evident role for the UK Government to play in providing financial support and incentives such as the UK's Blue Planet Fund and other development aid funds to assist seafood exporting countries, focusing on developing nations, to improve the sustainability and traceability of their seafood production activities, to safeguard human welfare and to reduce IUU fishing risks. Similarly, the UK Seafood Fund should provide financial support to the UK seafood producers to improve the sustainability of their seafood production.

Improve data product codes systems and sourcing data

With the UK no longer a member of the EU, an opportunity exists to update HRMC data requirements and improve the EU Commodity Coding system (or the TARIC), to make it fit for purpose for ensuring traceability of modern supply chains. Furthermore, there should be assurance that the correct codes can be more readily used, thereby improving the accuracy, reliability and replicability of the data.

Whether such a dataset is considered of general benefit in the UK is another matter. It is suggested that being able to determine the source of all raw materials entering the UK on a publicly available database would be helpful in tracking and improving the UK's accountability for its supply chains in the future. This could be relatively easily rectified by requiring the provenance of product to be recorded with the current import data requirements (so both the import source and raw material source are provided).

18.2 Recommendations for UK businesses

Alongside the UK and devolved governments, UK businesses also have an important role to play in making the UK's seafood consumption sustainable and reducing the footprint of seafood production at home and overseas. UK businesses should:

Commit to reduce the footprint of seafood sourced and sold with time-bound targets

UK businesses have been focused on voluntary certifications of seafood production (wild capture and farmed fish) in the last decade, but this report reveals that such an approach alone has proven inadequate to stop the continuous loss of marine biodiversity, particularly ETP species, and tackle climate change. Additionally, sustainability of seafood has been continuously threatened by records of human rights abuses, a lack of transparency and IUU fishing in supply chains.

As part of their sustainable seafood sourcing policy, UK businesses should adopt the Seascape Approach of the WWF Basket and commit to set targets to reduce the footprint of seafood they source from, and invest in sectoral changes such as bycatch reduction, fish stock rebuilding, better feed with lower reliance on wild caught fish and Scope 3 emissions (including food mileage) to tackle climate change. To gain the confidence of their customers, these commitments should be time-bounded and publicly available.

Support and promote low footprint seafood

This report identifies seafood resources that have low footprint scores such as molluscs like rope-grown mussels and small pelagics like herring. Seafood with a low footprint can be an excellent alternative animal protein to more impactful land-based animal protein like beef.

UK businesses should support low footprint seafood in their sourcing portfolios and promote the consumption of these seafood species to their customers. This can include product innovations with low footprint seafoods to provide more purchasing options and increase accessibility, and investing in regional seafood processing facilities to decrease 'food miles'.

Work with the supply chain for better traceability and transparency

Industry wide sea-to-plate traceability would allow seafood companies to simultaneously validate sustainability claims and satisfy demand for sustainable seafood, while avoiding exposure to social and environmental issues.

UK seafood businesses should work with the supply chain to close supply chain traceability gaps (especially at the processing stage and in some cases associated with high seas transshipment). This can be achieved through supporting initiatives like the Global Dialogue on Seafood Traceability (GDST) to enhance data interoperability between various seafood value chain stakeholders for different traceability systems. Additionally, adopting newly developed blockchain technology is encouraged to provide a tamper-proof digital ledger that aims to guarantee provenance by verifying the accuracy of every step from boat to supermarket shelf. All these efforts will improve data capture and management and increase transparency of seafood supply chains in the UK.

UK businesses should also work with the fishmeal industry to increase transparency in the use of fishmeal and fish oil for feed in aquaculture so that the impacts associated with feed can be understood and addressed. This will also allow innovative solutions to be developed to reduce the footprint of aquaculture seafood production.

Advocate for better government regulations and improvement of certification schemes

Many UK companies have made sustainability commitments and sourcing policies to improve their seafood supply chains. However, there needs to be mandatory regulations to ensure there is a level playing field for all UK businesses to change. As such, UK businesses should advocate for the improvement of regulatory instruments to manage our domestic and imported seafood production.

While voluntary third-party certification schemes are important tools for the seafood sustainability journey, there are questions on whether they can ultimately truly achieve seafood sustainability and there is a need to support small scale fisheries. UK businesses should ensure there are continuous improvements in these schemes so that they are credible, fit for purpose and meet stakeholders' expectations.

18.3 Recommendations for UK consumers

UK consumers can also play an important role in driving change to support the reduction of the UK's footprint on marine resources and to make seafood production sustainable. In particular, UK consumers can:

1. Opt for lower footprint seafood choices where possible, particularly locally produced seafood such as UK mussels, to decrease the demand for imported seafood.
2. Follow WWF's top tips[261] on seafood consumption, including more diverse and low trophic level species like sardines, to reduce pressure on more popular choices.
3. Support calls for more stringent core environmental standards for imported food and improved labelling requirements, including for seafood.

[261] https://www.wwf.org.uk/seafood-top-tips

Appendices

Appendix 1 – Risk assessment justifications

Please refer to the glossary of terms (Appendix 4) when reading these justifications.

Seafood commodity – Whitefish

Atlantic cod

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic cod stocks in UK waters are largely considered to be in a depleted state and / or subject to overfishing[262,263], resulting in a 'high risk' score.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[264]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[265]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[266], it is felt this underestimates the impact on blue carbon habitats[267]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. UK fisheries in the south west (Celtic Sea and western English Channel) are associated with risk of harbour porpoise mortality[268]. MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. A 'high risk' score is provided on a precautionary basis.

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262 https://www.ices.dk/advice/Pages/Latest-Advice.aspx

263 https://europe.oceana.org/en/uk-fisheries-audit-2021

264 https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

265 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

266 http://seafoodco2.dal.ca/

267 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

268 https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

Social concerns associated with supply chain (Social_1): Reports of social concerns associated with Scottish whitefish fisheries have featured in the media in past years[269]. In the absence of information to confirm such issues are no longer present in the industry, a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Whilst a variety of management measures and recovery plans are in place for UK cod fisheries and the stocks they target, there is clearly scope for improvements in management effectiveness given the risks posed to the target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The UK North Sea cod & whiting seine and trawl fishery is part of a FIP[270]. The UK fishery targeting Northeast Arctic cod is MSC certified with conditions[271]. MSC certification for the North Sea cod fishery was suspended in 2019 due to concerns about the status of the stock[272]. A 'medium risk' score is provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Icelandic cod is assessed as having a healthy stock size and sustainably fished relative to MSY reference points[273]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[274]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[275]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[276], it is felt this underestimates the impact on blue carbon habitats[277]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some risk posed to seabirds as a result of gillnet and longline fisheries, some of which could be considered ETP species, such as the

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[269] https://www.express.co.uk/news/uk/456085/Boat-slave-shame-of-fishing-industry and https://www.independent.co.uk/news/uk/crime/police-investigate-claims-slavery-uk-fishing-fleet-9877879.html

[270] https://fisheryprogress.org/fip-profile/uk-north-sea-cod-and-whiting-seine-trawl

[271] https://fisheries.msc.org/en/fisheries/uk-fisheries-ltd-dffu-doggerbank-northeast-arctic-cod-haddock-and-saithe/about/

[272] https://fisheries.msc.org/en/fisheries/scottish-fisheries-sustainable-accreditation-group-sfsag-north-sea-cod/@@view

[273] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[274] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[275] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[276] http://seafoodco2.dal.ca/

[277] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

Northern fulmar[278]. The endangered Atlantic halibut is also caught as bycatch, although mitigation measures are in place[279]. A 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Icelandic fisheries management is generally considered to be effective – a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Icelandic cod fishery is MSC certified with conditions[280,281], leading to a 'medium risk' score.

Supply chain: Norway wild capture production

Env_1: Whilst the Northeast Arctic cod stock which dominates Norway's catches is considered as having a healthy stock size and sustainably fished relative to MSY reference points, the Norwegian coastal cod stock is data limited but a rebuilding plan is in place due to low biomass[282]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage (including potentially VME habitats) and bycatch of target (including the depleted Norwegian coastal cod stock) and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[284]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[285], it is felt this underestimates the impact on blue carbon habitats[286]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some risk posed to seabirds as a result of gillnet and longline fisheries, some of which could be considered ETP species, such as auk species[287],[288]. Fisheries, especially trawlers, targeting Northeast Arctic (NEA) cod and haddock

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[278] https://www.sustainablefish.org/News/Top-UK-Seafood-Products-May-Pose-Risks-to-Sharks-Seabirds-Marine-Mammals-and-Sea-Turtles

[279] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[280] https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

[281] https://fisheries.msc.org/en/fisheries/isf-iceland-cod/@@view

[282] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[283] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[284] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[285] http://seafoodco2.dal.ca/

[286] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[287] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[288] https://www.sustainablefish.org/News/Top-UK-Seafood-Products-May-Pose-Risks-to-Sharks-Seabirds-Marine-Mammals-and-Sea-Turtles

take a bycatch of golden redfish (*Sebastes norvegicus*), which is on the Norwegian Redlist as a threatened (EN) species, indicating that it's at risk of extinction[289]. Harbour porpoises are the most common marine mammal bycatch in the Norwegian fishery. The cod fishery also catches harp seals, harbour seals, and ringed seals[290]. A 'high risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst there are specific concerns associated with the Norwegian coastal cod stock and the cod fishery, Norwegian fisheries management is generally considered to be effective. A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): Norway's Northeast Arctic cod fishery is currently MSC certified[291]. WWF previously submitted objections to this certification, which were subsequently withdrawn[292]. A 'medium risk' score is therefore provided.

Supply chain: Germany wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Both North Sea cod and Western Baltic cod are in a depleted state and subject to overfishing[282]. A 'high risk' score is provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[287]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[293]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[294], it is felt this underestimates the impact on blue carbon habitats[295]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is risk of bycatch of cetaceans such as harbour porpoise, the population of which is critically endangered in the Baltic Sea, and seabirds in the gillnet fisheries[287]. A 'high risk' score is therefore provided.

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289 https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

290 https://www.sustainablefish.org/News/Top-UK-Seafood-Products-May-Pose-Risks-to-Sharks-Seabirds-Marine-Mammals-and-Sea-Turtles

291 https://fisheries.msc.org/en/fisheries/norway-north-east-arctic-cod-offshore-12nm/@@view

292 *See WWF_Amended Notice of Objection and IA_Notice of Cessation at* https://fisheries.msc.org/en/fisheries/norway-north-east-arctic-cod-offshore-12nm/@@assessments

293 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

294 http://seafoodco2.dal.ca/

295 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst a wide variety of EU CFP management measures and recovery plans are in place for EU cod fisheries and the stocks they target, there is clearly scope for improvements in management effectiveness given the risks posed to the target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The German fishery targeting Northeast Arctic cod is partially MSC certified with conditions[296]. A 'medium risk' score is provided.

Supply chain: Russia wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Northeast Arctic cod stock is considered as having a healthy stock size and sustainably fished relative to MSY reference points[282]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[297]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[298], it is felt this underestimates the impact on blue carbon habitats[299]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Interaction between the fishery and a number of ETP species were noted in the MSC certification assessments, plus a weakness of the Murmanseld fishery was noted as 'There is no formal regular review of the specific information collected by the UoA on interactions with ETP species, nor a wider-ranging review on the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of ETP species'[300]. The evidence of ETP impact available for the Norwegian Northeast Arctic (NEA) cod fishery is likely to be applicable to the Russian fishery too. This includes bycatch of golden redfish (*Sebastes norvegicus*) by trawlers targeting NEA cod and haddock, which is on the Norwegian Redlist as a threatened (EN) species indicating that it's at risk of extinction[283]. A 'high risk' score is therefore provided.

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[296] https://fisheries.msc.org/en/fisheries/uk-fisheries-ltd-dffu-doggerbank-northeast-arctic-cod-haddock-and-saithe/about/

[297] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[298] http://seafoodco2.dal.ca/

[299] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[300] https://fisheries.msc.org/en/fisheries/murmanseld-2-barents-sea-cod-and-haddock/@@assessments

Social concerns associated with supply chain (Social_1): According to the Global Slavery Index (2018)[301], there are significant social concerns associated with Russia's fishing industry – a 'high risk' score is provided.

Management effectiveness (Mgt_1): Whilst Russian fisheries management is generally considered poor, joint management of this fishery with Norway is considered good (e.g. see MSC assessments). A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Russian fishery is largely MSC certified[302, 303,304,305]. WWF previously submitted objections to the Barents Sea cod, haddock and saithe certification, which were subsequently withdrawn[306], and also objections to the Murmanseld 2 Barents Sea cod and haddock certification. These were initially accepted by the Independent Adjudicator and then dismissed. WWF did not withdraw the objections[307]. The FIUN Barents & Norwegian Seas cod and haddock certification is associated with conditions[308]. A 'medium risk' score is therefore provided on a proportionate basis.

Supply chain: Faroe Islands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The exploitation rate of the Faroe Plateau stock is above Fmsy although the biomass is recovering after a decade of being at very low levels. The Faroe Bank cod stock is data limited, with the latest assessment in 2018 - no reference points are defined, and so the conclusion of critical stock size, but sustainable fishing rate is based on a qualitative assessment. The Faroe Islands also fish Northeast Arctic cod which is in a healthy state[282]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines, as well as jigging or handlining in this fishery. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical and other management measures applied to the fishery seek to reduce unwanted bycatch, but risks remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[309]. Whilst an average score of 2 tonnes of CO2 per kg of

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[301] *Global Slavery Index 2018. Spotlight on Sectors – Modem Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[302] *https://fisheries.msc.org/en/fisheries/russian-federation-barents-sea-cod-haddock-and-saithe/@@view*

[303] *https://fisheries.msc.org/en/fisheries/murmanseld-2-barents-sea-cod-and-haddock/@@assessments*

[304] *https://fisheries.msc.org/en/fisheries/barents-sea-cod-haddock-and-saithe/@@view*

[305] *https://fisheries.msc.org/en/fisheries/fiun-barents-norwegian-seas-cod-and-haddock/about/*

[306] *See pp 258-260 of Public Certification Report (Sept. 2016): https://fisheries.msc.org/en/fisheries/barents-sea-cod-haddock-and-saithe/@@assessments*

[307] *See p 215 of the Public Certification Report (March 2020): https://fisheries.msc.org/en/fisheries/murmanseld-2-barents-sea-cod-and-haddock/@@assessments*

[308] *https://fisheries.msc.org/en/fisheries/fiun-barents-norwegian-seas-cod-and-haddock/about/*

[309] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

fish ('low risk') is provided by The Seafood Carbon Emissions Tool[310], it is felt this underestimates the impact on blue carbon habitats[311]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is no evidence of ETP mortality risk in the Faroe Plateau fishery potentially due to the lack of gillnet effort. However, the Faroe Islands also fish beyond these waters. A 'medium risk' score is provided on a precautionary basis and more information is required.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Faroe Islands groundfish fishery is considered to be of concern due to lack of catch control (effort based management is in place with documented issues and criticism) and management plan. Catches have exceeded scientific advice for an extended period. A new management plan has been agreed but is in the process of being implemented[283]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Faroe Islands Northeast Arctic cod fishery is MSC certified[312], however there is no such progress in relation to the Faroe Bank or Faroe Plateau fisheries – a 'medium risk' score is provided.

Supply chain: Denmark wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Both North Sea cod and Western Baltic cod are in a depleted state and subject to overfishing. The Kattegat stock is data limited but zero catches are advised[282]. A 'high risk' score is provided.

Ecosystem impact (Env_2): Cod fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[313]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[314], it is felt this underestimates the impact on blue carbon habitats[315]. A 'medium risk' score is therefore provided.

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[310] http://seafoodco2.dal.ca/

[311] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[312] https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

[313] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[314] http://seafoodco2.dal.ca/

[315] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

ETP impact (Env_4): There is risk of bycatch of cetaceans such as harbour porpoise, the population of which is critically endangered in the Baltic Sea, and seabirds in the gillnet fisheries[316]. A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst a wide variety of EU CFP management measures and recovery plans are in place for EU cod fisheries and the stocks they target, there is clearly scope for improvements in management effectiveness given the risks posed to the target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): Denmark's North Sea fishery is partially MSC certified (with conditions)[317]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Pacific cod

Supply chain: United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Bering Sea and Gulf of Alaska stocks are considered to be above target population levels and not subject to overfishing. The Aleutian Islands stock is data limited although it is not considered to be subject to overfishing. The Pacific coast population has not been formally assessed[318,319]. Given the status of the main populations involved in the fishery, a 'low risk' score is provided.

Ecosystem impact (Env_2): the United States Pacific cod fisheries typically use a mixture of bottom towed gear, longlines and pots. Bottom towed gear poses risk to the ecosystem through habitat damage and both gear types pose risk of bycatch of target and non-target species, although some area closures are in place to protect sensitive habitats and organisms. Bycatch mitigation measures and limits are in place, including to reduce catches of Pacific halibut and incidental catches of seabirds by longlines[318]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[320]. Whilst an average score of 2.6-3 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool for bottom trawling and

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[316] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[317] https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/@@view

[318] https://www.fisheries.noaa.gov/species/pacific-cod

[319] https://fishchoice.com/buying-guide/pacific-cod

[320] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

longlining[321], it is felt this underestimates the impact on blue carbon habitats[322]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Whilst the MSC certification concludes negligible impacts on populations of ETP species, low levels of interaction can occur with a number of species (e.g. Steller sea lion, Ringed seal, Dall's porpoise and Black-footed Albatross) and there are uncertainties over the size of the associated populations[323] and therefore long-term effects of bycatch mortality. A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery by NOAA, the North Pacific Fishery Management Council and Pacific Fishery Management Council[318] is considered effective – a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The United States fishery is largely MSC certified, however the BSAI and Goa Pacific cod certification is associated with conditions[324,323] resulting in a 'medium risk' score.

Supply chain: Russia wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Information on the status of the Pacific cod stock in the Western Bering Sea is limited (or not made publicly available)[325,326,327]. However, according to the MSC assessment report[328], the Pacific cod stock in the Western Bering Sea is at high levels of production. This statement is however based on information that only extends to 2017 and significant variation in stock size prior to that is also noted. As a result, a 'medium risk' score is provided.

Ecosystem impact (Env_2): Russian Pacific cod fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and both gear types pose risk of bycatch of target and non-target species. It was noted in the MSC assessment of the longline fishery that "*the effect of the fishery on the ecosystem generally is not strong, due to limited bycatch of non-target species and weak effect of the longline on bottom communities. Composition of by-catch in the fishery has been studied in the framework of several observer programs, but more comprehensive information on quantitative composition and stock status of non-target species is still needed*"[328]. A 'medium risk' score is therefore provided.

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[321] http://seafoodco2.dal.ca/

[322] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[323] https://fisheries.msc.org/en/fisheries/bsai-and-goa-pacific-cod/@@view

[324] https://fisheries.msc.org/en/fisheries/us-west-coast-limited-entry-groundfish-trawl/about/

[325] https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/GOApcod.pdf

[326] https://www.fishsource.org/stock_page/1416

[327] https://seafood.ocean.org/seafood/type/cod/

[328] https://fisheries.msc.org/en/fisheries/western-bering-sea-pacific-cod-and-pacific-halibut-longline/@@view

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[329]. Whilst an average score of 2.6-3 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool for bottom trawling and longlining[330], it is felt this underestimates the impact on blue carbon habitats[331]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): A number of ETP species have the potential to interact with the Russian Pacific cod fishery including Steller sea lion, northern fur seal, Short-tailed albatross and Red-legged kittiwake. Whilst there is some evidence to suggest that the impacts of the longline fishery on such species are low, including due to the compulsory use of streamers as seabird bycatch mitigation devices[328], this is supported by limited empirical evidence (e.g. observer data) particularly in terms of pinniped interactions. Very limited information is available for the bottom trawl fishery[332]. A 'high risk' score is therefore provided on the basis of the interactions that are reported and that the risks are likely to be higher (i.e. see United States assessment), but lack of observer data limits such an assessment.

Social concerns associated with supply chain (Social_1): According to the Global Slavery Index (2018)[333], there are significant social concerns associated with Russia's fishing industry – a 'high risk' score is provided.

Management effectiveness (Mgt_1): Russian fisheries management is considered variable, with concerns typically relating to lack of transparency over policy making and operational management, minimal data availability and economic prosperity as a key objective of management measures[334,332]. Whilst management of the longline fishery is considered effective[328], information on the bottom trawl fishery is lacking. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Russian fishery is partially MSC certified (longlines)[328], resulting in a 'medium risk' score.

Haddock

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Haddock stocks in UK waters are considered to be in a healthy state and fished at a sustainable rate compatible with Fmsy[335,336]. A 'low risk' score is provided.

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[329] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[330] http://seafoodco2.dal.ca/

[331] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[332] https://www.seafoodwatch.org/recommendation/cod/red-cod-pacific-cod-russia-northwest-pacific-ocean-bottom-trawls?species=111

[333] Global Slavery Index 2018. Spotlight on Sectors – Modem Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/

[334] https://seafood.ocean.org/seafood/type/cod/

[335] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[336] https://europe.oceana.org/en/uk-fisheries-audit-2021

Ecosystem impact (Env_2): Haddock fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain, including bycatch of depleted cod stocks[337]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[338]. Whilst an average score of 4 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[339], it is felt this underestimates the impact on blue carbon habitats[340]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. UK fisheries in the south west (Celtic Sea and western English Channel) in particular are associated with risk of harbour porpoise mortality. Whilst ETP impact risks are generally perceived to be lower than for cod fisheries[283], in part due to the more limited use of gillnets in the fishery, depleted North Sea cod are also caught by vessels targeting haddock. Further, MSC certification assessments (see Mgt_2) note a number of interactions with ETP species of rays, skates and seals. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Reports of social concerns associated with Scottish whitefish fisheries have featured in the media in past years[341]. In the absence of information to confirm such issues are no longer present in the industry, a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Whilst a variety of management measures are in place for UK haddock fisheries and the stocks they target, there is clearly scope for improvements in management effectiveness given the risks posed to non-target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The UK haddock fishery is MSC certified under multiple certifications, all of which have conditions[342,343,344]. A 'medium risk' score is provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Northeast Arctic haddock stock has a healthy biomass but the exploitation rate is just above Fmsy. The North

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[337] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[338] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[339] http://seafoodco2.dal.ca/

[340] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[341] https://www.express.co.uk/news/uk/456085/Boat-slave-shame-of-fishing-industry *and* https://www.independent.co.uk/news/uk/crime/police-investigate-claims-slavery-uk-fishing-fleet-9877879.html

[342] https://fisheries.msc.org/en/fisheries/uk-fisheries-ltd-dffu-doggerbank-northeast-arctic-cod-haddock-and-saithe/@@view

[343] https://fisheries.msc.org/en/fisheries/sfsag-northern-demersal-stocks/@@view

[344] https://fisheries.msc.org/en/fisheries/scottish-fisheries-sustainable-accreditation-group-sfsag-rockall-haddock/@@view

Sea haddock stock is considered to be in a healthy state and fished a rate that is compatible with Fmsy[282]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Haddock fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage (including potentially VME habitats) and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[345]. Whilst an average score of 4 tonnes of CO_2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[346], it is felt this underestimates the impact on blue carbon habitats[347]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some low-level risk posed to seabirds as a result of longline fisheries, some of which could be considered ETP species[283]. MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. Fisheries, especially trawlers, targeting Northeast Arctic (NEA) cod and haddock take a bycatch of golden redfish (*Sebastes norvegicus*), which is on the Norwegian Redlist as a threatened (EN) species, indicating that it's at risk of extinction[283]. A 'high risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is generally considered to be effective on the basis of the management plan, technical measures and control and enforcement capabilities that are in place[283], a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): Norway's Northeast Arctic and North Sea haddock fisheries are MSC certified with conditions[348,349] – a 'medium risk' score is provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The haddock stock in Icelandic waters is assessed as having a healthy stock size but fishing pressure is above Fmsy, but below Flim[350]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Haddock fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage (including potentially VME habitats) and bycatch of target and non-target species. Technical

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[345] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[346] http://seafoodco2.dal.ca/

[347] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[348] https://fisheries.msc.org/en/fisheries/norway-north-east-arctic-haddock-offshore-12nm/@@view

[349] https://fisheries.msc.org/en/fisheries/norway-north-sea-demersal/@@view

[350] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[351]. Whilst an average score of 4 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[352], it is felt this underestimates the impact on blue carbon habitats[353]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some low-level risk posed to seabirds as a result of longline fisheries, some of which could be considered ETP species[283]. A 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is generally considered to be effective on the basis of the management plan, technical measures and control and enforcement capabilities that are in place, however fishing pressure is above recommended levels and catch limits are regularly exceeded[283], a 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): Iceland's haddock fishery is MSC certified[354,] with conditions in part[355] – a 'medium risk' score is provided.

Supply chain: Denmark wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The North Sea, West of Scotland and Skagerrak haddock stocks are considered to be in a healthy state and fished at a rate that is compatible with Fmsy[282]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Haddock fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain, including bycatch of depleted cod stocks[356]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[357]. Whilst an average score of 4 tonnes of CO2 per kg of

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[351] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[352] http://seafoodco2.dal.ca/

[353] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[354] https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

[355] https://fisheries.msc.org/en/fisheries/isf-iceland-haddock/@@view

[356] https://www.mcsuk.org/goodfishguide/species/atlantic-cod/

[357] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

fish ('low risk') is provided by The Seafood Carbon Emissions Tool[358], it is felt this underestimates the impact on blue carbon habitats[359]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There are no reported ETP mortality risks associated with the fishery although MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. However, for the cod fishery there is risk of bycatch of cetaceans such as harbour porpoise, the population of which is critically endangered in the Baltic Sea, and seabirds in the gillnet fisheries[283]. A 'medium risk' score is therefore provided on a precautionary basis, including due to depleted North Sea cod being caught alongside haddock.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst a wide variety of EU CFP management measures are in place, there is clearly scope for improvements in management effectiveness given the risks posed to non-target species and other marine life, and discarding levels. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): Denmark's North Sea fishery is partially MSC certified (with conditions)[360]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Supply chain: Faroe Islands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Faroes Islands haddock stock has recovered to a healthy status and fishing pressure is compatible with Fmsy, after a prolonged period of poor stock status. The Northeast Arctic haddock stock has a healthy biomass, but the exploitation rate is just above Fmsy[282,361]. A 'medium risk' score is provided on a precautionary basis.

Ecosystem impact (Env_2): Longlining is associated with seabird mortality risk and bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species[361]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses longlining gear[361], a 'medium risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[362]. Whilst an average score of 4 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[363], it is felt this

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[358] http://seafoodco2.dal.ca/

[359] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[360] https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/@@view

[361] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/73/

[362] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[363] http://seafoodco2.dal.ca/

underestimates the impact on blue carbon habitats from the mixture of gear types[364]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some low-level risk posed to seabirds as a result of longline fisheries, some of which could be considered ETP species[283]. Fisheries, especially trawlers, targeting Northeast Arctic (NEA) cod and haddock take a bycatch of golden redfish (Sebastes norvegicus), which is on the Norwegian Redlist as a threatened (EN) species, indicating that it's at risk of extinction[283]. A 'high risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Faroe Islands groundfish fishery is considered to be of concern due to lack of catch control (effort based management is in place with documented issues and criticism) and management plan. A new management plan has been agreed but is in the process of being implemented[361]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Faroe Islands Northeast Arctic haddock fishery is partially MSC certified[365] – a 'medium risk' score is provided.

Supply chain: Russia wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Northeast Arctic haddock stock has a healthy biomass but the exploitation rate is just above Fmsy[282]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Haddock fisheries typically use a mixture of bottom towed gear and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage (including potentially VME habitats) and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[283]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[366]. Whilst an average score of 4 tonnes of $CO2$ per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[367], it is felt this underestimates the impact on blue carbon habitats[368]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): There is considered to be some low-level risk posed to seabirds as a result of longline fisheries, some of which could be considered ETP species[283]. Fisheries, especially trawlers, targeting Northeast Arctic (NEA) cod and haddock take a bycatch of golden redfish (*Sebastes norvegicus*), which is on the Norwegian Redlist as a threatened (EN) species,

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[364] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[365] https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

[366] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[367] http://seafoodco2.dal.ca/

[368] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

indicating that it's at risk of extinction[283]. MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. A ‘high risk’ score is provided.

Social concerns associated with supply chain (Social_1): According to the Global Slavery Index (2018)[369], there are significant social concerns associated with Russia’s fishing industry – a ‘high risk’ score is provided.

Management effectiveness (Mgt_1): Whilst Russian fisheries management is generally considered poor, joint management of this fishery with Norway is considered good (e.g. see MSC assessments). A ‘low risk’ score is provided.

Sustainability certification progress (Mgt_2): The Russian fishery is largely MSC certified[370,371,372373]. WWF previously submitted objections to the Barents Sea cod, haddock and saithe certification, which were subsequently withdrawn[374], and also objections to the Murmanseld 2 Barents Sea cod and haddock certification. These were initially accepted by the Independent Adjudicator and then dismissed. WWF did not withdraw the objections[375]. The FIUN Barents & Norwegian Seas cod and haddock certification is associated with conditions[373]. A ‘medium risk’ score is therefore provided on a proportionate basis.

Saithe

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Saithe stocks in UK waters are lower than the MSY biomass level and fishing pressure is just above Fmsy[376]. A ‘medium risk’ score is provided.

Ecosystem impact (Env_2): Saithe fisheries typically use a mixture of bottom towed gear and to a lesser extent demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Bycatch of depleted cod stocks is of particular concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[377]. A ‘medium risk’ score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a ‘high risk’ score would be applied to the carbon footprint of the production method

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[369] *Global Slavery Index 2018. Spotlight on Sectors – Modem Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[370] *https://fisheries.msc.org/en/fisheries/russian-federation-barents-sea-cod-haddock-and-saithe/@@view*

[371] *https://fisheries.msc.org/en/fisheries/murmanseld-2-barents-sea-cod-and-haddock/@@assessments*

[372] *https://fisheries.msc.org/en/fisheries/barents-sea-cod-haddock-and-saithe/@@view*

[373] *https://fisheries.msc.org/en/fisheries/fiun-barents-norwegian-seas-cod-and-haddock/about/*

[374] *See pp 258-260 of Public Certification Report (Sept. 2016): https://fisheries.msc.org/en/fisheries/barents-sea-cod-haddock-and-saithe/@@assessments*

[375] *See p 215 of the Public Certification Report (March 2020): https://fisheries.msc.org/en/fisheries/murmanseld-2-barents-sea-cod-and-haddock/@@assessments*

[376] *https://www.ices.dk/advice/Pages/Latest-Advice.aspx*

[377] *https://www.mcsuk.org/goodfishguide/species/coley/*

based on Parker & Tyedmers (2014)[378]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[379], it is felt this underestimates the impact on blue carbon habitats[380]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Bycatch of the vulnerable North Sea cod stock is an issue in this fishery. There are also potential bycatch impacts for species such as common skate and starry ray, although more data are needed[377]. MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Reports of social concerns associated with Scottish whitefish fisheries, namely forced labour and human trafficking ('modern day slavery'), have featured in the media in past years[381]. In the absence of information to confirm such issues are no longer present in the industry, a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Whilst a variety of management measures are in place, there is clearly scope for improvements in management effectiveness given the risks posed to the target and non-target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The North Sea saithe fishery is covered by two MSC certificates, with conditions[382,383]. A 'medium risk' score is provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The saithe stock in Icelandic water is assessed as having a biomass level and exploitation rate that are in line with MSY reference points[282]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Saithe fisheries typically use a mixture of bottom towed gear and to a lesser extent demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[384]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[385]. Whilst an average score of 2 tonnes of CO2 per kg of

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[378] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[379] http://seafoodco2.dal.ca/

[380] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[381] https://www.express.co.uk/news/uk/456085/Boat-slave-shame-of-fishing-industry *and* https://www.independent.co.uk/news/uk/crime/police-investigate-claims-slavery-uk-fishing-fleet-9877879.html

[382] https://fisheries.msc.org/en/fisheries/uk-fisheries-dffu-doggerbank-group-saithe/about/

[383] https://fisheries.msc.org/en/fisheries/sfsag-northern-demersal-stocks/about/

[384] https://www.mcsuk.org/goodfishguide/species/coley/

[385] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

fish ('low risk') is provided by The Seafood Carbon Emissions Tool[386], it is felt this underestimates the impact on blue carbon habitats[387]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): ETP mortality is generally not considered a concern for saithe fisheries although MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. A 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Icelandic fisheries management is generally considered to be effective – a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Icelandic saithe fishery is MSC certified with conditions[388,389], leading to a 'medium risk' score.

Supply chain: Faroe Islands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Faroe Islands saithe stock is in a good state, with biomass well above the target points and fishing pressure just below[390]. The Northeast Arctic saithe stock is assessed as having a biomass level and exploitation rate that are in line with MSY reference points[282]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Saithe fisheries typically use a mixture of bottom towed gear and to a lesser extent demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[391]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[392]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[393], it is felt this underestimates the impact on blue carbon habitats[394]. A 'medium risk' score is therefore provided.

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386 http://seafoodco2.dal.ca/

387 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

388 https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

389 https://fisheries.msc.org/en/fisheries/isf-iceland-multi-species-demersal-fishery/@@view

390 https://www.mcsuk.org/goodfishguide/ratings/wild-capture/401/

391 https://www.mcsuk.org/goodfishguide/species/coley/

392 Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

393 http://seafoodco2.dal.ca/

394 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

ETP impact (Env_4): ETP mortality is generally not considered a concern for saithe fisheries although MSC certification assessments for other North Atlantic fisheries do note a number of interactions with ETP species. Further monitoring is required for this fishery in particular. A 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Faroe Islands groundfish fishery is considered to be of concern due to lack of catch control (effort based management is in place with documented issues and criticism) and management plan. A new management plan has been agreed but is in the process of being implemented[390]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Faroe Islands Northeast Arctic saithe fishery is MSC certified, with conditions[395,396] – a 'medium risk' score is provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Northeast Arctic saithe stock is assessed as having a biomass level and exploitation rate that are in line with MSY reference points. Saithe stocks in the North Sea, Skagerrak and Kattegat are lower than the MSY biomass level and fishing pressure is just above Fmsy[282]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Saithe fisheries typically use a mixture of bottom towed gear and to a lesser extent demersal gillnets. Purse seines are also used in the Northeast Arctic fishery. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[397]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[398]. Whilst an average score of 2 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[399], it is felt this underestimates the impact on blue carbon habitats[400]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): ETP mortality is generally not considered a concern for saithe fisheries although MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. For the Norwegian fisheries, interactions with ETP species (cetaceans, elasmobranchs, fish) have been recorded and this may include golden redfish (*Sebastes*

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[395] https://fisheries.msc.org/en/fisheries/faroe-islands-and-iceland-north-east-arctic-cod-haddock-and-saithe/@@view

[396] https://fisheries.msc.org/en/fisheries/faroe-islands-saithe/about/

[397] https://www.mcsuk.org/goodfishguide/species/coley/

[398] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[399] http://seafoodco2.dal.ca/

[400] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

norvegicus), which is on the Norwegian Redlist as a threatened (EN) species, indicating that it's at risk of extinction[283]. However, the level of interaction is likely to be lower than for other whitefish fisheries and so a 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is generally considered to be effective on the basis of the management plan, technical measures and control and enforcement capabilities that are in place[283], however there is cause for concern over the status of the North Sea, Skagerrak and Kattegat stock. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): Norway's Northeast Arctic and North Sea saithe fisheries are MSC certified with conditions[401,402] – a 'medium risk' score is provided.

Supply chain: Denmark wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Saithe stocks in the North Sea, Skagerrak and Kattegat are lower than the MSY biomass level and fishing pressure is just above Fmsy[403]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Saithe fisheries typically use a mixture of bottom towed gear and to a lesser extent demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Bycatch of depleted cod stocks is of particular concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[404]. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear, a 'high risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[405]. Whilst an average score of 2 tonnes of CO_2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[406], it is felt this underestimates the impact on blue carbon habitats[407]. A 'medium risk' score is therefore provided.

ETP impact (Env_4): ETP mortality is generally not considered a concern for saithe fisheries although MSC certification assessments (see Mgt_2) note a number of interactions with ETP species. A 'medium risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

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[401] https://fisheries.msc.org/en/fisheries/norway-north-east-arctic-saithe/@@view

[402] https://fisheries.msc.org/en/fisheries/norway-north-sea-demersal/@@view

[403] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[404] https://www.mcsuk.org/goodfishguide/species/coley/

[405] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[406] http://seafoodco2.dal.ca/

[407] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

Management effectiveness (Mgt_1): Whilst a wide variety of EU CFP management measures are in place, there is clearly scope for improvements in management effectiveness given the risks posed to non-target species and other marine life, and discarding levels. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): Denmark's North Sea fishery is partially MSC certified[408]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Monkfish

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of anglerfish stocks is variable, with those in the Celtic Sea considered to be in a healthy state and not subject to overfishing, while in the North Sea the assessment is data limited. There are also concerns over limited consideration of stock and species structure in scientific advice and management approaches[409,410,411]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Monkfish fisheries typically use a mixture of bottom towed gear (otter trawls and beam trawls) and demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Bycatch of depleted cod stocks is of particular concern. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear (and in the absence of any conflicting evidence), a 'high risk' score is applied to the carbon footprint of the production method[412,413].

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. The common skate and spurdogs are caught as bycatch in demersal trawl fisheries within the Celtic Seas and Bay of Biscay ecoregions, and deep-water sharks are reported to being caught in the mixed deep-water trawl fishery in the Celtic Seas. UK fisheries in the southwest (Celtic Sea and western English Channel) in particular are associated with risk of harbour porpoise mortality. On the basis of perception of potential risk[411], a 'high risk' score is provided on a precautionary basis.

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[408] https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/@@view

[409] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[410] https://europe.oceana.org/en/uk-fisheries-audit-2021

[411] https://www.mcsuk.org/goodfishguide/?search=monkfish&page=1

[412] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[413] http://seafoodco2.dal.ca/

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst a variety of management measures are in place for UK groundfish fisheries and the stocks they target, there is clearly scope for improvements in management effectiveness given the risks posed to non-target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The southwest UK fishery is part of a FIP[414], a 'medium risk' score is provided.

Supply chain: The Republic of Ireland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of anglerfish stocks is variable, with those in the Celtic Sea considered to be in a healthy state and not subject to overfishing, while in the North Sea the assessment is data limited. There are also concerns over limited consideration of stock and species structure in scientific advice and management approaches[415,416,417]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Monkfish fisheries typically use a mixture of bottom towed gear (otter trawls and beam trawls) and demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Bycatch of depleted cod stocks is of particular concern. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear (and in the absence of conflicting evidence), a 'high risk' score is applied to the carbon footprint of the production method[418,419].

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. The common skate and spurdogs, are caught as bycatch in demersal trawl fisheries within the Celtic Seas and Bay of Biscay ecoregions, and deep-water sharks are reported to being caught in the mixed deep-water trawl fishery in the Celtic Seas. UK fisheries in the southwest (Celtic Sea and western English Channel) in particular are associated with risk of harbour porpoise mortality. On the basis of perception of potential risk[411], a 'high risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): A recent article on human trafficking in the Republic of Ireland's seafood industry[420] raises concerns about social issues that require further investigation – a 'medium risk' score is provided.

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[414] https://www.projectukfisheries.co.uk/monkfish

[415] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[416] https://europe.oceana.org/en/uk-fisheries-audit-2021

[417] https://www.mcsuk.org/goodfishguide/?search=monkfish&page=1

[418] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[419] http://seafoodco2.dal.ca/

[420] https://www.seafoodsource.com/news/supply-trade/irish-government-ngo-clash-over-human-trafficking-call-out

Management effectiveness (Mgt_1): Whilst a wide variety of EU CFP management measures and recovery plans are in place for EU groundfish fisheries, there is clearly scope for improvements in management effectiveness given the risks posed to the target species and other marine life. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): There is no known third-party sustainable certification progress – a 'high risk' score is provided.

Supply chain: Faroe Islands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): There is no available information on the status of anglerfish stocks in Faroe Islands waters. The stock(s) in the North Sea are data limited. There are also concerns over limited consideration of stock and species structure in scientific advice and management approaches[421,422,423]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Monkfish fisheries typically use a mixture of bottom towed gear (otter trawls and beam trawls) and demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear (and in the absence of conflicting evidence), a 'high risk' score is applied to the carbon footprint of the production method[424,425].

ETP impact (Env_4): In the absence of information on ETP specific to the Faroe Islands fishery, a 'medium risk' score is provided on a precautionary and data limited basis.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Faroe Islands groundfish fishery is considered to be of concern due to lack of catch control (effort based management is in place with documented issues and criticism) and management plan. The same is assumed to apply to the monkfish fishery. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): There is no known third-party sustainable certification progress – a 'high risk' score is provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Icelandic monkfish assessment is data limited but there are indications that the stock is in a poor state, such as

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[421] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[422] https://europe.oceana.org/en/uk-fisheries-audit-2021

[423] https://www.mcsuk.org/goodfishguide/?search=monkfish&page=1

[424] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[425] http://seafoodco2.dal.ca/

substantial reductions in biomass and persistently poor recruitment[426]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Monkfish fisheries typically use a mixture of bottom towed gear (otter trawls and beam trawls) and demersal gillnets. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. A 'medium risk' score is provided.

Climate change impact (Env_3): Given that a large proportion of the fishery uses bottom towed gear (and in the absence of conflicting evidence), a 'high risk' score is applied to the carbon footprint of the production method[427,428].

ETP impact (Env_4): Weaknesses identified in the Icelandic anglerfish MSC assessment included lack of monitoring of ETP interactions, limited data and lack of a specific bycatch management strategy[429]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Whilst Icelandic fisheries management is generally considered effective, there is no management plan in place for this fishery, the stock is considered depleted and there are potential issues with bycatch. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Icelandic monkfish fishery is MSC certified[429], but with seven conditions therefore a 'medium risk' score is provided.

Alaska pollock

Supply chain: the United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Alaska pollock in the Gulf of Alaska, Bering Sea and Aleutian Islands is considered to have a healthy stock size and is not being overfished[430]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Pollock is fished with pelagic trawls which do not interact with the seafloor and bycatch is considered to be minimal[430]. A 'low risk' score is provided.

Climate change impact (Env_3): Pelagic trawls are associated with a 'medium risk' in relation to carbon footprint of the production method[431].

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[426] https://www.hafogvatn.is/static/extras/images/14-anglerfish1206912.pdf

[427] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[428] http://seafoodco2.dal.ca/

[429] https://fisheries.msc.org/en/fisheries/isf-iceland-anglerfish/@@assessments

[430] https://www.mcsuk.org/goodfishguide/species/alaska-pollock/

[431] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

ETP impact (Env_4): "*Marine mammals are rarely taken as bycatch in the Bering Sea and Aleutian Islands fishery and in 2019, it was classified as Category II (occasional incidental mortality and serious injury of marine mammals). From 2012-2016, 28 stellar sea lions (6 per year average) and no northern fur seals were taken in the pollock fishery. Other marine mammals at risk in this area include species of seal, porpoise and whale, however interactions are thought to be mitigated by 100% observer coverage. Sharks are sometimes taken as bycatch and the number of tonnes taken per year has ranged from 26 t to 512 t between 2003 and 2018, however, since 2010, there has been under 100 t taken each year. Relatively few seabirds are taken in the East Bering Sea and Aleutian Island fishery using pelagic trawl and no short-tailed albatross or black-footed albatross from 2007-2017.*

Marine mammals such as species of seal, dolphin and whale are at risk of interaction with the pollock fishery, however are rarely taken as bycatch in the Gulf of Alaska fishery and the fishery continues to be listed as a Category III (remote likelihood or no known interaction with marine mammals) fishery. No seabirds were recorded as bycatch in the pollock fishery in 2017, however, sharks can sometimes be taken as bycatch have averaged at 171 tonnes per year since 1997"[430].

Despite some of the reassurances provided by the description above, given the number of species for which interactions have been recorded (see MSC certification report[432]), a 'high risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is considered effective – a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The United States Alaskan pollock fishery is MSC certified[432] – a 'low risk' score is provided.

Supply chain: Russia wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Sea of Okhotsk pollock stock is considered healthy however there is concern for both biomass and fishing pressure of the west Bering Sea stock. The stock has been below the target reference point for biomass since 2014 and has hovered just above Blim in recent years. Data on fishing mortality is not available[430]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Pollock is fished with pelagic trawls which do not interact with the seafloor and bycatch is considered to be minimal[430]. However, there are concerns over inadequate strategies for addressing trophic interactions in relation to Stellar sealions[433]. A 'medium risk' score is provided.

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[432] https://fisheries.msc.org/en/fisheries/bsai-and-goa-alaska-pollock/@@view

[433] https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BWalleye%20pollock

Climate change impact (Env_3): Pelagic trawls are associated with a 'medium risk' in relation to carbon footprint of the production method[434].

ETP impact (Env_4): "*Russian Far East seas are important areas for feeding, seasonal concentrations and breeding aggregations for 19 rare species of marine mammals and 22 endangered, threatened or protected (ETP) seabird species. Alaskan pollock are important prey for Steller sea lions, making up 23% of their diet, but there is not thought to be any impact on Steller sea lion populations from this fishery. There are 9 area closures in the pollack fishery to protect marine mammal forage grounds and certain seabed habitats*"[430].

More information on these potential interactions and their impacts is needed however, with the limited observer coverage being a key constraining factor. A 'high risk' score is therefore provided in accordance with that for the United States fishery.

Social concerns associated with supply chain (Social_1): According to the Global Slavery Index (2018)[435], there are significant social concerns associated with Russia's fishing industry – a 'high risk' score is provided.

Management effectiveness (Mgt_1): Management of the Russian component of the fishery is considered largely effective, although there are specific concerns about TACs being set above scientific advice, lack of information about activity in some components of the fishery and inadequate strategies for addressing trophic interactions[430,436]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Russian Alaskan pollock fishery is MSC certified[437,438,439,440,441]. WWF previously submitted objections to the Russian Sea of Okhotsk certification, which were subsequently withdrawn[442]. A 'medium risk' score is therefore provided.

European pollack

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): European pollack stocks are data limited and their status is unknown[443], a 'medium risk' score is provided.

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[434] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[435] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[436] *https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BWalleye%20pollock*

[437] *https://fisheries.msc.org/en/fisheries/russia-sea-of-okhotsk-pollock/@@view*

[438] *https://fisheries.msc.org/en/fisheries/western-bering-sea-pollock/@@view*

[439] *https://fisheries.msc.org/en/fisheries/east-kamchatka-alaska-walleye-pollock-mid-water-trawl/@@view*

[440] *https://fisheries.msc.org/en/fisheries/vityaz-avto-danish-seine-walleye-pollock-fishery/@@view*

[441] *https://fisheries.msc.org/en/fisheries/kuril-islands-pelagic-trawl-and-danish-seine-pollock-fishery/@@view*

[442] *https://www.msc.org/media-centre/press-releases/press-release/independent-adjudicator-issues-final-decision-in-russia-sea-of-okhotsk-pollock-fishery-objection*

[443] *https://www.ices.dk/advice/Pages/Latest-Advice.aspx*

Ecosystem impact (Env_2): Pollack fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[444]. A 'medium risk' score is provided.

Climate change impact (Env_3): The mix of gear types means a 'medium risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[445]. Data are not provided within the Seafood Carbon Emissions Tool[446]. A 'medium risk' score is therefore applied, also for consistency with other whitefish fisheries.

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. UK fisheries in the southwest (Celtic Sea and western English Channel) in particular are associated with risk of harbour porpoise mortality. On the basis of perception of potential risk[444], a 'medium risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Scientific advice has frequently been exceeded in the setting of TACs, recreational catches are unknown but could be substantial, and there are significant uncertainties associated with the stock status' and structure[444]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): There is no known third-party sustainable certification progress – a 'high risk' score is provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): European pollack stocks are data limited and their status is unknown[447], a 'medium risk' score is provided.

Ecosystem impact (Env_2): Pollack fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[448]. A 'medium risk' score is provided.

Climate change impact (Env_3): The mix of gear types means a 'medium risk' score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[449].

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[444] https://www.mcsuk.org/goodfishguide/species/pollack/

[445] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[446] http://seafoodco2.dal.ca/

[447] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[448] https://www.mcsuk.org/goodfishguide/species/pollack/

[449] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

Data are not provided within the Seafood Carbon Emissions Tool[450]. A ‘medium risk’ score is therefore applied, also for consistency with other whitefish fisheries.

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. On the basis of perception of potential risk[444], a ‘medium risk’ score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a ‘low risk’ score is provided.

Management effectiveness (Mgt_1): Information about the management of pollack fisheries specifically is limited, although Norwegian fisheries management is generally considered effective. A ‘medium risk’ score is provided on an information limited and precautionary basis.

Sustainability certification progress (Mgt_2): There is no known third-party sustainable certification progress – a ‘high risk’ score is provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): European pollack stocks are data limited and their status is unknown[447,451] , a ‘medium risk’ score is provided.

Ecosystem impact (Env_2): Pollack fisheries typically use a mixture of bottom towed gear, demersal gillnets and longlines. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. Gillnet bycatch is also of notable concern. Technical measures applied to the fishery seek to reduce unwanted bycatch, but issues remain[448]. A ‘medium risk’ score is provided in the absence of more specific information for Iceland.

Climate change impact (Env_3): The mix of gear types means a ‘medium risk’ score would be applied to the carbon footprint of the production method based on Parker & Tyedmers (2014)[452]. Data are not provided within the Seafood Carbon Emissions Tool[453]. A ‘medium risk’ score is therefore applied, also for consistency with other whitefish fisheries.

ETP impact (Env_4): Gillnets in particular pose the risk of ETP mortality, including sharks, cetaceans and other mammals. On the basis of perception of potential risk[444], a ‘medium risk’ score is provided on a precautionary basis and in the absence of more specific information for Iceland.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a ‘low risk’ score is provided.

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[450] http://seafoodco2.dal.ca/

[451] https://www.hafogvatn.is/en/harvesting-advice

[452] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[453] http://seafoodco2.dal.ca/

Management effectiveness (Mgt_1): Information about the management of pollack fisheries specifically is limited, although Icelandic fisheries management is generally considered effective. A ‘medium risk’ score is provided on an information limited and precautionary basis.

Sustainability certification progress (Mgt_2): There is no known third-party sustainable certification progress – a ‘high risk’ score is provided.

Seafood commodity – Salmonids

Atlantic Salmon

Supply chain: UK aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic Salmon is farmed in cage systems around the coast of Scotland (240,000 tonnes in 2019). No production occurs in England or Wales. A wide range of views exist on the potential impact of farmed salmon on its wild counterpart. Salmon farms are often located on the migratory paths of salmon as they return to the freshwater rivers to breed (as seen in Scotland, Norway, Faroe Islands and Eastern Canada). This has created concerns around the interaction of the two on a number of fronts.

Sea lice are currently a major problem in farmed salmon production. Infestation can cause severe skin damage, resulting in chronic osmoregulatory stress[454]. In addition, the impact of sea lice from salmon farms is well recognised as a hazard to wild anadromous salmonids[455] due to their proximity to farms during migration. The high larval loads of sea lice produced in the farms can increase sea lice infestation in these wild species and is likely to limit the survival ability of these fish, creating a direct threat to the wild population. However, it must be noted that much scientific debate is currently occurring as to the levels of effect that sea lice from farms actually have on wide population survival. Some studies have concluded that the effect of sea lice from farms has no direct association with wild salmon productivity[456] while others have found a direct link between the two[457].

Concerns have also been raised over farmed salmon escapes and potential interactions with wild stocks. Salmon escapes occur when cages / nets become damaged and can often involve large numbers of fish (for example, the Chilean aquaculture agency, Sernapesca, have reported that 4.7 million salmon are estimated to have escaped from salmon farms between 2010 and 2020[458]). Interaction of escapees with native species raises a number of concerns that include competition for habitat and food resources, predation and the introduction and spreading of diseases and parasites[459], however it is the hybridisation or breeding of escaped farmed stock with indigenous populations of Atlantic salmon that is currently of the greatest concern and has been outlined as the most important contemporary challenge to wild salmon populations[459]. In Norway it has been recently documented that 51 of 109 Norwegian Atlantic salmon populations

[454] *Gonzalez MP, Marin SL, Vargas-Chacoff L. 2015. Effects of Caligus rogercresseyi (Boxshall and Bravo, 2000) infestation on physiological response of host Salmo salar (Linnaeus 1758): establishing physiological thresholds. Aquaculture 438: 47– 54.*

[455] *Serra-Llinares, R.M., Bjørn, P.A., Finstad, B., Nilsen, R., Harbitz, A., Berg, M. and Asplin, L., 2014. Salmon lice infection on wild salmonids in marine protected areas: an evaluation of the Norwegian'National Salmon Fjords'. Aquaculture Environment Interactions, 5(1), pp.1-16.*

[456] *Marty, G. D., Saksida, S. M., & Quinn, T. J. (2010). Relationship of farm salmon, sea lice, and wild salmon populations. Proceedings of the National Academy of Sciences, 107(52), 22599-22604.*

[457] *Krkošek, M., Lewis, M. A., & Volpe, J. P. (2005). Transmission dynamics of parasitic sea lice from farm to wild salmon. Proceedings of the Royal Society B: Biological Sciences, 272(1564), 689-696.*

[458] *https://www.fishfarmingexpert.com/article/chile-47-million-salmon-escaped-in-last-10-years/*

[459] *Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B. and Vøllestad, L.A., 2017. The major threats to Atlantic salmon in Norway. ICES Journal of Marine Science, 74(6), pp.1496-1513.*

showed significant genetic introgression (the movement of genes from one species to another) from farmed salmon[460].

While the above issues are clearly a concern for wild salmon, the evidence of direct effects and reduction in wild stocks is still relatively limited. Furthermore, the species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern).

The UK is a major producer and has been constantly updating its management and licensing systems to reduce the risks set out above. While improvements have clearly been made, it is also true that significant issues have been seen with high sea lice infection rates being reported (Salmon Scotland reported a significant increase in infection numbers in recent years[461]) and major escape events occurring in recent years (50,000 fish were reported to have escaped from a Mowi owned farmed near Campbeltown in 2020[462]).

A 'medium risk' score is provided here on the basis that salmon production in the UK is considered to be having some detrimental effects on wild populations but with these effects not yet fully understood or assessed. This is set against a story of ever reducing migratory salmon numbers in Scotland as seen through significant falls in wild salmon catches[463], although this is seen to be due to a variety of different factors (of which salmon farming may be one).

Ecosystem impact (Env_2): Cage farming of salmon is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed[464], but also the release of high levels of nitrate and phosphate into the water column[465] and resulting eutrophication and red tide events. Salmon produce both solid and dissolved waste during production. Solid waste falls to the seabed and over time can build up to create an anoxic layer. Furthermore, this waste can be high in nitrate and phosphate which will breakdown and enter the water column in dissolved form. This can have the effect of encouraging primary production in the area.

A 'medium risk' score is provided here since some evidence of degradation through cage farming in the UK does exist, but this is not considered widespread.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[466] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was

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460 Karlsson, S., Diserud, O.H., Fiske, P., Hindar, K. and Handling editor: W. Stewart Grant, 2016. Widespread genetic introgression of escaped farmed Atlantic salmon in wild salmon populations. ICES Journal of Marine Science, 73(10), pp.2488-2498.

461 https://www.scottishsalmon.co.uk/reports

462 https://www.bbc.co.uk/news/uk-scotland-glasgow-west-53913708

463 https://sp-bpr-en-prod-cdnep.azureedge.net/published/2019/8/19/Wild-Salmon/SB%2019-48.pdf

464 Haya, K., Burridge, L.E. and Chang, B.D., 2001. Environmental impact of chemical wastes produced by the salmon aquaculture industry. ICES Journal of Marine Science, 58(2), pp.492-496.

465 Quinones, R.A., Fuentes, M., Montes, R.M., Soto, D. and León‐Muñoz, J., 2019. Environmental issues in Chilean salmon farming: a review. Reviews in Aquaculture, 11(2), pp.375-402.

466 Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture. https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[467] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced - slightly above the previous study.

What is clear in all the studies is that the production of fish feeds is the biggest factor relating to CO2 production in salmon production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In salmon cage production no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as 'medium risk'.

ETP impact (Env_4): Salmon farming in the UK is known to interaction with a variety of species as set out below.

<u>Grey seals (*Halichoerus grypus*)</u>: Grey seals are known to commonly interact with salmon farms in the UK and can cause significant mortality if able to infiltrate a cage farm. In response, the industry implemented several mitigation measures of which one used to be lethal control (others include the use of acoustic deterrents, seal netting). However, since the 1st February 2021, the shooting of seals has been banned in Scotland.

Grey seals are currently listed as a species of 'Least Concern' by the IUCN with numbers seen to be increasing.

<u>Harbour porpoises (*Phocoena phocoena*):</u> Evidence has been seen of harbour porpoises both interacting with, and reducing presence in an area due to, salmon farm activity[468]. These interactions though are much less regular than those seen for grey seals and rarely result in salmon fish kills or the death of porpoises. However, some recent evidence has been reported that also shows that harbour porpoises may suffer from auditory impairment when exposed to the noise emitted from acoustic seal deterrents (ADDs) used on farms[469].

Harbour porpoises are currently listed as a species of 'Least Concern' by the IUCN.

<u>Common Bottlenose Dolphin (*Tursiops truncates*):</u> Similar interactions as described above for harbour porpoises.

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[467] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature*, 597(7876), 360-365*

[468] *Haarr, M. L., Charlton, L. D., Terhune, J. M., & Trippel, E. A. (2009). Harbour Porpoise (Phocoena phocoena) Presence Patterns at an Aquaculture Cage Site in the Bay of Fundy, Canada. Aquatic Mammals, 35(2).*

[469] *Johnston, D. W. (2002). The effect of acoustic harassment devices on harbour porpoises (Phocoena phocoena) in the Bay of Fundy, Canada. Biological Conservation, 108(1), 113-118.*

Bottlenose Dolphins are currently listed as a species of 'Least Concern' by the IUCN.

Cleaner fish (Ballan wrasse and lumpfish): A relatively recent addition to salmon farming has been the inclusion of cleaner fish (normally ballan wrasse and lumpfish) in the cages. These work by eating the juvenile sea lice as they settle on the salmon and are seen as an effective natural lice control.

Both species are currently taken from the wild (in the UK and elsewhere) with attempts at effective captive breeding being undertaken. However, little is known about the stock of each species in the UK, nor the impacts of their removal for this purpose, although management measures have been introduced in some areas to help limit potential impacts[470]. Ballan wrasse are currently listed as a species of 'Least Concern' by the IUCN while no information is available for lumpfish. Both though are considered to be data deficient and there have been concerns raised about direct and indirect impacts on wild wrasse population status[471].

Bird Species: Very little information is available on the interaction of salmon farms with bird species. It is known that indirect mortality of birds is seen occasionally on farms[471] but that this is not considered a significant event and has been well mitigated by effective use of bird predator netting.

Although interactions do exist with many species none are currently ETP or considered highly significant. Most interactions are also managed to some degree.

A 'low risk' score is therefore provided as no ETP species were identified as being at significant risk from salmon farming in the UK.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of Atlantic salmon in the UK. A 'low risk' score is provided.

Management effectiveness (Mgt_1): UK salmon farming is relatively well managed and developed. The farming process has strict controls on licensing and requires regular inspections and environmental monitoring to occur. However, improvements are still needed in helping reduce the risks of escapes, use of chemicals and reporting of sea lice levels.

A 'medium risk' score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): UK retailers require evidence of third-party certification of farmed salmon. Traditionally, this has been completed through the Global GAP Farm standard. Salmon farming was an initial target area for the Aquaculture Stewardship Council (ASC) and the first UK based farms were certified in 2015 (MOWI Loch Leven salmon farm). Since then, the majority of MOWI farms (currently 16) have been certified in the UK against the ASC standard. Other producers, such as the Scottish Salmon Company though have decided to use Best Aquaculture Practices (BAP) standard for its third-party verification system.

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[470] *For example, https://www.devonandsevernifca.gov.uk/Environment-and-Research/Research/Finfish-Research/Wrasse*

[471] *Tett, P., Benjamins, S., Black, K., Coulson, M., Davidson, K., Fernandes, T. F., ... & Wittich, A. (2018). Review of the environmental impacts of salmon farming in Scotland.*

Given the UK salmon industry is largely covered by a mixture of third party certification standards, a ‘medium risk’ score is provided.

Supply chain: Norway aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic salmon are farmed in cage systems around the coast of Norway (1,350,000 tonnes were produced in 2019). A wide range of views exist on the potential impact of farmed salmon on its wild counterpart. Salmon farms are often located on the migratory paths of wild salmon as they return to the freshwater rivers to breed (as seen in Scotland, Norway, Faroe Islands and Eastern Canada). This has created concerns around the interaction of the two on a number of fronts.

Sea lice are currently a major problem in farmed salmon production. Infestation can cause severe skin damage, resulting in chronic osmoregulatory stress[454]. In addition, the impact of sea lice from salmon farms is well recognised as a hazard to wild anadromous salmonids[455] due to their proximity to farms during migration. The high larval loads of sea lice produced in the farms can increase sea lice infestation in these wild species and is likely to limit the survivability of these fish, creating a direct threat to the wild population. However, it must be noted that much scientific debate is currently occurring as to the levels of effect that sea lice from farms actually have on wild population survival. Some studies have concluded that the effect of sea lice from farms has no direct association with wild salmon productivity[472] while others have found a direct link between the two[473].

Concerns have also been raised over farmed salmon escapes and potential interactions with wild stocks. Salmon escapes occur when cages / nets become damaged and can often involve large numbers of fish (for example, the Chilean aquaculture agency, Sernapesca, have reported that 4.7 million salmon are estimated to have escaped from salmon farms between 2010 and 2020[474]). Interaction of escapees with native species raises a number of concerns that include competition for habitat and food resources, predation and the introduction and spreading of diseases and parasites[459], however it is the hybridisation or breeding of escaped farmed stock with indigenous populations of Atlantic salmon that is currently of the greatest concern and has been outlined as the most important contemporary challenge to wild salmon populations[459]. In Norway it has been recently documented that 51 of 109 Norwegian Atlantic salmon populations showed significant genetic introgression (the movement of genes from one species to another) from farmed salmon[460].

While the above issues are clearly a concern for wild salmon, the evidence of direct effects and reduction in wild stocks is still relatively limited. Furthermore, the species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern).

Norway is the largest producer of farmed salmon globally and has been constantly updating its management and licensing systems to reduce the risks set out above. While improvements

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[472] *Marty, G. D., Saksida, S. M., & Quinn, T. J. (2010). Relationship of farm salmon, sea lice, and wild salmon populations. Proceedings of the National Academy of Sciences, 107(52), 22599-22604.*

[473] *Krkošek, M., Lewis, M. A., & Volpe, J. P. (2005). Transmission dynamics of parasitic sea lice from farm to wild salmon. Proceedings of the Royal Society B: Biological Sciences, 272(1564), 689-696.*

[474] *https://www.fishfarmingexpert.com/article/chile-47-million-salmon-escaped-in-last-10-years/*

have clearly been made, such as a traffic-light management system along the Norwegian coastline, it is also true that significant issues have been seen with high sea lice infection rates being reported and major escape events occurring in recent years (290,000 fish were reported to have escaped in 2019, largely due to two specific incidents[475]).

A 'medium risk' score is provided here on the basis that salmon production in Norway is considered likely to be having some detrimental effects on wild populations, but the scale of these effects is not yet fully understood or assessed. This is set against a background of ever reducing migratory salmon numbers in Norway as seen through significant falls in wild salmon catches[476], although this is seen to be due to a variety of different factors (of which salmon farming may be one).

Ecosystem impact (Env_2): Cage farming of salmon is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed[464], but also the release of high levels of nitrate and phosphate into the water column[465] and resulting eutrophication and red tide events. Salmon produce both solid and dissolved waste during production. Solid waste falls to the seabed and overtime can build up to create this anoxic layer. Furthermore, this waste can be high in nitrate and phosphate which will breakdown and enter the water column eventually in dissolved form. This can have the effect of encouraging primary production in the area.

A 'medium risk' score is provided here since some evidence of degradation through cage farming in the Norway does exist, but this is not considered widespread.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[477] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[478] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced - slightly above the previous study.

What is clear in all the studies is that the production of fish feeds is the biggest factor relating to CO2 production in salmon production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production

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[475] https://www.fishfarmingexpert.com/article/norway-290000-salmon-escaped-in-2019/

[476] https://www.vitenskapsradet.no/Portals/vitenskapsradet/Pdf/Status%20of%20wild%20Atlantic%20salmon%20in%20Norway%202020T.pdf

[477] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[478] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

system specific. In salmon cage production no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as ‘medium risk’.

ETP impact (Env_4): Species interactions in Norway are considered the same as those reported for the UK.

Although interactions do exist with a number of species none are currently ETP or considered highly significant. Most interactions are also managed to some degree. A ‘low risk’ score is therefore provided.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of Atlantic salmon in Norway. A ‘low risk’ score is provided here.

Management effectiveness (Mgt_1): Norwegian salmon farming is comparable with the UK in that it is well managed and developed. The farming process has strict controls on licensing and requires regular inspections and environmental monitoring to occur. However, improvements are still needed in helping reduce the risks of escapes, use of chemicals and reporting of sea lice levels.

A ‘medium risk’ score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Norwegian retailers require evidence of third-party certification of farmed salmon. Traditionally, this has been completed through the Global GAP Farm standard. Salmon farming was an initial target area for the Aquaculture Stewardship Council (ASC) and the first Norwegian based farms were certified in 2013 (Bremnes Seashore AS salmon farm). As of 2020,182 salmon farms in Norway were certified against the ASC standard. Other producers, such as Kvarøy Fiskeoppdrett, have achieved Best Aquaculture Practices (BAP) standards for their third-party verification system.

Given the Norwegian salmon industry is largely covered by a mixture of third party certification standards, a ‘medium risk’ score is provided.

Supply chain: Faroe Islands aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic Salmon is farmed in cage systems around the coast of the Faroe Islands (73,000 tonnes in 2019). The country has developed one of the best regarded management systems of any producers globally. A wide range of views exist on the potential impact of farmed salmon on its wild counterpart. Salmon farms are often located on the migratory paths of salmon as they return to the freshwater rivers to breed (as seen in Scotland, Norway, Faroe Islands and Eastern Canada). This has created concerns around the interaction of the two on a number of fronts.

Sea lice are currently a major problem in farmed salmon production. Infestation can cause severe skin damage, resulting in chronic osmoregulatory stress[454]. In addition, the impact of sea lice from salmon farms is well recognised as a hazard to wild anadromous salmonids[455] due to their proximity to farms during migration. The high larval loads of sea lice produced in the farms can increase sea lice infestation in these wild species and is likely to limit the survival ability of these fish, creating a direct threat to the wild population. However, it must be noted that much scientific debate is currently occurring as to the levels of effect that sea lice from farms actually have on wide population survival. Some studies have concluded that the effect of sea lice from farms has no direct association with wild salmon productivity[456] while others have found a direct link between the two[457].

Concerns have also been raised over farmed salmon escapes and potential interactions with wild stocks. Salmon escapes occur when cages / nets become damaged and can often involve large numbers of fish (for example, 787,000 fish were reported to have escaped from a farm in Chile in 2013). Interaction of escapees with native species raises a number of concerns that include competition for habitat and food resources, predation and the introduction and spreading of diseases and parasites[459], however it is the hybridisation or breeding of escaped farmed stock with indigenous populations of Atlantic salmon that is currently of the greatest concern and has been outlined as the most important contemporary challenge to wild salmon populations[459]. In Norway it has been recently documented that 51 of 109 Norwegian Atlantic salmon populations showed significant genetic introgression (the movement of genes from one species to another) from farmed salmon[460].

While the above issues are clearly a concern for wild salmon, the evidence of direct effects and reduction in wild stocks is still relatively limited. Furthermore, the species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern).

In addition, the Faroes Islands is currently recognised as having one of the best management systems of any major producing nation, with strong mitigation measures in place for sea lice (fallowing, distance between farms) and escape events (requirement on farm locations, equipment used and emergency response plans in the event of an incident).

A ‘medium risk’ score is provided here on the basis that whilst salmon production in Faroe Islands is considered well controlled and the species is not seen as threatened currently, there are risks to wild populations from caged production that cannot be ruled out entirely.

Ecosystem impact (Env_2): Cage farming of salmon is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed[464], but also the release of high levels of nitrate and phosphate into the water column[465] and resulting eutrophication and red tide events.

A ‘medium risk’ score is provided since some evidence of degradation through cage farming in the Faroe Islands does exist, but this is not considered widespread. Some consideration was given to reducing this to ‘low risk’ to mark the higher management standards in place to avoid environmental effects. However, although positive, these weren’t considered enough to warrant a ‘low risk’ score in this assessment.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[479] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[480] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced - slightly above the previous study.

What is clear in all the studies is that the production of fish feeds is the biggest factor relating to CO2 production in salmon production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In salmon cage production no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as ‘medium risk’.

ETP impact (Env_4): Species interactions in the Faroe Islands are considered the same as those reported in the UK.

Although interactions do exist with several marine mammal species none are currently ETP or considered highly significant. Most interactions are also managed to some degree. A ‘low risk’ score is therefore provided.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of Atlantic salmon in Faroe Islands. A ‘low risk’ score is provided here.

Management effectiveness (Mgt_1): Salmon farming in the Faroe Islands is considered to be one of the best managed in the world with strict measures in place. The farming process has strict controls on licensing and requires regular inspections and environmental monitoring to occur. The country operates and ‘all in-all out’ policy for fish, meaning that once harvesting has occurred, a fallow period of 6 months must occur before re-stocking is allowed. Furthermore, only one generation is allowed at a time. These measures help to control the spread of sea lice in the Faroe Islands. The country also has strict requirements on third party reporting of lice numbers.

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[479] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[480] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

These management systems are considered to be advanced on those presented for other countries and so a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed salmon. In the Faroe Islands, the uptake of certification has been relatively recent. The largest company, Bakkafrost, has opted for ASC certification for its farms with all 18 now certified. This on its own represents the majority of salmon supplied from the Faroe Islands. Other producers (for example MOWI Faroes) are already Global GAP certified but have also committed to ASC certification in the near future.

The Faroe Islands salmon industry is very largely covered by ASC certification standards and so a 'low risk' score is provided.

Supply chain: Iceland aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic Salmon is farmed in cage systems around the coast of Iceland (34,200 tonnes in 2020). A wide range of views exist on the potential impact of farmed salmon on its wild counterpart. Salmon farms are often located on the migratory paths of salmon as they return to the freshwater rivers to breed (as is the case in Iceland). This has created concerns around the interaction of the two on a number of fronts.

Sea lice are currently a major problem in farmed salmon production. Infestation can cause severe skin damage, resulting in chronic osmoregulatory stress[454]. In addition, the impact of sea lice from salmon farms is well recognised as a hazard to wild anadromous salmonids[455] due to their proximity to farms during migration. The high larval loads of sea lice produced in the farms can increase sea lice infestation in these wild species and is likely to limit the survival ability of these fish, creating a direct threat to the wild population. However, it must be noted that much scientific debate is currently occurring as to the levels of effect that sea lice from farms actually have on wide population survival. Some studies have concluded that the effect of sea lice from farms has no direct association with wild salmon productivity[456] while others have found a direct link between the two[457].

Concerns have also been raised over farmed salmon escapes and potential interactions with wild stocks. Salmon escapes occur when cages / nets become damaged and can often involve large numbers of fish (for example, 787,000 fish were reported to have escaped from a farm in Chile in 2013). Interaction of escapees with native species raises a number of concerns that include competition for habitat and food resources, predation and the introduction and spreading of diseases and parasites[459], however it is the hybridisation or breeding of escaped farmed stock with indigenous populations of Atlantic salmon that is currently of the greatest concern and has been outlined as the most important contemporary challenge to wild salmon populations[459]. In Norway it has been recently documented that 51 of 109 Norwegian Atlantic salmon populations showed significant genetic introgression (the movement of genes from one species to another) from farmed salmon[460].

While the above issues are clearly a concern for wild salmon, the evidence of direct effects and reduction in wild stocks is still relatively limited. Furthermore, the species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern).

Very little is known about the status of environmental impacts of salmon farming in Iceland despite significant increases in production. Reports of mortality events have been made and other commentators have reported negatively on the impact of farming on the country. However, little specific information or evidence is available to base a more detailed assessment on.

Based on the above a 'medium risk' score is provided.

Ecosystem impact (Env_2): Cage farming of salmon is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed[464], but also the release of high levels of nitrate and phosphate into the water column[465] and resulting eutrophication and red tide events.

A 'medium risk' score is provided here since some evidence of degradation through cage farming in Iceland does exist, but this is not considered widespread.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[481] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[482] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced - slightly above the previous study.

What is clear in all the studies is that the production of fish feeds is the biggest factor relating to CO2 production in salmon production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In salmon cage production no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as 'medium risk'.

ETP impact (Env_4): Species interactions in Iceland are considered likely to be very similar to those reported in the other North Atlantic countries.

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[481] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[482] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

Although interactions likely do exist with several marine species it is unlikely that those are ETP species and / or considered highly significant. Most interactions are also managed to some degree. A 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of Atlantic salmon in Iceland. A 'low risk' score is provided here.

Management effectiveness (Mgt_1): Little is currently known about the management of salmon farming in Iceland. Bjarnson A. et al. (2019)[483] completed a review of salmon legislation in the country and it appears to follow a similar system to Scotland with planning required and an EIA process included. Legislation is in place and included limits on areas that can involve farming activities (due to risks to migrating wild salmon). However, a lack of detailed information is available to fully ascertain the strength of the management system in place in Iceland.

Management systems are in place, but a lack of information is available to fully assess their relative effectiveness. A 'medium risk' score is provided on this basis.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed salmon. In Iceland, production is dominated by only four major producers;

Arnarlax: The biggest producer, Arnarlax, is 100% ASC certified.

Ice Fish Farm: Produces quantities of Organic salmon and is certified under EU Organice requirements. Is also certified under the AquaGAP Certification program (run by EcoCert).

Arctic Sea Farm: Arctive Sea Farm is 100% ASC Certified

Laxar Fiskeldi: Not currently certified.

Given the Icelandic salmon industry is largely covered by a mixture of third party certification standards, a 'medium risk' score is provided.

Supply chain: Denmark aquaculture production

Denmark is a relatively small producer of farmed salmon and the UK is not known to import any cage farmed salmon from the country. However, small quantities of RAS based product from the Atlantic Sapphire pilot facility are known to be sold to Whole Foods stores in the UK[484]. On this basis, the below assessment has considered the imports of RAS based salmon products only from Denmark and not any cage farmed products.

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic Salmon are farmed in the Atlantic Sapphire RAS based facility in Denmark.

A 'low risk' score is provided here on the basis that RAS salmon has no interaction with its wild counterparts.

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[483] *Bjarnason A, Magnusdottir KS. (2019) The Salmon Sea Fish Farming Industry in Iceland. A review. Fish Aqua J 10: 272. doi: 10.35248/2150-3508.19.10.272,* https://www.longdom.org/open-access/the-salmon-sea-fish-farming-industry-in-iceland-a-review.pdf

[484] https://salmonbusiness.com/land-based-farmed-salmon-goes-on-sale-in-uk/

Ecosystem impact (Env_2): The very nature of RAS based salmon farming removes virtually all of the concerns around the environmental impact of the industry which are commonly seen in the cage farming sector.

A 'low risk' score is provided as RAS farming does not have a direct significant negative effect on the environment.

Climate change impact (Env_3): Little work has been completed to date on the actual climate footprint of RAS based systems. Clearly RAS systems will have high energy requirements through the pumping needed to operate the systems 24 hours a day, seven days a week. The amount of energy required will vary greatly from system to system and species to species.

Bergman, K. et al. (2020)[485] stated an estimated requirement of 8,000 kWh to produce one tonne of farmed salmon in a RAS system. A corresponding figure for pond-based production systems quoted by the author was 528 KwH, highlighting the much higher energy use requirements in RAS.

However, while RAS systems require large quantities of electricity, they use much less in the way of fuel than cage farming (no vessels, etc). On this basis, it will be significantly easier for RAS farms to switch to renewable energy sources to resource its electricity requirements. Further, an average score of 3.55 tonnes of CO_2 per kg of fish is provided by The Seafood Carbon Emissions Tool[486].

A 'medium risk' score is provided here since information is lacking and although RAS clearly has high electricity requirements, it also has the potential to switch to renewable resources quite easily.

ETP impact (Env_4): The adoption of land-based RAS farming means that no interaction with other species (including ETP species) occurs. A 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of Atlantic salmon in Denmark. A 'low risk' score is provided here.

Management effectiveness (Mgt_1): Denmark has recently introduced new limits on marine farming and has announced no new farms will be licensed in the sea. Hence Denmark has become a centre for the development of RAS based systems (led by Atlantic Sapphire).

No known issues currently exist with the management and legislatory regime in relation to land based RAS farming in Denmark. A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Atlantic Sapphire facility in Denmark is not currently certified by any third-party program (withdrawn)[487], mainly because they are yet to be developed in full for what is a relatively new concept. A 'high risk' score is therefore provided on this basis. However, most sustainability rating systems provide RAS based salmon with the

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[485] Bergman K, Henriksson PJG, Hornborg S, et al. Recirculating Aquaculture Is Possible without Major Energy Tradeoff: Life Cycle Assessment of Warmwater Fish Farming in Sweden. Environ Sci Technol. 2020;54(24):16062-16070. doi:10.1021/acs.est.0c01100

[486] http://seafoodco2.dal.ca/

[487] https://www.asc-aqua.org/find-a-farm/ASC01581/

highest possible rating and see it as the gold standard for sustainable production. As an example, the MCS system for RAS farmed salmon is given a 'Best Choice' rating[488].

Pacific Salmon

Supply chain: United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of the different Pacific salmon species, and stocks of each species, is variable. Alaskan stocks of all five species are considered healthy, as is chum salmon more widely, whereas other populations are 'endangered', 'threatened' or even a 'species of concern'[489]. A significant proportion of the harvest in some components of the MSC certified Alaska fishery is made up of hatchery-reared fish. The 'hatch and catch' rearing system is intended to supplement, not supplant, the wild stock production. However, there are conflicting views over risks posed by hatchery production to wild stocks and the ecosystem. These concerns are largely focused on interbreeding between hatchery reared and wild fish, resulting in impacts on genetic diversity and populations that are less well adapted to their environment and therefore less likely to survive[490,491]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Pacific salmon are typically caught using gillnets, purse seines, and trolling gear, which has limited or no interaction with the seafloor. Bycatch is typically comprised of other salmon species or stocks, including those of significant concern such as the endangered winter-run chinook stock[489]. Further, there are concerns over the potential ecosystem effects of large-scale hatchery production of salmon throughout the Pacific (see Env_1). A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mix of hook and lines, fixed nets and purse seines results in a 'medium risk' score in relation to climate change impacts arising from the production method based on Parker & Tyedmers (2014)[492]. An average of 1.4 to 4 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool for the different Pacific salmon species, caught by gill nets and purse seines (with slightly higher values for troll lines)[493]. A 'low risk' score is assigned, although the low confidence in the data needs to be noted.

ETP impact (Env_4): Bycatch of birds and mammals does occur in the Pacific salmon net fisheries, although it is not considered to pose significant risk to ETP species. However, the

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[488] https://www.mcsuk.org/goodfishguide/ratings/aquaculture/1025/

[489] https://fishchoice.com/seafood-buying-guides

[490] https://fisheries.msc.org/en/fisheries/alaska-salmon/@@assessments

[491] https://salmonchronicles.files.wordpress.com/2019/01/brannon-afs-hatchery-study.pdf

[492] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[493] http://seafoodco2.dal.ca/

variable levels of bycatch across the different fisheries, combined with some data limitations to fully inform an assessment of risk[489,494], results in a 'medium risk' score for this indicator.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the United States salmon fisheries and therefore a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of Alaska's salmon fisheries is considered highly effective and significant progress in the management of other salmon fisheries along the US west coast has been noted, although there is scope for further improvement given the poor status of some salmon populations. As the focus of this assessment is on the Alaskan fishery, a 'low risk' score has been applied.

Sustainability certification progress (Mgt_2): The Alaska salmon fishery[495] and Annette Islands Reserve salmon fishery[496] are MSC certified, with conditions. A 'medium risk' score is provided.

Supply chain: Canada wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of the different Pacific salmon species, and stocks of each species, is variable. For example, whilst some British Columbia salmon populations appear to be stable, catches are also derived from depleted populations of chinook and coho salmon for example. The status of some populations is uncertain. Many salmon runs in British Columbia are augmented by hatchery salmon. However, there are conflicting views over risks posed by hatchery production to wild stocks and the ecosystem. These concerns are largely focused on interbreeding between hatchery reared and wild fish, resulting in impacts on genetic diversity and populations that are less well adapted to their environment and therefore less likely to survive[497,498]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Pacific salmon are typically caught using gillnets, purse seines, and trolling gear, which has limited or no interaction with the seafloor. Bycatch is typically comprised of other salmon species or stocks, including those which are depleted, 'threatened' or 'endangered' (such as Interior Fraser coho which is the primary stock of concern in chinook and coho salmon fisheries of southern British Columbia[497]). Further, there are concerns over the potential ecosystem effects of large-scale hatchery production of salmon throughout the Pacific[123,497]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mix of hook and lines, fixed nets and purse seines results in a 'medium risk' score in relation to climate change impacts arising from the production

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[494] *https://www.mcsuk.org/goodfishguide/species/keta-salmon/*; *https://www.mcsuk.org/goodfishguide/species/red-salmon/*; *https://www.mcsuk.org/goodfishguide/species/pink-salmon/*

[495] *https://fisheries.msc.org/en/fisheries/alaska-salmon/@@view*

[496] *https://fisheries.msc.org/en/fisheries/annette-islands-reserve-salmon/@@view*

[497] *https://www.seafoodwatch.org/recommendations/search?query=%3Acountry%3BCanada%3Aspecies%3BSalmon*

[498] *https://salmonchronicles.files.wordpress.com/2019/01/brannon-afs-hatchery-study.pdf*

method based on Parker & Tyedmers (2014)[499]. An average score of 1.4 to 4 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool for the different Pacific salmon species, caught by gill nets and purse seines (with slightly higher values for troll lines)[500]. A 'low risk' score is assigned, although the low confidence in the data needs to be noted.

ETP impact (Env_4): Bycatch of birds and mammals does occur in the Pacific salmon net fisheries, although it is not considered to pose significant risk to ETP species. However, the variable levels of bycatch across the different fisheries, combined with some data limitations to fully inform an assessment of risk[489,501], results in a 'medium risk' score for this indicator.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the Canadian salmon fisheries and therefore a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of Canada's salmon fisheries is generally considered moderately effective, challenged by the presence of depleted populations of certain species of Pacific salmon and other complex factors[497]. A 'medium risk' score has therefore been applied.

Sustainability certification progress (Mgt_2): There are currently no certified Canadian salmon fisheries nor any under a FIP, resulting in a 'high risk' score.

Trout

Supply chain: UK aquaculture production

The UK farms around 17,000 tonnes of rainbow and brown trout a year with the majority going to domestic consumption. The majority of production is in ponds / raceways and it is this production system which is considered below.

Direct impact on population(s) or stock(s) of resource (Env_1): Rainbow trout (*Onchorynchus mykiss*) are a non-native species to all countries outside of the United States and Canada. They were introduced in the 19th century and have continued to be bred and stocked in increasing numbers of river and lakes around the country (as well as being the main freshwater trout species produced in aquaculture throughout Europe). However, despite this widespread stocking, only limited evidence of natural breeding stocks becoming established have been found (although numbers have increased over time). Welton et al. (1995)[502], reported that increasing levels of natural breeding have been seen in the UK but that these still represent relatively minimal levels compared to the numbers being stocked around the country. Rainbow trout cannot therefore be considered to have become indigenous within the EU.

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[499] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[500] http://seafoodco2.dal.ca/

[501] https://www.mcsuk.org/goodfishguide/species/keta-salmon/; https://www.mcsuk.org/goodfishguide/species/red-salmon/; https://www.mcsuk.org/goodfishguide/species/pink-salmon/

[502] *Welton, J. S., A. T. Ibbotson, and M. Ladle. (1995). Impact of stocked Rainbow Trout on resident salmonid populations. Phase I, scoping study. R&D Progress Report.*

Evidence of negative interaction with wild species of trout and salmon (Brown trout, Atlantic salmon and Arctic charr) in Europe are limited but have been reported in some countries. For example, in Norway, the rainbow trout was found on the 'Alien Species Black List' due to the risks it is considered to pose (in terms of competition, disease and hybridisation) to the native brown trout populations[503].

Based on the above, a 'medium risk' score is provided since the species is not indigenous and may have some impacts on wild stocks (although reported interactions are relatively limited).

Ecosystem impact (Env_2): Trout farming in the UK does have some limited negative concerns related to it.

Farming releases liquid effluent into natural rivers and watercourses. Although this is well monitored by the Environment Agency it can have some negative impacts on water courses during periods of high effluent release. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[504] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[505] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated trout farming at a figure of around 5 kg of CO2 per kg of meat produced - slightly above the previous study.

What is clear in all the studies is that the production of fish feeds is the biggest factor relating to CO2 production in trout production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In trout production, some aeration and mechanical equipment is used to facilitate pond and raceway systems.

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as 'medium risk'.

ETP impact (Env_4): Trout farming in the UK is known to interact with a variety of animals including birds (grey heron, cormorants, etc) and to a less degree, otters.

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[503] *Gederaas, L., et al. (2012). Alien species in Norway-with the Norwegian Black List 2012.*

[504] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[505] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature*, 597(7876), 360-365*

Of these, only the Eurasion otter (*Lutra lutra*) is ranked by the IUCN as near threatened. In the UK, the otter has undergone reintroduction schemes and is protected by UK Law. The otter has shown an increasing interaction with pond-based farms and commercial angling sites[506], however it is not considered at risk from trout farming (if anything the opposite is possible). A 'low risk' score is therefore provided for this indicator.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the production of trout in the UK. A 'low risk' score is provided.

Management effectiveness (Mgt_1): The UK has a relatively well-defined and effective management system for aquaculture with no obvious major weaknesses from an environmental standpoint, although there is always scope for improvement. A 'low risk' score is therefore provided.

Sustainability certification progress (Mgt_2): UK trout farming has not yet fully embraced global certification standards, with limited BAP, Global GAP or ASC certifications in the country. The UK's largest producer, Dawnfresh Ltd is Global GAP certified, however. Most smaller producers are certified under the Quality Trout UK scheme[507]. This though is very much a 'UK only' scheme and not recognised globally. The reasons for this are not entirely clear but it appears that the market in the UK simply does not require any of the global standards to be adopted for trout specifically. A 'medium risk' score is therefore assigned.

Supply chain: All other countries' aquaculture production

No significant differences are expected in the other major countries which supply to the UK (albeit with very small quantities – Sweden, Netherlands, the Republic of Ireland, Denmark, Norway, France). All are located in western Europe and have very similar production requirements and systems, as well as levels of third party sustainable certification (including ASC and Global GAP).

The same risk scores as those detailed above for the UK have therefore been allocated for all countries.

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[506] *Kruuk, H., (2006). Otters: ecology, behaviour and conservation. Oxford University Press, Oxford, UK*

[507] *http://qualitytrout.co.uk/*

Seafood commodity – Crustaceans

European lobster, American lobster

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Assessments of European lobster (*Homarus gammarus*) stocks around the UK are constrained by data and model limitations, but the current indications are that most stocks are at or around the minimum reference size in terms of biomass and are either fully exploited or close to that level[508,509]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Lobsters are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species. A 'low risk' score is therefore provided.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[510]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[511]. Therefore, a 'high risk' score is provided.

ETP impact (Env_4): A recent study[512] on entanglements of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries revealed relatively high occurrences of interactions at the fleet level, with minke whales, grey seals and basking sharks being the most commonly reported species from 1992-present, the majority of which were discovered entangled in groundlines. Whilst there was variation with factors such as fishing area, season, gear, depth and target species, the findings of the study suggest **"***the extent and incidence of entanglement events in Scottish waters may be sufficient to impact at a local population level, and this is a concern for conservation and the population recovery trajectories of minke and humpback whales".* A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Lobster fishery management is largely undertaken on a regional basis in the UK with variable measures in place through IFCA and MMO byelaws. Given the generally poor status of stocks, effectiveness of that management seems questionable[513]. A 'medium risk' score is provided.

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[508] *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928795/Lobster_assessments_2019..pdf*

[509] *https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37487*

[510] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[511] *http://seafoodco2.dal.ca/*

[512] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

[513] *https://www.mcsuk.org/goodfishguide/species/european-lobster/*

Sustainability certification progress (Mgt_2): The lobster fishery in the Western Channel (ICES subarea 7e), Bristol Channel and Celtic Sea (7f,g) are in the final stages of a FIP[514]. The North East fishery has recently started a new MSC assessment[515]. The Jersey (and Normandy) lobster fishery is MSC certified[516]. A 'medium risk' score is provided.

Supply chain: Canada wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Canadian American lobster (*Homarus americanus*) fishery is the largest in the world and is divided into around 40 Lobster Fishing Areas, with significant variation between them in terms of population status and exploitation rate[517]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Lobsters are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species, although the ratio of bait to catch is high and the sustainability of the bait sources are potentially a cause for concern according to some sources[517]. A 'low risk' score is provided however relative to other fisheries.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[518]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[519]. Therefore, a 'high risk' score is provided.

ETP impact (Env_4): There have been a significant number of incidences of entanglements of the IUCN critically endangered north Atlantic right whale and humpback whales in buoy ropes in the American fishery, which is of high conservation concern; however, seasonal closures in the Canadian fishery may help to mitigate this issue[520]. A 'high risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The effectiveness of the Canadian Government's management of the fishery is considered to be variable across the Lobster Fishing Areas. Limited routine monitoring resulting in data limitations as well as lack of allowable catch control measures are areas of concern[517,520]. A 'medium risk' score is therefore provided given the scale of the fishery.

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[514] https://fisheryprogress.org/fip-profile/uk-brown-crab-and-european-lobster-pottrap

[515] https://thefishsite.com/articles/ne-lobster-pot-fishery-for-msc-certification

[516] https://fisheries.msc.org/en/fisheries/normandy-and-jersey-lobster/@@view

[517] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/220/

[518] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[519] http://seafoodco2.dal.ca/

[520] https://www.fishsource.org/search?query=american%20lobster&type=

Sustainability certification progress (Mgt_2): Multiple components of the Canadian fishery are MSC certified with conditions[521] and there is a lobster FIP in Newfoundland and Labrador[522]. A 'medium risk' score is therefore provided.

Supply chain: United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of the American lobster stocks fished in US waters is variable, with some in good shape and others considered to be severely depleted[520,523]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Lobsters are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species, although the ratio of bait to catch is high and the sustainability of the bait sources are potentially a cause for concern[523]. A 'low risk' score is provided however relative to other fisheries.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[524]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[525]. Therefore, a 'high risk' score is provided.

ETP impact (Env_4): There have been a significant number of incidences of entanglements of the IUCN endangered north Atlantic right whale and humpback whales in buoy ropes in the American fishery, which is of high conservation concern (and has result in loss of MSC certification for the Gulf of Maine fishery) [520][523]. A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Effectiveness of the management of United States lobster fisheries is variable given the stock status variation. Whilst various monitoring, control and enforcement measures are in place, there is evident scope for improvement[520,523]. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Gulf of Maine fishery recently regained MSC certification with conditions[526]. A 'medium risk' score is therefore provided.

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[521] https://fisheries.msc.org/en/fisheries/maritime-canada-inshore-lobster-trap-fishery/@@view; https://fisheries.msc.org/en/fisheries/gaspesie-lobster-trap-fishery/about/; https://fisheries.msc.org/en/fisheries/iles-de-la-madeleine-lobster/about; https://fisheryprogress.org/fip-profile/canada-newfoundland-and-labrador-lobster-pottrap

[522] https://fisheryprogress.org/fip-profile/canada-newfoundland-and-labrador-lobster-pottrap

[523] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/797/ and https://www.mcsuk.org/goodfishguide/ratings/wild-capture/796/

[524] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[525] http://seafoodco2.dal.ca/

[526] https://fisheries.msc.org/en/fisheries/maritime-canada-inshore-lobster-trap-fishery/@@view; https://fisheries.msc.org/en/fisheries/gaspesie-lobster-trap-fishery/about/; https://fisheries.msc.org/en/fisheries/iles-de-la-madeleine-lobster/about; https://fisheryprogress.org/fip-profile/canada-newfoundland-and-labrador-lobster-pottrap

Supply chain: France wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Assessment of the status of European lobster stocks fished by France has been limited by data availability although progress is being made. The current indications are that the populations are relatively stable, however[509]. Given the uncertainty, a 'medium risk' score is provided.

Ecosystem impact (Env_2): Around 85% of lobsters caught by the French fleet are associated with pots and traps which have relatively low ecosystem impacts beyond removal of the target species. The remainder arises through gillnets and limited trawling activity. A 'low risk' score is therefore provided on a proportionate basis.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[527]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[528]. Therefore, a 'high risk' score is provided.

ETP impact (Env_4): Information on ETP interactions or impacts are scarce. However, given the recent study on marine animal entanglements with Scottish creel fisheries[529] (see UK assessment), some level of risk is considered likely – although the extent to which the data can be reasonably extrapolated to French fisheries is uncertain. A 'medium risk' score is therefore provided on a precautionary and data limited basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The main management measures relate to effort control and gear restrictions[509]. Otherwise, there is little information to support an assessment of management effectiveness. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The (Jersey and) Normandy lobster fishery is MSC certified[530]. Given the limited scope of this progress, a 'high risk' score is provided.

Norway lobster

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): There is a mixed picture across the Norway lobster functional units (FUs) for both population status and exploitation rate

[527] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[528] *http://seafoodco2.dal.ca/*

[529] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

[530] *https://fisheries.msc.org/en/fisheries/normandy-and-jersey-lobster/@@view*

and many FUs are data limited (with additional concerns over mismatches between management units and biological populations)[531,532]. A ‘medium risk’ score is therefore provided.

Ecosystem impact (Env_2): Whilst some Norway lobster are caught by UK static gear (creel) fisheries, the majority of fishing activity is associated with Nephrops trawls. These bottom otter trawls are associated with various ecosystem risks including damage to the seabed and sessile fauna and bycatch of various other commercial and non-commercial species (both juveniles and adults) due to the small mesh sizes. Some of those bycatch species are of particular concern due to their declining or poor population status, including North Sea cod and Irish Sea whiting[531, 532,533]. A ‘high risk’ score is therefore provided.

Climate change impact (Env_3): As bottom towed gear is the dominant production method, and in the absence of conflicting evidence, a ‘high risk’ score is provided[534,535].

ETP impact (Env_4): Information on the level and extent of ETP interaction with the trawl fishery is relatively limited, although it may pose high risk to several species of skates, rays and sharks.

A recent study[536] on entanglements of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries revealed relatively high occurrences of interactions at the fleet level, with Minke whales, grey seals and basking sharks being the most commonly reported species from 1992-present, the majority of which were discovered entangled in groundlines. Whilst there was variation with factors such as fishing area, season, gear, depth and target species, the findings of the study suggest **“***the extent and incidence of entanglement events in Scottish waters may be sufficient to impact at a local population level, and this is a concern for conservation and the population recovery trajectories of minke and humpback whales”.* A ‘high risk’ score is therefore provided.

Social concerns associated with supply chain (Social_1): There have previously been reports of social risks on-board Scottish whitefish and Nephrops vessels, relating to human trafficking[537]. A ‘medium risk’ score is provided on the basis of the age of this information.

Management effectiveness (Mgt_1): Given the variable status of the FUs and the ongoing issues with bycatch of vulnerable species, the management of the fishery cannot be considered fully effective despite the measures that are in place (which includes catch quotas and technical restrictions). A ‘medium risk’ score is therefore provided.

Sustainability certification progress (Mgt_2): Trawl- and creel-caught Norway lobster in the North Sea, Irish Sea, and West of Scotland (functional units 5-15 and 34) are part of a Project

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[531] https://www.mcsuk.org/goodfishguide/species/scampi/

[532] https://www.ices.dk/advice/Pages/Latest-Advice.aspx

[533] https://www.projectukfisheries.co.uk/nephrops

[534] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[535] http://seafoodco2.dal.ca/

[536] https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland

[537] https://www.heraldscotland.com/news/14171641.scottish-fishing-firm-human-trafficking-probe-ireland-uk-unite-fight-maritime-slavery/

UK FIP and is reported to have made some recent progress[538,533]. A number of other previous certifications or accreditation efforts have subsequently been withdrawn[539]. A 'medium risk' score is therefore provided.

Supply chain: The Republic of Ireland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): There is a mixed picture across the Norway lobster functional units (FUs) for both population status and exploitation rate and many FUs are data limited (with additional concerns over mismatches between management units and biological populations)[531,532]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The majority of fishing activity is associated with Nephrops trawls. These bottom otter trawls are associated with various ecosystem risks including damage to the seabed and sessile fauna and bycatch of various other commercial and non-commercial species (both juveniles and adults) due to the small mesh sizes. Some of those bycatch species are of particular concern due to their declining or poor population status, including North Sea cod and Irish Sea whiting[531,532]. A 'high risk' score is therefore provided.

Climate change impact (Env_3): As bottom towed gear is the dominant production method, and in the absence of conflicting evidence, a 'high risk' score is provided[540,541].

ETP impact (Env_4): Information on the level and extent of ETP interaction is relatively limited, although the trawl fishery may pose high risk to several species of skates, rays and sharks (based on the UK supply chain assessment). The recent study on marine animal entanglements with Scottish creel fisheries[542] (see UK assessment), indicates some level of risk – although the extent to which the data can be reasonably extrapolated to Irish Sea fisheries (from an ecosystem and gear perspective) is uncertain. A 'medium risk' score is therefore provided on a precautionary and data limited basis.

Social concerns associated with supply chain (Social_1): It has previously been reported that an investigation into Irish whitefish and Norway lobster fisheries found widespread abuse of workers. A recent article on human trafficking in the Republic of Ireland's seafood industry[543] raises concerns about social issues that require further investigation – a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Given the variable status of the FUs and the ongoing issues with bycatch of vulnerable species, the management of the fishery cannot be considered fully effective despite the measures that are in place (which includes catch quotas and technical restrictions). A 'medium risk' score is therefore provided.

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[538] https://fisheryprogress.org/fip-profile/uk-norway-lobster-bottom-trawl-and-creel

[539] https://fisheries.msc.org/en/fisheries/

[540] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[541] http://seafoodco2.dal.ca/

[542] https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland

[543] https://www.seafoodsource.com/news/supply-trade/irish-government-ngo-clash-over-human-trafficking-call-out

Sustainability certification progress (Mgt_2): There is no known progress on third party certification but the Irish fleet targeting *Nephrops norvegicus* in ICES Area 7 are part of a FIP[544]. A 'medium risk' score is therefore provided.

Edible crab

Supply chain: UK wild capture production

Env_1: Assessments of Edible crab stocks around the UK are constrained by data and model limitations. Where possible to assess, there are indications are that some stocks have a biomass around the MSY level and are being exploited at a rate that is close to MSY. For others there are suggestions that one or both are further away from target levels[545,546]. A 'medium risk' score is provided.

Ecosystem impact (Env_2): Crabs are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species. A 'low risk' score is therefore provided.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[547]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[548]. There is uncertainty over the robustness of extrapolating those data to crab fisheries, however a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): A recent study[549] on entanglements of cetaceans, elasmobranchs, turtles and other marine animals in Scottish creel fisheries revealed relatively high occurrences of interactions at the fleet level, with Minke whales, grey seals and basking sharks being the most commonly reported species from 1992-present, the majority of which were discovered entangled in groundlines. Whilst there was variation with factors such as fishing area, season, gear, depth and target species, the findings of the study suggest **"***the extent and incidence of entanglement events in Scottish waters may be sufficient to impact at a local population level, and this is a concern for conservation and the population recovery trajectories of minke and humpback whales".* A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

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[544] *https://fisheryprogress.org/fip-profile/ireland-area-7-prawn-trawl-fip*

[545] *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/974752/Crab_assessments_2019__March_21_update.pdf*

[546] *https://www.mcsuk.org/goodfishguide/species/brown-crab/*

[547] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[548] *http://seafoodco2.dal.ca/*

[549] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

Management effectiveness (Mgt_1): Crab fishery management is largely undertaken on a regional basis in the UK with variable measures in place through IFCA and MMO byelaws[546]. Given the variable or unknown status of stocks, effectiveness of that management is uncertain. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The crab fishery in the Western Channel (ICES subarea 7e) is in the final stages of a FIP[550] and the inshore edible crab fishery off Shetland is MSC certified[551]. A 'medium risk' score is provided on the basis of this progress.

Supply chain: The Republic of Ireland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): No assessment is currently available for the four stocks / assessment units around the Irish coast[552], which are very data limited[553], although there are indications that stock abundance and recruitment is declining in some areas[554]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Crabs are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species. A 'low risk' score is therefore provided.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[555]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[556]. There is uncertainty over the robustness of extrapolating those data to crab fisheries, however a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Information on ETP interactions or impacts are scarce. However, given the recent study on marine animal entanglements with Scottish creel fisheries[557] (see UK assessment), some level of risk is considered likely – although the extent to which the data can be reasonably extrapolated to Irish fisheries is uncertain. A 'high risk' score is however provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The Irish edible crab fishery is managed through technical measures such as a minimum landing size and some spatial limits on effort. The

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[550] *https://fisheryprogress.org/fip-profile/uk-brown-crab-and-european-lobster-pottrap*

[551] *https://fisheries.msc.org/en/fisheries/ssmo-shetland-inshore-brown-crab-and-scallop/@@view*

[552] *https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37487*

[553] *https://www.mcsuk.org/goodfishguide/ratings/wild-capture/526/*

[554] *http://inshoreforums.ie/wp-content/uploads/2021/06/Shellfish-Stocks-and-Fisheries-Review-2020.pdf*

[555] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[556] *http://seafoodco2.dal.ca/*

[557] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

fishing and scientific community have agreed that additional management measures should be introduced to conserve spawning stock while recruitment remains low[553]. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Irish edible crab FIP covers the entire country and is open to all fishers. Good progress on the agreed objectives is reported[558]. A 'medium risk' score is therefore provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): "*Due to the limited data availability, no analytical assessment or reference point exist for the Norwegian stock of edible crab. However, catch sizes and CPUE as registered by the reference fleet show no major changes over time. This picture is consistent with the stable to positive trend in total landings of the commercial fishery. Considering that the fishery is open access and, thus, self-regulated, the available information indicates a robust status of the stock and a sustainable fishing pressure*"[552]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Crabs are fished with pots and traps which have relatively low ecosystem impacts beyond removal of the target species. A 'low risk' score is therefore provided.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[559]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool for lobster trap fisheries[560]. There is uncertainty over the robustness of extrapolating those data to crab fisheries, however a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Information on ETP interactions or impacts are scarce. However, given the recent study on marine animal entanglements with Scottish creel fisheries[561] (see UK assessment), some level of risk is considered likely – although the extent to which the data can be reasonably extrapolated to Norwegian fisheries is uncertain. A 'high risk' score is however provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The Norwegian fishery is open access and therefore self-regulated. Stock and catch data are provided by a reference fleet of crab fishers. The number of participating crab fishers has varied from 5 to 25 fishermen in the period 2001 to 2019. A significant recreational fishery also targets edible crab but is unmonitored[552]. A 'medium risk'

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558 https://fisheryprogress.org/fip-profile/irish-brown-crab-pottrap

559 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

560 http://seafoodco2.dal.ca/

561 https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland

score is provided given the limited management and monitoring of the fishery, but indications of sustainable fishing levels.

Sustainability certification progress (Mgt_2): There is no known progress on third party certification or FIP participation. A 'high risk' score is therefore provided.

Other crab

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of velvet crab populations in UK waters is unknown given significant data limitations and lack of monitoring – they are predominantly a non-target species, although there is some limited commercial fishing activity for the species for the export market. They are however considered to have relatively low vulnerability to fishing pressure (i.e. high discard survival)[562]. The spider crab fishery is the second largest crab fishery in England and Wales. Within the UK, it is generally targeted along the South and West coasts. There is no assessment of population status or exploitation rate[563]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Velvet crabs and spider crabs are largely fished with pots and traps, which have relatively low ecosystem impacts beyond removal of the target species. Spider crabs are also caught in gillnets and tangle nets which are less selective. A 'low risk' score is therefore provided on a proportionate basis.

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[564]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool for lobster trap fisheries[565]. There is uncertainty over the robustness of extrapolating those data to crab fisheries, however a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): ETP mortality risks are considered negligible – a 'low risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Crab fishery management is largely undertaken on a regional basis in the UK, although there are limited measures or monitoring in place for spider crab and velvet crab fisheries[562,563]. Given the unknown status of stocks, effectiveness of that limited management is uncertain. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): There is no known progress on third party certification or FIP participation. A 'high risk' score is therefore provided.

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562 https://www.mcsuk.org/goodfishguide/species/velvet-swimming-crab/

563 https://www.mcsuk.org/goodfishguide/species/spider-crab/

564 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

565 http://seafoodco2.dal.ca/

Supply chain: Vietnam wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of Vietnam's Kien Giang blue swimming crab (*Portunus pelagicus*) stock is uncertain due to data limitations and lack of monitoring[566]. However, it is considered to be threatened by overfishing[567]. A 'high risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery largely uses gillnets and entangling nets, as well as pots and traps, and is associated with relatively high levels of bycatch of over 100 species[568]. A 'high risk' score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[569]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[570], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): There is evidence of concerning levels of bycatch of a number of vulnerable species, such as those listed as 'Near threatened' on the IUCN Redlist. These include the red stingray (*Dasyatis akajei*), sharpnose stingray *(Dasyatis zugei*) and brownbanded bamboo shark (*Chiloscyllium punctatum*). There is also indirect evidence of risks to other highly vulnerable species such as green turtles and hawksbill turtles. A 'high risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Vietnam is categorised as medium risk of modern slavery in their fishing industry[571] and therefore the same score is applied here.

Management effectiveness (Mgt_1): Management, including enforcement and monitoring, of the fishery is considered to be poor[568]. A 'high risk' score is provided.

Sustainability certification progress (Mgt_2): The FIP, initiated in 2012 by WWF-Vietnam, is categorised as inactive due to lack of ability to implement and enforce meaningful regulation[572,566]. A 'high risk' score is provided.

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566 https://fisheryprogress.org/fip-profile/vietnam-blue-swimming-crab-bottom-gillnetpottrap

567 https://www.moore.org/docs/default-source/Environmental-Conservation/50-in-10-project---resources/case-study---vietnam-crab-fishery.pdf?sfvrsn=2

568 https://www.seafoodwatch.org/recommendation/crab/red-crab-blue-swimming-crab-vietnam-gulf-of-siam-gulf-of-thailand-gillnets-and-entangling-nets-unspecified?species=285

569 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

570 http://seafoodco2.dal.ca/

571 https://downloads.globalslaveryindex.org/ephemeral/4_Spotlight-on-Sectors-1627039244.pdf

572 https://www.worldwildlife.org/stories/making-blue-swimming-crab-fishing-sustainable-in-vietnam

Supply chain: Indonesia wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Blue swimming crab stocks in Indonesian waters are considered to be undergoing overfishing[573]. A 'high risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery largely uses gillnets and entangling nets, as well as pots and traps, and is associated with relatively high levels (albeit variable in space and time) of bycatch of a variety of species[568]. A 'high risk' score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[574]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[575], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): There is lack of information on the level of bycatch of species of concern (listed as 'vulnerable' or 'near-threatened' on the IUCN Redlist) however there is considered to be a risk to a number of species, including dugongs, several species of sea turtles, sharks and rays[568]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Indonesia is categorised as medium risk of modern slavery in their fishing industry[582] and therefore the same score is applied here.

Management effectiveness (Mgt_1): Management of the fisheries has been categorised as ineffective due to, for example, lack of an explicit harvest strategy and lack of review and limited monitoring of other measures that have been introduced or the absence of a management strategy[568]. A 'high risk' score is therefore provided here.

Sustainability certification progress (Mgt_2): The Indonesia blue swimming crab FIP (trap & gillnets) has membership which includes 33 of 39 seafood industry businesses and processors, covering more than 85% of purchased crab in Indonesia. The FIP is rated as 'advanced progress'[576,577]. A 'medium risk' score is therefore provided.

Supply chain: Thailand wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Blue swimming crab stocks fished by Thai fleets are considered to be undergoing overfishing and likely to be depleted[578,579]. A 'high risk' score is therefore provided.

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[573] https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BBlue%20swimming%20crab%3Acountry%3BIndonesia

[574] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[575] http://seafoodco2.dal.ca/

[576] https://fisheryprogress.org/fip-profile/indonesian-blue-swimming-crab-gillnettrap-apri

[577] https://www.seafoodsource.com/news/environment-sustainability/indonesia-commits-to-new-plan-for-blue-swimming-crab-fishery-at-our-ocean-conference

[578] https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BBlue%20swimming%20crab%3Acountry%3BThailand

[579] https://www.fishsource.org/fishery_page/1611

Ecosystem impact (Env_2): The fisheries largely use gillnets and entangling nets, as well as traps, and are associated with bycatch of unidentified sharks and rays, several crab species (mud, musk / crucifix, etc.), shrimp, and prawns[578]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[580]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[581], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): There is limited information on the level of bycatch of species of concern (listed as 'vulnerable' or 'near-threatened' on the IUCN Redlist) however there is considered to be a risk to a number of species of sharks and rays, as well as potentially sea turtles[578]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Thailand is categorised as high risk of modern slavery in their fishing industry[582] and therefore the same score is applied here.

Management effectiveness (Mgt_1): Management of the fisheries has previously (in 2018) been considered ineffective due to lack of a fisheries management plan, open access to the fishery, overfished status of the resource and limited measures (many localised) with low level of enforcement of those rules[578,579]. In the absence of more recent information, a 'high risk' score is provided.

Sustainability certification progress (Mgt_2): The fishery in the Gulf of Thailand is part of a FIP[583] that is categorised as having made 'advanced progress'[584]. A 'medium risk' score is therefore provided.

Supply chain: China wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of the red (or warty) swimming crab stock(s) fished by China is unknown due to data limitations and lack of monitoring[585], although there are indications abundance may be declining[586]. It's estimated that undersized crabs might account for as much as 80% of the harvest[587]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery largely uses bottom trawls (approximately 60% of catches), traps and gillnets. Bottom trawls are associated with various ecosystem impacts

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[580] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[581] http://seafoodco2.dal.ca/

[582] https://downloads.globalslaveryindex.org/ephemeral/4_Spotlight-on-Sectors-1627039244.pdf

[583] https://wwf.panda.org/wwf_news/?228130/Thai-Blue-Swimming-Crab-Fishery-Improvement-Project---a-pathway-to-sustaining-marine-environments-and-local-livelihoods

[584] https://fisheryprogress.org/fip-profile/thailand-blue-swimming-crab-bottom-gillnettrap

[585] https://www.sciencedirect.com/science/article/abs/pii/S0165783620303453

[586] https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BCrab%3Acountry%3BChina

[587] https://fisheryprogress.org/fip-profile/china-fujian-zhangzhou-red-swimming-crab-bottom-trawl-pottrap

including physical damage to the seafloor and associated fauna. Bycatch of other marine species is a key risk posed by the fishery, although very little information is available. Some of the other target species caught in the bottom trawl fishery include: round sardinella (*Sardinella aurita*), Pacific chub mackerel (*Scomber japonicus*), striped bonito (*Sarda orientalis*), common Chinese / mitre squid (*Loligo chinensis*) and Neon flying squid *(Ommastrephes bartramii*)[586]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[588]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[589], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): The level of risk posed to ETP species by the fishery is unknown[586]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): China is categorised as high risk of modern slavery in their fishing industry[582] and therefore a 'high risk' score is provided.

Management effectiveness (Mgt_1): The fishery is subject to general fishery management including mesh size regulation, fishing permits, fishing zone regulations, seasonal fishing bans, and Fujian provincial regulations, such as minimum catchable size, MPAs, etc. However, the effectiveness of these measures is uncertain given the unknown stock status and ecosystem impacts, as well as suspected low levels of compliance and enforcement, particularly with regulations such as mesh size. A 'high risk' score is therefore provided[585,586].

Sustainability certification progress (Mgt_2): The fishery is part of a FIP that has been rated as 'some recent progress'[587]. A 'medium risk' score is provided.

Supply chain: Sri Lanka wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The 2018 stock assessment of Gulf of Mannar blue swimming crab indicated that the stock biomass was above the limit reference point but below the target reference point and that the proportion of mature females was at a sustainable level. Some conflicts in the data lead to greater uncertainty in the assessment, however[590]. The 2019 assessment for both the Gulf of Mannar and Palk Bay show the stocks are above the target of 30% spawner potential[591]. A 'medium risk' score is therefore provided on the basis of conflicting and limited information.

Ecosystem impact (Env_2): The fishery primarily uses gillnets and tangle nets (bottom set crab nets). Research suggests that on average across 777 landings to 8 landing sites ~17% of the catch is discarded, across a wide range of species. No species made up >5% of these landings, and only two species made up >2% - the chocolate chip seastar and the pale-edged

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[588] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[589] *http://seafoodco2.dal.ca/*

[590] *https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BCrab%3Acountry%3BSri%20Lanka*

[591] *https://fisheryprogress.org/fip-profile/sri-lanka-blue-swimming-crab-bottom-gillnet*

stingray. The stingray is sometimes classed as wanted catch. There is potential risk of damage to sensitive habitats – seagrass in particular, which the nets overlap with (estimated as <20% footprint overlap)[591]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[592]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[593], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): Bycatch of several species categorised as 'vulnerable' or above on the IUCN Redlist has been associated with the fishery, including various shark or ray species as well as the orange-spotted grouper and a species of sea cucumber (*Actinopyga mauritiana*). All these species are considered vulnerable because of fishing pressure as target species across a large geographical area (Indo-West Pacific or wider). The authors of the MSC pre-assessment for the fishery therefore considered it likely that the very small catches of these species taken by this fishery do not have much of an impact. Bycatch of turtles and dugongs is considered negligible. A 'medium risk' score is therefore provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): Sri Lanka is categorised as medium risk of modern slavery in their fishing industry[582] and therefore a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery has previously been categorised as 'moderately effective' given the national and fishery-specific management measures that are in place[590]. Since then, the FIP which has the objective of reaching a level equivalent to a pass against the MSC's Fisheries Standard by December 2020 has been classed as having made 'advanced progress'[591]. A 'medium risk' score is provided on a precautionary basis.

Sustainability certification progress (Mgt_2): The fishery is part of a FIP that has been classed as having made 'advanced progress'[591]. A 'medium risk' score is therefore provided.

Supply chain: India wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The Palk Bay blue swimming crab stock is considered to be overexploited with catches on the decline[594]. More widely in the India EEZ, the stock and exploitation status are uncertain. However, regular harvesting of egg-bearing and juvenile crabs and the lack of fishing limits suggests there is a strong possibility of overfishing[595]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery primarily uses bottom trawls and bottom gillnets. There is limited information on the bycatch of the fishery in the Indian EEZ or interaction with

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[592] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[593] http://seafoodco2.dal.ca/

[594] https://fisheryprogress.org/system/files/documents_assessment/MSC%20Pre%20Assessment%20Report-Final.pdf

[595] https://www.seafoodwatch.org/recommendations/search?query=%3Aspecies%3BCrab%3Acountry%3BIndia

sensitive habitats such as coral, seagrass and mangroves, although these are widespread in Palk Bay, for example. The taxa that are most likely to interact with the fishery include: finfish, forage fish, sharks, benthic invertebrates, mammals, turtles, and seabirds[594]. A 'medium risk' score is provided on the basis of lack of information.

Climate change impact (Env_3): The mixture of gear types results in a 'medium risk' score for production carbon footprint based on Parker & Tyedmers (2014)[596]. Whilst an average score of 12 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool[597], this is based on traps alone. A 'medium risk' score is therefore provided to account for the mixture of gear types.

ETP impact (Env_4): There is very limited information on risk to ETP species due to lack of monitoring. However, the fishery gear and area of operation are such that ETP interactions are possible. Such species include dugongs, various species of turtles and Irrawaddy dolphins (*Oracaella brevirostris*)[594,595]. A 'medium risk' score is provided on the basis of lack of information.

Social concerns associated with supply chain (Social_1): India is categorised as medium risk of modern slavery in their fishing industry[582] and therefore a 'medium risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery has previously been categorised as 'moderately effective' given the national management measures that are in place[595]. However, management of the fishery specifically appears to be weak given the lack of monitoring and measures to prevent removal of juvenile and spawning crabs, for example. A 'high risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Palk Bay component of the fishery is part of a FIP which is categorised as having made 'advanced progress'. This fishery represents approximately 5% of the total landings of blue swimming crab in the Indian EEZ. A 'high risk' score is therefore provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The snow crab (*Chionoecetes opilio*) stock has since 1996 increased rapidly both in distribution and abundance in the Barents Sea. However, there is insufficient information to support an assessment of the stock and exploitation status. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Snow crab in the Barents Sea fishery are exclusively harvested using conical pots deployed in strings connected to longline. This gear is likely to have relatively low ecosystem impacts beyond removal of the target species. A 'low risk' score is therefore provided on a proportionate basis.

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[596] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[597] *http://seafoodco2.dal.ca/*

Climate change impact (Env_3): Static gear fisheries are categorised as 'medium risk' from a carbon footprint of the production method perspective based on Parker & Tyedmers (2014)[598]. However, an average score of 11.7 tonnes of CO2 per kg of fish ('high risk') is provided by the Seafood Carbon Emissions Tool for lobster trap fisheries[599]. There is uncertainty over the robustness of extrapolating those data to crab fisheries, however a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Information on ETP interactions or impacts are scarce. However, given the recent study on marine animal entanglements with Scottish creel fisheries[600] (see UK assessment), some level of risk is considered likely – although the extent to which the data can be reasonably extrapolated to Norwegian snow crab fisheries is uncertain. A 'high risk' score is however provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Norwegian management of the fishery includes measures such as a catch quota, minimum landing size and closed seasons. There is however limited information available on the fishery and therefore effectiveness cannot be determined. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): There is no known progress on third party certification or FIP participation. A 'high risk' score is therefore provided.

Warm-water prawns

Supply chain: Vietnam aquaculture production

Vietnam has a wide range of production systems in country including a strong organic production. However, the majority of shrimp imported to the UK is produced in intensive pond systems and so the below review focuses on this.

Direct impact on population(s) or stock(s) of resource (Env_1): Vietnam produces predominantly *Penaeus vannamei* (70% of production) and *P. monodon* (30% of production) for export. *P. monodon* is an indigenous species to Vietnam. *P. vannamei* however is indigenous to South America but has been introduced throughout Asia since the 1970s. Despite not being native to Vietnam, it does not appear to have formed non-native species in local watercourses (despite being caught regularly)[601].

Concerns though do exist around the use of wild sources of *monodon* for breeding programs related to aquaculture. Traditionally, broodstock are taken from the wild which has led to concerns

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[598] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[599] *http://seafoodco2.dal.ca/*

[600] *https://www.nature.scot/doc/naturescot-research-report-1268-scottish-entanglement-alliance-sea-understanding-scale-and-impacts#Entanglements+in+Scotland*

[601] *https://www.cabi.org/isc/datasheet/71097#toDistributionMaps*

over wild shrimp stocks in the country[602]. Recent developments have focused on removing the use of wild broodstock for breeding and this has had some success in recent years[603]. However, the majority of production of *monodon* remains reliant on wild capture.

A 'medium risk' score is provided here since concerns do exist for wild *monodon* populations but technology is improving and the species is not considered threatened.

Ecosystem impact (Env_2): Intensive shrimp farming has significant environmental concerns associated with it. Specific areas of concern in Vietnam are as follows;

Mangrove destruction: The rapid development of shrimp farming has had a very serious impact on mangrove forests. Over the last 50 years, Vietnam has lost at least 220,000 ha of mangrove forests[604]. Despite some changes in policy to include replanting, it appears that government plans for significant aquaculture expansion are placing incredible pressure on coastal areas, and there may be conflict between reforestation and shrimp cultivation expansion program[605].

Saltwater Intrusion: The construction of a series of large shrimp ponds along the coast, estuaries and riverbanks has considerably decreased the area of tidal water distribution. During high tides that coincide with the northeast monsoon, saline water may intrude further inland and produce saline pollution not just in the land outside the dykes, but also in the plain inside the dyke. Under dry, low humidity weather patterns, saline pollution may emerge at the surface and affect plant life. Saline pollution disrupts the ecological balance of estuarine areas as some brackish water organisms will invade further inland. Freshwater organisms will die because they cannot adapt to the salinity or they will migrate further inland[606].

Water Pollution: Semi-intensive and intensive farming methods with a high stocking density have led to high levels of feeds, pesticides and antibiotics being used. Increase in water exchange means that chemical inputs (disinfectants, antibiotics, fertilizers, pesticides, hormones) and wastes (uneaten food, faeces, ammonia, phosphorous and carbon dioxide) may reach and contaminate groundwater supplies, rivers and coastal habitats. Shrimp pond effluents high in organic matters have a high biological oxygen demand (BOD) and can cause oxygen depletion in receiving waters[607].

A 'high risk' score is provided here since intensive shrimp farming in Vietnam is considered to have significant environmental impacts.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and

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[602] Craig, L. B., (1998). Recent development in penaeid broodstock and seed production technologies: improving the outlook for superior captive stocks. Aquaculture 164, 3-21.

[603] Hai, T. N., Duc, P. M., Son, V. N., Minh, T. H., & Phuong, N. T. (2015). Innovation in seed production and farming of marine shrimp in Vietnam. World Aquaculture, 46(1), 32-37

[604] Vietnam News. Fisheries to shell out on shrimp farms. Vietnam News, 30 June 2001.

[605] Minh, Le Quang. (2001). Environmental Governance: A Mekong Delta case study with downstream perspectives. In: N. Badenoch & M Dupat (ed~.) Mekong Regional Environmental governance: Perspective on opportunities and challenges. Working papers of the REPS. Mekong: 8

[606] Hong, Phan Nguyen (1996). Impact of shrimp pond construction along the mangrove coastal accretion in Ca Mau Cape, Vietnam. In: SEAFDEC Asia Aquaculture. Vol. XVIII No.4. Dec. 1996: 6-11

[607] Environmental Justice Foundation (EJF). (2002). Risky business - Vietnamese shrimp aquaculture - Impacts and improvements. http://www.ejfoundation.org/reports.html.: 7-25

species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[608] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

According to The Seafood Carbon Emissions Tool[609], shrimp production is associated with an average of 4.4 tonnes of CO2 per kg of fish.

A recent study completed by Gephart, J.A. et al. (2021)[610] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shrimp farming at a figure of around 9 kg of CO2 per kg of meat produced so significantly higher than the studies referenced above and almost twice that of species produced in cage farming.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in shrimp farming. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In shrimp production the use of aeration and mechanical pumping is significant to facilitate pond aquaculture techniques. It is this additional requirement that raises the CO2 use higher for shrimp than for cage farmed species.

For the above reasons, it is concluded that the farming method has high climate impacts (fossil fuel use), and significantly higher that cage-based production methods, when considered across the life cycle of the production method and is therefore scored as 'high risk'.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Vietnam. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Historically, concerns have been raised about labour and social practices in the shrimp industry. However, these concerns have mainly been targeted at Bangladesh and Thai production and not Vietnam. In 2021 though, the US downgraded Vietnam to Tier 3 on its 'Trafficking in Persons' report. The report raised trafficking concerns in the country (although not specifically targeted at the shrimp sector).

A 'medium risk' score is provided here as no significant concerns exist specifically for shrimp farming in Vietnam, but concerns have been raised on social factors in the country at the wider level.

Management effectiveness (Mgt_1): Management of the shrimp farming industry in Vietnam has historically been considered poor with environmental regulation considered weak. This has led to significant environmental challenges as discussed above. Regulatory improvements have

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[608] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[609] http://seafoodco2.dal.ca/

[610] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

been made in recent years but it is clear that further improvements are required. A 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): Intensive production in Vietnam has shown a strong take up in certification schemes with the majority being certified under the ASC or BAP standards. A more significant challenge exists though with smaller scale producers in the country (of which a lot exist). To help with this, the ASC has set up a group certification scheme methodology (launched in 2019)[611]. This is expected to fill gaps in the current certification market in the country in the coming years.

A 'medium risk' score is provided here as many of the larger producers are covered but the smaller scale sector is still working on obtaining certification.

Supply chain: Thailand aquaculture production

Thailand has a similar split of species to Vietnam with *P. vannamei* dominating over *P. monodon* production. The country has less variety in its production systems however and favours more intensive systems across all suppliers.

Direct impact on population(s) or stock(s) of resource (Env_1): Thailand produces predominantly *Penaeus vannamei* (80% of production) and *P. monodon* (20% of production) for export. *P. monodon* is an indigenous species to Thailand. *P. vannamei* however is indigenous to South America but has been introduced throughout Asia since the 1970s. Despite not being native to Thailand, it does not appear to have formed non-native species in local watercourses (despite being caught regularly)[612].

Concerns though do exist around the use of wild sources of *monodon* for breeding programs related to aquaculture. Traditionally, broodstock are taken from the wild which has led to concerns over wild shrimp stocks in the country[613]. Recent developments have focused on removing the use of wild broodstock for breeding and this has had some success in recent years[614]. However, the majority of production of *monodon* remains reliant on wild capture.

A 'medium score' is provided here since concerns do exist for wild *monodon* populations but technology is improving and the species is not considered threatened.

Ecosystem impact (Env_2): Intensive shrimp farming has significant environmental concerns associated with it. The concerns in Thailand are similar in nature to those already outlined for the Vietnam supply chain.

A 'high risk' score is provided here since intensive shrimp farming in Thailand is considered to have significant environmental impacts.

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[611] https://www.seafoodsource.com/news/aquaculture/aquaculture-stewardship-council-introduces-group-certification-in-vietnam

[612] https://www.cabi.org/isc/datasheet/71097#toDistributionMaps

[613] *Craig, L. B., (1998). Recent development in penaeid broodstock and seed production technologies: improving the outlook for superior captive stocks. Aquaculture 164, 3-21.*

[614] *Hai, T. N., Duc, P. M., Son, V. N., Minh, T. H., & Phuong, N. T. (2015). Innovation in seed production and farming of marine shrimp in Vietnam. World Aquaculture, 46(1), 32-37*

Climate change impact (Env_3): As per the assessment for Vietnam, it is concluded that the farming method has a 'high risk' of climate impacts.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Thailand. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Significant social concerns have been raised in Thailand with regards to shrimp production. These concerns centred around bonded, debt and slave labour on both the farms, in processing factories and particularly in the collection of wild *monodon* broodstock.

The United States has previously listed Thailand under Tier 3 level in its 'Trafficking in Persons' report. This is the lowest ranking available for a country. In 2016 though the country was upgraded to Tier 2 following improvements in human rights issues. The report still raised trafficking concerns in the country (although not specifically targeted at the shrimp sector).

A 'medium risk' is identified here since improvements have been made on human rights issues in the country in recent years.

Management effectiveness (Mgt_1): Management of the shrimp farming industry in Thailand has historically been considered poor with environmental regulation considered weak. This has led to significant environmental challenges as discussed above. Similar to Vietnam, regulatory improvements have been made in recent years, but it is clear that further improvements are required. A 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): Thailand has shown a similar uptake for certification as that of Vietnam with 18 farms currently ASC certified and 22 BAP certified. The ASC has undertaken similar initiatives in Thailand in an attempt to make the program more accessible (with the help of Thai Union)[615] to smaller producers. A 'medium risk' score is therefore provided here with many farms certified but some gaps remaining.

Supply chain: Bangladesh aquaculture production

Bangladesh is unique in that the majority of shrimp is produced in polyculture systems (referred to as Ghers). Furthermore, *P. monodon* remains the most commonly produced species in the country.

Direct impact on population(s) or stock(s) of resource (Env_1): Bangladesh produces predominantly *Penaeus monodon* (80% of production) for export. *P. monodon* is an indigenous species to Bangladesh.

Concerns though do exist around the use of wild sources of *monodon* for breeding programs related to aquaculture. Traditionally, broodstock are taken from the wild which has led to concerns over wild shrimp stocks in the country[613]. Recent developments have focused on removing the use of wild broodstock for breeding and this has had some success in recent years[614]. However, the majority of production of *monodon* remains reliant on wild capture.

[615] https://fishfocus.co.uk/thailand-project-to-make-asc/

A 'medium score' is provided here since concerns do exist for wild *monodon* populations but technology is improving and the species is not considered threatened.

Ecosystem impact (Env_2): Intensive shrimp farming has significant environmental concerns associated with it. The concerns in Bangladesh are similar in nature to those already outlined for the Vietnam supply chain. A summary of these issues is provided by Kabir, M. H. et al. (2014)[616].

A 'high risk' score is provided here since intensive shrimp farming in Bangladesh is considered to have significant environmental impacts.

Climate change impact (Env_3): As per the assessment for Vietnam, it is concluded that the farming method has a 'high risk' of climate impacts.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Bangladesh. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Significant social concerns have been raised in Bangladesh with regards to shrimp production. These concerns centred around debt labour, sexual violence, abuse and harassment, child labour and low earnings[617]. Some anecdotal evidence exists that conditions have improved but little up to date information is available confirm this.

A 'high risk' score is provided here as serious concerns have been raised around social conditions in the Bangladeshi shrimp sector. The lack of certification within the country also means that evidence of improvements is not readily available.

Management effectiveness (Mgt_1): Management of the shrimp farming industry in Bangladesh has significant weaknesses and has historically been considered poor especially around environmental regulation. This has led to significant environmental challenges as discussed above. Similar to Vietnam and Thailand, regulatory improvements have been made in recent years, but it is clear that further improvements are required[616]. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): Bangladesh shrimp has seen little penetration by the certification market. Two farms are currently ASC certified and only three have received BAP certification. The reason for this appears to be both related to a lack of interest but also potential gaps in requirements for Bangladesh producers. A 'high risk' score is provided as low coverage by certification standards exists in Bangladesh.

Supply chain: India aquaculture production

India has seen phenomenal growth in shrimp production as a result of the commencement of *P. vannamei* production. In 2019 it reached almost 800,000 tonnes of production (falling behind China alone).

Direct impact on population(s) or stock(s) of resource (Env_1): India now produces predominantly *P. vannamei* (90% of production). *P. vannamei* however is indigenous to South

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[616] *Kabir, M. H., & Eva, I. J. (2014). Environmental impacts of shrimp aquaculture: the case of Chandipur village at Debhata upazila of Satkhira district, Bangladesh. Journal of the Asiatic Society of Bangladesh, Science, 40(1), 107-119.*

[617] *Anchovy, S. B. (2011) Research On Indicators Of Forced Labor In The Supply Chain Of Shrimp In Bangladesh, Verite. https://www.verite.org/wp-content/uploads/2016/11/Research-on-Indicators-of-Forced-Labor-in-the-Bangladesh-Shrimp-Sector__9.16.pdf*

America but has been introduced throughout Asia since the 1970s. Despite not being native to India, it does not appear to have formed non-native species in local watercourses (despite being caught regularly)[612].

A 'low risk' score is provided here since limited concerns seem to exist for *P. vannamei* in the country and its effect on wild populations.

Ecosystem impact (Env_2): Intensive shrimp farming has significant environmental concerns associated with it. This remains the case in India. However, compared to other Asian producers, India has generally adopted a low-density model[618] which has limited these environmental risks to some extent. Concerns do remain, however especially around mangrove destruction in the country[619].

A 'medium risk' score is provided here since shrimp farming in India appears to have slightly less environmental risks than some of the other Asian producers, but these concerns clearly do still exist.

Climate change impact (Env_3): As per the assessment for Vietnam, it is concluded that the farming method has a 'high risk' of climate impacts.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and shrimp farming in India. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Concerns exist around labour conditions in India, but they are not as wide spread as other countries in the region. A 'medium risk' is identified here.

Management effectiveness (Mgt_1): Management of the shrimp farming industry in India is relatively well developed with strong procedures relating to new species imports. However, concerns around environmental mitigation exist. Also, despite significant decreases in recent years, antibiotic control is still not considered to be fully controlled. A 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): India has a relatively positive uptake on certification with 57 farms certified against the ASC standard and 51 against BAP. However, the size of production in India means significant gaps remain especially around small-scale producers (similar to Vietnam).

A 'medium risk' score is provided here as many of the larger producers are covered but the smaller scale sector is still working on obtaining certification.

Supply chain: Indonesia aquaculture production

Direct impact on population(s) or stock(s) of resource (Env 1): As with most other regional producers, Indonesia has switched to the production of *P. vannamei* (85% of production) from its traditional *P. monodon* (15% of production) for export. *P. monodon* is an indigenous species to Indonesia. *P. vannamei* however is indigenous to South America but has been introduced

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[618] *https://www.aquaculturealliance.org/advocate/how-india-became-the-worlds-top-shrimp-producer/*

[619] *Jayanthi, M., Thirumurthy, S., Muralidhar, M., & Ravichandran, P. (2018). Impact of shrimp aquaculture development on important ecosystems in India. Global Environmental Change, 52, 10-21.*

throughout Asia since the 1970s. Despite not being native to Thailand, it does not appear to have formed non-native species in local watercourses (despite being caught regularly)[612].

Concerns though do exist around the use of wild sources of *P. monodon* for breeding programs related to aquaculture. Traditionally, broodstock are taken from the wild which has led to concerns over wild shrimp stocks in the country[613]. Recent developments have focused on removing the use of wild broodstock for breeding and this has had some success in recent years[614]. However, the majority of production of *P. monodon* remains reliant on wild capture.

A 'medium risk' score is provided here since concerns do exist for wild *monodon* populations, but technology is improving and the species is not considered threatened.

Ecosystem impact (Env_2): Intensive shrimp farming has significant environmental concerns associated with it. The concerns in Indonesia are similar in nature to those already outlined for a variety of other producers (such as Vietnam above). Furthermore, Indonesia has targeted significant increases in production which have created additional environmental concerns in the country[620].

A 'high risk' score is provided here since intensive shrimp farming in Indonesia is considered to have significant environmental impacts.

Climate change impact (Env_3): As per the assessment for Vietnam, it is concluded that the farming method has a 'high risk' of climate impacts.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Indonesia. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Some concerns exist over human rights issues in Indonesia, including in the shrimp sector. A 'medium risk' score is identified here on that basis.

Management effectiveness (Mgt_1): Significant concerns exist around the management of shrimp production in Indonesia especially against a backdrop of significant planned expansion of the industry. A 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): 8 farms are currently ASC certified and 38 BAP certified in Indonesia. The relatively limited uptake of certification has been recognised by the ASC who have subsequently translated the standards into Indonesian. A 'medium risk' score is provided here with many farms certified but some gaps remaining.

Supply chain: Ecuador aquaculture production

Ecuador is the largest producer of shrimp outside Asia (and one of the largest in the world) but its market is dominated by supplies to China[621](42% of product goes direct and a further 22% via Vietnam), where shrimp is seen as a luxury product.

Direct impact on population(s) or stock(s) of resource (Env_1): Virtually all shrimp production in Ecuador is for *P. vannamei* and Ecuador is actually one of the few major producing countries

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[620] https://www.seafoodsource.com/news/supply-trade/indonesia-unlikely-to-realize-ambitious-shrimp-sector-growth-target

[621] *National Chamber of Aquaculture 2019*

which can call the species indigenous**.** The production cycle for *P. vannamei* is now developed meaning little requirement for wild broodstock.

No evidence of harm to wild *vannamei* stocks from farming operations has been recorded in Ecuador. A 'low risk' score is provided here**.**

Ecosystem impact (Env_2): Shrimp farming in Ecuador suffers from the same environmental concerns as raised in other countries. Of particular concern to the country are

Mangrove Destruction: Rapid and substantial depletion of mangrove forests has occurred in Ecuador with the expansion of the industry, often unchecked by management based approaches[622].

Saltwater Intrusion: Evidence has been presented that salinity levels in Ecuadorian estuaries has increased as a result of significant water pumping and saltwater intrusion from shrimp farming activities[623].

Antibiotic Use: Antibiotics are not as widely used in Ecuador as they are in Latin America as operations are not as intensive [624]. However, some concerns still exist over their use and release into the wider environment.

In general, Ecuadorian shrimp farming has more positive environmental credentials than most production in Asia. This is because the country has continued to follow a more extensive production system than its competitors in Asia[625]

These differences are considered significant enough to warrant a lower score for Ecuador than for its Asia counterparts and so a 'medium risk' score is provided here.

Climate change impact (Env_3): As per the assessment for Vietnam, it is concluded that the farming method has a 'high risk' of climate impacts.

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Ecuador. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Concerns have been raised around social impacts in Ecuador but mainly related to a loss of mangrove habitat by local residents and a complete lack of voice and often intimidation by farming companies.

Some of the more significant concerns which have been reported regarding working conditions in Asian farms are not reported in Ecuador.

A 'low risk' score is provided here as social concerns exist, but previous issues have been raised specifically in relation to community interaction.

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[622] *Hamilton, S. E. (2011). The impact of shrimp farming on mangrove ecosystems and local livelihoods along the Pacific coast of Ecuador.*

[623] *Twilley, R. (1989), "Impacts of Shrimp Aquaculture Practices on the Ecology of Coastal Ecosystems in Ecuador," in Olsen, S. and L. Arriega (eds.), A Sustainable Shrimp Mariculture Industry for Ecuador. Coastal resources Center, University of Rhode Island*

[624] *Tobey, J.* et al*. (2017) https://www.crc.uri.edu/download/MAN_0032.pdf*

[625] *(Herve L.B. (2017).https://www.researchgate.net/publication/317703862_A_SUCCESS_STORY_ECUADORIAN_SHRIMP_FARMING*

Management effectiveness (Mgt_1): Concerns exist around the management of shrimp production in Ecuador, mainly around mangrove destruction and disease control (the country suffered from significant white spot disease outbreaks previously).

It is noted that significant improvements have been made in management practices in the country, however. A 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): 41 farms are certified against the ASC standard in Ecuador which is a significant number. 39 farms have been certified under the BAP Standard. Furthermore, the country has a strong organic production scene.

Ecuador has seen a significant uptake in certification standards but is not 100% covered. A 'medium risk' score is therefore provided.

Supply chain: Honduras aquaculture production

Honduras is the second largest producer of shrimp in the Western Hemisphere (only behind Ecuador), but its sales are dominated by the US and Europe (and not China). The country has a more intensive approach to farming than is seen in Ecuador.

Direct impact on population(s) or stock(s) of resource (Env_1): Virtually all shrimp production in Honduras is for *P. vannamei* and Honduras is actually one of the few major producing countries which can call the species indigenous**.** The production cycle for *P. vannamei* is now developed meaning little requirement for wild broodstock.

No evidence of harm to wild *vannamei* stocks from farming operations has been recorded in Honduras. A 'low risk' score is provided here**.**

Ecosystem impact (Env_2): Shrimp farming in Honduras suffers from many of the same environmental concerns raised in Ecuador[626].

With regards to mangrove destruction however, many of the farms are located on salt flats behind the mangrove belt and so much less impact has been seen in the country[627].

Many of the larger producers in Honduras also report that they do not use antibiotics in production which is a significant milestone.

In general, Honduran shrimp farming has more positive environmental credentials than most production in Asia and also its competitors in Ecuador[628]. These differences are considered significant enough to warrant a lower score for Honduras than for its Asia counterparts and so a 'medium risk' score is provided here.

Climate change impact (Env_3): As per the assessment for Vietnam (and other shrimp producers), it is concluded that the farming method has 'low risk' of climate impacts.

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[626] *Valderrama, D. and Engle, C. (2000). Risk Analysis of Shrimp Farming in Honduras. In: K. McElwee, D. Burke, M. Niles, X. Cummings, and H. Egna (Editors), Seventeenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Oregon State University, Corvallis, Oregon.*

[627] *Valiela, I., Bowen, J.L. and York, J.K. (2001). Mangrove forests: one of the World's threatened major tropical environments. BioScience 51 (10). Pp 807-815.*

[628] *Teichert-Coddington, D.R., Martinez, D., and Ramírez E. 2000. Partial nutrient budget for semiintensive shrimp farms in Honduras. Aquaculture. 190. pp 139-154.*

ETP impact (Env_4): No specific concerns exist over interaction with ETP species and intensive shrimp farming in Honduras. A 'low risk' score is provided here.

Social concerns associated with supply chain (Social_1): Limited social concerns have been raised in Honduras. A 'low risk' score is provided here.

Management effectiveness (Mgt_1): Limited information or data is available on the management practices in Honduras. Farms are required to follow an EIA process when applying for licences and that some have been required to develop settling ponds as a result of this[629]. It is also noted that evidence of legal proceedings exists against farms that exceed regulatory limits. It does appear some form of regulatory systems is working in the country for improper farming activities.

A 'medium risk' score is provided here as it does appear that a management system is in place and working but a lack of data or information make a more detailed consideration impossible.

Sustainability certification progress (Mgt_2): 8 farms are currently ASC certified and 38 BAP certified in Honduras. The country has shown a good uptake in certification standards, but gaps do still exist. A 'medium risk' score is provided here with many farms certified but some gaps remaining

Cold-water prawns

Supply chain: United Kingdom wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Assessment of the status of the North Sea and Solway Firth brown shrimp (*Crangon crangon*) stocks is constrained by data and model limitations. There are however indications that stock size is low due to fishing pressure and high abundance of whiting as a predator[630] and could be considered to be growth overfished[631]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The brown shrimp fishery uses a type of beam trawl, typically town-rigged, with a relatively small mesh size. Shrimp are also caught in flatfish fisheries. Despite their lighter weight, shrimp trawls are still associated with damage to the seabed and bycatch – particularly juvenile shrimp, flatfish such as plaice and other key species such as whiting and cod[631,632]. A 'medium risk' score is provided.

Climate change impact (Env_3): The dominance of bottom towed gear as the production method results in a 'high risk' carbon footprint based on Parker & Tyedmers (2014)[633]. Whilst an

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629 https://www.seachoice.org/wp-content/uploads/2015/11/MBA_SeafoodWatch_Honduras_Farmed_Shrimp_Report.pdf

630 https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/EPDSG/2018/WGCRAN%20-%20Report%20of%20the%20Working%20Group%20on%20Crangon%20Fisheries%20and%20Life%20History.pdf

631 https://fisheries.msc.org/en/fisheries/wash-brown-shrimp/@@assessments

632 *Tom L. Catchpole, Andrew S. Revill, James Innes, Sean Pascoe, Evaluating the efficacy of technical measures: a case study of selection device legislation in the UK Crangon crangon (brown shrimp) fishery, ICES Journal of Marine Science, Volume 65, Issue 2, March 2008, Pages 267–275,* https://doi.org/10.1093/icesjms/fsn016

633 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

average score of 5.4 tonnes of CO_2 per kg of fish ('medium risk') is provided by the Seafood Carbon Emissions Tool[634], it is felt this may underestimate the impact on blue carbon habitats[635]. Therefore a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Risks to ETP mortality are considered negligible[631], a 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The fishery is largely managed by the Eastern Inshore Fisheries and Conservation Authority (EIFCA). There is strong statutory backing (and enforcement) for many of the management measures (such as vessel size, gear specifications, etc) detailed in the management plan. However, the fishery is not subject to catch controls and there are uncertainties over how effective the harvest control rule will be. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Wash brown shrimp fishery is MSC certified with conditions. Over 90% of UK landings originate from the Wash and surrounding areas[631] and the client for the MSC certification is the Shrimp Producers Organisation Ltd., a company set up by the two main buyers of Wash Brown Shrimp. A 'medium risk' score is therefore provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Although there is no formal analytical assessment of stock and exploitation status, the status of Northern shrimp (*Pandalus borealis*) stocks in Icelandic waters is considered to be poor[636]. The offshore stock biomass is considered to be above the limit reference point although higher predation pressure may affect this status. The fishing mortality rate is considered to be close to Fproxy, but data limitations mean this conclusion is uncertain[637]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): Northern shrimp are caught using bottom otter trawls which are associated with risks of habitat damage and bycatch of commercial and non-commercial species. Technical measures to reduce such impacts by the Icelandic fishery are considered to be quite effective[637]. A 'medium risk' score is provided.

Climate change impact (Env_3): The dominance of bottom towed gear as the production method results in a 'high risk' carbon footprint based on Parker & Tyedmers (2014)[638]. Whilst an average score of 5.4 tonnes of CO_2 per kg of fish ('medium risk') is provided by the Seafood

[634] http://seafoodco2.dal.ca/

[635] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[636] https://www.hafogvatn.is/en/harvesting-advice

[637] https://fisheries.msc.org/en/fisheries/isf-iceland-northern-shrimp-inshore-and-offshore/@@assessments

[638] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

Carbon Emissions Tool[639], it is felt this may underestimate the impact on blue carbon habitats[640]. Therefore a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Whilst risks of ETP impact may be low relative to other fisheries, there are still records of ETP bycatch[637], a 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is generally considered to be effective[637], a 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Icelandic fishery is fully MSC certified with conditions[637], a 'medium risk' score is provided.

Supply chain: Denmark wild capture production

Denmark fishes both brown shrimp (*Crangon crangon*) in the North Sea[630] and Northern shrimp (*Pandalus borealis*) in the 'Skagerrak and Kattegat and northern North Sea in the Norwegian Deep' region[641]. It is not possible to determine from the trade data the proportional composition of each species that is imported. The following assessment is therefore based on a combination of both species.

Direct impact on population(s) or stock(s) of resource (Env_1): Assessment of the status of the North Sea brown shrimp stock is constrained by data and model limitations. There are however indications that stock size is low due to fishing pressure and high abundance of whiting as a predator[630] and could be considered to be growth overfished[631]. The stock size of Northern shrimp is ICES divisions 3a and 4a East is considered to be below MSY Btrigger, although fishing pressure is estimated to be below Fmsy[641]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): As per the justifications for the UK and Icelandic fisheries for the two species, a 'medium risk' score is applied to this bottom trawl fishery.

Climate change impact (Env_3): The dominance of bottom towed gear as the production method results in a 'high risk' carbon footprint based on Parker & Tyedmers (2014)[642]. Whilst an average score of 5.4 tonnes of CO2 per kg of fish ('medium risk') is provided by the Seafood Carbon Emissions Tool[643], it is felt this may underestimate the impact on blue carbon habitats[644]. Therefore a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Whilst risks of ETP impact may be low relative to other fisheries, there are still records of ETP bycatch[645], a 'medium risk' score is therefore provided.

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639 http://seafoodco2.dal.ca/

640 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

641 https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/pra.27.3a4a-3.pdf

642 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

643 http://seafoodco2.dal.ca/

644 https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

645 https://www.mcsuk.org/goodfishguide/ratings/wild-capture/346/

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of both fisheries is generally considered quite effective, although improvements are required in order to ensure the stocks do not further decline and are adequately monitored. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The joint demersal fisheries in the North Sea and adjacent waters MSC certification includes the Danish capture of northern shrimp[646] and Denmark's brown shrimp fishery is also certified[647]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the joint demersal fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. WWF also submitted objections to the North Sea Brown shrimp fishery certification, which were withdrawn after all parties reached an agreement[648]. On that basis, a 'medium risk' score is provided overall.

Supply chain: Canada wild capture production

Northern shrimp and striped shrimp (*Pandalus montagui*) are fished in inshore and offshore waters off Canada's Atlantic coast, off Baffin Island, the Newfoundland coast and the Flemish Cap[649]. The majority of shrimp caught by the offshore fleet is size sorted, with most of the sizes being cooked, and then frozen at sea, and packaged for export to various global markets. The inshore fleet's catches are typically landed fresh, destined for the domestic market.

Direct impact on population(s) or stock(s) of resource (Env_1): The stocks of both species are generally considered to be in a healthy state and being fished at a sustainable rate[650]. Biological reference points have recently been reviewed and updated[651]. A 'low risk' score is provided.

Ecosystem impact (Env_2): Most of the offshore sector and inshore sector vessels use otter trawls, with a very limited number using beam trawls[649]. This gear poses the risk of habitat damage as well as bycatch of a variety of different species, with recovering groundfish stock such as cod being the greatest concern[649]. A 'medium risk' score is provided.

Climate change impact (Env_3): The dominance of bottom towed gear as the production method results in a 'high risk' carbon footprint based on Parker & Tyedmers (2014)[652]. Whilst an average score of 5.4 tonnes of CO_2 per kg of fish ('medium risk') is provided by the Seafood

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[646] *https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/about/*

[647] *https://fisheries.msc.org/en/fisheries/north-sea-brown-shrimp/about/*

[648] *See Appendix 11 of the Public Certification Report (Dec. 2017): https://fisheries.msc.org/en/fisheries/north-sea-brown-shrimp/@@assessments*

[649] *https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/shrimp-crevette/shrimp-crevette-2018-002-eng.html#n2*

[650] *https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2019/2019_011-eng.html*

[651] *https://waves-vagues.dfo-mpo.gc.ca/Library/40951261.pdf*

[652] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

Carbon Emissions Tool[653], it is felt this may underestimate the impact on blue carbon habitats[654]. Therefore a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): The leatherback sea turtle (*Dermochelys coriacea*) is listed as endangered under Canada's Species at Risk Act (SARA)[655] and is occasionally encountered in the Northern shrimp fishery, however the use of the Nordmore grate prevents it from being inadvertently captured. Two species of wolffish, *Anarhichus denticulatus* (Northern) and *Anarhichus minor* (Spotted), are bycatch in the Northern shrimp fishery and listed as threatened under SARA. A third species, the Atlantic Wolffish (*Anarhichas lupusis*) is also listed under SARA with Special Concern designation[649]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is generally considered effective given the measures that are in place and the status of the resource[649]. A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): Canada's northern and striped shrimp fisheries are MSC accredited under three different certificates, with conditions[656,657,658]. A 'medium risk' score is provided.

Supply chain: Norway wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The stock size of Northern shrimp is ICES divisions 3a and 4a East is considered to be below MSY Btrigger, although fishing pressure is estimated to be below Fmsy[641]. The Northeast Arctic stock, which dominates Norway's catches, is assessed as being healthy and exploited at a sustainable level (relative to MSY reference points)[659]. A 'low risk' score is therefore provided.

Ecosystem impact (Env_2): Bottom (otter) trawling poses the risk of habitat damage and bycatch of target and non-target species. The small mesh size used in shrimp trawls means juvenile fish are retained in the net. Increasing effort in this fishery could lead to increased bycatch of juvenile fish in the 5–25 cm size range, including redfish, cod, haddock, and Greenland halibut[659]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The dominance of bottom towed gear as the production method results in a 'high risk' carbon footprint based on Parker & Tyedmers (2014)[660]. Whilst an average score of 5.4 tonnes of CO2 per kg of fish ('medium risk') is provided by the Seafood

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[653] http://seafoodco2.dal.ca/

[654] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[655] https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

[656] https://fisheries.msc.org/en/fisheries/canada-northern-and-striped-shrimp/@@view

[657] https://fisheries.msc.org/en/fisheries/gulf-of-st-lawrence-northern-shrimp-trawl-fishery/about/

[658] https://fisheries.msc.org/en/fisheries/canada-scotian-shelf-northern-prawn-trawl-and-trap/about/

[659] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/pra.27.1-2.pdf

[660] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

Carbon Emissions Tool[661], it is felt this may underestimate the impact on blue carbon habitats[662]. Therefore a 'high risk' score is provided on a precautionary basis.

ETP impact (Env_4): Risks of ETP impact are considered relatively low[663,664], however there are interactions with potential ETP species recorded (including wolfish and redfish), a 'medium risk' score is therefore provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is considered generally effective given the measures that are in place and the status of the main stock. A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Norway Skagerrak and the Norwegian Deep cold-water prawn fishery, located in the North Sea, in Swedish, Danish and Norwegian waters is MSC certified[664], as is the Norwegian Northeast Arctic fishery[663]. Both are associated with conditions. A 'medium risk' score is therefore provided.

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[661] http://seafoodco2.dal.ca/

[662] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[663] https://fisheries.msc.org/en/fisheries/norway-north-east-arctic-cold-water-prawn/@@assessments

[664] https://fisheries.msc.org/en/fisheries/norway-skagerrak-and-the-norwegian-deep-cold-water-prawn-fishery/@@view

Seafood commodity – Large pelagics

Given the management of large pelagic species is governed by RFMOs, and the geographic scope of those RFMOs includes multiple countries, the risk assessment justification below will consider each resource individually, but countries are grouped by their respective RFMO regions and explained collectively.

Supply chains: Swordfish wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Three of the eight countries responsible for the majority of the UK's swordfish imports are targeting Indian Ocean swordfish (Sri Lanka, India, and Seychelles) and are governed by the Indian Ocean Tuna Commission (IOTC). According to the most recent stock assessment (2020), the spawning biomass in 2018 was estimated to be 40-83% of the unfished levels and catches in 2019 were just below MSY level[665]. Therefore, the stock is thought to be not overfished and not subject to overfishing which is reflected in the 'low risk' score.

Vietnam falls under the jurisdiction of the Western Central Pacific Fisheries Commission (WCPFC), which similarly to the IOTC region, currently states the North Pacific swordfish stock status as not likely overfished and not experiencing overfishing, resulting again in a 'low risk' score[666].

Brazil is considered part of the International Commission for the Conservation of Atlantic Tunas (ICCAT), which published a swordfish stock status report in 2019. The most recent stock assessment was conducted in 2017 and found that stock biomass was overfished, and that overfishing is either occurring or current F is very close to Fmsy[667], resulting in a 'high risk' score.

Similarly, the stock targeted by Spain is also governed by ICCAT, although this stock is assessed as part of the North Atlantic Ocean. According to ICCAT, catches have decreased by 56.2% from a peak in swordfish landings in 1987 to 2018 levels and have largely been a result of regulatory changes and a redistribution of fleets to the south Atlantic or out of the Atlantic. The available stock assessment information suggests that overfishing is not occurring, and that biomass is either higher than or very close to Bmsy[667]. A 'low risk' score was therefore provided.

Swordfish in the Mediterranean (also falls under ICCAT) is considered overfished[668], resulting in a 'high risk' score for Greece.

The swordfish fishery targeted by Chile is regulated by the Inter-American-Tropical-Tuna-Commission (IATTC). Although a stock assessment was conducted in 2017 for the southern hemisphere, including an overlapping area with the WCPFC jurisdictions, the assessment did not extend further than east of 130°W, therefore the most applicable stock assessment for this

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[665] https://www.iotc.org/science/status-summary-species-tuna-and-tuna-species-under-iotc-mandate-well-other-species-impacted-iotc

[666] https://www.wcpfc.int/doc/07/north-pacific-swordfish

[667] https://www.iccat.int/Documents/SCRS/ExecSum/SWO_ATL_ENG.pdf

[668] https://www.iccat.int/Documents/SCRS/ExecSum/SWO_MED_ENG.pdf

region was in 2011[669]. At the time, the stock was not experiencing overfishing and was not overfished and catches in this region appear to have been steady or declined. However, given the lack of stock assessment in recent years, a 'medium risk' score has been provided.

Ecosystem impact (Env_2): The primary capture method for swordfish is pelagic longline, although driftnets and handlines are also used. Given pelagic longlines are typically set on or near the surface resulting in little contact with bottom substrates, habitat damage is minimal. However, bycatch of non-target species, including other fish, marine mammals, sea turtles, elasmobranchs and seabirds is well documented and remains a concern in all geographic regions in the assessment[670]. On this basis, a 'medium risk' score is provided.

Climate change impact (Env_3): Pelagic gears such as those used in swordfish fisheries are associated with a 'medium risk' score in relation to the carbon footprint of the production method[671,672].

ETP impact (Env_4): Pelagic longlines in all regions of the world are known to have interactions with ETP species including turtles, elasmobranchs, sea birds and less frequently, marine mammals. The following species are known to be associated as bycatch from large pelagic longline fisheries;

Sea turtle: The Olive Ridley (*Lepidochelys olivacea*), classified as threatened, Green (*Chelonia mydas*) classified as threatened, Hawksbill (*Eretmochelys imbricata*) classified as endangered, leatherback (Dermochelys coriacea) classified as endangered, and loggerhead (Caretta caretta) are all known to interact with longline vessels[673]. According to the WCPFC[670], the condition-at-release varies between species, but evidence suggests >60% are dead for olive ridley and green turtles, whereas 45% of hawksbill are found alive, and the condition of loggerhead and leatherback turtles are largely unknown (caveating the degrees of uncertainty in catch rates). While this specific paper is restricted to the western central Pacific ocean, reports suggest turtle bycatch occurs also within the Indian Ocean swordfish fishery[674], the Greek swordfish fishery[675], and in the Chilean longline fishery targeting swordfish[676].

Elasmobranchs: Some studies suggest up to a quarter of the total catch in some pelagic longline tuna and billfish fisheries are shark species[677]. Commonly caught sharks are blue shark (healthy status), shortfin mako, thresher and hammerhead species which are listed as

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[669] *https://www.iattc.org/PDFFiles/FisheryStatusReports/_English/No-18-2020_Tunas%20billfishes%20and%20other%20pelagic%20species%20in%20the%20eastern%20Pacific%20Ocean%20in%202019.pdf*

[670] *https://www.researchgate.net/publication/337331839_Summary_of_longline_fishery_bycatch_at_a_regional_scale_2003-2017*

[671] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[672] *http://seafoodco2.dal.ca/*

[673] *https://www.researchgate.net/publication/325435693_Bycatches_of_endangered_threatened_and_protected_species_in_marine_fisheries*

[674] *https://www.seafish.org/responsible-sourcing/risk-assessment-for-sourcing-seafood-rass/records/swordfish-indian-ocean-gillnet/*

[675] *https://www.researchgate.net/publication/237428204_By_catches_and_discards_of_the_Greek_swordfish_fishery*

[676] *https://www.researchgate.net/publication/223261403_Sea_turtle_bycatch_in_the_Chilean_pelagic_longline_fishery_in_the_southeastern_Pacific_Opportunities_for_conservation*

[677] *https://www.sustainablefish.org/News/Briefing-on-Tuna-Longline-Fisheries-Identifies-Best-Practices-for-Reducing-Bycatch*

vulnerable and endangered. Instances of elasmobranch bycatch are evident for all countries in the supply network.

Sea birds: Sea birds are most at risk during longline setting and primarily affect petrels and albatross. It has been estimated that 15 of 22 species of albatross alone are threatened with extinction[678].

For the reasons above, all countries associated with swordfish longlining are awarded a 'high risk' score.

Social concerns associated with supply chain (Social_1): With the exception of Spain, all of the assessed countries are assigned a 'medium risk' score on the basis of the Global Slavery Index (2018) fishery sector report[679]. Spain is however considered to have 'high' risk of modern slavery in the fishing industry and so the same score is applied here.

Management effectiveness (Mgt_1): Sri Lanka, Vietnam, Greece, Spain, India and Seychelles have all been awarded a 'medium risk' score. The respective stock status for each of the associated countries within the RFMOs are all "not subject to overfishing and not overfished", therefore management measures currently in place are maintaining the stock at sustainable levels. However, management could be strengthened to reduce or mitigate threat of bycatch for ETP species, for example.

Conversely, swordfish fisheries associated with Greece, Brazil and Chile are in poorer condition and data deficient, which suggests current management measures are not adequate. This, in combination with the high bycatch rates associated with pelagic longlines, and the limited measures in place to reduce this risk has resulted in an overall 'high risk' score.

Sustainability certification progress (Mgt_2): Three countries – Sri Lanka[680], Vietnam[681] and Spain[682] – are currently involved in a FIP and have therefore been awarded a 'medium risk' score. The remaining countries, are not currently associated with a sustainability certification scheme, therefore have been awarded a 'high risk' score.

Supply chains: Skipjack tuna wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Seychelles, Mauritius, Spain and Indonesia (in part) target Indian Ocean skipjack tuna, falling under the governance of the IOTC. The 2020 stock assessment suggests current spawning biomass relative to unexploited levels is 45%, and catches have been within the range of estimated yield. Overall, the stock is classed as not overfished and not subject to overfishing[683]. That said, the WWF-UK

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[678] *Paleczny M, Hammill E, Karpouzi V and Pauly D. 2015. Population Trend of the World's Monitored Seabirds, 1950-2010. PLoS ONE 10(6): e0129342. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0129342*

[679] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[680] *https://fisheryprogress.org/fip-profile/sri-lanka-tuna-and-swordfish-longline*

[681] *https://fisheryprogress.org/fip-profile/vietnam-swordfish-handline-0*

[682] *https://fisheryprogress.org/fip-profile/atlantic-ocean-blue-shark-and-swordfish-surface-longline*

[683] *https://www.iotc.org/science/status-summary-species-tuna-and-tuna-species-under-iotc-mandate-well-other-species-impacted-iotc*

Back to Biology report[684] suggests Indian Ocean skipjack is on the SSB40 boundary. Whilst the overall score has been awarded 'low risk', it is on the limit between medium risk and low risk.

The Philippines, Papua New Guinea and Indonesia (in part) are under the jurisdiction of the WCPFC who last conducted a stock assessment in 2019. The results of that assessment suggest that the stock is currently moderately exploited, and the level of fishing mortality is sustainable[685]. It is also noted that fishing mortality is continuously increasing for both adult and juvenile while the spawning biomass reached the historical lowest level. However, the more recent WWF-UK Back to Biology report[684] suggests skipjack in the WCPFC region is just above SSB40 target level. On that basis, a 'low risk' score was awarded.

Ghana and Portugal target East Atlantic Skipjack, which is assessed under ICCAT. The last full quantitative stock assessment occurred in 2014, but catches have been updated to 2018. On that basis the stock is suggested to be not likely 'over fished and not like to be subject to overfishing'. The WWF-UK Back to Biology report[684] documents that the status of the stock relative to SSB40 is unknown. Given the lack of recent quantitative stock assessment, a 'medium risk' score was awarded.

IATTC are responsible for the skipjack fishery targeted by Ecuador. There are many uncertainties associated with the assessment of this species, largely due to the lack of age-composition data, and tagging data, which means a conventional stock assessment is not possible. Risk analysis results for bigeye are commonly used as a reference for skipjack, although there are suggestions that skipjack is much more productive than bigeye and that there is <50% probability that Fmsy has been exceeded and <5% probability that Flimit has been exceeded. The WWF-UK Back to Biology report[684] similarly documents that the status of the stock relative to SSB40 is unknown. On the basis of a lack of robust stock assessment specific for skipjack, a 'medium risk' score has been given.

Ecosystem impact (Env_2): Pelagic gears tend to impose minimal habitat damage due to their largely midwater or near surface positioning. However, there is evidence particularly for those countries targeting Indian Ocean skipjack (Seychelles, Mauritius, Spain), and Eastern Atlantic Skipjack that the use of Fish Aggregating Devices (FADs) results in significant proportions of juvenile yellowfin bycatch[686]. Furthermore, instances of bycatch in the Western Central Pacific purse seine fishery particularly of rainbow runner, silky shark, oceanic triggerfish, mackerel scad and mahi-mahi have been observed[687]. Gill nets are also relatively indiscriminate in their catch profiles. Due to the minimal impact to habitat but frequent bycatch from purse seines and gill nets, all countries except Indonesia under this assessment have been awarded a 'high risk' score.

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684 https://www.wwf.org.uk/sites/default/files/2021-05/WWF%20-%20Back%20to%20Biology%20report%20%28new%29.pdf

685 https://www.wcpfc.int/doc/03/skipjack-tuna

686 https://www.bluemarinefoundation.com/wp-content/uploads/2020/10/Failure-To-Manage-Yellowfin-Tuna-by-the-IOTC-FINAL.pdf

687 https://www.researchgate.net/publication/337332226_Summary_of_purse_seine_fishery_bycatch_at_a_regional_scale_2003-2016

Indonesia is known for its relatively low impact pole and line fishery[688]. Whilst the longline and purse seine fleets do land high quantities of skipjack[689,690], it is believed (but could not be verified) that the majority of skipjack entering the UK from Indonesia is produced by the pole and line fishery. Therefore a 'medium risk' score is provided, which may prove to be an over-estimate of risk if the UK Indonesian skipjack imports can be more robustly traced to the fishery of origin.

Climate change impact (Env_3): Pelagic gears such as those used in skipjack tuna fisheries are associated with a 'medium risk' score in relation to the carbon footprint of the production method based on Parker & Tyedmers (2014)[691]. An average score of 2.4 tonnes of CO2 per kg of fish ('low risk') is however provided by The Seafood Carbon Emissions Tool, based on purse seines as the production method[692]. On that basis, a 'low risk' score is provided. The prevalence of pole and line gear in the Indonesian fishery also supports a 'low risk' score.

ETP impact (Env_4): Bycatch is an issue related to purse seine skipjack fisheries, particularly where FADs are used, although little evidence is available for widespread ETP mortality. On the basis of the high number of ETP species (including sharks, turtles and cetaceans) with which interactions are reported within the MSC certification assessments (see Mgt_2), a precautionary 'high risk' score was provided for all countries except Indonesia. Improved data and monitoring are required.

As per the rationale above for Env_2 for Indonesia, a 'medium risk' score is provided on a precautionary basis as pole and line fisheries are highly selective, however there is some uncertainty over the extent to which UK imports are dominated by production from this relatively low impact fishery.

Social concerns associated with supply chain (Social_1): Ghana, Philippines[693], Spain and Papua New Guinea have all presented 'high risk' scores in relation to risk of modern slavery in their fishing industry[694]. According to Seafish, there is substantial evidence of forced labour in the Philippines tuna industry, including workers working under conditions of debt bondage.

Indonesia, Ecuador and Mauritius were considered to be 'medium risk' on the basis of the modern slavery index[694]. In addition, Seafish suggest that there is a risk for women in particular to be employed on informal, low paid and vulnerable contracts with little benefits or access to labour rights in Ecuador[695]. A score of 'medium risk' was awarded in this instance. Little

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688 https://indonesiantuna.com/

689 https://iotc.org/documents/SC/23/NR07

690 https://www.wcpfc.int/doc/wcpfc-tuna-fishery-yearbook-2020

691 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

692 http://seafoodco2.dal.ca/

693 https://www.seafish.org/document/?id=7df16f02-245e-4fc2-a1a3-1163f05d79b4

694 *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at:* https://www.globalslaveryindex.org/resources/downloads/

695 https://www.seafish.org/document/?id=04df1965-0a31-4d02-b3a2-2e10191abdff

information is available for the Seychelles and so a 'medium risk' score was provided on a precautionary basis.

Portugal was the only country to be awarded a 'low risk' score in relation to modern slavery in their fishing industry[694].

Management effectiveness (Mgt_1): Countries associated with Indian Ocean skipjack tuna have been awarded a 'medium risk' score for management effectiveness. While the stock is still classified as "not overfished and not subject to overfishing" by the IOTC, catches in 2018 exceeded the limit stated in the Harvest Control Rule (HCR) for the 2018-2020 period[696], putting the stock at risk of deterioration.

Assessments by the relevant RFMOs related to Ghana, Portugal and Ecuador are lacking recent stock assessments to inform sound management recommendations. For that primary reason, a 'medium risk' score was given. However, in light of the EU yellow card received by Ecuador in 2019 for their shortfalls in relation to IUU management[697], the score has been amended to a 'high risk'[698].

Management effectiveness for Papua New Guinea, Philippines and Indonesia was classed as a 'medium risk' given the status of the stock and exploitation status.

Sustainability certification progress (Mgt_2): Indonesia was classed as 'medium risk' as they have MSC certification – largely with conditions – and FIPs for large portions of their pole and line fisheries[699,700,701].

Ghana[702], Seychelles and Mauritius[703] are involved with FIPs for their purse seine fisheries, therefore a 'medium risk' score was applied. Ecuador is undergoing assessment for portions of its purse seine fisheries[704,705] also resulting in a 'medium risk' score.

Papua New Guinea is also part of a FIP[706], as well as MSC certification[707,708]. However, objections to the 'PNA Western and Central Pacific skipjack and yellowfin, unassociated / non-FAD set, tuna purse seine' certification were made by the International Pole and Line

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[696] https://www.iotc.org/science/status-summary-species-tuna-and-tuna-species-under-iotc-mandate-well-other-species-impacted-iotc

[697] https://ec.europa.eu/commission/presscorner/detail/en/QANDA_19_6037

[698] *The decision to take this factor into account in relation to the management effectiveness risk indicator (Mgt_1) rather than IUU Fishing risk (Mgt_3) was to avoid introducing any inconsistencies in the application of the IUU Index.*

[699] https://fisheries.msc.org/en/fisheries/indonesia-pole-and-line-and-handline-skipjack-and-yellowfin-tuna-of-western-and-central-pacific-archipelagic-waters/@@view

[700] https://fisheries.msc.org/en/fisheries/pt-citraraja-ampat-sorong-pole-and-line-skipjack-and-yellowfin-tuna/@@view

[701] https://fisheryprogress.org/fip-profile/indonesian-western-and-central-pacific-skipjack-tuna-pole-and-line

[702] https://fisheryprogress.org/fip-profile/ghana-tuna-pole-line

[703] https://fisheryprogress.org/fip-profile/indian-ocean-tuna-purse-seine-sioti

[704] https://fisheries.msc.org/en/fisheries/eastern-pacific-ocean-tropical-tuna-purse-seine-tunacons-fishery/@@view

[705] https://fisheries.msc.org/en/fisheries/eastern-pacific-purse-seine-skipjack-and-yellowfin-tuna-fishery-fsc-and-fad-set-fishery/@@view

[706] https://fisheryprogress.org/fip-profile/western-and-central-pacific-ocean-skipjack-yellowfin-tuna-purse-seine-cfc

[707] https://fisheries.msc.org/en/fisheries/pna-western-and-central-pacific-skipjack-yellowfin-and-bigeye-tuna-purse-seine-fishery-fad-and-non-fad-sets/@@view

[708] https://fisheries.msc.org/en/fisheries/tropical-pacific-yellowfin-and-skipjack-free-school-purse-seine-fishery/@@assessments

Foundation, supported by WWF. Those objections were not supported by the Independent Adjudicator[709]. A ‘medium risk’ score is provided on a pragmatic basis given the total scope of MSC certification progress for the fishery.

Small portions of skipjack targeted by Spain are involved in a FIP[703], along with an MSC certification[710] and another undergoing assessment[711]. However, WWF submitted objections to the existing certification in 2018 which were not withdrawn or upheld[712]. Therefore a ‘high risk’ score is provided overall.

Portugal and Philippines are not associated with any sustainability certification, so a ‘high risk’ score was awarded.

Supply chain: Yellowfin tuna wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Four (Mauritius, Spain, Seychelles, France) out of six countries contributing to yellowfin tuna imports to the UK target the Indian Ocean stock. Concerns over the state of the stock have been evident for Indian Ocean yellowfin tuna for a number of years, and on the basis of the 2018 stock assessment, the stock remains overfished and subject to overfishing[713]. The WWF-UK Back to Biology report[714] suggests the stock is at 0.3 of the SSB/SSB_0 (i.e. <SSB40) and that fishing mortality far exceeds the limit. A ‘high risk’ score is therefore provided.

ICCAT conducted a stock assessment in 2019, using data to 2018, which concluded the Eastern Atlantic yellowfin stock fished by Ghana was not overfished and not subject to overfishing[715]. However, the WWF-UK Back to Biology report[714] estimates that the SSB/SSB_0 = 0.39. Therefore, a ‘high risk’ score was provided here.

The Eastern Pacific yellowfin stock targeted by Ecuador was last assessed based on 2018 data. Results from IATTC suggest there is low probability of Fcur being above Fmsy (9%) and spawning biomass being below Bmsy_d[716]. However, according to the Stock SMART assessment performed by NOAA in 2018, the Eastern Pacific Stock is not overfished but is subject to overfishing[717]. Conversely, the WWF-UK Back to Biology report[714] estimates that the SSB/SSB_0 = 0.18. A ‘high risk’ score is therefore provided.

Ecosystem impact (Env_2): Similarly to other large pelagic species assessed in this risk assessment, the primary method used in this fishery is purse seines, operating in mid water to

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[709] https://www.pnatuna.com/sites/default/files/2018028_IA_Final_Decision_PNA_0.PDF

[710] https://fisheries.msc.org/en/fisheries/echebastar-indian-ocean-purse-seine-skipjack-tuna/@@view

[711] https://fisheries.msc.org/en/fisheries/agac-four-oceans-integral-purse-seine-tropical-tuna-fishery/@@assessments

[712] https://echebastar.com/wp-content/uploads/2019/02/Independent-Adjudicator-Fianl-Decision.pdf

[713] https://www.iotc.org/science/status-summary-species-tuna-and-tuna-species-under-iotc-mandate-well-other-species-impacted-iotc

[714] https://www.wwf.org.uk/sites/default/files/2021-05/WWF%20-%20Back%20to%20Biology%20report%20%28new%29.pdf

[715] https://www.iccat.int/Documents/SCRS/ExecSum/YFT_ENG.pdf

[716] https://www.iattc.org/PDFFiles/FisheryStatusReports/_English/No-18-2020_Tunas%20billfishes%20and%20other%20pelagic%20species%20in%20the%20eastern%20Pacific%20Ocean%20in%202019.pdf

[717] https://www.fisheries.noaa.gov/species/pacific-yellowfin-tuna

surface waters, so habitat damage is minimal. However, the use of FAD associated purse seines have the ability to catch juvenile yellowfin in addition to several other species of fish, marine mammals, particularly spotted dolphin in the Eastern Pacific Ocean[716], sea turtles and sharks. As a result, all countries in the supply chains have been awarded a ‘high risk’ score.

Climate change impact (Env_3): Pelagic gears such as those used in yellowfin tuna fisheries are associated with a ‘medium risk’ score in relation to the carbon footprint of the production method based on Parker & Tyedmers (2014)[718]. An average score of 2 tonnes of CO_2 per kg of fish (‘low risk’) is however provided by The Seafood Carbon Emissions Tool, based on purse seines as the production method[719]. On that basis, a ‘low risk’ score is provided.

ETP impact (Env_4): Bycatch is an issue related to purse seine fisheries, particularly where FADs are used. On the basis of the high number of ETP species (including sharks, turtles and cetaceans) with which interactions are reported within the MSC certification assessments (see Mgt_2), a precautionary ‘high risk’ score was provided for all countries.

Social concerns associated with supply chain (Social_1): The same scores, with the same rationale, were applied to the applicable countries as those provided in the skipjack tuna assessment. France was also provided a ‘medium risk’ score based on the categorised risk of modern slavery in the fishing industry[720].

Management effectiveness (Mgt_1): Management of Indian Ocean tuna is poor and is reflected in the unsustainable exploitation of the stock and failure to agree on an adequate rebuilding plan. For that reason, a ‘high risk’ score of 3 was provided for Seychelles, France, Mauritius and Spain.

Ecuador was given a ‘high risk’ score due to the uncertainty in the stock assessment in combination with the high risk of bycatch, as well as the EU yellow card received by Ecuador in 2019 for their shortfalls in relation to IUU management[721,722].

Although the stock is suggested to be in a healthy condition, management measures could be improved to reduce the risk of bycatch in the Ghana fishery. In addition, the EU awarded Ghana a ‘yellow IUU card’ in 2021 due to their inadequacy for combating IUU fishing. As a result, a ‘high risk’ score was given.

Sustainability certification progress (Mgt_2): All countries connected to the import of yellowfin tuna to the UK are involved in a FIP or are undergoing MSC assessment, but are not MSC certified except the ANABAC Atlantic unassociated purse seine yellowfin tuna[723], therefore a ‘medium risk’ score was applied.

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[718] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[719] *http://seafoodco2.dal.ca/*

[720] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[721] *https://ec.europa.eu/commission/presscorner/detail/en/QANDA_19_6037*

[722] *The decision to take this factor into account in relation to the management effectiveness risk indicator (Mgt_1) rather than IUU Fishing risk (Mgt_3) was to avoid introducing any inconsistencies in the application of the IUU Index.*

[723] *https://fisheries.msc.org/en/fisheries/anabac-atlantic-unassociated-purse-seine-yellowfin-tuna/@@assessments*

Supply chains: Albacore tuna wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): UK imports of Albacore are all sourced from European countries, and therefore all governed by ICCAT. The most recent stock assessment is based on 2014 data which states that the North Atlantic stocks are likely to be in good condition but there are too many uncertainties associated with the Mediterranean stocks to make an informed prediction of the stock status. The WWF-UK Back to Biology report[724] accordingly documents that the status relative to SSB40 is unknown. Due to the limited data, all stocks have been given a 'medium risk' score.

Ecosystem impact (Env_2): This stock is mainly targeted by traditional surface fisheries (troll and baitboat) and longliners**,** although longliners largely represent Chinese Taipei and Japan[725], which are not assessed under this risk assessment. Surface fisheries are unlikely to inflict habitat damage, however there is a reasonable likelihood of instances of bycatch. Little data exists to quantify this more thoroughly, therefore a conservative 'medium risk' score was awarded here.

Climate change impact (Env_3): The combination of pelagic and surface gears utilised for albacore in this region corresponds with a 'medium risk' of carbon footprint of the production method based on Parker & Tyedmers (2014)[726]. An average score of 4.9 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool, based only on longlines as the production method[727]. On that basis, a 'medium risk' score is provided.

ETP impact (Env_4): Relatively limited information is available to assess ETP impacts associated with European albacore fisheries. However, interactions with a number of ETP species (including sharks, turtles and birds) are reported within the limited MSC certification assessments (see Mgt_2). Therefore, a precautionary 'medium risk' score was awarded.

Social concerns associated with supply chain (Social_1): On the basis of the Global Slavery Index categorisation of modern slavery risk in the fishing industry[728], the Republic of Ireland, France and Greece were provided a 'medium risk' score, whereas Spain was given a 'high risk' score and Portugal a 'low risk' score. No categorisation of Malta was available, however a 'low risk' score was assigned on the basis of no documented or known evidence of social concerns in the industry. Further, a recent article on human trafficking in the Republic of Ireland's seafood industry[729] raises concerns about social issues that require further investigation.

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[724] *https://www.wwf.org.uk/sites/default/files/2021-05/WWF%20-%20Back%20to%20Biology%20report%20%28new%29.pdf*

[725] *https://www.iccat.int/Documents/SCRS/ExecSum/ALB_ENG.pdf*

[726] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[727] *http://seafoodco2.dal.ca/*

[728] *Global Slavery Index 2018. Spotlight on Sectors – Modern Slavery in the Fishing Industry. Available at: https://www.globalslaveryindex.org/resources/downloads/*

[729] *https://www.seafoodsource.com/news/supply-trade/irish-government-ngo-clash-over-human-trafficking-call-out*

Management effectiveness (Mgt_1): On the premise of the relatively unknown status of the stock as a result of data uncertainties, a ‘medium risk’ score of 2 was given for all countries in the supply chain.

Sustainability certification progress (Mgt_2): With the exception of Spain, the assessed producing countries of Albacore are not known to be currently involved with a sustainability certification scheme. For that reason, a ‘high risk’ score was provided here. Given that a proportion of the Spanish fishery is MSC certified[730], a ‘medium risk’ score was provided.

[730] https://fisheries.msc.org/en/fisheries/north-atlantic-albacore-artisanal-fishery/about/

Seafood commodity – Molluscs

Unless otherwise stated, the following scallop assessments are based on wild capture and dredging more specifically, as this is the main production method for most supply chains. Whilst hand-dived and / or farmed scallops would be considered lower risk for many of the indicators[731], the assessments take a precautionary approach.

Scallops inc. King and Queen scallop

Supply chain: UK wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): There was no routine assessment or monitoring of King scallop stocks prior to 2017 and many stocks remain unassessed or data poor[732]. Recent assessments indicate that of the 7 identified stocks in English waters, 1 is overfished, 3 are data limited and the remaining are sustainably exploited from a population perspective (based on proxy reference points)[733].

Most UK Queen scallop fisheries take place in the Irish Sea, in and around the waters of the Isle of Man, Welsh waters of Liverpool Bay and Cardigan Bay, the Clyde, off Shetland and the north Irish Sea. There are large data gaps which prevent reliable conclusions about population status for most areas. The Isle of Man stock is considered to be at a very low level having been persistently fished at a rate that is higher than advised by scientists. Information on population status and exploitation rate outside of Isle of Man territorial waters is however less reliable[731].

A ‘medium risk’ score is therefore provided on the basis of variable stock and fishery status’ and data limitations.

Ecosystem impact (Env_2): The majority of King scallop production arises from scallop dredgers which are associated with a range of abiotic and biotic impacts as result of damage caused to the seabed and benthic fauna[734,732].

Although Queen scallop dredges are generally considered to be less damaging than King scallop dredges as they are modified with skids or skis, and Queenies are also often fished with light otter trawls which are typically more environmentally friendly in terms of impacts to benthic habitats, the fishing methods are still associated with relatively high rates of bycatch of non-target species (including finfish, crustaceans such as edible crabs and fragile invertebrates such as urchins) and risk of potential damage to sensitive seafloor features, including within marine protected areas which may not be adequately protected from scallop fishing[731]. A ‘high risk’ score is therefore provided.

Climate change impact (Env_3): The mixture of gear types results in a ‘medium risk’ carbon footprint for the UK’s production based on Parker & Tyedmers (2014)[735]. Whilst an average score

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[731] https://www.mcsuk.org/goodfishguide/species/queen-scallop/

[732] https://www.mcsuk.org/goodfishguide/species/king-scallop/

[733] *Lawler A, Nawri N. 2019. Assessment of scallop stock status for selected waters around the English Coast 2018/2019. Cefas Project Report for Defra. Available from: https://www.gov.uk/government/publications/assessment-of-scallops-stocks-201819*

[734] *Stewart B, Howarth L. 2016. Quantifying and Managing the Ecosystem Effects of Scallop Dredge Fisheries. Developments in Aquaculture and Fisheries Science, vol. 40, pp. 585-609, https://doi.org/10.1016/B978-0-444-62710-0.00018-3*

[735] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

of 1.6 tonnes of CO_2 per kg of fish ('low risk') is provided by the Seafood Carbon Emissions Tool[736], it is felt this is likely to underestimate the impact on blue carbon habitats[737]. Therefore, a 'medium risk' score is provided.

ETP impact (Env_4): Whilst there is potential for scallop dredging to damage highly sensitive, and in some cases protected, habitat features such as Maerl beds and Sabellaria reefs, these risks are considered under Env_2. Direct ETP species mortality risks are however considered unlikely – a 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of King scallop fisheries is largely under the control of the Member States, except for EU set minimum sizes and an effort cap for vessels ≥15m in ICES subarea 7[738]. UK management measures[739] also involve effort restrictions through licence numbers for over 10m vessels plus gear restrictions and some inshore (<6nm) spatial restrictions, often related to Marine Protected Areas[740].

Management of UK Queen scallop fisheries is a devolved responsibility. Few specific management measures exist for the Welsh fisheries although there are some monitoring and control measures in place. Management effectiveness is uncertain given the limited information available on the status of the stocks. Similarly, there is evident scope for improvement of the management of the fishery on the Isle of Man stock and its extension into offshore waters, given the declining status of the stock[731], although there are more measures in place for the Manx fishery than most others. Further, the multi-jurisdictional nature of Irish Sea fisheries area, combined with the mismatch between the Manx territorial sea (which covers more than 80% of ICES statistical square 37E5 and around 20% of 36E5) and the stock assessment unit (which includes all of the two squares), has led to a complicated management situation. In general, as elsewhere around the United Kingdom, Scottish scallop fisheries are relatively poorly managed, and the direct application of scientific assessment is uncommon or slow[741]. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The Shetland King scallop dredge (and inshore brown / edible crab) fishery is MSC certified[742] and FIPs are in place for other fisheries[743]. No UK

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[736] *http://seafoodco2.dal.ca/*

[737] *https://www.wwf.org.uk/press-release/climate-smart-fisheries-report*

[738] *Marine Management Organisation. 2020. Manage your fishing effort: Western Waters crabs and scallops. Available from: https://www.gov.uk/guidance/manage-your-fishing-effort-western-waters-crabs*

[739] *Scallop Orders (Scotland): https://www.legislation.gov.uk/ssi/2017/127/made, (England): https://www.legislation.gov.uk/uksi/2012/2283/contents, (Wales): https://www.legislation.gov.uk/wsi/2010/269/made, (Northern Ireland): https://www.legislation.gov.uk/nisr/2008/430/made*

[740] *In England, such spatial restrictions are often regulated through Inshore Fisheries and Conservation Authority (IFCA) byelaws, and may be accompanied by other local effort-based and technical measures, such as: https://www.cornwall-ifca.gov.uk/scalloping and http://www.ne-ifca.gov.uk/news/scallop-dredging/*

[741] *Peter F. Duncan, Andrew R. Brand, Øivind Strand, Eric Foucher (2016), Chapter 19 - The European Scallop Fisheries for Pecten maximus, Aequipecten opercularis, Chlamys islandica, and Mimachlamys varia, Editor(s): Sandra E. Shumway, G. Jay Parsons, Developments in Aquaculture and Fisheries Science, Elsevier, Volume 40, 2016, Pages 781-858*

[742] *https://fisheries.msc.org/en/fisheries/ssmo-shetland-inshore-brown-crab-and-scallop/about/*

[743] *https://www.projectukfisheries.co.uk/channel-scallops*

Queen scallop fisheries currently have third-party certification or are part of a FIP. The Isle of Man fishery's MSC certification was suspended in 2014 after a stock assessment report was published indicating that the biomass of queen scallops in the area was below the level at which recruitment was likely to be impaired. The Isle of Man Government's Department of Environment Food and Agriculture (DEFA) has chosen not to re-enter the Isle of Man Queen Scallop trawl fishery into MSC assessment for a second term[744]. A 'medium risk' score is therefore provided on the basis of some progress.

Supply chain: Argentina wild capture production

There are two main scallop fisheries within Argentinean waters – a small inshore fishery for the Tehuelche scallop, *Aequipecten tehuelchus* and the industrial northern Patagonia fishery for the Patagonian scallop, *Zygochlamys patagonica*. Catches in the order of 50,000 tonnes per year now rank this fishery among the most important scallop fisheries in the world[745]. The following assessment is based on the Patagonian fishery and information is derived from the MSC certification assessment[746].

Direct impact on population(s) or stock(s) of resource (Env_1): The status of the stock is assessed using fishery dependent and independent data. Whilst the stock was previously considered to be stable, more recent assessments have indicated a potential decline in spawning stock biomass and risk of recruitment overfishing. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery uses bottom otter trawl gear which disturbs the seabed and risks damage to its physical and biological structure and composition. Studies have shown the fishery impacts the biomass and distribution of many species, for example through incidental bycatch, although retainment or mortality of bycatch species is considered to be relatively low. Bycatch of Chondrichthyes (most frequently skates & rays) has been recorded. A 'high risk' score is provided.

Climate change impact (Env_3): Given the fishery solely uses bottom towed fishing gear, a 'high risk' score would be provided based on Parker & Tyedmers (2014)[747]. Whilst an average score of 1.6 tonnes of CO2 per kg of fish ('low risk') is provided by the Seafood Carbon Emissions Tool[748], it is felt this is likely to underestimate the impact on blue carbon habitats[749]. Therefore, a 'medium risk' score is retained.

ETP impact (Env_4): According to the MSC assessment '*There are no populations of protected, threatened and endangered species in the habitat of the Patagonian scallop so ETP species will*

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[744] https://fisheries.msc.org/en/fisheries/isle-of-man-queen-scallop-trawl/about/

[745] Gaspar Soria, J.M. (Lobo) Orensanz, Enrique M. Morsán, Ana M. Parma, Ricardo O. Amoroso, Chapter 25 - Scallops Biology, Fisheries, and management in Argentina, Editor(s): Sandra E. Shumway, G. Jay Parsons, Developments in Aquaculture and Fisheries Science, Elsevier, Volume 40, 2016, Pages 1019-1046. https://www.sciencedirect.com/science/article/pii/B9780444627100000250

[746] https://fisheries.msc.org/en/fisheries/patagonian-scallop-zygochlamys-patagonica-bottom-otter-trawl-fishery/@@view

[747] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[748] http://seafoodco2.dal.ca/

[749] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

not be impacted by this fishery'. In the absence of any contradictory evidence, a 'low risk' score is provided.

Social concerns associated with supply chain (Social_1): There are no known social concerns associated with the fishery. Considering the Global Slavery Index 2018, a 'low risk' score is justified.

Management effectiveness (Mgt_1): Management of the fishery is considered largely effective based on the management plan and measures in place. A 'low risk' score is provided.

Sustainability certification progress (Mgt_2): The Patagonian scallop fishery was first MSC certified in 2006 and again in 2012. It entered its second re-assessment in 2016. The fishery continues to be certified, with conditions. Approximately 50% of the frozen-at-sea scallops are sold to European markets; an additional 40% is sold into the United States. Most of the remainder are sold to Canadian markets. A 'medium risk' score is provided.

Supply chain: United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Atlantic scallops (*Placopecten magellanicus*) fished off the Northwestern Atlantic Coast are considered to be at sustainable levels both in terms of biomass and exploitation rate[750]. A 'low risk' score is provided.

Ecosystem impact (Env_2): "The primary Atlantic sea scallop fishery operates along the Atlantic coast from the Mid-Atlantic to the US / Canada border. The scallop fishery uses predominantly paired or single scallop dredges throughout the entire range of the fishery. To a lesser extent, and mainly in the Mid-Atlantic region, the scallop fishery uses otter trawl gear"[751]. Scallop dredging is known to change the physical and biological properties of benthic habitats, with recovery dependent on factors such as fishing intensity and species sensitivity[752]. Sea turtles, finfish (such as yellowtail flounder, skates, and monkfish), and undersized scallops can be incidentally caught in the scallop fishery[751]. Given that 'the New Bedford scallop dredge is one of the sturdiest and heaviest in operation, and has changed very little since it was first introduced'[753], a 'high risk' score is provided.

Climate change impact (Env_3): Given the fishery solely uses bottom towed fishing gear, a 'high risk' score would be provided based on Parker & Tyedmers (2014)[754]. Whilst an average score of 1.6 tonnes of CO2 per kg of fish ('low risk') is provided by the Seafood Carbon Emissions Tool[755], it is felt this is likely to underestimate the impact on blue carbon habitats[756]. Therefore, a 'medium risk' score is retained.

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[750] *https://www.st.nmfs.noaa.gov/stocksmart?stockname=Sea%20scallop%20-%20Northwestern%20Atlantic%20Coast&stockid=10786*

[751] *https://www.fisheries.noaa.gov/species/atlantic-sea-scallop*

[752] *Stewart B, Howarth L. 2016. Quantifying and Managing the Ecosystem Effects of Scallop Dredge Fisheries. Developments in Aquaculture and Fisheries Science, vol. 40, pp. 585-609, https://doi.org/10.1016/B978-0-444-62710-0.00018-3*

[753] *https://fisheries.msc.org/en/fisheries/us-atlantic-sea-scallop/about/*

[754] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[755] *http://seafoodco2.dal.ca/*

[756] *https://www.wwf.org.uk/press-release/climate-smart-fisheries-report*

ETP impact (Env_4): Incidental bycatch of loggerhead sea turtles, an ETP species, has been recorded. Turtle deflection devices to reduce injuries or death to sea turtles have to be used. Catches of wolffish species (ETP status) have also been recorded. The level of bycatch is considered unlikely to pose significant risks to the recovery of the species, although limited data means this assumption cannot be robustly verified[757]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is considered effective on the basis of measures that have been successfully implemented to ensure recovery of the stock and to reduce impacts (e.g. turtle by-catch), which includes spatial and temporal closures, effort control and gear restrictions[758]. A 'low risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The United States Atlantic Sea Scallop fishery is MSC certified[757], therefore a 'low risk' score is provided.

Supply chain: France wild capture production

"*French Queen scallop fisheries are not as important or as well-developed as those for King scallops. The queen scallop fishery is sporadic and depends on good recruitment. Fishing is normally based on a single year-class and starts when a high-density aggregation is detected. The main ground is located in the Western Channel near the Channel Islands, but queen scallop is also sporadically caught in the Western part of the Bay of Brest and the Bay of Camaret. Queen scallops are only caught by trawlers in France and landings reached more than 4000 tonnes in the early 2000s (although the data remains uncertain), but has collapsed to under 1000 tonnes in recent years. This fishery, however, now appears very marginal, with less than 10 boats fishing during very limited periods*"[741].

Based on this information and knowledge of the fishery (and that Queen scallops are not farmed), it is unclear if the imports really are Queen scallops – they may be mis-recorded King scallops for example. However, as we are unable to verify the source of the imports it is assumed they are Queen scallops.

Direct impact on population(s) or stock(s) of resource (Env_1): A 'medium risk' score is provided on the basis of assumed variable stock status and data limitations.

Ecosystem impact (Env_2): A 'high risk' score is provided, based on the UK's domestic production assessment.

Climate change impact (Env_3): The likely mixture of gear types results in a 'medium risk' carbon footprint for the UK's production based on Parker & Tyedmers (2014)[759]. Whilst an average score of 1.6 tonnes of CO2 per kg of fish ('low risk') is provided by the Seafood Carbon Emissions

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[757] https://fisheries.msc.org/en/fisheries/us-atlantic-sea-scallop/@@assessments

[758] https://fishchoice.com/buying-guide/sea-scallops

[759] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

Tool[760], it is felt this is likely to underestimate the impact on blue carbon habitats[761]. Therefore, a 'medium risk' score is provided.

ETP impact (Env_4): Direct ETP species mortality risks are considered unlikely – a 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): A 'medium risk' score is provided on the basis of assumed limited management measures as per UK fisheries.

Sustainability certification progress (Mgt_2): There is currently no third-party certification or FIP, therefore a 'high risk' score is provided.

Supply chain: Canada wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): There is a mixed picture in terms of stock biomass status for the different areas associated with the Atlantic sea scallop fishery (e.g. Georges Bank, Browns Bank, Banquereau Bank, St. Pierre Bank)[762], although there is no evidence of recruitment overfishing. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): "The vessels fish by towing steel scallop drags (rakes) along the seabed and are capable of towing two to three: drags in use have ranged from approximately 12' to 17' wide each. The duration of fishing trips varies from 10-12 days on a wetfish vessel up to about 22 days on a freezer vessel"[763]. Scallop dredging is known to change the physical and biological properties of benthic habitats, with recovery dependent on factors such as fishing intensity and species sensitivity[752]. Whilst the new Bedford scallop dredge is considered to be highly selective for scallops (<5% bycatch by weight has been recorded)[763], a 'high risk' score is provided.

Climate change impact (Env_3): Given the fishery solely uses bottom towed fishing gear, a 'high risk' score would be provided based on Parker & Tyedmers (2014)[764]. Whilst an average score of 1.6 tonnes of CO2 per kg of fish ('low risk') is provided by the Seafood Carbon Emissions Tool[765], it is felt this is likely to underestimate the impact on blue carbon habitats[766]. Therefore, a 'medium risk' score is retained.

ETP impact (Env_4): Three species of wolffish which are listed as Special Concern or Threatened under Canada's Species at Risk Act (SARA)[767] have been observed bycatch of the

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[760] http://seafoodco2.dal.ca/

[761] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[762] https://fisheries.msc.org/en/fisheries/eastern-canada-offshore-scallop/@@assessments

[763] https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/scallop-petoncle/2018/index-eng.html

[764] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[765] http://seafoodco2.dal.ca/

[766] https://www.wwf.org.uk/press-release/climate-smart-fisheries-report

[767] https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

offshore scallop fishery. A further 10 species caught as bycatch are listed as Endangered, Threatened or Special Concern by Committee on the Status of Endangered Wildlife in Canada (COSEWIC). However, the levels of incidental catches of these species are not considered to be causing unsustainable levels of harm[763]. A ‘medium risk’ score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a ‘low risk’ score is provided.

Management effectiveness (Mgt_1): The fishery is extensively managed and regulated[763] and the stocks are generally considered to be being fished sustainably (Env_1). A ‘low risk’ score is therefore provided.

Sustainability certification progress (Mgt_2): The Eastern Canada Offshore Scallop fishery is MSC certified[768], therefore a ‘low risk’ score is provided.

Mussels (Mytilus spp.)

Supply chain: UK aquaculture production for rope-grown mussels

Direct impact on population(s) or stock(s) of resource (Env_1): Blue mussels are indigenous to the UK. No evidence of negative interactions between farmed and wild mussel exists. A ‘low risk’ score is given for mussel farming in the UK.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A ‘low risk’ score is given for mussel farming in the UK.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[769].

A recent study completed by Gephart, J.A. et al. (2021)[770] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as ‘low risk’.

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[768] *https://fisheries.msc.org/en/fisheries/eastern-canada-offshore-scallop/about/*

[769] *Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116*

[770] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species. A variety of diving birds and ducks are known to interact with rope mussel farms but the most relevant is the Eider Duck or Common Eider *(Somateria mollissima).* The Eider is listed as near threatened by the IUCN and so is classed as an ETP species. Its main food source is molluscs and the spat which can be found on rope grown mussels presents an ideal food source for the diving birds.

The Eider duck is protected in the UK and so cannot be culled. Instead, farmers are known to chase the birds away or to use acoustic deterrents[771]. A variety of MSC assessments have also concluded that the effects on interaction with ETP species are likely to be negligible[772].

A 'low risk' score is provided here. Although some interaction does occur with ETP species these are not thought to be significant or warrant a 'moderate risk' score.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the rope-grown production of mussels in the UK. A 'low risk' score is provided.

Management effectiveness (Mgt_1): The UK has a relatively well-defined management system for the culture of mussels with no obvious weaknesses from an environmental standpoint. The UK also employs a well-defined water classification scheme for mussel consumption. A 'low risk' score is provided here as the management system is seen as effective.

Sustainability certification progress (Mgt_2): Certification is becoming much more common in mussel farms in the UK but does not cover all production. Generally, and with some justification, mussel farms have seen themselves as low risk from an environmental point of view and so the requirement for certification is not felt as necessary.

Some confusion exists over which certification program is required for mussels with both the MSC and ASC covering the species. In Scotland, a significant number of farms are covered by MSC certification under the Scottish Shellfish Marketing Group (SSMG) (with no conditions)[773]. Currently only one farm is certified against the ASC standard and one against the BAP Standards.

A 'medium risk' score is provided here as it is clear that many farms are covered by certification standards, but a significant number remain uncertified.

Supply chain: Denmark aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Blue mussels are indigenous to Denmark. No evidence of negative interactions between farmed and wild mussel exists. A 'low risk' score is given for mussel farming in Denmark.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

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[771] *Ross, B. P., Lien, J., & Furness, R. W. (2001). Use of underwater playback to reduce the impact of eiders on mussel farms. ICES Journal of Marine Science, 58(2), 517-524.*

[772] *Hønneland, G., & Seip, C. (2019). Marine Stewardship Council (MSC) Final Report Scanfjord Swedish Rope Grown Mussel Fishery On behalf of Scanfjord Mollösund AB Prepared by.*

[773] *https://fisheries.msc.org/en/fisheries/shetland-scottish-mainland-rope-grown-mussel-enhanced-fishery*

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A 'low risk' score is given for mussel farming in Denmark.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[774].

A recent study completed by Gephart, J.A. et al. (2021)[775] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as 'low risk'.

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species. A variety of diving birds and ducks are known to interact with rope mussel farms but the most relevant is the Eider Duck or Common Eider *(Somateria mollissima).* The Eider is listed as near threatened by the IUCN and so is classed as an ETP species. Its main food source is molluscs and the spat which can be found on rope grown mussels presents an ideal food source for the diving birds.

Hunting of the Eider duck is allowed under strict controls in Denmark. However, a variety of MSC assessments have also concluded that the effects on interaction with ETP species are likely to be negligible[776].

A 'low risk' score is provided. Although some interaction does occur with ETP species these are not thought to be significant or warrant a 'moderate risk' score.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the rope-grown production of mussels in Denmark. A 'low risk' score is provided.

Management effectiveness (Mgt_1): Denmark has a well-defined management system for the culture of mussels with no obvious weaknesses from an environmental standpoint. Denmark also employs a well-defined water classification scheme for mussel consumption. A 'low risk' score is provided as the management system is seen as effective.

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[774] *Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116*

[775] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[776] *Andrews, J., Brand, A., Maar, M. (2017). Marine Stewardship Council (MSC) Final Report Limfjord Blue Shell Mussel (Rope grown)*

Sustainability certification progress (Mgt_2): In 2012, it was announced that all exporting mussel farms in Denmark had been certified under the MSC standard[777,778,779]. However, the largest of those farms[777] is certified with conditions. A 'medium risk' score is therefore provided.

Supply chain: Netherlands aquaculture production

The Netherlands uses a variety of different farming methods including rope and bottom culture

Direct impact on population(s) or stock(s) of resource (Env_1): Blue mussels are indigenous to The Netherlands. No evidence of negative interactions between farmed and wild mussel exists. A 'low risk' score is given for mussel farming in the Netherlands.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A 'low risk' score is given for mussel farming in the Netherlands.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[780].

A recent study completed by Gephart, J.A. et al. (2021)[781] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as 'low risk'.

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species. A variety of diving birds and ducks are known to interact with mussel farms but the most relevant is the Eider Duck or Common Eider *(Somateria mollissima).* The Eider is listed as near threatened by the IUCN and so is classed as an ETP species. Its main food source is molluscs and the spat which can be found on rope grown mussels presents an ideal food source for the diving birds.

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[777] https://www.seafoodsource.com/news/environment-sustainability/all-danish-mussels-now-msc-certified

[778] https://fisheries.msc.org/en/fisheries/limfjord-blue-shell-mussel-rope-grown/@@view

[779] https://fisheries.msc.org/en/fisheries/dfpo-mussel-cockle-and-oyster

[780] *Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116*

[781] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

It is common practice in the Netherlands to use relaying operations for export mussels. This presents concerns around the removal and / or availability of food for eider ducks (partly as a result of seed removal). A Mussel Transition Agreement has been agreed in The Netherlands to combat this and allows for areas to be closed from year to year to ensure plentiful natural beds[782].

A 'low risk' score is provided here. Although some interaction does occur with ETP species (Eider ducks) the potential impacts are being managed.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the rope-grown production of mussels in the Netherlands. A 'low risk' score is provided.

Management effectiveness (Mgt_1): The Netherlands has a well-defined management system for the culture of mussels with no obvious weaknesses from an environmental standpoint. The Netherlands also employs a well-defined water classification scheme for mussel consumption.

A 'low risk' score is provided here as the management system is seen as effective.

Sustainability certification progress (Mgt_2): Many Dutch mussel producers are covered by MSC certification[783] (certainly those responsible for exports).

A 'medium risk' score is provided here as many farms are covered by certification standards, although a number do remain uncertified.

Supply chain: France aquaculture production

France uses a variety of different farming methods including rope, bouchot and bottom culture.

Direct impact on population(s) or stock(s) of resource (Env_1): Blue mussels are indigenous to France. No evidence of negative interactions between farmed and wild mussels exists. A 'low risk' score is given for mussel farming in France.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A 'low risk' score is given for mussel farming in France.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[784].

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[782] Gascoigne, J,. Sieben, C., Collinson, K. and Lowenberg, U. (2016) Marine Stewardship Council (MSC) Final Report Netherlands Blue Shell Mussels.

[783] https://fisheries.msc.org/en/fisheries/netherlands-blue-shell-mussel-translocation-bottom-cultured-fishery/@@view

[784] Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116

A recent study completed by Gephart, J.A. et al. (2021)[785] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO_2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as 'low risk'.

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species. A variety of diving birds and ducks are known to interact with rope mussel farms but the most relevant is the Eider Duck or Common Eider *(Somateria mollissima).* The Eider is listed as near threatened by the IUCN and so is classed as an ETP species. Its main food source is molluscs and the spat which can be found on rope grown mussels presents an ideal food source for the diving birds.

Little information is specifically available for interactions between French mussel farms and ETP species (Eider ducks). It is highly likely that the issues seen in France are similar to those seen in other European countries.

A 'low risk' score is provided here. Some interaction is likely with ETP species but these are considered to be limited in nature.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the production of mussels in France. A 'low risk' score is provided.

Management effectiveness (Mgt_1): France is known to have a relatively well-defined management but specific information on mussel culture is not known. France has a strongly regional fisheries management system which can lead to geographical differences. The strength or weakness of this system cannot be fully assessed without further information.

A 'medium risk' score is provided here as the management system is not well documented or understood.

Sustainability certification progress (Mgt_2): French mussel producers have shown little appetite for certification with no MSC or ASC coverage of the species in the country. However, other standards are known to be employed to varying degrees in France (i.e. Global GAP).

A 'medium risk' score is provided here as it is clear that many farms are covered by certification standards, but a significant number remain uncertified.

Supply chain: Chile aquaculture production

Chile farms a slightly different native species of mussel (Mytilus chilensis) commonly known as the Chilean mussel. This compromises 98% of the total production in the country. The main production system is long line.

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[785] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

Direct impact on population(s) or stock(s) of resource (Env_1): Chilean mussels *(Mytilus chilensis)* are indigenous to Chile. No evidence of negative interactions between farmed and wild mussel exists. A 'low risk' score is given for mussel farming in Chile.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A 'low risk' score is given for mussels farming in Chile.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[786].

A recent study completed by Gephart, J.A. et al. (2021)[787] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as 'low risk'.

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species. In Chile, a limited amount of information is available in relation to risks associated with other species and in particular ETP species. In the MSC assessment report of the producer Toralla S.A., the only species identified as interacting with the mussel farms and being of ETP interest were Chilean dolphins *(Cephalorhynchus eutropia)*[788]. Ribeiro et al. (2005)[789] identified some concerns regarding loss of habitat for Chilean dolphins.

A 'medium risk' score is provided here. Although some interaction does occur with ETP species these are not fully understood and require further research.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the production of mussels in Chile. A 'low risk' score is provided here.

Management effectiveness (Mgt_1): Chile has a complex management system which is reliant on a variety of state agencies. The country lacks strategic environmental planning and in the case

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[786] *Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116*

[787] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[788] https://fisheries.msc.org/en/fisheries/chilean-mussel-fishery-and-suspended-culture-toralla-s.a-and-cultivos-toralla-s.a/@@assessments

[789] *Ribeiro, S., F. A. Viddy, and T.R.O. Freitas, 2005. Behavioral response of Chilean dolphins (Cephalorhynchus eutropia) to boats in Yaldad bay, Southern Chile. Aquatic Mammals 2005, 31 (2) 234-242.*

of salmon production, has shown serious shortfalls in management in the past. The system is improving however with an EIA process introduced recently.

For mussel production, management requirements are limited due to the much-reduced risk associated with the species.

A ‘medium risk’ score is provided here as the management system is improving but has been shown to be lacking within the aquaculture space in previous years (mainly in relation to salmon). Further improvement is required.

Sustainability certification progress (Mgt_2): In recent years, a number of farms have become certified in Chile. In 2014, the first MSC certification was awarded (although has since withdrawn), and a significant number of farms have been awarded Friends of the Sea. The ASC standard has also grown in the mussel sector in Chile with 19 farms currently certified.

A ‘medium risk’ score is provided here as it is clear that many farms are covered by certification standards but some gaps remain.

Mussels (Perna spp.)

Supply chain: New Zealand aquaculture production

Very small quantities of the Perna Spp. of mussel is shown as entering the UK from three sources, New Zealand, the Republic of Ireland and the Netherlands.

The Republic of Ireland and the Netherlands do not produce any members of the Perna Spp. of mussel and so it can only be assumed that these represent processing imports.

Based on the above, only the farming of green lipped mussels from New Zealand is considered below.

Direct impact on population(s) or stock(s) of resource (Env_1): Green-lipped mussel (*Perna canaliculus*) are indigenous to New Zealand. No evidence of negative interactions between farmed and wild mussel exists. A ‘low risk’ score is given for mussel farming in New Zealand.

Ecosystem impact (Env_2): Mussel farming is generally regarded as having very limited environmental impacts. The species is produced without the use of any chemical or fertilizers. No feed is required in the farming process.

Mussel farming has been shown to increase water quality at the farm site with the removal of excess nutrients and phytoplankton.

It is true that some bio deposition and sediment trapping can occur around mussel farms, but these impacts are seen as limited and not of significant concern. A ‘low risk’ score is given for mussel farming in New Zealand.

Climate change impact (Env_3): Mussel farming requires very little use of fossil fuels with the only significant use related to vessels servicing mussel lines. No other significant use of fossil fuels is needed in the production process[790].

A recent study completed by Gephart, J.A. et al. (2021)[791] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated shellfish farming at a figure of around 1.4kg of CO2 per kg of meat produced, so significantly lower than other aquaculture species and production methods.

For the above reasons, it is concluded that the farming method has low climate impacts (fossil fuel use) and is scored as ‘low risk’.

ETP impact (Env_4): The biggest risks associated with mussel farming relate to interactions with other species.

In New Zealand, a comprehensive review of ETP and other species interaction with New Zealand mussel farming was completed by Lloyd, B. (2003)[792]. This showed existing interactions with Brydes whales (entanglement) and dusky dolphins. The report stated that these interactions were limited but required closer monitoring as the industry grew.

Both the species mentioned above are listed as of ‘Least Concern’ by the IUCN and so are not classified as ETP. However Bryde’s whales in NZ are considered critically endangered[793].

A ‘low risk’ score is provided here. Although some interaction does occur with species these are not thought to be significant or warrant a ‘medium risk’ and are not linked to ETP species directly.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the rope-grown production of mussels in New Zealand. A ‘low risk’ score is provided.

Management effectiveness (Mgt_1): New Zealand is known to have a well-developed fisheries and aquaculture management system from an environmental standpoint.

A ‘low risk’ score is provided here as the management system is seen as effective.

Sustainability certification progress (Mgt_2): The biggest producer of greenlip mussels in New Zealand is Sanford (25% of the market). Sanford was certified against the BAP standard in 2016.

The other major producers in the country are Aotearoa Seafoods, Sealord and Talleys. Sealord are organically certified for their mussel production. These others are not yet certified.

A ‘medium risk’ score is provided here as it is clear that many farms are covered by certification standards but a significant number remain uncertified.

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[790] *Ziegler, F., Winther, U., Hognes, E. S., Emanuelsson, A., Sund, V., & Ellingsen, H. (2013). The carbon footprint of Norwegian seafood products on the global seafood market. Journal of Industrial Ecology, 17(1), 103-116*

[791] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[792] *Lloyd, B.D. 2003: Potential effects of mussel farming on New Zealand’s marine mammals and seabirds: a discussion paper. Department of Conservation, Wellington. vii + 34 p.*

[793] *https://www.wwf.org.nz/take_action/help_save_our_brydes_whales*

Loligo

Supply chain: UK wild capture production

Of around 30 cephalopod species in UK waters, three have significant commercial value as fishery target and bycatch species, namely common cuttlefish *Sepia officinalis* and two loliginid (longfin) squids, *Loligo forbesii* and *L. vulgaris*[794]. Around 99% of north-eastern Atlantic Loliginid catches (landings + discards) are taken in 6 fishing areas. In the period 2016–2018 the proportion of catches in these 6 areas varied between 18–23% in the North Sea, 7–22% in the Celtic Seas, 42–44% in the English Channel, 10–22% in the Bay of Biscay, 3–9% in Western Iberia and the Gulf of Cadiz and 1–5% in the Azores[795].

Direct impact on population(s) or stock(s) of resource (Env_1): There are no assessments of the status of Loligo spp. stocks in UK waters. Loliginid squid landings have increased in northern areas and decreased in southern areas. Survey data suggest a decrease in abundance of *L. forbesii* and an increase in *L. vulgaris*[795]. On the basis of limited information, a 'medium risk' score is applied.

Ecosystem impact (Env_2): Longfin squid are typically caught by demersal trawlers and to a lesser extent demersal seines[795]. There are also some small-scale handlining (jigging) fisheries in the south-west[796]. Whilst jigging is a highly selective fishing method that does not interact with the seafloor, demersal trawling poses risk of physical and biological impacts, including the ecosystem effects of unintended bycatch which in the small mesh trawl fisheries for squid includes juvenile fish[796,797]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): The mixture of fishing methods results in a 'medium risk' score[798,799].

ETP impact (Env_4): The fishery is considered to pose a threat to rare species of sharks and rays such as Angel sharks and Longnosed skate as a result of incidental bycatch[796]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): There is limited management or monitoring of squid fisheries (target or bycatch) in the UK[800], therefore a 'medium risk' score is provided.

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[794] http://randd.defra.gov.uk/Document.aspx?Document=13827_ME5311CephalopodsFinalReport.pdf

[795] https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/EPDSG/2020/Working%20Group%20on%20Cephalopod%20Fisheries%20and%20Life%20History%20(WGCEPH).pdf

[796] https://www.cornwallgoodseafoodguide.org.uk/fish-guide/squid.php

[797] https://www.seafish.org/responsible-sourcing/risk-assessment-for-sourcing-seafood-rass/records/squid-in-ices-areas-viie-h-celtic-sea-and-western-english-channel-demersal-otter-trawl/

[798] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[799] http://seafoodco2.dal.ca/

[800] https://www.devonandsevernifca.gov.uk/Environment-and-Research/Fisheries-Research-Management-Plans/FRMP-Documents

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a 'high risk' score is provided.

Supply chain: India wild capture production

This assessment assumes that the supply chain is dominated by the Indian squid (*Loligo duvauceli*) fishery along the west coast of India[801].

Direct impact on population(s) or stock(s) of resource (Env_1): There is no IUCN assessment for the stock and the last full assessment for India was conducted in 1993. Since then, there have been numerous regional studies conducted, suggesting varied results, mostly stating that stocks are fully exploited, though a study finalised in February 2016 concluded that southwest Indian stocks are abundant[801,802]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The fishery mainly uses a mixture of hook and line and otter trawl gear, although beach seines, drift gillnets, midwater trawls and seine nets are also used[802]. Whilst hook and line fishing is considered relatively low risk from an ecosystem impact, squid trawls have implications for the seabed (even though they interact less than demersal trawls), including squid eggs attached to the bottom, and trawl gear more generally poses risks to non-target species through bycatch as well as the target species through capture and discarding of juveniles. Specific information on the exact nature of and severity of any impacts from the range of gear types is however lacking, although it appears that different considerations need to be given to the artisanal compared to commercial fishing activities[801,802]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): Give the mix of gear types, a 'medium risk' score is provided[803,804].

ETP impact (Env_4): Trawl and gillnet fisheries has been reported to catch turtles and marine mammals off the Indian coast, in potentially high numbers (in part informed by strandings data), although lack of monitoring means the level of bycatch and population level implications cannot be determined, including for the squid fishery specifically[801,802]. A 'high risk' score is provided on the basis of the available information.

Social concerns associated with supply chain (Social_1): India is classified as 'medium risk' of modern slavery in its fishing industry[805].

Management effectiveness (Mgt_1): Due to lack of assessment of stocks and exploitation rate it is difficult to assess the effectiveness of the management system. There are measures in place such as seasonal / area closures and gear restrictions, but the compliance with and enforcement of these regulations is considered to generally be low and the fishery is open access[801,802]. A 'high risk' score is therefore provided.

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[801] *https://www.mcsuk.org/goodfishguide/species/indian-squid/*

[802] *https://www.fishsource.org/stock_page/1486*

[803] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[804] *http://seafoodco2.dal.ca/*

[805] *https://www.globalslaveryindex.org/resources/downloads/*

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a 'high risk' score is provided.

Supply chain: United States wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Regular stock assessments are undertaken to inform management of the US longfin squid (*Loligo pealeii*) fishery. The biomass appears to have generally fluctuated near or above target levels[806]. Determining the exploitation status is however more difficult due to data limitations. A 'medium risk' score is provided.

Ecosystem impact (Env_2): The majority of longfin squid are harvested using small-mesh bottom trawls. Benthic trawling is generally associated with risks of habitat damage and impacts on non-target species. Finfish such as butterfish, hake, herring, flukes, dogfish, and mackerel are known to be caught in the US Atlantic longfin squid fishery – with butterfish being the most commonly caught bycatch species, although a cap on incidental butterfish bycatch is in place[806,807]. A 'high risk' score is therefore provided.

Climate change impact (Env_3): A 'high risk' score is provided due to the dominance of bottom trawling (and lack of conflicting evidence)[808,809].

ETP impact (Env_4): The longfin squid fishery has experienced interactions with ETP species such as small cetaceans and leatherback and loggerhead sea turtles[806]. Gear restrictions as well as real time reporting are used to help mitigate bycatch risk. A 'medium risk' score is provided given the management and monitoring measures that are in place to minimise the risk.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the fishery is considered effective given the status of the stock(s) and the measures that are in place. Improvements such as more real-time assessment and monitoring have been recommended, so a 'medium risk' score is provided here.

Sustainability certification progress (Mgt_2): The bottom-trawl fishery is MSC certified with conditions[810]. A 'medium risk' score is therefore provided.

Supply chain: Thailand wild capture production

The following assessment is based on Thailand's fishery for Indian squid (*Loligo duvauceli*) and Loligo chinensis (Mitre squid), largely in the Indo- and West Pacific.

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[806] https://fishchoice.com/buying-guide/longfin-squid

[807] https://www.fishwatch.gov/profiles/longfin-squid

[808] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[809] http://seafoodco2.dal.ca/

[810] https://fisheries.msc.org/en/fisheries/u.s.-northeastern-coast-longfin-inshore-squid-and-northern-shortfin-squid-bottom-trawl-fishery/@@view and https://fisheries.msc.org/en/fisheries/us-northeast-squid-bottom-trawl-fishery/@@view

Direct impact on population(s) or stock(s) of resource (Env_1): Cephalopod resources are thought to be fully fished, and perhaps overfished, in Thailand's waters[811]. However, there are no formal assessments of stock or exploitation status. A 'medium risk' score is provided due to the data limitations but also the relatively low vulnerability of the species.

Ecosystem impact (Env_2): The fishery is largely executed by epibenthic otter trawls. Trawl gear generally poses risks to non-target species through bycatch as well as the target species through capture and discarding of juveniles. Cephalopods are frequently caught in mixed otter trawl catches such as those in Thailand, which report high proportions of trash fish (including juveniles of commercial species) at about 45.4%–62.5%. Some risk of seafloor damage is present, despite the squid trawls being designed to avoid being dragged along the bottom, particularly to corals and biogenic habitat[811]. Specific information on the exact nature of and severity of any impacts of the fishery is however lacking. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): A 'medium risk' score is provided on the basis that the trawl gear is designed to avoid being on the seafloor (although in reality it is likely it does interact in part with the seafloor)[811], and so the carbon footprint is likely to be less than that of bottom towed gear (but no specific evidence is available)[812,813].

ETP impact (Env_4): Little information is available on interactions with ETP species, largely due to lack of monitoring. It is expected that turtle bycatch is a key risk posed by the fishery[811]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Thailand is classified as 'high risk' of modern slavery in its fishing industry[805,814].

Management effectiveness (Mgt_1): Thailand's fishery management system has been rated as ineffective due to factors such as the open access nature of the fishery, lack of monitoring, poor enforcement and limited management of issues such as bycatch[811]. A 'high risk' score is therefore provided.

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a 'high risk' score is provided.

Supply chain: Indonesia wild capture production

Little information is available for the Indonesian *Loligo chinensis* (Mitre squid) fishery as a whole, even though the UK has been the main export market since 2011[815].

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[811] https://seafood.ocean.org/wp-content/uploads/2016/10/China-India-Thailand-squid.pdf

[812] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[813] http://seafoodco2.dal.ca/

[814] https://www.hrw.org/news/2018/08/17/joint-statement-thai-fishing-industry

[815] https://www.msc.org/what-we-are-doing/our-collective-impact/ocean-stewardship-fund/impact-projects/minimising-fishing-impacts-on-indonesian-squid-stocks-2021

Direct impact on population(s) or stock(s) of resource (Env_1): There is no assessment of the stock(s) or their exploitation levels[816]. A 'medium risk' score is provided due to the data limitations but also the relatively low vulnerability of the species.

Ecosystem impact (Env_2): It is understood that the fishery largely uses pole and line and lift net gear[816]. The ecosystem impacts of such gear may be relatively limited. Given the lack of evidence and monitoring however, a 'medium risk' score is applied.

Climate change impact (Env_3): A 'medium risk' score is applied on a precautionary basis given lack of confidence over the range and extent of gears being used.

ETP impact (Env_4): "Interviews with fishers indicated that interactions with ETP species are very low when it comes to sea snakes and none existing with species groups like marine mammals, turtles or sea birds due to the type and nature of the fishery. It is highly unlikely that any direct effect on ETP species would hinder their recovery"[816]. Given the lack of monitoring and robust evidence, a 'medium risk' score is applied.

Social concerns associated with supply chain (Social_1): Indonesia is classified as 'medium risk' of modern slavery in its fishing industry[805], with evidence of forced labour having been found[817], although not necessarily in this fishery specifically. A 'medium risk' score is provided.

Management effectiveness (Mgt_1): Some management measures appear to be in place but monitoring and enforcement of compliance is likely to be limited. The effectiveness of existing management cannot be assessed. A 'high risk' score is provided.

Sustainability certification progress (Mgt_2): One component of the fishery, the North Sumatra handline fishery, has recently become involved in a FIP[818]. A 'medium risk' score is provided.

Shortfin squid

Supply chain: UK wild capture production

Three ommastrephid (shortfin) squids (*Todaropsis eblanae, Illex coindetii, Todarodes sagittatus*) are typically landed as bycatch by the UK fleet[819].

Direct impact on population(s) or stock(s) of resource (Env_1): The relatively low commercial value of ommastrephids and octopods in the UK means that landings may not accurately reflect catches. Nevertheless, no evidence of long-term decline was apparent in any of the datasets examined in a 2014 study[819]. No assessment of squid populations is available. Fishery and survey data indicates that abundance of ommastrephid squid fluctuates widely with occasional peaks, the timing and size of which varies between species and areas[820]. However, it is generally considered these short-lived invertebrates are more susceptible to environmentally-induced

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816 https://fisheryprogress.org/system/files/documents_assessment/21_380EN_MSC_PA%20Report%20Squid%20_020620.pdf

817 https://www.greenpeace.org/static/planet4-southeastasia-stateless/2021/05/ef65bfe1-greenpeace-2021-forced-labour-at-sea-digital_final.pdf

818 https://fisheryprogress.org/fip-profile/indonesia-north-sumatra-squid-handline

819 http://randd.defra.gov.uk/Document.aspx?Document=13827_ME5311CephalopodsFinalReport.pdf

820 https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/EPDSG/2020/Working%20Group%20on%20Cephalopod%20Fisheries%20and%20Life%20History%20(WGCEPH).pdf

variation than fishing pressure, although the combination of the two could be a risk if not appropriately monitored. On the basis of limited information, a ‘medium risk’ score is applied.

Ecosystem impact (Env_2): Shortfin squid are typically caught as bycatch of trawl fisheries. Bottom towed gear poses risk to the ecosystem through habitat damage and bycatch of target and non-target species. A ‘medium risk’ score is therefore provided.

Climate change impact (Env_3): Shortfin squid are typically caught as bycatch of trawl fisheries. Such fisheries have largely been assessed (within this report) as having a ‘medium risk’ in relation to their relative carbon footprint and so the same score is provided here in the absence of more specific evidence.

ETP impact (Env_4): Shortfin squid are typically caught as bycatch of trawl fisheries. Such fisheries have largely been assessed (within this report) as having a ‘medium’ or ‘high’ risk in relation to their potential ETP impact. A ‘medium’ risk is provided here on a pragmatic (and data limited) basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a ‘low risk’ score is provided.

Management effectiveness (Mgt_1): There is limited management or monitoring of squid fisheries (target or bycatch) in the UK[821], therefore a ‘medium risk’ score is provided.

Sustainability certification progress (Mgt_2): Whilst the lack of third-party sustainability certification progress is unsurprising given their status as bycatch, a ‘high risk’ score is applied.

Supply chain: China wild capture production

China is responsible for as much as 70% of the global squid catch, and its vessels sail as far as West Africa and Latin America[822]. Recently, over one hundred Chinese flagged fishing vessels have been identified as active in the north west Indian Ocean squid fishery[823]. Specific information on many of the stocks and fisheries is limited. The following assessment is mainly based on China’s fishery for Argentine shortfin squid (*Ilex argentinus*).

Direct impact on population(s) or stock(s) of resource (Env_1): China is a key player in the Argentine shortfin squid fishery[824], however the status of Argentine squid stocks has been variable and currently may be at a low level, at least in part due to overfishing[825]. Information on the status of the stock(s) is however limited[824]. In response to reports of low abundance, “China has announced a temporary ban on its fishing fleet from catching squid in parts of the Pacific and Atlantic Oceans after overfishing pushed populations to the brink of collapse”[822]. Squid populations and their fisheries are however typically quite variable[826]. The International Union for the Conservation of Nature (IUCN) has assessed Argentine shortfin squid as of "Least Concern",

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[821] https://www.devonandsevernifca.gov.uk/Environment-and-Research/Fisheries-Research-Management-Plans/FRMP-Documents

[822] https://phys.org/news/2021-06-china-squid-fishing-pacific-atlantic.html

[823] https://stopillegalfishing.com/news-articles/china-flagged-vessels-target-unregulated-north-west-indian-ocean-squid-fishery/

[824] https://seafood.ocean.org/wp-content/uploads/2017/10/MBA_Seafood-Watch_Argentine-squid_Report.pdf

[825] https://www.fig.gov.fk/fisheries/publications/illex?task=download.send&id=143&catid=33&m=0

[826] https://oceana.org/marine-life/cephalopods-crustaceans-other-shellfish/argentine-shortfin-squid

primarily due to its short generation time and high productivity. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The fisheries use jig and mid-water trawl gear primarily and therefore there is little interaction with the seabed. However, due to the scale of fishing occurring in the high seas, it is likely that the sheer removal of squid from the fishery could cause ecosystem shifts[827]. A 'medium risk' score is provided.

Climate change impact (Env_3): A 'medium risk' score would be provided based on the gear types likely used in the fisheries (Parker & Tyedmers 2014)[828]. Whilst an average score of 3 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[829] for midwater trawls, a 'medium risk' score is retained.

ETP impact (Env_4): There is little information available on ETP mortality risk for the Chinese fisheries specifically. However, evidence from other fisheries, such as the Falkland Islands squid trawl and jigger fisheries, suggests it is likely that seabirds, some of which will be ETP species, are at risk[830]. A 'medium risk' score is provided on the basis of limited information, but a 'high risk' score may well be justified.

Social concerns associated with supply chain (Social_1): China is classified as 'high risk' of modern slavery in its fishing industry[831].

Management effectiveness (Mgt_1): The Chinese fleet is heavily subsidised[832], operates extensively on the high seas and is known for illegal fishing activities. A 'high risk' score is therefore provided.

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a 'high risk' score is provided.

Supply chain: Taiwan wild capture production

Taiwan is another key player in the Argentine shortfin squid fishery[824] and therefore this assessment is largely based on that fishery, although Taiwan may catch other shortfin squid species in other areas.

Direct impact on population(s) or stock(s) of resource (Env_1): The status of Argentine squid stocks has been variable and currently may be at a low level, at least in part due to overfishing[830]. Information on the status of the stock(s) is limited[824]. Squid populations and their fisheries are however typically quite variable[833]. The International Union for the Conservation of Nature (IUCN)

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[827] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/785/

[828] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[829] http://seafoodco2.dal.ca/

[830] https://www.fig.gov.fk/fisheries/publications/seabirds-conservation

[831] https://www.globalslaveryindex.org/resources/downloads/

[832] https://redanalysis.org/2021/04/20/chinese-fishing-fleet-influence-and-hunger-wars/

[833] https://oceana.org/marine-life/cephalopods-crustaceans-other-shellfish/argentine-shortfin-squid

has assessed Argentine shortfin squid as of ‘Least Concern’, primarily due to its short generation time and high productivity. A ‘medium risk’ score is therefore provided.

Ecosystem impact (Env_2): The fisheries use jig and mid-water trawl gear primarily and therefore there is little interaction with the seabed. However, due to the scale of fishing occurring in the high seas, it is likely that the sheer removal of squid from the fishery could cause ecosystem shifts[827]. A ‘medium risk’ score is provided.

Climate change impact (Env_3): A ‘medium risk’ score would be provided based on the gear types likely used in the fisheries (Parker & Tyedmers 2014)[834]. Whilst an average score of 3 tonnes of CO2 per kg of fish (‘low risk’) is provided by the The Seafood Carbon Emissions Tool[835] for midwater trawls, a ‘medium risk’ score is retained.

ETP impact (Env_4): There is little information available on ETP mortality risk for the Taiwan fisheries specifically. However, evidence from other fisheries, such as the Falkland Islands squid trawl and jigger fisheries – in which Taiwanese vessels participate[836] - suggests it is likely that seabirds, some of which will be ETP species, are at risk[830]. A ‘medium risk’ score is provided on the basis of limited information, but a ‘high risk’ score may well be justified.

Social concerns associated with supply chain (Social_1): Taiwan is classified as ‘high risk’ of modern slavery in its fishing industry[831] with evidence of such activities reported[837].

Management effectiveness (Mgt_1): The Taiwanese fleet operates extensively on the high seas and is known for illegal fishing activities[837]. A ‘high risk’ score is therefore provided.

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a ‘high risk’ score is provided.

Supply chain: Spain wild capture production

Spain is another key player in the Argentine shortfin squid fishery[824] and therefore this assessment is largely based on that fishery, although Spain may catch other shortfin squid species in other areas.

Direct impact on population(s) or stock(s) of resource (Env_1): The status of Argentine squid stocks has been variable and currently may be at a low level, at least in part due to overfishing[830]. Information on the status of the stock(s) is limited[824]. Squid populations and their fisheries are however typically quite variable[833]. The International Union for the Conservation of Nature (IUCN) has assessed Argentine shortfin squid as of ‘Least Concern’, primarily due to its short generation time and high productivity. A ‘medium risk’ score is therefore provided.

Ecosystem impact (Env_2): The fisheries use jig and mid-water trawl gear primarily and therefore there is little interaction with the seabed. However, due to the scale of fishing occurring

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[834] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[835] http://seafoodco2.dal.ca/

[836] https://www.fig.gov.fk/fisheries/overview/commercial-species/illex-squid

[837] https://ejfoundation.org/news-media/widespread-abuse-and-illegal-fishing-as-taiwans-fishing-fleet-remains-out-of-control-1 and https://www.lowyinstitute.org/the-interpreter/high-seas-danger-workers-taiwan-s-fishing-fleet

in the high seas, it is likely that the sheer removal of squid from the fishery could cause ecosystem shifts[827]. A 'medium risk' score is provided.

Climate change impact (Env_3): A 'medium risk' score would be provided based on the gear types likely used in the fisheries (Parker & Tyedmers 2014)[838]. Whilst an average score of 3 tonnes of CO2 per kg of fish ('low risk') is provided by The Seafood Carbon Emissions Tool[839] for midwater trawls, a 'medium risk' score is retained.

ETP impact (Env_4): There is little information available on ETP mortality risk for the Spanish squid fisheries specifically. However, evidence from other fisheries, such as the Falkland Islands squid trawl and jigger fisheries, suggests it is likely that seabirds, some of which will be ETP species, are at risk[830]. A 'medium risk' score is provided on the basis of limited information, but a 'high risk' score may well be justified.

Social concerns associated with supply chain (Social_1): Spain is classified as 'high risk' of modern slavery in its fishing industry[831].

Management effectiveness (Mgt_1): The Spanish fleet operates extensively on the high seas but is governed by EU law which aims to make the EU's long distance fishing fleet the most transparent, accountable and sustainable globally[840]. However, high seas fishing activity is more generally known for its environmental and social risks due to the significant challenges facing the effective management of such activities. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): There is no evidence of third-party certification progress and so a 'high risk' score is provided.

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[838] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[839] http://seafoodco2.dal.ca/

[840] https://europe.oceana.org/es/blog/eus-external-fishing-fleet-become-most-transparent-accountable-and-sustainable-globally

Seafood commodity – Small pelagics

Supply chains: Herring wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The status of herring populations is highly variable[841], with different nations fishing different populations in variable proportions – which are difficult to fully quantify. A 'medium risk' score is therefore provided throughout in the interests of pragmatism.

Ecosystem impact (Env_2): Pelagic trawls and seines are primarily used to catch pelagic species[842], and therefore have little contact with bottom habitats. Furthermore, bycatch is low given the more selective nature of the gear[841]. For this reason, all countries in the supply chain have been given a 'low risk' score.

Climate change impact (Env_3): Pelagic trawls for small species are associated with a 'low risk' score in relation to the carbon footprint of the production method[843,844].

ETP impact (Env_4): With the exception of static nets in the Central Baltic, which pose a significant threat to the Critically Endangered Baltic harbour porpoise population and are a gear type used by the Central Baltic herring fisheries, the risk of ETP mortality associated with herring fisheries is considered to be very low[841]. Of the countries included in this assessment, it is assumed that Denmark, Germany, Poland and Lithuania participate in the Central Baltic fishery, although the use of static nets by each nation is not confirmed[845]. On this basis, a 'medium risk' score is provided for those Baltic nations and a 'low risk' score for all other supply chains.

Social concerns associated with supply chain (Social_1): All countries, except the Republic of Ireland, in the UK herring supply chain are classed as 'low risk' in relation to social concerns within the fishery. A recent article on human trafficking in the Republic of Ireland's seafood industry[846] raises concerns about social issues that require further investigation – a 'medium risk' score is provided.

Management effectiveness (Mgt_1): International cooperation over management of the different herring stocks is variable and falls under different EU and third country agreements and management plans. Given the variable status of the stocks, and variable status of agreements over development and implementation of management measures, a precautionary 'medium risk' score is provided for all supply chains.

Sustainability certification progress (Mgt_2): A FIP has recently been initiated between the UK, Iceland, Greenland, Russia, Norway, the Faroe Islands and the EU for the Atlanto-Scandian

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841 https://www.mcsuk.org/goodfishguide/species/herring/

842 https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/GreaterNorthSeaEcoregion_FisheriesOverview.pdf

843 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

844 http://seafoodco2.dal.ca/

845 https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/her.27.25-2932.pdf

846 https://www.seafoodsource.com/news/supply-trade/irish-government-ngo-clash-over-human-trafficking-call-out

herring stock[847]. A 'medium risk' score is therefore provided for all supply chains on this basis. In addition, the Northern Ireland Irish Sea and North Sea fishery is MSC certified[848], along with the PFA & SPSG, SPFPO, DFPO and DPPO North Sea herring fishery involving UK, Dutch, German, Polish and Lithuanian (and French) vessels[849]. Given the relative volumes involved in these fisheries, a 'medium risk' score is retained for all countries.

Supply chains: Mackerel wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Seven of the eight (United Kingdom, Denmark, Netherlands, Republic of Ireland, Germany, Sweden and Portugal) main source countries of mackerel target North East Atlantic mackerel (*Scomber scombrus)*. Although stock assessments may be notoriously difficult for small pelagic species, according to the International Council for the Exploration of the Sea (ICES), the stock is currently harvested sustainably, and at full reproductive capacity[850], therefore a 'low risk' score was applied.

In contrast, the chub mackerel stock targeted by China in the North East Pacific is assessed as 'overfished' and subject to overfishing'[851] based on the North Pacific Fisheries Commission assessment, hence a 'high risk' score was awarded.

Ecosystem impact (Env_2): Pelagic trawls and seines are primarily used to catch pelagic species such as mackerel[852], which have little contact with bottom habitats. Furthermore, bycatch is low given the more selective nature of the gear[853]. For this reason, all players except China in the supply chain have been given a 'low risk' score. In the absence of information about the Chinese fishery, a 'medium risk' score is applied.

Climate change impact (Env_3): Pelagic trawls for small species are associated with a 'low risk' score in relation to the carbon footprint of the production method[854,855].

ETP impact (Env_4): There is generally low concern for risk to ETP species as a result of the selective pelagic gear primarily used in the North East Atlantic fisheries, so a 'low risk' score was given. Little information is available for Chinese fishing activities resulting in a 'medium risk' score.

Social concerns associated with supply chain (Social_1): China is considered 'high risk' as a result of several reports of forced labour onboard their flagged vessels[856]. There are no known social concerns associated with the small pelagic fleets of most of the other countries resulting

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[847] https://fisheryprogress.org/fip-profile/northeast-atlantic-ocean-mackerel-and-herring-hook-line-trawl-and-purse-seine

[848] https://fisheries.msc.org/en/fisheries/northern-ireland-pelagic-sustainability-group-nipsg-irish-sea-atlantic-mackerel-north-sea-herring/about/

[849] https://fisheries.msc.org/en/fisheries/pfa-spsg-spfpo-dfpo-and-dppo-north-sea-herring/@@view

[850] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/mac.27.nea.pdf

[851] https://www.npfc.int/system/files/2020-11/NPFC-2020-TWG%20CMSA03-WP09%28Rev%201%29%20Preliminary%20ASAP%20stock%20assessment%20CM_Chn.pdf

[852] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/GreaterNorthSeaEcoregion_FisheriesOverview.pdf

[853] https://www.mcsuk.org/goodfishguide/species/mackerel/

[854] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[855] http://seafoodco2.dal.ca/

[856] https://www.pnas.org/content/118/3/e2016238117

in a 'low risk' score. The exception is provided by a recent article on human trafficking in the Republic of Ireland's seafood industry[857], which raises concerns about social issues that require further investigation – a 'medium risk' score is therefore provided.

Management effectiveness (Mgt_1): All Coastal States participating in the North East Atlantic mackerel fishery (the EU Member States, Norway, Iceland, and the Faroe Islands) and the other participants in the fishery (Greenland and Russia) are signatories of North East Atlantic Fisheries Commission (NEAFC). There is however no long-term management strategy for North East Atlantic mackerel agreed by all parties involved in the mackerel fishery. There is also no internationally agreed quota and recent catches have been substantially above scientific advice. The North Sea component of the stock has been depleted due to fishing and adverse environmental conditions[853]. For that reason, a 'medium risk' score is provided, although a high risk score would have been considered had the stock been showing signs of decline.

Given the North East Pacific chub mackerel stock is assessed as overfished and subject to overfishing, management effectiveness is considered poor, therefore a 'high risk' score was provided for the supply chain from China.

Sustainability certification progress (Mgt_2): The North East Atlantic mackerel stock lost its MSC certification[858] in 2019 as the stock had fallen below the precautionary threshold, and catches remained higher than advised by scientists. The certification has not been reinstated following a revised stock assessment which suggested the stock was healthy. However, a FIP has recently been initiated between the UK, Iceland, Greenland, Russia, Norway, the Faroe Islands and the EU[859]. A 'medium risk' score is therefore provided for all supply chains except China.

The North East Pacific chub mackerel fishery is not known to be currently participating in any sustainability certification scheme. For this reason, a 'high risk' score is provided for China.

Supply chains: Sardines

Direct impact on population(s) or stock(s) of resource (Env_1): The UK and German fleet largely targets this stock in southern Celtic Seas and English Channel, but according to ICES, the stock is considered data limited as a result of unreliable catch data. Therefore a 'medium risk' score was given for the UK and Germany[860].

The Portuguese fleet largely fishes European Pilchard in the Bay of Biscay (ICES divisions 8.a.b and 8.d), as well as the Cantabrian Sea and Atlantic Iberian coastal waters (ICES divisions 8.c and 9.a). The stock size of the 8.a.b and 8.d stock in 2019 was estimated to be above MSY biomass reference points, and fishing pressure was thought to be below Fmsy[861]. In 2019, the sardine stock fished in 9.c and 9.a was above MSY Btrigger for the first time since 2009 and recruitment was also at its highest level since 2004. Fishing mortality has been declining since

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[857] https://www.seafoodsource.com/news/supply-trade/irish-government-ngo-clash-over-human-trafficking-call-out

[858] https://fisheries.msc.org/en/fisheries/minsa-north-east-atlantic-mackerel/about/

[859] https://fisheryprogress.org/fip-profile/northeast-atlantic-ocean-mackerel-and-herring-hook-line-trawl-and-purse-seine

[860] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/pil.27.7.pdf

[861] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/pil.27.8abd.pdf

2012 and was the lowest in the time-series; however, it was still above Fmsy[862]. For that reason, a 'medium risk' score was awarded.

Information for the Thai sardinella fishery is available via Fish Source, however much of the assessment is data limited, therefore a 'medium risk' score was given.

The Northwest African sardine fishery is primarily fished by Morocco and according to the MCS Good Fish Guide, the stock is at healthy levels with fishing mortality considered low, and the stock not considered to be fully exploited[863]. Given the healthy stock status, a 'low risk' score was applied.

Ecosystem impact (Env_2): Pelagic trawls and seines are primarily used to catch pelagic species[864], and therefore have little contact with bottom habitats. Furthermore, bycatch is low given the more selective nature of the gear. For this reason, all countries in the supply chain (except Thailand) have been given a 'low risk' score.

Thailand utilises gillnets and entangling nets, which are known to have negative bycatch implications, specifically for sea turtles and marine mammals[865], although, if they are midwater gillnets, which is expected then bottom habitat damage is minimal. Based on this, a 'medium risk' score was awarded.

Climate change impact (Env_3): Pelagic trawls for small species are associated with a 'low risk' score in relation to the carbon footprint of the production method[866,867].

The Thai supply chain is however provided a 'medium risk' score given the different gears in use[868,869].

ETP impact (Env_4): Existing evidence suggests there is low risk of impacts on ETP species in relation to the European pilchard UK supply chains.

ETP mortality is considered low risk for the Moroccan and Portuguese fisheries owing to their selective capture method. Recent observer data from the Moroccan trawl fleet has not shown significant ETP interactions[870]. All countries except Thailand were therefore scored as 'low risk'.

Data is limited in relation to the Thailand sardinella fishery. It is likely bycatch of ETP species occurs with the use of gillnets, however, evidence is scarce. For this reason, a 'medium risk' score was awarded.

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[862] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/Special_Requests/porsp.2020.06.pdf

[863] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/1061/

[864] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/GreaterNorthSeaEcoregion_FisheriesOverview.pdf

[865] https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-gillnets

[866] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[867] http://seafoodco2.dal.ca/

[868] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[869] http://seafoodco2.dal.ca/

[870] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/1060/

Social concerns associated with supply chain (Social_1): The UK, Portugal and Germany are considered ‘low risk’ for social concerns relating to the specific supply chains.

Morocco is suggested to be a ‘medium risk’ by the Global Slavery Report owing to limited levels of harmful subsidies, but also low catches and high levels of unreported catch. The above characteristics in some cases can make the country vulnerable to forced labour on board, however there is limited data to fully evidence this. As a result, a ‘medium risk’ score was given here.

Thailand is considered to be at ‘high risk’ of modern slavery in its fishing industry.

Management effectiveness (Mgt_1): There is currently no management plan or Total Allowable Catch (TAC) for the Southern Celtic Seas and English Channel stock, although there are some areas with localised management in place, such as in Cornwall[871]. Given management is limited, a ‘medium risk’ score is provided for the UK and Germany.

The Bay of Biscay fishery is jointly managed by Spain and Portugal, and although national measures and effort limitations are in place, catches have regularly exceeded advised catch limits and fishing pressure remains above sustainable limits[872]. For this reason, Portugal has been given a ‘medium risk’ score.

There are some measures in place for managing the Northeast African stock, which appear to be effective given the good condition of stock biomass and low fishing pressure, however issues such as slippage may require improved management. A ‘medium risk’ score has therefore been awarded for Morocco.

Thailand is subject to a fishery management framework at the national level, but this is not applied specifically to sardinella. According to the IFFO report, the management currently in place is not sufficient to ensure sustainable management of the stock[873]. Based on this evidence, a ‘high risk’ score was applied.

Sustainability certification progress (Mgt_2): Part of the sardine fishery, specifically in Cornwall[874], targeted by the UK is MSC certified, however there remains a portion of the fishery which is not certified. For this reason, a ‘medium risk’ score has been applied to the UK.

The respective sardine fisheries associated with Thailand, Germany and Portugal are not known to be working towards any sustainability certification, so a ‘high risk’ score is given.

The Northeast Atlantic sardine fishery targeted by Morocco is currently in stage five of a FIP[875], so a ‘medium risk’ score is awarded.

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[871] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/475/

[872] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/200/

[873] https://www.marin-trust.com/sites/marintrust/files/approved-raw-materials/product/goldstripe-sardinella-thailand-initial-byproduct_1.pdf

[874] https://fisheries.msc.org/en/fisheries/cornwall-sardine-uk/@@view

[875] https://fisheryprogress.org/fip-profile/morocco-sardine-pelagic-trawl-and-seine-maroc-sardine-chalut-pelagique-et-senne

Seafood commodity – Farmed whitefish

European sea bass

Supply chain: Greece aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): European Sea bass are farmed in cage systems off the coast of Greece. It is not known to have any direct or indirect impact on naturally occurring European seabass in the Mediterranean. The species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern). A 'low risk' score is provided here.

Ecosystem impact (Env_2): Cage farming of seabass is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed, but also the release of high levels of nitrate and phosphate into the water column. The majority of this impact is well documented to affect the immediate areas of culture[876]. For Greek sea bass farming, evidence of effects on seagrass (*Posidonia oceanica*) have been reported with increased leaf fragility and reduced growth[877]. Kallitsis, E. *et al*. (2020)[878] has also shown through life cycle assessment, that sea bass farming can produce high eutrophication impacts on the surrounding environment, especially if best management practices are not followed. However, it is also noted that sea bass impacts are generally considered to be less than those seen in sea bream farming due to a generally better Feed Conversion Ratio (FCR) and so less waste production.

A 'medium risk' score is provided here since some evidence of degradation through cage farming of sea bass in Greece does exist, but this is not considered widespread. Furthermore, although these impacts are considered less for sea bass than for sea bream, the difference is not considered great enough to warrant a different score.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[879] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

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[876] *García García, B., Rosique Jiménez, C., Aguado-Giménez, F., & García García, J. (2016). Life cycle assessment of gilthead seabream (Sparus aurata) production in offshore fish farms. Sustainability, 8(12), 1228.*

[877] *Gianluigi Cancemi, Giovanni De Falco, Gérard Pergent (2003) Effects of organic matter input from a fish farming facility on a Posidonia oceanica meadow, Estuarine, Coastal and Shelf Science, Volume 56, Issues 5–6*

[878] *Kallitsis, E., Korre, A., Mousamas, D., & Avramidis, P. (2020). Environmental Life Cycle Assessment of Mediterranean Sea Bass and Sea Bream. Sustainability, 12(22), 9617.*

[879] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture. https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/*

A recent study completed by Gephart, J.A. et al. (2021)[880] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. Although bass and bream cage production were not specifically considered under this study, it is considered highly likely that they will produce similar levels as reported for salmon cage production. The study estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced so slightly above the GAA study.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in bass and bream cage production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In bass and bream cage production, no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as ‘medium risk’.

ETP impact (Env_4): Cage farming of sea bass is known to have some interactions with a variety of species including birds and mammals. The following species have been reported to interact with sea cage farms (both bream and bass) in the Mediterranean on a year-round basis[881];

Bottlenose Dolphins (*Tursiops truncatus*): Known to interact widely with farms in the Mediterranean and considered ‘Vulnerable’ in the specific region. Effects of interaction are both positive (providing food) and negative (entanglement in anti-predator netting) with some annual mortalities reported. The species is listed as ‘Least Concern’ by IUCN.

Yellow-legged Gulls *(Larus michahellis*): Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as ‘Least Concern’ by IUCN.

European Shag *(Gulosus aristotelis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as ‘Least Concern’ by IUCN.

Grey herons *(Ardea cinerea)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as ‘Least Concern’ by IUCN.

Common Tern *(Sterna hirundo)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as ‘Least Concern’ by IUCN.

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[880] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[881] *López, B. D. (2012). Bottlenose dolphins and aquaculture: interaction and site fidelity on the north-eastern coast of Sardinia (Italy). Marine biology, 159(10), 2161-2172.*

Although interactions do exist with ETP species (not listed above) more occasionally, they are not considered highly significant and are managed to some degree. A ‘medium risk’ score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): No specific social concerns exist in the cage farmed production of European sea bass in Greece. A ‘low risk’ score is provided here.

Management effectiveness (Mgt_1): Greek sea bass farming is relatively well managed and developed. The farming process has controls on licensing and requires regular inspections and environmental monitoring to occur. That said, the Greek system still lacks some vital components to consider it fully effective (e.g. cumulative impact monitoring, use of antibiotics and escape monitoring).

A ‘medium risk’ score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed sea bass imports. Traditionally, this has been completed through the Global GAP Farm standard but with growth in Friends of the Sea and Best Aquaculture Practices (BAP) in recent years. Most recently, in 2019, the first Greek bass farmers received certification against the newly created Aquaculture Stewardship Council (ASC) bass and bream standard. There are currently 20 suppliers with ASC certification[882].

The Greek sea bass industry is largely covered by third party certification standards, particularly in reference to sales to the UK, however not all are ASC certified and so a ‘medium risk’ score is provided here.

Supply chain: Turkey aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): European Sea bass are farmed in cage systems off the coast of Turkey. It is not known to have any direct or indirect impact on naturally occurring European Sea bass in the Mediterranean. The species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern). A ‘low risk’ score is provided here.

Ecosystem impact (Env_2): Cage farming of sea bass is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed, but also the release of high levels of nitrate and phosphate into the water column. The majority of this impact is well documented to affect the immediate areas of culture[876]. For Turkish seabass farming, direct evidence of ecosystem impact is less well reported but is considered highly likely to be the same as for Greek farms. Both use similar systems and production takes place in similar environments. However, farming in Turkey has shown a greater move offshore than in Greece which is likely to help reduce these environmental impacts (although no direct evidence is available to support this hypothesis currently).

[882] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/

A ‘medium risk’ score is provided here since some evidence of degradation through cage farming in Turkey is likely to exist, but this is not considered widespread. Furthermore, it is considered possible that the ecosystem impacts in Turkey may be better managed due to increased offshore operation but since no evidence exists to currently support this hypothesis, the same score is provided for the two countries.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[883] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[884] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. Although bass and bream cage production were not specifically considered under this study, it is considered highly likely that they will produce similar levels as reported for salmon cage production. The study estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced so slightly above the GAA study.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in bass and bream cage production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In bass and bream cage production, no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as ‘medium risk’.

ETP impact (Env_4): Cage farming of sea bass is known to have some interactions with a variety of species including birds and mammals. The following species have been reported to interact with sea cage farms (both bream and bass) in the Mediterranean on a year-round basis[885];

Bottlenose Dolphins (*Tursiops truncatus*): Known to interact widely with farms in the Mediterranean and considered ‘Vulnerable’ in the specific region. Effects of interaction are both

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[883] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[884] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

[885] *López, B. D. (2012). Bottlenose dolphins and aquaculture: interaction and site fidelity on the north-eastern coast of Sardinia (Italy). Marine biology, 159(10), 2161-2172.*

positive (providing food) and negative (entanglement in anti-predator netting) with some annual mortalities reported. The species is listed as 'Least Concern' by IUCN.

Yellow-legged Gulls *(Larus michahellis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

European Shag *(Gulosus aristotelis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

Grey herons *(Ardea cinerea)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Common Tern *(Sterna hirundo)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, howeverimited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Although interactions do exist with ETP species (not listed above) more occasionally, they are not considered highly significant and are managed to some degree. A 'medium risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): Although noted that Turkish wages remain significantly lower than those found in Greece[886], no specific social concerns exist in the cage farmed production of European sea bass in Turkey. A 'low risk' score is therefore provided.

Management effectiveness (Mgt_1): Turkish sea bass farming is relatively well managed and developed. The farming process has controls on licensing and requires regular inspections and environmental monitoring to occur. It has also promoted the movement of farming operations further offshore and is considered in many ways to be slightly advanced on competitor management systems[886]. However, some concerns still exist around Turkish production with a lack of transparency often seen as the major issue.

A 'medium risk' score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed sea bass imports from Turkey. Traditionally, this has been completed through the Global GAP Farm standard but with growth in Friends of the Sea and Best Aquaculture Practices (BAP) in recent years. Most recently, in 2019, the first Turkish bass farmers received certification against the newly created Aquaculture Stewardship Council (ASC) bass and bream standard. There are currently 24 suppliers with ASC certification[887].

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[886] *WWF (2021) Sea bass and Sea bream supply chain study: From Turkey to Europe https://wwfint.awsassets.panda.org/downloads/wwf_fishforwardprojectsbsb_2021_v5.pdf*

[887] *https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/*

The Turkish sea bass industry is largely covered by third party certification standards, particularly with reference to sales to the UK. Indeed, it is considered more advanced in this area than its competitors (with a generally higher uptake on third party certification standards in the sector[886]). However not all are ASC certified and so a 'medium risk' score is provided here.

Supply chain: UK wild-capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The sustainability of bass stocks is variable following widespread overfishing and the species' sensitivity to environmental conditions. Spawning-stock biomass (SSB) of the central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea stock has been declining since 2009 and is currently below MSY $B_{trigger}$ and just above B_{lim}. Fishing mortality (F) has increased over the time-series, peaking in 2013 before a rapid decline to below F_{MSY}. Recruitment is low, fluctuating without trend since 2008[888]. Sea bass West of Scotland, West of Ireland and in the eastern part of southwest of Ireland are severely data limited and so the current status is unknown and total catches cannot be quantified[889].

Further, recreational catches of bass are poorly recorded adding additional uncertainty to scientific stock assessments and catch advice.

A 'high risk' score is therefore provided on a precautionary basis, largely reflecting the assessment of the main UK stock as well as acknowledging the data limitations more widely.

Ecosystem impact (Env_2): Typical commercial fishing gears associated with UK wild-caught sea bass include hook and line (longlines and handlines), demersal seine nets and otter trawls and fixed gillnets. Recreational fishing accounts for approximately 20% of catches. Whilst handlines are considered to be the lowest impact gear types and gillnets or fixed nets also have little to no habitat impacts, demersal towed gear damages the seafloor and gillnets are associated with issues such as ghost fishing and bycatch of non-target species including larger marine animals and seabirds (notably bass nets in St Ives Bay, Cornwall)[890,891]. Given the mixture of capture methods and their potential impacts, a 'medium risk' score is awarded.

Climate change impact (Env_3): The mix of hook and lines, fixed nets and towed demersal gears associated with the UK capture of sea bass results in a 'medium risk' score in relation to climate change impacts arising from the production method[892,893].

ETP impact (Env_4): Pair trawls (primarily used by the French fleet) and demersal set gillnets in the Celtic Sea and Bay of Biscay in particular are associated with large bycatches of ETP species such as harbour porpoise and common dolphin[894]. As a result, pelagic pair trawling for

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[888] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/bss.27.4bc7ad-h.pdf*

[889] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/bss.27.6a7bj.pdf*

[890] *https://www.mcsuk.org/goodfishguide/species/seabass/*

[891] *https://www.cornwallgoodseafoodguide.org.uk/fishing-methods/gill-netting.php*

[892] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[893] *http://seafoodco2.dal.ca/*

[894] *https://www.mcsuk.org/news/dolphin-bycatch-impacts-seabass-ratings/*

bass by UK vessels was banned within 12 miles of the south-west coast of England in 2004[895]. The majority of marine mammal bycatch in UK fisheries occur in gillnet fisheries[896]. A 'high risk' score is therefore provided for wild capture of sea bass.

Social concerns associated with supply chain (Social_1): There are no recorded social welfare issues associated with the UK sea bass fishery resulting in a 'low risk' score.

Management effectiveness (Mgt_1): Sea bass is a non-quota stock (it is not subject to EU TACs and quotas). However, management measures are in place, including commercial and recreational catch limits and MLS specifications to control fishing mortality and seasonal and spatial restrictions to protect spawning aggregations and juveniles. However, overfishing, discarding and illegal targeting of sea bass is known to be occurring indicating that management effectiveness requires improvement[897]. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): The UK sea bass fishery is not currently subject to any third-party sustainability certifications or FIPs resulting in a 'high risk' score.

Sea bream

Supply chain: Turkey aquaculture production

Alongside Gilthead sea bream (*Sparus aurata*), a small quantity of 'other' bream species (*Dentex dentex*, Pagellus spp. & Sparidae spp.) enter the UK from Turkey. These species are produced in very small quantities in the same cage farming systems as Gilthead sea bream and European sea bass. As a result, no significant differences in scoring would be seen for these species and so the risk assessment is applied to all species (and that for sea bass).

Direct impact on population(s) or stock(s) of resource (Env_1): Gilthead sea bream is farmed in cage systems off the coast of Turkey. It is not known to have any direct or indirect impact on naturally occurring Gilthead sea bream in the Mediterranean. The species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern). Whilst Common dentex (*Dentex dentex*) are listed as 'Vulnerable' on the IUCN red list[898], other porgy / bream species are also considered 'Least Concern'. A 'low risk' score is provided here.

Ecosystem impact (Env_2): Cage farming of sea bream is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed, but also the release of high levels of nitrate and phosphate into the water column. The majority of this impact is well documented as affecting the immediate areas of culture[876]. For Turkish sea bream farming, direct evidence of ecosystem impact is less well reported but is considered highly likely to be the same as for Greek farms. Both use similar systems and production takes place in similar environments. However, farming in Turkey has shown a greater move offshore

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[895] https://www.gov.uk/guidance/dangers-to-marine-species-and-measures-to-protect-them

[896] ICES. 2020. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 2:81. 209 pp. Available from: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/HAPISG/2020/WGBYC_2020.pdf

[897] https://www.mcsuk.org/goodfishguide/species/seabass/

[898] https://www.iucnredlist.org/species/170245/1300534

than for Greece which is likely to help reduce these environmental impacts (although no direct evidence is available to support this hypothesis currently).

A ‘medium risk’ score is provided here since some evidence of degradation through cage farming in Turkey is likely to exist, but this is not considered widespread. Furthermore, it is considered possible that the ecosystem impacts in Turkey may be better managed due to increased offshore operation but since no evidence exists to currently support this, the same score is provided for the two countries.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[899] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[900] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. Although bass and bream cage production were not specifically considered under this study, it is considered highly likely that they will produce similar levels as reported for salmon cage production. The study estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced so slightly above the GAA study.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in bass and bream cage production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In bass and bream cage production, no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as ‘medium risk’.

ETP impact (Env_4): Cage farming of sea bass is known to have some interactions with a variety of species including birds and mammals. The following species have been reported to interact with sea cage farms (both bream and bass) in the Mediterranean on a year-round basis[901];

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[899] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[900] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[901] *López, B. D. (2012). Bottlenose dolphins and aquaculture: interaction and site fidelity on the north-eastern coast of Sardinia (Italy). Marine biology, 159(10), 2161-2172.*

Bottlenose Dolphins (*Tursiops truncatus*): Known to interact widely with farms in the Mediterranean and considered 'Vulnerable' in the specific region. Effects of interaction are both positive (providing food) and negative (entanglement in anti-predator netting) with some annual mortalities reported. The species is listed as 'Least Concern' by IUCN.

Yellow-legged Gulls *(Larus michahellis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

European Shag *(Gulosus aristotelis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

Grey herons *(Ardea cinerea)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Common Tern *(Sterna hirundo)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Although interactions do exist with ETP species (not listed above) more occasionally, they are not considered highly significant and are managed to some degree. A 'medium risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): Although noted that Turkish wages remain significantly lower than those found in Greece[886], no specific social concerns exist in the cage farmed production of sea bream in Turkey. A 'low risk' score is therefore provided.

Management effectiveness (Mgt_1): Turkish sea bream farming is relatively well managed and developed. The farming process has controls on licensing and requires regular inspections and environmental monitoring to occur. It has also promoted the movement of farming operations further offshore and is considered in many ways to be slightly advanced on competitor management systems[886]. However, some concerns still exist around Turkish production with a lack of transparency often seen as the major issue.

A 'medium risk' score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed sea bream imports from Turkey. Traditionally, this has been completed through the Global GAP Farm standard but with growth in Friends of the Sea and Best Aquaculture Practices (BAP) in recent years. Most recently, in 2019, the first Turkish bream farmers received certification against the newly created Aquaculture Stewardship Council (ASC) bass and bream standard. There are currently 24 suppliers with ASC certification[902].

The Turkish sea bream industry is largely covered by third party certification standards, particularly with reference to sales to the UK. Indeed, it is considered more advanced in this

[902] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/

area than its competitors (with a generally higher uptake on third party certification standards in the sector[886]). However, not all are ASC certified and so a 'medium risk' score is provided here.

Supply chain: Greece aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Gilthead sea bream are farmed in cage systems off the coast of Greece. It is not known to have any direct or indirect impact on naturally occurring Gilthead sea bream in the Mediterranean. The species is not listed by CITES and does not form part of the IUCN red list (it is listed as Least Concern). A 'low risk' score is provided here.

Env 2: Cage farming of sea bream is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed, but also the release of high levels of nitrate and phosphate into the water column. The majority of this impact is well documented to affect the immediate areas of culture[876]. For Greek sea bream farming, evidence of effects on seagrass (*Posidonia oceanica*) have been reported with increased leaf fragility and reduced growth[877]. Kallitsis, E. *et al*. (2020)[878] has also shown through life cycle assessment, that sea bream farming can produce high eutrophication impacts on the surrounding environment, especially if best management practices are not followed.

A 'medium risk' score is provided here since some evidence of degradation through cage farming in Greece does exist, but this is not considered widespread.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[903] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[904] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. Although bass and bream cage production were not specifically considered under this study, it is considered highly likely that they will produce similar levels as reported for salmon cage production. The study estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced so slightly above the GAA study.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in bass and bream cage production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In bass and bream cage production, no aeration or mechanical

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[903] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

[904] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, *597(7876), 360-365*

equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as 'medium risk'.

ETP impact (Env_4): Cage farming of sea bass is known to have some interactions with a variety of species including birds and mammals. The following species have been reported to interact with sea cage farms (both bream and bass) in the Mediterranean on a year-round basis[905];

Bottlenose Dolphins (*Tursiops truncatus*): Known to interact widely with farms in the Mediterranean and considered 'Vulnerable' in the specific region. Effects of interaction are both positive (providing food) and negative (entanglement in anti-predator netting) with some annual mortalities reported. The species is listed as 'Least Concern' by IUCN.

Yellow-legged Gulls *(Larus michahellis*): Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

European Shag *(Gulosus aristotelis)*: Very regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported on most farms with mortalities occurring. The species is listed as 'Least Concern' by IUCN.

Grey herons *(Ardea cinerea)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Common Tern *(Sterna hirundo)*: Regularly interacts with sea cages in the Mediterranean and entanglement with nets is reported occasionally, however limited mortalities are seen. The species is listed as 'Least Concern' by IUCN.

Although interactions do exist with ETP species (not listed above) more occasionally, they are not considered highly significant and are managed to some degree. A 'medium risk' score is provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): No specific social concerns are associated with the cage farmed production of Gilthead sea bream in Greece. A 'low risk' score is therefore provided here.

Management effectiveness (Mgt_1): Greek sea bass farming is relatively well managed and developed. The farming process has controls on licensing and requires regular inspections and environmental monitoring to occur. That said, the Greek system still lacks some vital components to consider it fully effective (e.g. cumulative impact monitoring, use of antibiotics and escape monitoring).

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[905] López, B. D. (2012). Bottlenose dolphins and aquaculture: interaction and site fidelity on the north-eastern coast of Sardinia (Italy). Marine biology, 159(10), 2161-2172.

A ‘medium risk’ score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed sea bream imports from Turkey. Traditionally, this has been completed through the Global GAP Farm standard but with growth in Friends of the Sea and Best Aquaculture Practices (BAP) in recent years. Most recently, in 2019, the first Greek bream farmers received certification against the newly created Aquaculture Stewardship Council (ASC) bass and bream standard. There are currently 21 suppliers with ASC certification[906].

The Greek bream industry is largely covered by third party certification standards, particularly in reference to sales to the UK, however not all are ASC certified and so a ‘medium risk’ score is provided here.

Supply chain: Morocco aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Sea bream are farmed in cage systems off the coast of Morocco. There are no reported direct or indirect impacts on naturally occurring populations in the Mediterranean. Whilst Common dentex (*Dentex dentex*) are listed as ‘vulnerable’ on the IUCN red list[907], other porgy / bream species are considered ‘Least Concern’. A ‘low risk’ score is provided here.

Ecosystem impact (Env_2): Cage farming of sea bream is known to have some negative environmental impacts, mostly relating to the creation of anoxic conditions on the seabed, but also the release of high levels of nitrate and phosphate into the water column. The majority of this impact is well documented as affecting the immediate areas of culture[876]. For Moroccan sea bream farming, direct evidence of ecosystem impact is poorly reported but is considered highly likely to be the same as for Greek farms. Both use similar systems and production takes place in similar environments.

A ‘medium risk’ score is provided here since some evidence of degradation through cage farming in Morocco is likely to exist but this is not considered widespread.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[908] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

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[906] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/

[907] https://www.iucnredlist.org/species/170245/1300534

[908] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture.* https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/

A recent study completed by Gephart, J.A. et al. (2021)[909] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. Although bass and bream cage production were not specifically considered under this study, it is considered highly likely that they will produce similar levels as reported for salmon cage production. The study estimated salmon farming at a figure of around 5 kg of CO2 per kg of meat produced so slightly above the GAA study.

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in bass and bream cage production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In bass and bream cage production, no aeration or mechanical equipment is used (other than at the hatchery stage). However, regular vessel use is needed for maintenance of the cages and harvesting (although distances travelled are small).

For the above reasons, it is concluded that the farming method has medium climate impacts (fossil fuel use) when considered across the life cycle of the production method and is therefore scored as 'medium risk'.

ETP impact (Env_4): Cage farming of sea bream is known to have some interactions with a variety of species including birds and mammals. These are set out in more detail for Greece and Turkey and in the absence of any specific information, are considered unlikely to differ significantly for Morocco.

Although interactions with ETP species are likely to occur, they are not considered highly significant and are managed to some degree. A 'medium risk' score is provided on a precautionary and data limited basis.

Social concerns associated with supply chain (Social_1): Virtually no information is available on social issues in the Moroccan sea bream farming sector. However, concerns have been raised about human rights issues in the country on a more generic level[910]. These concerns and a lack of information means a 'medium risk' score is raised here.

Management effectiveness (Mgt_1): Aquaculture is not well developed in Morocco currently, but the Government has plans for its future development. Current regulation though is based around a 1973 Act and is considered somewhat outdated[911]. That said, new supporting regulation has been introduced which provides quite a solid base for aquaculture development in the country, including requirements for permitting and the completion of an EIA.

A 'medium risk' score is provided here as legislation is in place which covers the main areas but is likely to need strengthening as and when the sector grows.

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[909] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature, 597*(7876), 360-365*

[910] *Human Rights Watch (2014) Summary of Key Issues related to Child Domestic Workers in Morocco https://tbinternet.ohchr.org/Treaties/CRC/Shared%20Documents/MAR/INT_CRC_NGO_MAR_16381_E.pdf*

[911] *http://www.fao.org/fishery/legalframework/nalo_morocco/en*

Sustainability certification progress (Mgt_2): Only 1 sea bream supplier is ASC certified at present[912], with no other know certifications for other farms. A 'high risk' score is therefore provided here.

Catfish

Supply chain: Vietnam aquaculture production

Direct impact on population(s) or stock(s) of resource (Env_1): Pangasius is farmed around the waterways of the Mekong Delta in cage-based systems. The stocks used in the Vietnamese industry all originate from wild populations of the Mekong River but the breeding process is well established and rarely requires access to significant numbers of wild broodstock[913].

UK suppliers farm pangasius in pond-based systems which makes escapes much less likely (certainly than cage-based systems). It is likely however that some farmed Pangasius have and will escape into the wild environment. The relatively new nature of the production of Pangasius though means little work has been done on the possible genetic interactions of farmed and wild populations in the Mekong.

A 'medium risk' score is provided here on the basis that escapes are not likely to be common occurrences, but no information exists on the potential impacts that such events may have on wild populations.

Ecosystem impact (Env_2): Significant concerns have been raised by various parties regarding the environmental impacts of farmed Pangasius in the Mekong Delta.

For example, habitat alteration has occurred in the region to make space for new pond systems often with little environmental impact consideration. Many concerns have been raised about the water quality of the Mekong Delta and the impacts of Pangasius farming on it directly. Surprisingly, little specific environmental impact assessment work has been done to quantify this. Anh, P.T. *et al.* (2010)[914] calculated that the production of 1 tonne of Pangasius was responsible for the production of 99kg of Nitrogen and 26kg of Phosphorous, with wastewater being the biggest direct source of water pollution from farming activities. For comparison, these figures are thought to be roughly twice the amounts produced in commercial salmon farming activities[915]. Despite this relatively high load, the study suggested that Pangasius production represented a minor source of nutrients in the Mekong river (less than 1% of the total nitrogen and phosphorous loads). Other studies have indicated a significant seasonal variation in this effluent discharge however and identify key hotspots (both spatially and temporally) which led to very high nutrient loading[916]. Further research is clearly needed to provide definitive understanding on the nutrient loading effects of Pangasius farming on the Mekong River.

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[912] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/ASC-C-00169-MSC-C-50132-8/

[913] *Ha, T. T. P., van Dijk, H., & Visser, L. (2014). Impacts of changes in mangrove forest management practices on forest accessibility and livelihood: A case study in mangrove-shrimp farming system in Ca Mau Province, Mekong Delta, Vietnam. Land Use Policy, 36, 89-101.*

[914] *Anh, P. T., Kroeze, C., Bush, S. R., & Mol, A. P. (2010). Water pollution by Pangasius production in the Mekong Delta, Vietnam: causes and options for control. Aquaculture Research, 42(1), 108-128.*

[915] *Davies, I.M. (2000). Waste production by farmed Atlantic salmon (Salmo salar) in Scotland. ICES CM 2000/ O:01, 12 pp.*

[916] *Bosma, R. H., Hanh, C. T., Potting, J., Anh, P. T., Dung, V. V., Fransen, M., & Ut, V. N. (2009). Environmental impact assessment of the pangasius sector in the Mekong Delta. Wageningen University.*

Pangasius farming has also been linked to significant use of antibiotics[917]. Several studies have warned about the spread of high levels of antibiotic pollution in the Mekong Delta[918,919]. In recent years, significant changes in antibiotic use have occurred in Vietnam with some being banned outright (VMARD, 2012) and stricter controls on the use of many. Furthermore, most farms supplying the UK are now ASC certified and this has introduced quite strict controls on the use of antibiotics[920] .

A ‘medium risk' score is provided here since some evidence of degradation through pond farming in Vietnam does exist. However, the extent to which this is currently an issue is not fully known with general consensus being that improvements need to be made. Consideration was given to providing a 'high risk' score here but recent improvements in the industry and mitigation through certification were seen as significant enough to not justify this higher risk rating.

Climate change impact (Env_3): A variety of assessments on the climate impacts of aquaculture have been completed in recent years and show great variability across production methods and species. The Global Aquaculture Alliance (GAA) funded work by Dr Claude Boyd[921] provided a more generic consideration of the carbon footprint of aquaculture. Here it was estimated that aquaculture CO2 emissions averaged around 4kg of CO2 per kg of meat produced. This was more than the 1-3 kg estimated for wild capture fisheries. However, this figure includes the capture and manufacturing of pelleted feeds (including fishmeal capture) and their transport to the farm which is thought to contribute 50-60% of this figure.

A recent study completed by Gephart, J.A. et al. (2021)[922] and published in Nature also considered the GHG emissions of different aquaculture production systems and species. This estimated pangasius farming at a figure of around 9 kg of CO2 per kg of meat produced so significantly higher than the previous study and almost twice that of species produced in cage farming (indeed, similar to shrimp farming).

What is clear in all the studies is that the production of fish feed is the biggest factor relating to CO2 production in Pangasius production. The second biggest factor regarding CO2 emissions is in mechanical pumping and aeration which can contribute 20% of the total figure and is production system specific. In pangasius production the use of aeration and mechanical pumping is significant to facilitate pond aquaculture techniques. It is this additional requirement that raises the CO2 production for pangasius above that of cage farmed species (and similar to shrimp production).

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[917] *Phan, L. T., Bui, T. M., Nguyen, T. T., Gooley, G. J., Ingram, B. A., Nguyen, H. V., & De Silva, S. S. (2009). Current status of farming practices of striped catfish, Pangasianodon hypophthalmus in the Mekong Delta, Vietnam. Aquaculture, 296(3-4), 227-236*

[918] *Managaki, S., Murata, A., Takada, H., Tuyen, B. C., & Chiem, N. H. (2007). Distribution of macrolides, sulfonamides, and trimethoprim in tropical waters: ubiquitous occurrence of veterinary antibiotics in the Mekong Delta. Environmental Science & Technology, 41(23), 8004-8010.*

[919] *Shimizu, A., Takada, H., Koike, T., Takeshita, A., Saha, M., Nakada, N., & Reungsang, A. (2013). Ubiquitous occurrence of sulfonamides in tropical Asian waters. Science of the total environment, 452, 108-115.*

[920] *https://www.asc-aqua.org/what-we-do/our-standards/farm-standards/*

[921] *Boyd, C.E. (2013) Assessing the carbon footprint of aquaculture. https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/*

[922] *Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., ... & Troell, M. (2021). Environmental performance of blue foods.* Nature*, 597(7876), 360-365*

For the above reasons, it is concluded that the farming method has high climate impacts (fossil fuel use), and significantly higher that cage-based production methods, when considered across the life cycle of the production method and is therefore scored as 'high risk'.

ETP impact (Env_4): Interactions with ETP species or indeed other species are thought to be limited in Pangasius production in Vietnam. Potential interaction species may include cormorants and monitor lizards[923]. Most farms are ASC certified and so are not allowed to practice lethal control of predators.

Although limited data on ETP interactions exists, available evidence suggests they are likely to be limited. Most interactions are also managed to some degree. A 'low risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): Social concerns have existed in the past, particularly relating to labour practices, in a variety of Asian countries including Vietnam. However, in recent years, most major commercial companies supplying the UK with Pangasius have undergone ASC assessment which includes a social certification component.

For the above reasons, no red flag is considered necessary and a 'low risk' score is provided.

Management effectiveness (Mgt_1): Significant improvements in management systems have been made in Vietnam aquaculture in the past decade. However, it is still considered that significant gaps and improvements are required. Specific areas of concern remain around the use of EIAs in farm licensing, antibiotic use and regulatory control of outputs[924].

A 'medium risk' score is provided here as the management system is seen as effective but could still benefit from improvement.

Sustainability certification progress (Mgt_2): Virtually all UK retailers require evidence of third-party certification of farmed Pangasius. In Vietnam, the major suppliers[925,926] are all certified by the ASC standard. Indeed, currently 63 suppliers of pangasius in Vietnam are listed as certified by the ASC[927]. It is commonly known that the use of these standards for companies supplying western countries such as the UK is a pre-requisite.

The Vietnamese Pangasius industry is largely covered by third party certification standards and so a 'low risk' score is provided.

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[923] de Silva, S. S. and Phuong, N. T. 2011. Striped catfish farming in the Mekong Delta, Vietnam: a tumultuous path to a global success. Reviews in Aquaculture. 3, pp. 45-73.

[924] Bush, S. R., Khiem, N. T., & Sinh, L. X. (2009). Governing The Environmental and Social Dimensions Of Pangasius Production In Vietnam: A Review. Aquaculture Economics & Management, 13(4), 271-293.

[925] https://godaco-seafood.com.vn/en/

[926] https://vinhhoan.com/

[927] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/

Seafood commodity – Flatfish

Sole

Supply chain: United Kingdom wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Sole in the North Sea has recently been assessed as above the biomass reference points (SSB>MSY Btrigger), although fishing mortality is above Fmsy (but below Fpa and Flim)[928]. Stock biomass of sole in the western and eastern English Channel, Bristol Channel and Celtic Sea[929] is considered to be above the biological reference point (MSY Btrigger proxy) and the exploitation rate is considered sustainable (F<Fmsy proxy)[930,931]. Reported landings for the Irish Sea[932] and Celtic Sea south[933] are low. Given the distribution of catches across the main stocks fished by the UK, a 'low risk' score is provided.

Ecosystem impact (Env_2): Fishery uses a mixture of demersal fishing gear (beam trawls, otter trawls, trammel / gill nets)[934] some of which (bottom towed gear) does interact with the seafloor, with variable levels of physical and biological impacts. Bycatch of (undersized) commercial species such as plaice may be of concern, depending on their stock status[935,936]. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): Given the mix of gear types (see Env_2), a 'medium risk' score is associated with the carbon footprint of the production method based on Parker & Tyedmers (2014)[937]. Whilst an average score of 12.6 tonnes of CO2 per kg of fish ('high risk') is provided The Seafood Carbon Emissions Tool[938], this is for 'bottom trawls' generally and the associated evidence suggested a high degree of variability. A 'medium risk' score is therefore provided.

ETP impact (Env_4): ETP interactions are considered to be low risk in the North Sea and eastern English Channel[939,940]. In the western English Channel, whilst interactions with for example cetaceans and birds are considered to be low, the pink sea fan (*Eunicella verrucosa*) and other hard coral species mentioned in the UK Biodiversity Action Plan, as well as skates and rays such as the Blonde ray and Undulate ray, which may be considered ETP have previously been considered to be at risk from the fishery[935]. More generally, gill nets and fixed nets can result in bycatch of cetaceans and sharks, for example and the south-west of England represents an area of high concern for bycatch of harbour porpoise and common dolphins[941], although data

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[928] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.4.pdf

[929] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.7fg.pdf

[930] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/sol.27.7d.pdf

[931] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.7e.pdf

[932] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.7a.pdf

[933] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.7h-k.pdf

[934] https://www.fishsource.org/stock_page/764

[935] https://www.fishsource.org/stock_page/768

[936] https://www.mcsuk.org/goodfishguide/species/dover-sole/

[937] *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

[938] http://seafoodco2.dal.ca/

[939] https://www.fishsource.org/stock_page/766

[940] https://www.mcsuk.org/goodfishguide/ratings/wild-capture/131/

[941] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/FisheriesOverview_GreaterNorthSea_2020.pdf

are limited[942]. A 'medium risk' score is therefore provided on the basis of potential risk but also limited information.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the UK's sole fishery is generally considered to be effective, although there is scope for improvement (such as reduction and monitoring of discards and bycatch). The stocks fall under the EU's multi annual plans (MAPs) and the fishery is subject to various technical measures, although the UK will now need to implement effective and sustainable national fisheries plans and assess the suitability of the adopted CFP measures for its own fisheries. A 'medium risk' score is provided at present.

Sustainability certification progress (Mgt_2): No UK sole fisheries have gained third-party certification or are part of a FIP. A 'high risk' score is therefore provided.

Supply chain: Iceland wild capture production

The majority of sole catches by the Icelandic fleet are estimated to comprise of lemon sole[943].

Direct impact on population(s) or stock(s) of resource (Env_1): The stock is data limited and MSY reference points are undefined. The biomass and juvenile indices suggest the stock is in a period of high variability but in relatively good state. Fishing mortality is estimated to be above target Fproxy, however[944]. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): The majority of landings are associated with demersal seines, although bottom trawls also make a notable contribution[944] and sole are also caught by Nephrops trawls[945]. Little information could be found on assessed impacts of the fishery specifically, with the exception of potential risks from interactions with some vulnerable benthic habitats such as Lophelia coral reefs[945]. A 'medium risk' score is therefore provided on the basis of potential risk of damage by bottom towed gear and information gaps on level of impact.

Climate change impact (Env_3): Given the mix of gear types (see Env_2), a 'medium risk' score is associated with the carbon footprint of the production method based on Parker & Tyedmers (2014)[946]. Whilst an average score of 12.6 tonnes of CO_2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool[947], this is for 'bottom trawls' generally and the associated evidence suggested a high degree of variability. A 'medium risk' score is therefore provided.

ETP impact (Env_4): The scope for interaction between the fishery and most ETP species in Icelandic waters is considered to be negligible. The only species that is given further consideration within the MSC certification assessment is the Hooded seal (*Cystophora cristata*), for which reports of rare bycatch incidences exist, and the Northern gannet (*Morus bassanus*). Based on a worst-case scenario, it was estimated that mortality of Hooded seals associated with the fishery would account for 0.03-0.04% of the total estimated annual number of hooded seals which visit Icelandic waters to feed. This percentage of bycatch is considered unlikely to be of

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942 https://www.mcsuk.org/goodfishguide/ratings/wild-capture/414/

943 https://www.hafogvatn.is/static/extras/images/lemon_sole24203.pdf

944 https://www.hafogvatn.is/static/extras/images/10-lemonsole1259413.pdf

945 https://fisheries.msc.org/en/fisheries/isf-iceland-lemon-sole/@@view

946 *Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087*

947 http://seafoodco2.dal.ca/

concern. A similar conclusion has been drawn for gannets. Whilst they do not meet the ETP criterion, Harbour porpoise (*Phocoena phocoena*) and Grey seal (*Halichoerus grypus*) are considered as main secondary species[948] and vulnerable in Europe[949]. Whilst the potential level of interaction between the fishery and these species (and other cetacean / bird species) is considered to be low risk to the populations, such a conclusion cannot be made with high confidence due to uncertainty associated with population level data. A 'medium risk' score is therefore provided here.

Social concerns associated with supply chain (Social_1): There are no known social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The management of Iceland's fisheries and this fishery in particular is generally considered to be effective[945] resulting in a 'low risk' score.

Sustainability certification progress (Mgt_2): Iceland's lemon sole fishery is MSC certified with condition[945] and therefore a 'medium risk' score is provided.

Supply chain: Netherlands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Sole in the North Sea has recently been assessed as above the biomass reference points (SSB>MSY Btrigger), although fishing mortality is above Fmsy (but below Fpa and Flim)[928]. The Netherlands accounts for the largest share of landings from this fishery. Reported landings for the Irish Sea[932] (and other applicable areas) are relatively low. A 'medium risk' score is therefore provided.

Ecosystem impact (Env_2): A high proportion of catches are associated with beam trawlers or pulse trawlers, along with seine nets, set gill nets and otter trawls[950,951]. Given the risk of habitat damage and bycatch or mortality of non-target species posed by these bottom towed gears, a 'high risk' score is provided.

Climate change impact (Env_3): The dominance of beam trawler activity results in a 'high risk' score in relation to the carbon footprint of the production method based on Parker & Tyedmers (2014)[952]. Further, an average score of 13 tonnes of CO_2 per kg of fish is provided by The Seafood Carbon Emissions Tool[953]. A 'high risk' score is therefore provided.

ETP impact (Env_4): Monitoring of bycatch of ETP species, such as harbour porpoise (*Phocoena phocoena*), Thorny skate (*Amblyraja radiata*), and spurdog (*Squalus acanthias*), indicate low levels of interactions with the fishery. However, there is lack of confidence over the potential population level impacts of such interactions with species such as Starry ray (*Raja radiata*), Porbeagle (*Lamna nasus*) and Common skate (*Dipturus batis*)[950]. A 'medium risk' score is therefore provided.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Netherland's sole fishery, under the EU Common Fisheries Policy, is generally considered to be effective, although there is scope for improvement (such as

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[948] https://fisheries.msc.org/en/fisheries/isf-iceland-lemon-sole/@@assessments

[949] https://en.ni.is/resources/publications/red-lists/red-list-mammals

[950] https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/@@assessments

[951] https://www.fishsource.org/stock_page/766

[952] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[953] http://seafoodco2.dal.ca/

reduction and monitoring of discards and bycatch). The stocks fall under the EU's multi annual plans (MAPs) and the fishery is subject to various technical measures. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Netherland's sole fishery in the North Sea is partially certified by MSC (e.g. the pulse trawl component is not covered)[950]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Supply chain: Denmark wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Sole in the North Sea has recently been assessed as above the biomass reference points (SSB>MSY Btrigger), although fishing mortality is above Fmsy (but below Fpa and Flim)[928]. Stock biomass of sole in Skagerrak, Kattegat and Western Baltic Sea, which is largely caught by the Danish fleet, is considered to be above the biological reference point (MSY Btrigger) and the exploitation rate is considered sustainable (F<Fmsy)[954]. A 'low risk' score is therefore provided.

Ecosystem impact (Env_2): Sole in the Skagerrak, Kattegat and Western Baltic Sea are caught in a directed trawl fishery with bycatch of Nephrops, plaice and cod and as bycatch in the Nephrops trawl fishery. There is also a directed gill net fishery, mainly in Skagerrak in spring and summer. Denmark took 88% of the total catch in 2019[955]. The bycatch of cod in the Kattegat is of particular concern given the status of the stock and advised zero catches[956]. The risk of habitat damage due to bottom towed gears is also of consideration. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): Given the mix of gear types (see Env_2), a 'medium risk' score is associated with the carbon footprint of the production method based on Parker & Tyedmers (2014)[957]. Whilst an average score of 12.6 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool[958], this is for 'bottom trawls' generally and the associated evidence suggested a high degree of variability. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Low levels of cetacean bycatch monitoring are in place for the Danish fleet[959]. Other assessments of the fishery suggest bycatch of cetaceans, elasmobranchs and seabirds, some of which are likely to be ETP species, is a risk posed by the fishery[960]. Given the risks associated with other sole fisheries as well, a 'medium risk' score is provided here.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of Denmark's sole fisheries, under the EU Common Fisheries Policy, is generally considered to be effective, although there is scope for improvement (such as

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954 https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/sol.27.20-24.pdf

955 https://www.mcsuk.org/goodfishguide/ratings/wild-capture/124/

956 https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/cod.27.21.pdf

957 Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

958 http://seafoodco2.dal.ca/

959 https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/HAPISG/2020/WGBYC_2020.pdf

960 https://www.mcsuk.org/goodfishguide/ratings/wild-capture/125/ and https://www.mcsuk.org/goodfishguide/ratings/wild-capture/124/

reduction and monitoring of discards and bycatch). The stocks fall under the EU's multi annual plans (MAPs) and the fishery is subject to various technical measures. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Danish sole fishery is partially covered by MSC certification (e.g. the North Sea component is certified)[950]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Supply chain: Faroe Islands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): No assessment of the status of sole in Faroes waters could be found and therefore a 'medium risk' score is provided on the basis of data limitations.

Ecosystem impact (Env_2): It is assumed, but could not be confirmed, that at least some proportion of the catches are associated with bottom towed fishing gear. A 'medium risk' score is therefore provided on the basis of potential risk of damage to benthic habitats and information gaps.

Climate change impact (Env_3): It is assumed, but could not be confirmed, that a mixture of bottom towed gear and set nets are associated with the sole fishery in Faroes waters and therefore a 'medium risk' score is provided for the carbon footprint of the fishery's production method (as per the other supply chains, with exception of The Netherlands).

ETP impact (Env_4): No information could be found relating to risks to ETP species for this fishery specifically. A 'medium risk' score is therefore provided on the basis of data limitations and risks associated with other fisheries in the region.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): No information could be found regarding the management of the Faroes Islands sole fishery. More generally there are concerns about the effort-based management of the country's demersal fisheries. A 'medium risk' score is therefore provided.

Sustainability certification progress (Mgt_2): No Faroe Islands sole fisheries have gained third-party certification or are part of a FIP. A 'high risk' score is therefore provided.

Plaice

Supply chain: United Kingdom wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The North Sea[961], Irish Sea[962], eastern English Channel[963] and western English Channel[964] plaice stocks are considered to be healthy and not overfished (fishing mortality is above Fmsy for the latter stock, but below Fpa and Flim). Plaice are caught as bycatch in the Celtic Sea, where the stock is considered depleted[965]. A 'low risk' score is therefore provided.

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[961] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/ple.27.420.pdf*

[962] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/ple.27.7a.pdf*

[963] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/ple.27.7d.pdf*

[964] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/ple.27.7e.pdf*

[965] *https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/ple.27.7h-k.pdf*

Ecosystem impact (Env_2): Fishery uses a mixture of demersal fishing gear (beam trawls, otter trawls, seine nets)[966,967] which interacts with the seafloor, with variable levels of potential physical and biological impacts. A 'medium risk' score is therefore provided.

Climate change impact (Env_3): Given the mix of gear types (see Env_2), a 'medium risk' score is associated with the carbon footprint of the production method based on Parker & Tyedmers (2014)[968]. Whilst an average score of 13.4 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool[969], this is for 'bottom trawls' generally and the associated evidence suggested a high degree of variability. A 'medium risk' score is therefore provided.

ETP impact (Env_4): For the western English Channel fishery at least, it has been concluded that '*The rate of interactions with endangered elasmobranchs is considered to be high*' and '*High interaction occurs between the fishery's demersal trawl gear and many elasmobranch species, and there are PET species that may be impacted*'[967]. Interactions with elasmobranchs and harbour porpoise are also noted in MSC certification assessments. A 'medium risk' score is provided to account for the variation in risk across the whole UK plaice fishery.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the UK's plaice fishery is generally considered to be effective, although there is scope for improvement (such as reduction and monitoring of discards and bycatch). The stocks fall under the EU's multi annual plans (MAPs) and the fishery is subject to various technical measures, although the UK will now need to implement effective and sustainable national fisheries plans and assess the suitability of the adopted CFP measures for its own fisheries. A 'medium risk' score is provided at present.

Sustainability certification progress (Mgt_2): Plaice caught by the SFSAG certified haddock fishery are MSC certified[970] and the plaice and lemon sole seine / trawl FIP is making good progress[971]. A 'medium risk' score is therefore provided.

Supply chain: Iceland wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): Icelandic Marine and Fisheries Research Institute assessment in 2021 concluded: **'***Fishing pressure on the stock is at Fmsy. MFRI cannot assess the stock status relative to maximum sustainable yield (MSY) and precautionary approach (PA) reference points because the reference points are undefined. Exploitable biomass is assumed to be above candidate reference points*.'[972]. A 'low risk' score is therefore provided.

Ecosystem impact (Env_2): The majority of catches are associated with otter trawls and Danish seines. Whilst this bottom towed gear poses risk to benthic habitats, the interactions specific to the Icelandic fishery combined with the existing management measures for protection of VMEs lead the MSC certification team to

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[966] https://www.fishsource.org/stock_page/1753

[967] https://www.fishsource.org/stock_page/1755

[968] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[969] http://seafoodco2.dal.ca/

[970] https://fisheries.msc.org/en/fisheries/sfsag-northern-demersal-stocks/about/

[971] https://fisheryprogress.org/fip-profile/uk-european-plaice-lemon-sole-seinetrawl

[972] https://www.hafogvatn.is/static/extras/images/09-plaice1259407.pdf

conclude the likelihood of prolonged impact is low[973]. A 'medium risk' score is therefore provided on a precautionary basis.

Climate change impact (Env_3): Given the mix of gear types (see Env_2), a 'medium risk' score is associated with the carbon footprint of the production method based on Parker & Tyedmers (2014)[974]. Whilst an average score of 13.4 tonnes of CO2 per kg of fish ('high risk') is provided by The Seafood Carbon Emissions Tool[975], this is for 'bottom trawls' generally and the associated evidence suggested a high degree of variability. A 'medium risk' score is therefore provided.

ETP impact (Env_4): Potential interactions between bottom trawls, harbour seals and grey seals are considered in the MSC assessment, which concludes that the levels of bycatch are highly likely to not hinder the recovery of ETP species, based on current understanding of the populations and the level of monitoring in place. A 'medium risk' score is therefore provided on a precautionary basis.

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): The management of Iceland's fisheries and this fishery in particular is generally considered to be effective[973] resulting in a 'low risk' score.

Sustainability certification progress (Mgt_2): Iceland's plaice fishery is MSC certified with conditions[973] and therefore a 'medium risk' score is provided.

Supply chain: Netherlands wild capture production

Direct impact on population(s) or stock(s) of resource (Env_1): The North Sea plaice stock is considered to be healthy and not overfished[961]. A 'low risk' score is therefore provided.

Ecosystem impact (Env_2): A high proportion of catches are associated with beam trawlers or pulse trawlers, along with seine nets, set gill nets and otter trawls[976,977]. Given the risk of habitat damage and bycatch or mortality of non-target species posed by these bottom towed gears, a 'high risk' score is provided.

Climate change impact (Env_3): The dominance of beam trawler activity results in a 'high risk' score in relation to the carbon footprint of the production method based on Parker & Tyedmers (2014)[978]. An average score of 13.4 tonnes of CO2 per kg of fish ('high risk') is also provided by The Seafood Carbon Emissions Tool[979]. A 'high risk' score is therefore provided.

ETP impact (Env_4): Monitoring of bycatch of ETP species, such as harbour porpoise (*Phocoena phocoena*), Thorny skate (*Amblyraja radiata*), and spurdog (*Squalus acanthias*), indicate low levels of interactions with the fishery. However, there is lack of confidence over the potential population level impacts of such interactions with species such as Starry ray (*Raja radiata*), Porbeagle (*Lamna nasus*) and Common skate (*Dipturus batis*)[950]. A 'medium risk' score is therefore provided.

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[973] https://fisheries.msc.org/en/fisheries/isf-iceland-multi-species-demersal-fishery/@@assessments

[974] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[975] http://seafoodco2.dal.ca/

[976] https://fisheries.msc.org/en/fisheries/joint-demersal-fisheries-in-the-north-sea-and-adjacent-waters/@@assessments

[977] https://www.fishsource.org/stock_page/766

[978] Parker RWR, Tyedmers PH. 2014. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries, DOI: 10.1111/faf.12087

[979] http://seafoodco2.dal.ca/

Social concerns associated with supply chain (Social_1): There are no known (or anticipated) social concerns – a 'low risk' score is provided.

Management effectiveness (Mgt_1): Management of the Netherland's plaice fishery, under the EU Common Fisheries Policy, is generally considered to be effective, although there is scope for improvement (such as reduction and monitoring of discards and bycatch). The stocks fall under the EU's multi annual plans (MAPs) and the fishery is subject to various technical measures. A 'medium risk' score is provided.

Sustainability certification progress (Mgt_2): The Netherland's plaice fishery in the North Sea is partially certified by MSC (e.g. the pulse trawl component is not covered)[950]. In 2019, WWF as part of an NGO consortium submitted objections to the certification of the fishery. One of the four objections was supported by the Independent Adjudicator. The others were not withdrawn by WWF. On that basis, a 'high risk' score is provided.

Appendix 2 – Production, import, export and consumption estimates for 2019

Resource	UK Capture Prod. (UK & non-UK waters) (tonnes)	UK Capture Prod. (UK & non-UK waters) - UK landings only (where available) (tonnes)	UK Aquac. Prod. (tonnes)	Total UK Prod. (tonnes)	Imports (tonnes)	Exports (tonnes)	Consump. (tonnes)	Exports manually amended (tonnes)	Consumption (tonnes) - amended	Notes	Resource included in focus Commodity categories?	Commodity
Abalone nei	0.0	0.0	0.0	0.0	7.9	17.5	-9.6	7.9	0.0	Assume exports = imports	No	
Alfonsinos nei	0.4	0.4	0.0	0.4	0.0	0.0	0.4	0.0	0.4	See note 1	No	
Allis and twaite shads	0.4	0.4	0.0	0.4	0.0	0.0	0.4	0.0	0.4	See note 1	No	
American plaice(=Long rough dab)	12.8	12.8	0.0	12.8	0.0	0.0	12.8	0.0	12.8	See note 1	No	
Anchovies nei	361.3	361.3	0.0	361.3	1755.5	1397.2	719.7	1397.2	719.7		No	
Angelshark	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	See note 1	No	
Arctic char	0.0	0.0	6.1	6.1	0.0	0.0	6.1	0.0	6.1	See note 1	No	
Arctic skate	1.3	1.2	0.0	1.2	0.0	0.0	1.2	0.0	1.2	See note 1	No	
Argentines	1.5	1.5	0.0	1.5	0.0	0.0	1.5	0.0	1.5	See note 1	No	
Atlantic redfishes nei	649.7	649.7	0.0	649.7	3300.9	399.2	3551.4	399.2	3551.4		No	
Atlantic wolffish	520.5	520.5	0.0	520.5	0.0	0.0	520.5	0.0	520.5	See note 1	No	
Ballan wrasse	36.9	36.9	0.0	36.9	0.0	0.0	36.9	0.0	36.9	See note 1	No	
Beaked redfish	6.7	6.7	0.0	6.7	0.0	0.0	6.7	0.0	6.7	See note 1	No	
Below threshold trade	0.0	0.0	0.0	0.0	34711.5	9955.2	24756.3	9955.2	24756.3		No	
Bivalves (clams, cockles, ark shells)	10745.7	10745.7	0.0	10745.7	2108.1	6887.2	5966.5	6887.2	5966.5		No	
Black marlin	13.0	13.0	0.0	13.0	0.0	0.0	13.0	0.0	13.0	See note 1	No	
Black scabbardfish	44.9	44.9	0.0	44.9	0.0	0.0	44.9	0.0	44.9	See note 1	No	
Blackbelly rosefish	101.1	101.1	0.0	101.1	0.0	0.0	101.1	0.0	101.1	See note 1	No	
Blonde ray	871.2	770.9	0.0	770.9	0.0	0.0	770.9	0.0	770.9	See note 1	No	
Blue ling	722.8	722.8	0.0	722.8	0.0	0.0	722.8	0.0	722.8	See note 1	No	
Blue shark	382.9	382.9	0.0	382.9	0.0	116.3	266.6	116.3	266.6		No	
Blue skate	1.9	1.7	0.0	1.7	0.0	0.0	1.7	0.0	1.7	See note 1	No	

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Blue whiting	60791.2	9291.2	0.0	9291.2	0.1	21605.3	-12314.0	9291.2	0.1	Assume exports = UK production	No	
Boarfish	30.2	30.2	0.0	30.2	0.0	0.0	30.2	0.0	30.2	See note 1	No	
Bonito	0.0	0.0	0.0	0.0	24.0	4.6	19.4	4.6	19.4		No	
Brill	434.2	334.2	0.0	334.2	0.0	0.0	334.2	0.0	334.2	See note 1	No	
Carps, barbels and other cyprinids	0.0	0.0	2.9	2.9	4434.8	66.4	4371.3	66.4	4371.3		No	
Caviar, Roes nei	23.0	23.0	0.0	23.0	314.8	9.1	328.7	9.1	328.7		No	
Cobia	0.0	0.0	0.0	0.0	3.4	901.0	-897.6	3.4	0.0	Assume exports = imports	No	
Common dab	467.4	467.4	0.0	467.4	0.0	0.0	467.4	0.0	467.4	See note 1	No	
Common dolphinfish	3.9	3.9	0.0	3.9	0.0	0.0	3.9	0.0	3.9	See note 1	No	
Common stingray	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	See note 1	No	
Corkwing wrasse	11.3	11.3	0.0	11.3	0.0	0.0	11.3	0.0	11.3	See note 1	No	
Crustaceans nei	0.0	0.0	0.0	0.0	875.0	440.5	434.5	440.5	434.5		No	
Cuckoo ray	485.6	429.7	0.0	429.7	0.0	0.0	429.7	0.0	429.7	See note 1	No	
Cuttlefish, bobtail squids nei	4928.1	4828.1	0.0	4828.1	8446.4	5626.4	7648.1	5626.4	7648.1		No	
Dogfish, hounds & cat sharks nei	2520.0	2520.0	0.0	2520.0	326.1	273.8	2572.2	273.8	2572.2	inc. Picked dogfish, small-spotted catshark, nursehound, starry smooth-hound	No	
Eels (European, Pink cusk-eel, nei)	3.2	3.2	0.0	3.2	266.1	305.2	-36.0	3.2	266.1	Assume exports = UK production	No	
Escolar	17.6	17.6	0.0	17.6	0.0	0.0	17.6	0.0	17.6	See note 1	No	
European conger	223.6	223.6	0.0	223.6	0.0	0.0	223.6	0.0	223.6	See note 1	No	
European flounder	69.8	69.8	0.0	69.8	0.0	0.0	69.8	0.0	69.8	See note 1	No	

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Fish (various, nei)	0.4	0.4	0.0	0.4	62863.8	33809.5	29054.8	33809.5	29054.8	e.g. inc. 'Groundfishes nei' production / 'Gadoids (various)' & Flatfishes nei & Pelagic nei & Caviar imports / exports included under Fish (other, nei) categories	No	
Forkbeard	4.4	4.4	0.0	4.4	0.0	0.0	4.4	0.0	4.4	See note 1	No	
Freshwater crayfish	0.0	0.0	0.0	0.0	497.5	15.8	481.7	15.8	481.7		No	
Freshwater fish (various, nei)	0.0	0.0	0.0	0.0	5355.4	3273.7	2081.6	3273.7	2081.6	inc. Tilapia, catfish, eels, carp, Nile perch	No	
Garfish	0.2	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.2	See note 1	No	
Goldsinny-wrasse	34.7	34.7	0.0	34.7	0.0	0.0	34.7	0.0	34.7	See note 1	No	
Greater argentine	6.8	6.8	0.0	6.8	0.0	0.0	6.8	0.0	6.8	See note 1	No	
Greater forkbeard	111.0	111.0	0.0	111.0	0.0	0.0	111.0	0.0	111.0	See note 1	No	
Greater weever	3.2	3.2	0.0	3.2	0.0	0.0	3.2	0.0	3.2	See note 1	No	
Grey gurnard	737.3	737.3	0.0	737.3	0.0	0.0	737.3	0.0	737.3	See note 1	No	
Gurnards, searobins nei	1069.6	469.6	0.0	469.6	0.0	0.0	469.6	0.0	469.6	See note 1	No	
Hake nei	11436.0	10336.0	0.0	10336.0	2617.9	4824.9	8129.0	4824.9	8129.0		No	
Halibut (Atlantic)	251.1	251.1	0.0	251.1	411.0	46.8	615.4	46.8	615.4		No	
Halibut (Greenland)	122.9	122.9	0.0	122.9	702.6	228.2	597.3	228.2	597.3		No	
Halibut (Pacific)	0.0	0.0	0.0	0.0	32.1	0.0	32.1	0.0	32.1		No	
Hoki	0.0	0.0	0.0	0.0	398.4	14.0	384.5	14.0	384.5		No	
Indo-Pacific sailfish	2.9	2.9	0.0	2.9	0.0	0.0	2.9	0.0	2.9	See note 1	No	

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Invertebrates nei	0.0	0.0	0.0	0.0	567.2	758.2	-191.0	567.2	0.0	Assume exports = imports	No	
Jack and horse mackerels (Atlantic, Chilean, nei)	10343.8	2443.8	0.0	2443.8	414.2	8528.0	-5670.0	2443.8	414.2	Assume exports = UK production	No	
Jellyfish nei	0.0	0.0	0.0	0.0	41.0	1.0	39.9	1.0	39.9		No	
John dory	252.2	252.2	0.0	252.2	0.0	0.0	252.2	0.0	252.2	See note 1	No	
Lemon sole	2019.1	1619.1	0.0	1619.1	0.0	0.0	1619.1	0.0	1619.1	See note 1	No	
Ling	5873.9	5673.9	0.0	5673.9	386.8	1734.4	4326.4	1734.4	4326.4		No	
Lobster (Palinurid spiny)	22.0	22.0	0.0	22.0	303.4	2466.3	-2140.9	22.0	303.4	Assume exports = UK production	No	
Longnosed skate	145.0	128.3	0.0	128.3	0.0	0.0	128.3	0.0	128.3	See note 1	No	
Marlins, sailfishes, etc. nei	1.1	1.1	0.0	1.1	0.0	0.0	1.1	0.0	1.1	See note 1	No	
Megrim nei	4699.6	3299.4	0.0	3299.4	20.3	3781.2	-461.5	3299.4	20.3	Assume exports = UK production	No	
Molluscs nei	0.0	0.0	0.0	0.0	641.5	0.0	641.5	0.0	641.5		No	
Mullets nei	71.4	71.4	0.0	71.4	0.0	0.0	71.4	0.0	71.4	See note 1	No	
Nile perch	0.0	0.0	0.0	0.0	155.0	441.0	-286.0	155.0	0.0	inc. snakeheads nei	No	
Northern quahog(=Hard clam)	24.8	24.8	0.0	24.8	0.0	0.0	24.8	0.0	24.8		No	
Norway pout	0.7	0.7	0.0	0.7	0.0	0.0	0.7	0.0	0.7	See note 1	No	
Octopus nei	440.4	440.4	0.0	440.4	881.5	316.1	1005.8	316.1	1005.8	Inc. common octopus	No	
Oilfish	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	See note 1	No	
Oysters	9.6	9.6	2238.8	2248.4	205.4	1077.9	1375.9	1077.9	1375.9		No	
Patagonian grenadier	0.3	0.3	0.0	0.3	0.0	0.0	0.3	0.0	0.3	See note 1	No	
Periwinkles nei	23.3	23.3	0.0	23.3	0.0	0.0	23.3	0.0	23.3		No	
Pink cusk-eel	2.5	2.5	0.0	2.5	0.0	0.0	2.5	0.0	2.5	See note 1	No	

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Porgies, seabreams nei	110.6	110.6	0.0	110.6	0.0	0.0	110.6	0.0	110.6		No	
Pouting(=Bib)	705.2	705.2	0.0	705.2	0.0	0.0	705.2	0.0	705.2	See note 1	No	
Queen snapper	0.2	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.2	See note 1	No	
Raja rays nei	28.7	25.4	0.0	25.4	403.0	359.1	69.3	359.1	69.3		No	
Red codling	0.6	0.6	0.0	0.6	0.0	0.0	0.6	0.0	0.6	See note 1	No	
Red gurnard	481.4	481.4	0.0	481.4	0.0	0.0	481.4	0.0	481.4	See note 1	No	
Red scorpionfish	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	See note 1	No	
Rock cook	1.1	1.1	0.0	1.1	0.0	0.0	1.1	0.0	1.1	See note 1	No	
Roughhead grenadier	0.2	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.2	See note 1	No	
Roundnose grenadier	6.0	6.0	0.0	6.0	0.0	0.0	6.0	0.0	6.0	See note 1	No	
Rudderfish	0.6	0.6	0.0	0.6	0.0	0.0	0.6	0.0	0.6	See note 1	No	
Salmonidae nei	0.0	0.0	0.0	0.0	98.8	3733.5	-3634.7	98.8	0.0	Assume exports = imports	No	
Sand sole	33.2	33.2	0.0	33.2	0.0	0.0	33.2	0.0	33.2	See note 1	No	
Sandeels(=Sandlances) nei	1066.8	1066.8	0.0	1066.8	0.0	0.0	1066.8	0.0	1066.8	See note 1	No	
Sandy ray	40.7	36.0	0.0	36.0	0.0	0.0	36.0	0.0	36.0	See note 1	No	
Sea cucumbers nei	2.7	2.7	0.0	2.7	0.1	3.5	-0.8	2.7	0.1	Assume exports = UK production	No	
Sea urchins nei	0.4	0.4	0.0	0.4	63.7	0.1	64.1	0.1	64.1		No	
Shagreen ray	17.0	15.0	0.0	15.0	0.0	0.0	15.0	0.0	15.0	See note 1	No	
Sharks nei	0.3	0.3	0.0	0.3	0.0	20.4	-20.0	0.3	0.0	Assume exports = UK production	No	
Shortfin mako	70.7	70.7	0.0	70.7	0.0	0.0	70.7	0.0	70.7	See note 1	No	
Small-eyed ray	102.4	90.6	0.0	90.6	0.0	0.0	90.6	0.0	90.6	See note 1	No	
Spotted ray	347.1	307.1	0.0	307.1	0.0	0.0	307.1	0.0	307.1	See note 1	No	
Sprat (European)	4337.5	4337.5	0.0	4337.5	2735.9	608.4	6465.0	608.4	6465.0		No	

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Squid (other, nei)	968.8	485.1	0.0	485.1	107.1	656.3	-64.1	485.1	107.1	Assume exports = UK production	No	
Starry ray	0.5	0.5	0.0	0.5	0.0	0.0	0.5	0.0	0.5	See note 1	No	
Surimi	0.0	0.0	0.0	0.0	10344.4	221.3	10123.1	221.3	10123.1		No	
Surmullet	644.4	644.4	0.0	644.4	0.0	0.0	644.4	0.0	644.4	See note 1	No	
Tadpole codling	10.4	10.4	0.0	10.4	0.0	0.0	10.4	0.0	10.4	See note 1	No	
Thornback ray	1366.0	1208.7	0.0	1208.7	0.0	0.0	1208.7	0.0	1208.7	See note 1	No	
Thresher sharks nei	0.6	0.6	0.0	0.6	0.0	0.0	0.6	0.0	0.6	See note 1	No	
Tilapia	0.0	0.0	0.0	0.0	3854.2	72.6	3781.6	72.6	3781.6		No	
Toothfish nei	0.0	0.0	0.0	0.0	74.8	180.2	-105.4	74.8	0.0	Assume exports = imports	No	
Tope shark	15.6	15.6	0.0	15.6	0.0	0.0	15.6	0.0	15.6	See note 1	No	
Triggerfishes, durgons nei	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	See note 1	No	
Tub gurnard	302.1	302.1	0.0	302.1	0.0	0.0	302.1	0.0	302.1	See note 1	No	
Tuna (Atlantic bluefin)	0.0	0.0	0.0	0.0	70.5	0.0	70.5	0.0	70.5	See note 1	No	
Tuna (Bigeye)	1.2	1.2	0.0	1.2	68.1	37.0	32.3	37.0	32.3		No	
Tuna (Pacific bluefin)	0.0	0.0	0.0	0.0	0.1	14.8	-14.7	0.1	0.0	Assume exports = imports	No	
Turbot	800.1	500.1	0.0	500.1	152.3	352.6	299.8	352.6	299.8		No	
Tusk(=Cusk)	142.3	142.3	0.0	142.3	0.0	0.0	142.3	0.0	142.3	See note 1	No	
Undulate ray	63.6	56.3	0.0	56.3	0.0	0.0	56.3	0.0	56.3	See note 1	No	
Velvet belly	6.8	6.8	0.0	6.8	0.0	0.0	6.8	0.0	6.8	See note 1	No	
Wahoo	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	See note 1	No	
Weeverfishes nei	0.3	0.3	0.0	0.3	0.0	0.0	0.3	0.0	0.3	See note 1	No	
Whelks	20336.1	20136.1	0.0	20136.1	0.0	5429.3	14706.8	5429.3	14706.8		No	
White skate	2.5	2.2	0.0	2.2	0.0	0.0	2.2	0.0	2.2	See note 1	No	

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Whiting	12885.1	12485.1	0.0	12485.1	823.5	2683.2	10625.5	2683.2	10625.5		No	
Witch flounder	1257.7	957.7	0.0	957.7	0.0	0.0	957.7	0.0	957.7	See note 1	No	
Wrasses, hogfishes, etc. nei	22.1	22.1	0.0	22.1	0.0	0.0	22.1	0.0	22.1	See note 1	No	
Wreckfish	2.0	2.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	See note 1	No	
Anglerfishes nei	17667.1	14367.1	0.0	14367.1	1520.9	3835.5	12052.4	3835.5	12052.4		Yes	Whitefish
Catfish (inc. Pangasius)	0.0	0.0	0.0	0.0	15165.1	616.1	14549.0	616.1	14549.0		Yes	Farmed whitefish
Cod (Atlantic)	28999.4	21999.4	0.0	21999.4	99116.3	8440.2	112675.5	8440.2	112675.5		Yes	Whitefish
Cod (Pacific)	0.0	0.0	0.0	0.0	5158.8	3294.1	1864.7	**0.0**	**5158.8**	Assume exports = UK production	Yes	Whitefish
Crabs (other, nei)	3155.0	2703.7	0.0	2703.7	2090.7	2929.6	1864.8	**2703.7**	2090.7	inc. production of Velvet swimcrab, Spinous spider crab, Green crab, Red crab	Yes	Crustaceans
Edible crab	31837.4	27288.2	0.0	27288.2	760.6	13207.2	14841.6	13207.2	14841.6		Yes	Crustaceans
European plaice	9765.7	3865.7	0.0	3865.7	2212.4	1782.0	4296.1	1782.0	4296.1		Yes	Flatfish
Haddock (Atlantic)	33752.4	33352.4	0.0	33352.4	49933.8	1918.5	81367.7	1918.5	81367.7		Yes	Whitefish
Herring (Atlantic, Pacific)	75458.8	34758.8	0.0	34758.8	5386.4	34121.0	6024.1	34121.0	6024.1	Inc. nei	Yes	Small pelagic
Lobster (Homarus spp.)	3349.1	3349.1	0.0	3349.1	1971.3	2171.5	3149.0	2171.5	3149.0		Yes	Crustaceans
Mackerel (Atlantic, Pacific)	152146.9	61546.9	0.0	61546.9	18888.6	61288.5	19147.0	61288.5	19147.0	Inc. Atlantic, Pacific, Pacific chub	Yes	Small pelagic
Mussels (Mytilus spp.)	104.4	104.4	14247.0	14351.4	4547.5	3418.1	15480.8	3418.1	15480.8		Yes	Molluscs
Mussels (Perna spp.)	0.0	0.0	0.0	0.0	663.2	18.2	645.0	18.2	645.0		Yes	Molluscs
Norway lobster	34519.5	33919.5	0.0	33919.5	2176.5	13149.9	22946.0	13149.9	22946.0		Yes	Crustaceans
Pollack (Alaskan)	0.0	0.0	0.0	0.0	39220.4	1464.3	37756.1	1464.3	37756.1		Yes	Whitefish
Pollack (European)	1533.8	1333.8	0.0	1333.8	432.6	789.1	977.3	789.1	977.3		Yes	Whitefish

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Saithe(=Pollock)	15292.7	12892.7	0.0	12892.7	1807.9	7311.5	7389.1	7311.5	7389.1		Yes	Whitefish
Salmon (Atlantic)	0.0	0.0	156025.0	156025.0	81571.9	117273.7	120323.2	117273.7	120323.2	Inc. Danube salmon imports / exports	Yes	Salmonids
Salmon (Pacific)	0.0	0.0	0.0	0.0	17906.0	6229.4	11676.6	6229.4	11676.6		Yes	Salmonids
Sardines (European pilchard, other)	7053.3	6953.3	0.0	6953.3	13149.5	6938.6	13164.2	6938.6	13164.2		Yes	Small pelagic
Scallops	29179.3	28179.3	5.0	28184.3	1144.4	6827.0	22501.8	6827.0	22501.8	inc. King Scallop	Yes	Molluscs
Sea bream	0.0	0.0	0.0	0.0	3835.7	397.9	3437.8	397.9	3437.8		Yes	Farmed whitefish
Seabass (European)	412.2	412.2	0.0	412.2	7538.6	298.6	7652.2	298.6	7652.2		Yes	Farmed whitefish
Prawns (cold-water)	713.9	413.9	0.0	413.9	20822.7	8162.2	13074.4	**0.0**	**21236.6**	Assume some UK production is re-imported (processed in EU). Therefore assume consumption = UK production (recorded) + imports	Yes	Crustaceans
Prawns (warm-water)	0.0	0.0	0.0	0.0	56298.3	2563.0	53735.3	2563.0	53735.3		Yes	Crustaceans
Sole	1766.9	1566.9	0.0	1566.9	386.4	1096.9	856.3	1096.9	856.3		Yes	Flatfish
Squid (Illex spp.)	175.6	88.0	0.0	88.0	1940.6	118.5	1910.1	**88.0**	**1940.6**	Assume exports = UK production	Yes	Molluscs
Squid (Loligo spp.)	6266.8	3138.1	0.0	3138.1	1467.0	2679.1	1926.1	2679.1	1926.1		Yes	Molluscs
Swordfish	340.5	340.5	0.0	340.5	494.3	476.5	358.3	**340.5**	**494.3**	Assume exports = UK production	Yes	Large pelagic
Trout (Rainbow, Sea, other)	2.6	2.6	12078.0	12080.6	1149.1	10807.9	2421.9	10807.9	2421.9		Yes	Salmonids
Tuna (Albacore)	1.3	1.3	0.0	1.3	1.9	10.1	**-7.0**	**1.3**	**1.9**	Assume exports = UK production	Yes	Large pelagic

Resource	UK Capture Prod. (UK & non-UK waters) (tonnes)	UK Capture Prod. (UK & non-UK waters) - UK landings only (where available) (tonnes)	UK Aquac. Prod. (tonnes)	Total UK Prod. (tonnes)	Imports (tonnes)	Exports (tonnes)	Consump. (tonnes)	Exports manually amended (tonnes)	Consumption (tonnes) - amended	Notes	Resource included in focus Commodity categories?	Commodity
Tuna (Skipjack)	0.0	0.0	0.0	0.0	100026.1	4107.9	95918.2	4107.9	95918.2		Yes	Large pelagic
Tuna (Yellowfin)	14.2	14.2	0.0	14.2	8697.9	444.8	8267.3	**14.2**	**8697.9**	Assume exports = UK production	Yes	Large pelagic
TOTAL	**621885.9**	**395585.2**	**184602.7**	**580188.0**	**719349.5**	**451881.4**	**847656.1**	**412635.6**	**886901.8**			

Note 1 - Production volume may fall under generic code for exports e.g. 'Fish (other, nei)' or 'Below threshold trade'

Appendix 3 – Case Study – ETP Species Interaction List

Appendix 3 lists a total of 528 species of ETP that are at risk interacting with fisheries and farms associated with the UK's global seafood supply chains, and 253 (highlighted in green) of these have recorded interactions. The UK ETP Interaction column indicates that at least 57 ETP species had records of interaction with fisheries and fish farms in the UK.

	Common name	Scientific name	UK ETP Interaction	Group
1	Abbott's booby	*Papasula abbotti*		Bird
2	Acadian redfish	*Sebastes fasciatus*		Non cartilaginous (bony) fish
3	Albino chambered nautilus	*Nautilus pompili*		Mollusc
4	Allis shad	*Alosa alosa*	X	Non cartilaginous (bony) fish
5	Amboina box turtle	*Cuora amboinensis*		Reptile
6	American crocodile	*Crocodylus acutus*		Reptile
7	American eel	*Anguilla rostrata*		Non cartilaginous (bony) fish
8	American plaice	*Hippoglossoides platessoides*		Non cartilaginous (bony) fish
9	Ancient murrelet	*Synthiboramphus antiques*		Bird
10	Angelshark	*Squatina squatina*	X	Cartilaginous fish (sharks and rays)
11	Angular roughshark	*Oxynotus centrina*		Cartilaginous fish (sharks and rays)
12	Arctic char	*Salvelinus alpinus*		Non cartilaginous (bony) fish
13	Arctic tern	*Sterna paradisaea*		Bird
14	Arthritic spider conch	*Lambis chiragra arthritica*		Mollusc
15	Asian arowana	*Scleropages formosus*		Non cartilaginous (bony) fish
16	Asian openbill	*Anastomus oscitans*		Bird
17	Asian small-clawed otter	*Aonyx cinerea*		Terrestrial mammal
18	Asiatic softshell turtle	*Amyda cartilaginea*		Reptile
19	Atlantic bluefin tuna	*Thunnus thynnus*		Non cartilaginous (bony) fish
20	Atlantic cod	*Gadus morhua*		Non cartilaginous (bony) fish
21	Atlantic halibut	*Hippoglossus hippoglossus*	X	Non cartilaginous (bony) fish
22	Atlantic puffin	*Fratercula arctica*		Bird
23	Atlantic salmon	*Salmo salar*		Non cartilaginous (bony) fish
24	Atlantic sturgeon	*Acipenser oxyrinchus*	X	Non cartilaginous (bony) fish
25	Atlantic torpedo	*Tetronarce nobiliana*	X	Cartilaginous fish (sharks and rays)
26	Atlantic wolffish	*Anarhichas lupus*		Non cartilaginous (bony) fish
27	Audouinâ's gull	*Larus audouinii*		Bird
28	Australian humpback dolphin	*Sousa sahulensis*		Aquatic mammal
29	Australian snubfin dolphin	*Orcaella heinsohni*		Aquatic mammal
30	Bairdi tanner crab	*Chionoecetes bairdi*		Arthropod
31	Balearic shearwater	*Puffinus mauretanicus*		Bird
32	Baltic ringed seal	*Phoca hispida botnica*		Aquatic mammal

	Common name	Scientific name	UK ETP Interaction	Group
33	Banded krait	*Bungarus fasciatus*		Reptile
34	Banna caecilian	*Ichthyophis bannanicus*		Amphibian
35	Barnacle goose	*Branta leucopsis*		Bird
36	Barolo shearwater	*Puffinus baroli*		Bird
37	Bar-tailed godwit	*Limosa lapponica*		Bird
38	Basking shark	*Cetorhinus maximus*	X	Cartilaginous fish (sharks and rays)
39	Bats Chiroptera several species	***Bats Chiroptera several species***		Terrestrial mammal
40	Bearded seal	*Erignathus barbatus*		Aquatic mammal
41	Beluga whale	*Delphinapterus leucas*		Aquatic mammal
42	Bengal Cone	*Conus bengalensis*		Mollusc
43	Bengal florican	*Houbaropsis bengalensis*		Bird
44	Bentfin devil ray	*Mobula thurstoni*		Cartilaginous fish (sharks and rays)
45	Bermuda petrel	*Pterodroma cahow*		Bird
46	Bewick swan	*Cygnus columbianus bewickii*		Bird
47	Bicolored conebill	*Conirostrum bicolor*		Bird
48	Bigeye thresher shark	*Alopias superciliosus*		Cartilaginous fish (sharks and rays)
49	Bigeye tuna	*Thunnus obesus*		Non cartilaginous (bony) fish
50	Birdbeak dogfish	*Deania calcea*	X	Cartilaginous fish (sharks and rays)
51	Black guillemot	*Cepphus grylle*		Bird
52	Black marsh turtle	*Siebenrockiella crassicollis*		Reptile
53	Black seabream	*Spondyliosoma cantharus*		Non cartilaginous (bony) fish
54	Black sharkminnow	*Morulius chrysophekadion*		Non cartilaginous (bony) fish
55	Black tern	*Chlidonias niger*		Bird
56	Black turtle	*Chelonia mydas agassizii*		Reptile
57	Black-faced spoonbill	*Platalea minor*		Bird
58	Black-footed albatross	*Phoebastria nigripes*		Bird
59	Black-handed spider monkey	*Ateles geoffroyi*		Terrestrial mammal
60	Black-headed gull	*Chroicocephalus ridibundus*		Bird
61	Black-headed ibis	*Threskiornis melanocephalus*		Bird
62	Black-legged kittiwake	*Rissa tridactyla*		Bird
63	Blackmouth catshark	*Galeus melastomus*	X	Cartilaginous fish (sharks and rays)
64	Black-necked swan	*Cygnus melancoryphus*		Bird
65	Blackskin catfish	*Clarias meladerma*		Non cartilaginous (bony) fish
66	Blackspotted smooth-hound	*Mustelus punctulatus*		Cartilaginous fish (sharks and rays)
67	Black-tailed godwit	*Limosa islandica*		Bird
68	Black-throated diver	*Gavia arctica*		Bird
69	Blainville’s beaked whale	*Mesoplodon densirostris*		Aquatic mammal
70	Blonde ray	*Raja brachyura*	X	Cartilaginous fish (sharks and rays)

	Common name	Scientific name	UK ETP Interaction	Group
71	Blue king crab	*Paralithodes platypus*		Arthropod
72	Blue ling	*Molva dypterygia*		Non cartilaginous (bony) fish
73	Blue shark	*Prionace glauca*	X	Cartilaginous fish (sharks and rays)
74	Blue skate	*Dipturus flossada*	X	Cartilaginous fish (sharks and rays)
75	Blue whale	*Balaenoptera musculus*		Aquatic mammal
76	Bluefish	*Pomatomus saltatrix*		Non cartilaginous (bony) fish
77	Bluntnose sixgill shark	*Hexanchus griseus*	X	Cartilaginous fish (sharks and rays)
78	Boa constrictor	*Boa constrictor*		Reptile
79	Bottlenose dolphin	*Tursiops truncatus*	X	Aquatic mammal
80	Bottlenose skate	*Rostroraja alba*		Cartilaginous fish (sharks and rays)
81	Bowhead whale	*Balaena mysticetus*		Aquatic mammal
82	Brook lamprey	*Lampetra planeri*		Non cartilaginous (bony) fish
83	Brook trout	*Salvelinus fontinalis*		Non cartilaginous (bony) fish
84	Brown wood rail	*Aramides wolfi*		Bird
85	Brünnich's guillemot	*Uria lomvia*		Bird
86	Bryde's whale	*Balaenoptera brydei*		Aquatic mammal
87	Bull ray	*Aetomylaeus bovinus*		Cartilaginous fish (sharks and rays)
88	Bulwer's petrel	*Bulweria bulwerii*		Bird
89	Burmese python	*Python bivittatus*		Reptile
90	Burnt-tailed barb	*Balantiocheilos ambusticauda*		Non cartilaginous (bony) fish
91	Cape gannet	*Morus capensis*		Bird
92	Cape petrel	*Daption capense*		Bird
93	Carnelian cowry	*Cypraea carneola*		Mollusc
94	Caspian tern	*Hydroprogne caspia*		Bird
95	Cassin's auklet	*Ptychoramphus aleuticus*		Bird
96	Ceylon caecilian	*Ichthyophis glutinosus*		Amphibian
97	Chank shell	*Xancus pyrum*		Mollusc
98	Chilean devil ray	*Mobula tarapacana*		Cartilaginous fish (sharks and rays)
99	Chilean dolphin	*Cephalorhynchus eutropia*		Aquatic mammal
100	Chinese egret	*Egretta eulophotes*		Bird
101	Chinese ratsnake	*Ptyas korros*		Reptile
102	Chinook salmon	*Oncorhynchus tshawytscha*		Non cartilaginous (bony) fish
103	Chiragra spider conch	*Lambis chiragra*		Mollusc
104	Christmas frigatebird	*Fregata andrewsi*		Bird
105	Chum salmon	*Oncorhynchus keta*		Non cartilaginous (bony) fish
106	Cinereous vulture	*Aegypius monachus*		Bird
107	Clown featherback	*Chitala ornata*		Non cartilaginous (bony) fish
108	Coho salmon	*Oncorhynchus kisutch*		Non cartilaginous (bony) fish

	Common name	Scientific name	UK ETP Interaction	Group
109	Colombian white-faced capuchin	*Cebus capuchinus*		Terrestrial mammal
110	Commercial top shell	*Trochus niloticus*		Mollusc
111	Commerson's dolphin	***Cephalorhynchus commersonii***		Aquatic mammal
112	Common archerfish	*Toxotes chatareus*		Non cartilaginous (bony) fish
113	Common black hawk	*Buteogallus anthracinus*		Bird
114	Common dolphin	*Delphinus delphis*	X	Aquatic mammal
115	Common eagle ray	*Myliobatis aquila*		Cartilaginous fish (sharks and rays)
116	Common eider	*Somateria mollissima*	X	Bird
117	Common Goldeneye	*Bucephala clangula*		Bird
118	Common guillemot	*Uria aalge*	X	Bird
119	Common guitarfish	*Rhinobatos rhinobatos*		Non cartilaginous (bony) fish
120	Common gull	*Larus canus*		Bird
121	Common Kingfisher	*Alcedo atthis*		Bird
122	Common loon	*Gavia immer*		Bird
123	Common merganser	*Mergus merganser*		Bird
124	Common pochard	*Aythya ferina*		Bird
125	Common Scoter	*Melanitta nigra*		Bird
126	Common seahorse	*Hippocampus kuda*		Non cartilaginous (bony) fish
127	Common shelduck	*Tadorna tadorna*		Bird
128	Common skate	*Dipturus batis*	X	Cartilaginous fish (sharks and rays)
129	Common smoothhound	*Mustelus mustelus*	X	Cartilaginous fish (sharks and rays)
130	Common stingray	*Dasyatis pastinaca*	X	Cartilaginous fish (sharks and rays)
131	Common tern	*Sterna hirundo*		Bird
132	Common thresher shark	*Alopias vulpinus*	X	Cartilaginous fish (sharks and rays)
133	Coral Hind Thabuwa	*Cephalopholis sonnerati*		Non cartilaginous (bony) fish
134	Cory's shearwater	*Calonectris borealis*		Bird
135	Cosmochilus harmandis	*Cosmochilus harmandis*		Non cartilaginous (bony) fish
136	Cotton pygmy goose	*Nettapus coromandelianus*		Bird
137	Couch's goby	*Gobius couchi*		Non cartilaginous (bony) fish
138	Crab	*Sesarma mederi*		Arthropod
139	Crab-eating macaque	*Macaca fascicularis*		Terrestrial mammal
140	Crested caracara	*Polyborus plancus*		Bird
141	Cusk	*Brosme brosme*		Non cartilaginous (bony) fish
142	Cuvier's beaked whale	*Ziphius cavirostris*		Aquatic mammal
143	Dall's porpoise	*Phocoenoides dalli*		Aquatic mammal
144	Darwin's fox	*Lycalopex fulvipes*		Terrestrial mammal
145	Date mussel	*Lithophaga lithophaga*		Mollusc
146	Deepwater redfish	*Sebastes mentella*		Non cartilaginous (bony) fish

	Common name	Scientific name	UK ETP Interaction	Group
147	Desertas petrel	*Pterodroma deserta*		Bird
148	Devil fish	*Mobula mobular*		Non cartilaginous (bony) fish
149	Dog whelk	*Nucella lapillus*		Mollusc
150	Dugong	*Dugong dugon*		Aquatic mammal
151	Dusky dolphin	*Lagenorhynchus obscurus*		Aquatic mammal
152	Dusky shark	*Carcharinhus obscurus*		Cartilaginous fish (sharks and rays)
153	Dwarf sawfish	*Pristis clavata*		Cartilaginous fish (sharks and rays)
154	Dwarf sperm whale	*Kogia sima*		Aquatic mammal
155	Eastern grass owl	*Tyto longimembris chinensis*		Bird
156	Ecuadorian mantled howler	*Alouata palliata aequatorials*		Terrestrial mammal
157	Eden's whale	*Balaenoptera edeni*		Aquatic mammal
158	Elegant tern	*Thalasseus elegans*		Bird
159	Episcopal miter	*Mitra mitra*		Mollusc
160	Eurasian coot	*Fulica atra*		Bird
161	Eurasian curlew	*Numenius arquata*		Bird
162	Eurasian Golden Plover	*Pluvialis apricaria*		Bird
163	Eurasian marsh harrier	*Circus aeruginosus*		Bird
164	Eurasian otter	*Lutra lutra*		Aquatic mammal
165	European badger	*Meles meles*		Terrestrial mammal
166	European eel	*Anguilla anguilla*	**X**	Non cartilaginous (bony) fish
167	European flat oyster	*Ostrea edulis*		Mollusc
168	European herring gull	*Larus argentatus*	**X**	Bird
169	European sea sturgeon	*Acipenser sturio*		Non cartilaginous (bony) fish
170	European shag	*Phalacrocorax aristotelis*		Bird
171	European storm petrel	*Hydrobates pelagicus*		Bird
172	Eyed cowry	*Cypraea argus*		Mollusc
173	False killer whale	*Pseudorca crassidens*		Aquatic mammal
174	Fan mussel	*Atrina fragilis*		Mollusc
175	Fin whale	*Balaenoptera physalus*		Aquatic mammal
176	Fishing cat	*Prionailurus viverrinus*		Terrestrial mammal
177	Flapper skate	*Dipturus intermedia*	**X**	Cartilaginous fish (sharks and rays)
178	Flatback turtle	*Natator depressus*		Reptile
179	Flathead grey mullet	*Mugil cephalus*		Non cartilaginous (bony) fish
180	Fluted giant clam	*Tridacna squamosa*		Mollusc
181	Forest snakehead	*Channa lucius*		Non cartilaginous (bony) fish
182	Frilled shark	*Chlamydoselachus anguineus*	**X**	Cartilaginous fish (sharks and rays)
183	Distaff spindle	*Fusinus longicaudus*		Mollusc
184	Gadwall	*Anas strepera*		Bird
185	Geography cone	*Conus geographus*		Mollusc

	Common name	Scientific name	UK ETP Interaction	Group
186	Giant barb	*Catlocarpio siamensis*		Non cartilaginous (bony) fish
187	Giant goby	*Gobius cobitis*		Non cartilaginous (bony) fish
188	Giant limpet	*Patella ferruginea*		Mollusc
189	Giant manta ray	*Mobula birostris*		Cartilaginous fish (sharks and rays)
190	Giant mudskipper	*Periophthalmodon schlosser*		Non cartilaginous (bony) fish
191	Giant pangasius	*Pangasius sanitwongsei*		Non cartilaginous (bony) fish
192	Giant snakehead	*Ophiocephalus micropeltes*		Non cartilaginous (bony) fish
193	Giant spider conch	*Lambis truncata*		Mollusc
194	Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*		Aquatic mammal
195	Glaucous gull	*Larus hyperboreus*		Bird
196	Glory of India	*Conus milneedwardsi*		Mollusc
197	Golden eagle	*Aquila chrysaetos*		Bird
198	Golden king crab	*Lithodes aequispinus*		Arthropod
199	Golden redfish	*Sebastes norvegicus*		Non cartilaginous (bony) fish
200	Grey seal	*Halichoerus grypus*	X	Aquatic mammal
201	Grey whale	*Eschrichtius robustus*		Aquatic mammal
202	Great auk	*Pinguinus impennis*		Bird
203	Great bittern	*Botaurus stellaris*		Bird
204	Great black-backed gull	*Larus marinus*		Bird
205	Great cormorant	*Phalacrocorax carbo*	X	Bird
206	Great egret	*Ardea alba*		Bird
207	Great hammerhead shark	*Sphyrna mokarran*		Cartilaginous fish (sharks and rays)
208	Great lanternshark	*Etmopterus princeps*		Cartilaginous fish (sharks and rays)
209	Great Seahorse	*Hippocampus kelloggi*		Non cartilaginous (bony) fish
210	Great shearwater	*Puffinus gravis*		Bird
211	Great skua	*Stercorarius skua*		Bird
212	Great white shark	*Carcharodon carcharias*		Cartilaginous fish (sharks and rays)
213	Great-crested grebe	*Podiceps cristatus*		Bird
214	Greater adjutant	*Leptoptilos dubius*		Bird
215	Greater long-tailed bat	*Choeroniscus periosus*		Terrestrial mammal
216	Greater Scaup	*Aythya marila*		Bird
217	Green Iguana	*Iguana iguana*		Reptile
218	Green sawfish	*Pristis zijsron*		Cartilaginous fish (sharks and rays)
219	Green sturgeon	*Acipenser medirostris*		Non cartilaginous (bony) fish
220	Green Turtle	*Chelonia mydas*		Reptile
221	Greenland halibut	*Reinhardtius hippoglossoides*		Non cartilaginous (bony) fish
222	Greenland shark	*Somniosus microcephalus*	X	Cartilaginous fish (sharks and rays)
223	Grey Heron	*Ardea cinerea*		Bird

	Common name	Scientific name	UK ETP Interaction	Group
224	Grey plover	*Pluvialis squatarola*		Bird
225	Grey-cheeked parakeet	*Brotogeris pyrrhoptera*		Bird
226	Grey-headed albatross	*Thalassarche chrysostoma*		Bird
227	Gulper shark	*Centrophorus granulosus*		Cartilaginous fish (sharks and rays)
228	Gyrfalcon	*Falco rusticolus*		Bird
229	Hairy triton	*Cymatium pileare*		Mollusc
230	Hall's giant petrel	*Macronectes halli*		Bird
231	Harbour porpoise	*Phocoena phocoena*	X	Aquatic mammal
232	Harbour seal	*Phoca vitulina*	X	Aquatic mammal
233	Harbour seal	*Phoca vitulina concolor*		Aquatic mammal
234	Harbour seal	*Phoca vitulina richardsi*		Aquatic mammal
235	Harp seal	*Pagophilus groenlandicus*		Aquatic mammal
236	Harris's hawk	*Parabuteo unicinctus*		Bird
237	Hawksbill turtle	*Eretmochelys imbricata*		Reptile
238	Heart cockle	*Glossus humanus*		Mollusc
239	Hedgehog Seahorse	*Hippocampus spinosissimus*		Non cartilaginous (bony) fish
240	Hooded Seal	*Cystophora cristata*		Aquatic mammal
241	Horned Grebe	*Podiceps auritus*		Bird
242	Horned helmet	*Cassis cornuta*		Mollusc
243	Horse hoof clam	*Hippopus hippopus*		Mollusc
244	Houting	*Coregonus oxyrinchus*		Non cartilaginous (bony) fish
245	Hudsonian godwit	*Limosa haemastica*		Bird
246	Humpback cowry	*Cypraea mauritiana*		Mollusc
247	Humpback whale	*Megaptera novaeangliae*		Aquatic mammal
248	Iceland gull	*Larus glaucoides*		Bird
249	Indian cobra	*Naja naja*		Reptile
250	Indian featherback	*Notopterus chitala*		Non cartilaginous (bony) fish
251	Indian python	*Python molurus*		Reptile
252	Indian yellow-nosed albatross	*Thalassarche carteri*		Bird
253	Indochinese spitting cobra	*Naja siemensis*		Reptile
254	Indo-Pacific bottlenose dolphin	*Tursiops aduncus*		Aquatic mammal
255	Indo-Pacific finless porpoise	*Neophocaena phocaenoides*		Aquatic mammal
256	Indo-pacific humpback dolphin	*Sousa chinensis*		Aquatic mammal
257	Irrawaddy dolphin	*Orcaella brevirostris*		Aquatic mammal
258	Ivory gull	*Pagophila eburnea*		Bird
259	Japanese horseshoe crab	*Tachypleus tridentatus*		Arthropod
260	Japanese Sea Horse	*Hippocampus mohnikei*		Non cartilaginous (bony) fish
261	Jullien's golden carp	*Probarbus jullieni*		Non cartilaginous (bony) fish
262	Kemp's ridley turtle	*Lepidochelys kempii*		Reptile
263	Killer whale	*Ocrinus orca*		Aquatic mammal

	Common name	Scientific name	UK ETP Interaction	Group
264	Killifish	*Killifish*		Non cartilaginous (bony) fish
265	King cobra	*Ophiophagus hannah*		Reptile
266	King eider	*Somateria spectabilis*		Bird
267	Kinkajou	*Potos flavus*		Terrestrial mammal
268	Kitefin shark	*Dalatias licha*	X	Cartilaginous fish (sharks and rays)
269	Knifetooth sawfish	*Anoxypristis cuspidata*		Cartilaginous fish (sharks and rays)
270	Kuril habour seal	*Phoca vitulina stejnegeri*		Aquatic mammal
271	Lambis cricea	*Lambis cricea*		Mollusc
272	Largetooth sawfish	*Pristis pristis*		Cartilaginous fish (sharks and rays)
273	Lavaret	*Coregonus lavaretus*		Non cartilaginous (bony) fish
274	Laysan albatross	*Phoebastria immutabilis*		Bird
275	Leach's Storm-petrel	*Hydrobates leucorhous*		Bird
276	Leafscale gupler shark	*Centrophorus squamosus*		Cartilaginous fish (sharks and rays)
277	Leaping mullet	*Liza saliens*		Non cartilaginous (bony) fish
278	Leatherback turtle	*Dermochelys coriacea*		Reptile
279	Lesser adjutant	*Leptoptilos javanicus*		Bird
280	Lesser black-backed gull	*Larus fuscus*		Bird
281	Lesser devil ray	*Mobula hypostoma*		Cartilaginous fish (sharks and rays)
282	Lesser Guinean devil ray	*Mobula rochebrunei*		Cartilaginous fish (sharks and rays)
283	Lesser-spotted dogfish	*Scyliorhinus canicula*		Cartilaginous fish (sharks and rays)
284	Lister's conch	*Strombus listeris*		Mollusc
285	Little auk	*Alle alle*		Bird
286	Little egret	*Egreta garzetta*		Bird
287	Little gull	*Hydrocoloeus minutus*		Bird
288	Little tern	*Sternula albifrons*		Bird
289	Loggerhead turtle	*Caretta caretta*		Reptile
290	Long finned pilot whale	*Globicephala melas*	X	Aquatic mammal
291	Long snouted sea horse	*Hippocampus guttulatus*		Non cartilaginous (bony) fish
292	Long-beaked common dolphin	*Delphinus capensis*		Aquatic mammal
293	Longfin mako shark	*Isurus paucus*		Cartilaginous fish (sharks and rays)
294	Longhorned mobula	*Mobula eregoodootenkee*		Cartilaginous fish (sharks and rays)
295	Longnosed skate	*Dipturus oxyrinchus*	X	Cartilaginous fish (sharks and rays)
296	Long-tailed duck	*Clangula hyemalis*		Bird
297	Long-tailed jaeger	*Stercorarius longicaudus*		Bird
298	Long-wattled umbrellabird	*Cephalopterus penduliger*		Bird
299	Madeiran storm petrel	*Oceanodroma castro*		Bird
300	Mallard	*Anas platyrhynchos*		Bird
301	Mangrove hummingbird	*Amazilia boucardi*		Bird

	Common name	Scientific name	UK ETP Interaction	Group
302	Manx shearwater	*Puffinus puffinus*		Bird
303	Map cowry	*Cypraea mappa*		Mollusc
304	Marbled Cone	*Conus marmoreus*		Mollusc
305	Marbled electric ray	*Torpedo marmorata*	X	Cartilaginous fish (sharks and rays)
306	Marbled murrelet	*Brachyramphus marmoratus*		Bird
307	Margay	*Leopardus wiedii*		Terrestrial mammal
308	Maxima clam	*Tridacna maxima*		Mollusc
309	Meadow pipit	*Anthus pratensis*		Bird
310	Mediterranean gull	*Ichthyaetus melanocephalus*		Bird
311	Mediterranean monk seal	*Monachus monachus*		Aquatic mammal
312	Mekong giant catfish	*Pangasianodon gigas*		Non cartilaginous (bony) fish
313	Mekong snail-eating turtle	*Malayemys subtrijuga*		Reptile
314	Melon-headed whale	*Peponocephala electra*		Aquatic mammal
315	Milky stork	*Mycteria cinerea*		Bird
316	Millipede spider conch	*Lambis millepeda*		Mollusc
317	Minke whale	*Balaenoptera acutorostrata*		Aquatic mammal
318	Mole cowry	*Cypraea talpa*		Mollusc
319	Monocled cobra	*Naja kaouthia*		Reptile
320	Montagu's harrier	*Circus pygargus*		Bird
321	Monteiro's storm petrel	*Hydrobates monteiroi*		Bird
322	Moor frog	*Rana arvalis*		Amphibian
323	Mourning gecko	*Lepidodactylus lugubris*		Reptile
324	Mud Snail	*Omphiscola glabra*		Mollusc
325	Munk’s devil ray	*Mobula munkiana*		Cartilaginous fish (sharks and rays)
326	Murex haustellum	*Murex haustellum*		Mollusc
327	Murex palmorosae	*Murex palmorosae*		Mollusc
328	Narrow-footed bristly mouse	*Neacomys tenuipes*		Terrestrial mammal
329	Narwhal	*Monodon monoceros*		Aquatic mammal
330	Neotropical Cormorant	*Phalacrocorax brasilianum*		Bird
331	Noble cone	*Conus nobilis*		Mollusc
332	North Altantic right whale	*Eubalaena glacialis*		Aquatic mammal
333	North Pacific Right Whale	*Eubalaena japonica*		Aquatic mammal
334	Northern Bottlenose Whale	*Hyperoodon ampullatus*		Aquatic mammal
335	Northern crested newt	*Triturus cristatus*		Amphibian
336	Northern elephant seal	*Mirounga angustirostris*		Aquatic mammal
337	Northern fulmar	*Fulmarus glacialis*	X	Bird
338	Northern fur seal	*Callorhinus ursinus*		Aquatic mammal
339	Northern gannet	*Morus bassanus*	X	Bird
340	Northern pig-tailed macaque	*Macaca leonina*		Terrestrial mammal

	Common name	Scientific name	UK ETP Interaction	Group
341	Northern royal albatross	*Diomedea sanfordi*		Bird
342	Northern wolffish	*Anarhichas denticulatus*		Non cartilaginous (bony) fish
343	Norwegian skate	*Dipturus nidarosiensis*	X	Cartilaginous fish (sharks and rays)
344	Nursehound	*Scyliorhinus stellaris*	X	Cartilaginous fish (sharks and rays)
345	Ocean quahog	*Arctica islandica*		Mollusc
346	Oceanic whitetip shark	*Carcharhinus longimanus*		Cartilaginous fish (sharks and rays)
347	Ocelot (cat)	*Leopardus pardalis*		Terrestrial mammal
348	Olive ridley sea turtle	*Lepidochelys olivacea*		Reptile
349	Olive Ridley Turtle	*Lepidochelys olivacea*		Reptile
350	Olive-throated parakeet	*Aratinga nana*		Bird
351	Oncilla	*Leopardus tigrinus*		Terrestrial mammal
352	Onyx cowry	*Cypraea onyx*		Mollusc
353	Orange roughy	*Hoplostethus atlanticus*		Non cartilaginous (bony) fish
354	Orange-chinned parakeet	*Brotogeris jugularis*		Bird
355	Oriental darter	*Anhinga melanogaster*		Bird
356	Oriental ratsnake	*Ptyas mucosus*		Reptile
357	Osprey	*Pandion haliaetus*		Bird
358	Oystercatcher	*Haematopus ostralegus*		Bird
359	Pacific halibut	*Hippoglossus stenolepis*		Non cartilaginous (bony) fish
360	Pacific herring	*Clupea pallasii*		Non cartilaginous (bony) fish
361	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*		Aquatic mammal
362	Painted stork	*Mycteria leucocephala*		Bird
363	Pale ray	*Dipturus linteus*	X	Cartilaginous fish (sharks and rays)
364	Pale-bellied brent goose	*Branta bernicla hrota*		Bird
365	Pallid dove	*Leptotila pallida*		Bird
366	Pantropical spotted dolphin	*Stenella attenuata*		Aquatic mammal
367	Papal mitre	*Mitra papalis*		Mollusc
368	Parasitic jaeger	*Stercorarius parasiticus*		Bird
369	Pearl oyster	*Pteria brevilata*		Mollusc
370	Pelagic stingray	*Pteroplatytrygon violacea*		Cartilaginous fish (sharks and rays)
371	Pelagic thresher shark	*Alopias pelagicus*		Cartilaginous fish (sharks and rays)
372	Peruvian pelican	*Pelicans thagus*		Bird
373	Pink-footed goose	*Anser brachyrhynchus*		Bird
374	Pintail	*Anas acuta*		Bird
375	Piter erycina	*Piter erycina*		Mollusc
376	Butter Catfish	*Ompok bimaculatus*		Non cartilaginous (bony) fish
377	Plumbeous forest falcon	*Micrastur plumbeus*		Bird
378	Polar Bear	*Ursus maritimus*		Aquatic mammal

	Common name	Scientific name	UK ETP Interaction	Group
379	Pomarine jaeger	*Stercorarius pomarinus*		Bird
380	Pondicherry shark	*Carcharhinus hemiodon*		Cartilaginous fish (sharks and rays)
381	Porbeagle	*Lamna nasus*	X	Cartilaginous fish (sharks and rays)
382	Portuguese dogfish	*Centroscymnus coelolepis*	X	Cartilaginous fish (sharks and rays)
383	Pygmy blue whale	***Balaenoptera musculus brevicauda***		Aquatic mammal
384	Pygmy killer whale	*Feresa attenuata*		Aquatic mammal
385	Pygmy sperm whale	*Kogia breviceps*		Aquatic mammal
386	Rabbit fish	*Chimaera monstrosa*		Non cartilaginous (bony) fish
387	Raccoon dog	*Nyctereutes procyonoides*		Terrestrial mammal
388	Radiated ratsnake	*Coelognathus radiata*		Reptile
389	Ramose murex	*Murex ramosus*		Mollusc
390	Razorbill	*Alca torda*		Bird
391	Red brocket	*Mazama amaericana*		Terrestrial mammal
392	Red fox	*Vulpes vulpes*		Terrestrial mammal
393	Red king crab	*Paralithodes camtschaticus*		Arthropod
394	Red Kite	*Milvus milvus*		Bird
395	Red knot	*Calidris canutus*		Bird
396	Red knot	*Calidris canutus rufa*		Bird
397	Red porgy	*Pagrus pagrus*		Non cartilaginous (bony) fish
398	Red-breasted merganser	*Mergus serrator*		Bird
399	Red-legged kittiwake	*Rissa brevirostris*		Bird
400	Red-lored amazon	*Amazona autumnalis*		Bird
401	Red-necked grebe	*Podiceps grisegena*		Bird
402	Red-necked stint	*Calidris ruficollis*		Bird
403	Red-throated diver	*Gavia stellata*	X	Bird
404	Reef manta ray	*Manta alfredi*		Cartilaginous fish (sharks and rays)
405	Rhinocerus auklet	*Cerorhinca monocerata*		Bird
406	Ribbon seal	*Histriophoca fasciata*		Aquatic mammal
407	Ringed seal	*Phoca hispida*	X	Aquatic mammal
408	Risso's dolphin	*Grampus griseus*		Aquatic mammal
409	River lamprey	*Lampetra fluviatilis*	X	Non cartilaginous (bony) fish
410	Roseate tern	*Sterna dougallii*		Bird
411	Rough-toothed dolphin	*Steno bredanensis*		Aquatic mammal
412	Rufous-headed chachalaca	*Ortalis erythroptera*		Bird
413	Sabine's gull	*Xema sabini*		Bird
414	Sabre carp	*Pelecus cultratus*		Non cartilaginous (bony) fish
415	Salema porgy	*Sarpa salpa*		Non cartilaginous (bony) fish
416	Sand tiger shark	*Carcharias taurus*		Cartilaginous fish (sharks and rays)
417	Sandwich tern	*Thalasseus sandvicensis*		Bird

	Common name	Scientific name	UK ETP Interaction	Group
418	Sandy ray	*Leucoraja circularis*	X	Cartilaginous fish (sharks and rays)
419	Sarus crane	*Grus antigone*		Bird
420	Scalloped Hammerhead shark	*Sphyrna lewini*		Cartilaginous fish (sharks and rays)
421	Scopoli's Shearwater	*Calonectris diomedea*		Bird
422	Sea lamprey	*Petromyzon marinus*	X	Cartilaginous fish (sharks and rays)
423	Sea lamprey	*Petromyzon marinus*		Non cartilaginous (bony) fish
424	Sea otter	*Enhydra lutris*		Aquatic mammal
425	Sei whale	*Balaenoptera borealis*		Aquatic mammal
426	Shagreen ray	*Leucoraja fullonica*	X	Cartilaginous fish (sharks and rays)
427	Sharpnose sevengill shark	*Heptranchias perlo*		Cartilaginous fish (sharks and rays)
428	Shortfin devil ray	*Mobula kuhlii*		Cartilaginous fish (sharks and rays)
429	Shortfin mako shark	*Isurus oxyrinchus*	X	Cartilaginous fish (sharks and rays)
430	Short-finned pilot whale	*Globicephala macrorhynchus*		Aquatic mammal
431	Shortnose sturgeon	*Acipenser brevirostrum*		Non cartilaginous (bony) fish
432	Short-snouted seahorse	*Hippocampus hippocampus*		Non cartilaginous (bony) fish
433	Short-tailed albatross	*Phoebastria albatrus*		Bird
434	Siamese crocodile	*Crocodylus siamensis*		Reptile
435	Sieve/tan and white cowry	*Cypraea cribraria*		Mollusc
436	Silky shark	*Carcharhinus falciformis*		Cartilaginous fish (sharks and rays)
437	Silver tiger perch	*Datnioides quadrifasciatus*		Non cartilaginous (bony) fish
438	Slender walking catfish	*Clarias nieuhofii*		Non cartilaginous (bony) fish
439	Slender-billed gull	*Chroicocephalus genei*		Bird
440	Slipper lobster	*Scyllarides latus*		Arthropod
441	Slug-like cowry	*Cypraea limacina*		Mollusc
442	Small-eyed ray	*Raja microocellata*	X	Cartilaginous fish (sharks and rays)
443	Smallscale mud carp	*Cirrhinus microlepis*		Non cartilaginous (bony) fish
444	Smalltooth sand shark	*Odontaspis ferox*		Cartilaginous fish (sharks and rays)
445	Smalltooth sawfish	*Pristis pectinata*		Cartilaginous fish (sharks and rays)
446	Smew	*Mergellus albellus*		Bird
447	Smooth hammerhead shark	*Sphyrna zygaena*		Cartilaginous fish (sharks and rays)
448	Smooth lanternshark	*Etmopterus pusillus*		Cartilaginous fish (sharks and rays)
449	Smooth skate	*Malacoraja senta*		Cartilaginous fish (sharks and rays)
450	Smooth-coated otter	*Lutra perspicillata*		Aquatic mammal
451	Snow crab	*Chionocetes opilio*		Arthropod
452	Sockeye salmon	*Oncorhynchus nerka*		Non cartilaginous (bony) fish
453	Sooty albatross	*Phoebetria fusca*		Bird
454	Sooty shearwater	*Puffinus griseus*		Bird

	Common name	Scientific name	UK ETP Interaction	Group
455	South American sea lion	*Otaria byronia*		Aquatic mammal
456	South American fur seal	*Arctocephalus australis*		Aquatic mammal
457	Southern New Guinea giant softshell turtle	*Pelochelys bibroni*		Reptile
458	Southern right whale	*Eubalaena australis*		Aquatic mammal
459	Southern royal albatross	*Diomedea epomophora*		Bird
460	Sowerby's Beaked Whale	*Mesoplodon bidens*		Aquatic mammal
461	Spectacled eider	*Somateria fischeri*		Bird
462	Spectacled porpoise	*Phocaena dioptrica*		Aquatic mammal
463	Specticled petrel	*Procellaria conspicillata*		Bird
464	Sperm whale	*Physeter macrocephalus*		Aquatic mammal
465	Spinetail mobula	*Mobula japanica*		Cartilaginous fish (sharks and rays)
466	Spinner dolphin	*Stenella longirostris*		Aquatic mammal
467	Spiny butterfly ray	*Gymnura altavela*		Cartilaginous fish (sharks and rays)
468	Spiny lobster	*Palinurus elephas*		Arthropod
469	Spinytail skate	*Bathyraja spinicauda*		Cartilaginous fish (sharks and rays)
470	Spotted ray	*Raja montagui*	X	Cartilaginous fish (sharks and rays)
471	Spotted Seahorse	*Hippocampus kuda*		Non cartilaginous (bony) fish
472	Spotted seal	*Phoca largha*		Aquatic mammal
473	Spotted wolffish	*Anarchicas minor*		Non cartilaginous (bony) fish
474	Spurdog	*Squalus acanthias*	X	Cartilaginous fish (sharks and rays)
475	Starry ray	*Raja asterias*		Cartilaginous fish (sharks and rays)
476	Starry smoothhound	*Mustelus asterias*	X	Cartilaginous fish (sharks and rays)
477	Steelhead Trout	*Oncorhynchus mykiss*		Non cartilaginous (bony) fish
478	Steller sea lion	*Eumetopias jubatus*		Aquatic mammal
479	Steller's eider	*Polysticta stelleri*		Bird
480	Striped dolphin	*Stenella coeruleoalba*		Aquatic mammal
481	Strombus	*plicatus sibbaldi*		Mollusc
482	Sulawesi coelacanth	*Latimeria menadoensis*		Non cartilaginous (bony) fish
483	Sunda pangolin	*Manis javanica*		Terrestrial mammal
484	Textile cone	*Conus textile*		Mollusc
485	Thicklip grey mullet	*Chalon Labrosus*		Non cartilaginous (bony) fish
486	Thornback ray	*Raja clavata*	X	Cartilaginous fish (sharks and rays)
487	Thorny skate	*Amblyraja radiata*	X	Cartilaginous fish (sharks and rays)
488	Three-Spot Seahorse	*Hippocampus trimaculatus*		Non cartilaginous (bony) fish
489	Tiger cowry	*Cypraea tigris*		Mollusc
490	Tinfoil barb	*Barbonymus schwanenfeldii*		Non cartilaginous (bony) fish
491	Tokay gecko	*Gekko gecko*		Reptile

	Common name	Scientific name	UK ETP Interaction	Group
492	Tope shark	*Galeorhinus galeus*	X	Cartilaginous fish (sharks and rays)
493	Trapezium horse conch	*Fasciolaria trapazium*		Mollusc
494	Tristan albatross	*Diomedea dabbenena*		Bird
495	Triton's trumpet	*Charonia Tritonis*		Mollusc
496	Trues Beaked Whale	*Mesoplodon mirus*		Aquatic mammal
497	Tufted Duck	*Aythya fuligula*		Bird
498	Twait shad	*Alosa fallax*	X	Non cartilaginous (bony) fish
499	Undulate ray	*Raja undulata*	X	Cartilaginous fish (sharks and rays)
500	Velvet belly lanternshark	*Etmopterus spinax*	X	Cartilaginous fish (sharks and rays)
501	Velvet scoter	*Melanitta fusca*		Bird
502	Vimba bream	*Vimba vimba*		Non cartilaginous (bony) fish
503	Walking catfish	*Clarias batrachus*		Non cartilaginous (bony) fish
504	Walrus	*Odobenus rosmarus*		Aquatic mammal
505	Wandering albatross	*Diomedea exulans*		Bird
506	Wattle-necked softshell turtle	*Palea steindachneri*		Reptile
507	Whale shark	*Rhincodon typus*		Cartilaginous fish (sharks and rays)
508	White sturgeon	*Acipenser transmontanus*		Non cartilaginous (bony) fish
509	White-beaked dolphin	*Lagenorhynchus albirostris*		Aquatic mammal
510	White-bellied sea eagle	*Haliaeetus leucogaster*		Bird
511	White-chinned petrel	*Procellaria aequinoctialis*		Bird
512	White-faced storm petrel	*Pelagodroma marina*		Bird
513	White-shouldered ibis	*Pseudibis davisoni*		Bird
514	White-Sided Dolphin	*Lagenorhynchus acutus*		Aquatic mammal
515	White-tailed eagle	*Haliaeetus albicilla*		Bird
516	White-winged duck	*Asarcornis scutulata*		Bird
517	Whooper swan	*Cygnus cygnus*		Bird
518	Winter hake	*Urophycis tenuis*		Non cartilaginous (bony) fish
519	Winter skate	*Leucoraja ocellata*		Cartilaginous fish (sharks and rays)
520	Woolly-necked stork	*Ciconia episcopus*		Bird
521	Yelkouan shearwater	*Puffinus yelkouan*		Bird
522	Yellow-billed loon	*Gavia adamsii*		Bird
523	Yellow-breasted bunting	*Emberiza aureola*		Bird
524	Yelloweye rockfish	*Sebastes ruberrimus*		Non cartilaginous (bony) fish
525	Yellow-headed temple turtle	*Hieremys annandalii*		Reptile
526	Yellow-legged gull	*Larus michahellis*		Bird
527	Yellow-nosed albatross	*Thalassarche chlororhynchos*		Bird
528	Zino's petrel	*Pterodroma madeira*		Bird

Appendix 4 – Glossary of Terms

Maximum Sustainable Yield (MSY) is a theoretical maximum yield (catch) that can be taken from a stock in the long term under constant environmental conditions when that stock is at the biomass reference point B_{MSY}.

B_{lim} is the limit biomass reference point, below which the stock has reduced reproductive capacity and an increased risk of stock collapse.

B_{MSY} is a biomass reference point which in theory represents the stock size at maximum population growth rate and therefore the biomass of a stock at which it could deliver its MSY.

Fishing mortality (F) is a parameter used in fisheries population dynamics (which forms the basis of stock assessments) to account for the rate of loss of organisms from a population due to removals associated with fishing.

F_{lim} is the fishing mortality which will result in an average stock size of B_{lim} in the long term.

F_{MSY} is the fishing mortality rate that should, on average (all other things being equal) lead to a stock reaching B_{MSY}.

$B_{trigger}$ is a biomass reference point defined as the parameter in the ICES advice framework which triggers a more cautious response, typically reduced fishing mortality, to allow the stock to rebuild to levels compatible with MSY ($F<F_{MSY}$).

Spawning Stock Biomass (SSB) is typically the metric used to indicate the status of a stock. SSB represents the reproductive capacity of the stock as it is an estimate of the combined weight of all (mature) individuals which are capable of reproducing.

Perna mussels @Clarus Chu/WWF-UK

OUR MISSION IS TO CONSERVE NATURE AND REDUCE THE MOST PRESSING THREATS TO THE DIVERSITY OF LIFE ON EARTH.