Seafood Strategic Outlook
Spring 2018

UK seafood supply base to 2030:
An initial review of developments, implications and practical responses from industry and Seafish

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SEAFISH

Contents

Executive Summary

This report concerns the UK seafood supply base. Covering both domestic and international sources of supply, it considers how the supply base has evolved over the long-term and how supplies may look towards 2030, identifying major impacts arising and areas of response.

Seafood supply is highly uncertain; with ongoing near-term volatility, this report provides a degree of due diligence on longer term developments. The report helps stakeholders understand the breadth of the UK seafood supply base, identifies the significant species and sources and explores major changes experienced, and anticipated, in supply. The report:

- Sets out the UK seafood supply base in the context of global protein supply.
- Frames changing supply in terms of key risk dimensions and developments: **availability; affordability; nutrition/safety; preferences; environmental constraints;** and **innovations**.
- Considers long-term drivers (global food security and climate change) affecting seafood.
- Draws on industry experience to reflect on changes in the supply base over the last 15 years and what may be expected to 2030.
- Confirms seafood to be a significant component of global meat production (particularly in Asia) with important contributions from whitefish, tunas, prawn and salmon; seafood production is likely to expand – particularly those species amenable to aquaculture.
- Confirms that seafood consumption levels, relative to other meat proteins, are at a high level globally (Asia particularly), but at lower levels in developed countries like the UK.
- Shows that industry stakeholders have a generally positive view of anticipated supplies to the UK to 2030 across capture and aquaculture. Tuna and cold-water prawn are expected to remain vulnerable; warm-water prawn and UK domestic mussel could increase considerably; Canadian cod and farmed salmon could produce significant additional supply, but this is highly uncertain.

Supply changes highlight a range of industry exposure points and response; at a broad level:

- EU exit is a major disruption across the supply base, raising **opportunities** and **threats**.
- A central challenge for operators reliant on UK domestic supply is long-term competitiveness in securing **available** and **affordable** supplies from UK waters. For some this has been compromised by excessively open trading conditions. Market **preferences** play a key role in market access with industry practices and product quality likely to improve further through new **innovations**.
- For operators in the international domain, a strategic challenge centres on the interaction between **availability** (with pressure in capture but expansion in farmed sources), and **affordability**, **preferences** and **environmental constraints** (where the increasing presence of emerging economies is driving competition for supply, weakening the drive for certification, and increasing pressure on resource exploitation).
- For industry, all operators emphasise the need to respond to availability and market preferences, with domestic operators' further emphasising affordability.
- The Seafish offer and role must be clear. Ongoing support to help industry respond in a timely fashion is valued and should continue. However, there is a requirement for additional support to help industry in a number of strategic level responses (positioning of seafood in UK food strategy and a stronger leadership role in 'issues groups', integrity solutions and international marketing). Long-term levy trends should be reviewed given the growth of aquaculture production (particularly the use of recirculating systems).

1. Introduction and requirement

This report is focussed on the UK seafood supply base. It considers the major industry impacts arising from key drivers of UK seafood supply and sets out major areas where industry and Seafish response may be required.

The Seafish mission is to secure a profitable, sustainable, and socially responsible future for the UK seafood industry. An important underlying function for Seafish in achieving this mission is to help *protect* the industry in the face of supply-related risks and challenges.

Risk developments in the macro trade landscape can present longer-term, strategic challenges for the industry (see Appendix 1). Reflecting on these developments in 2016, the Seafish horizon steering group reflected on the need (given the price sensitivity of protein) to *"look ahead at what the supply base will look like in 15 years. We cannot rely on existing species, alternatives need to be explored."* This review is an important part of responding to this need.

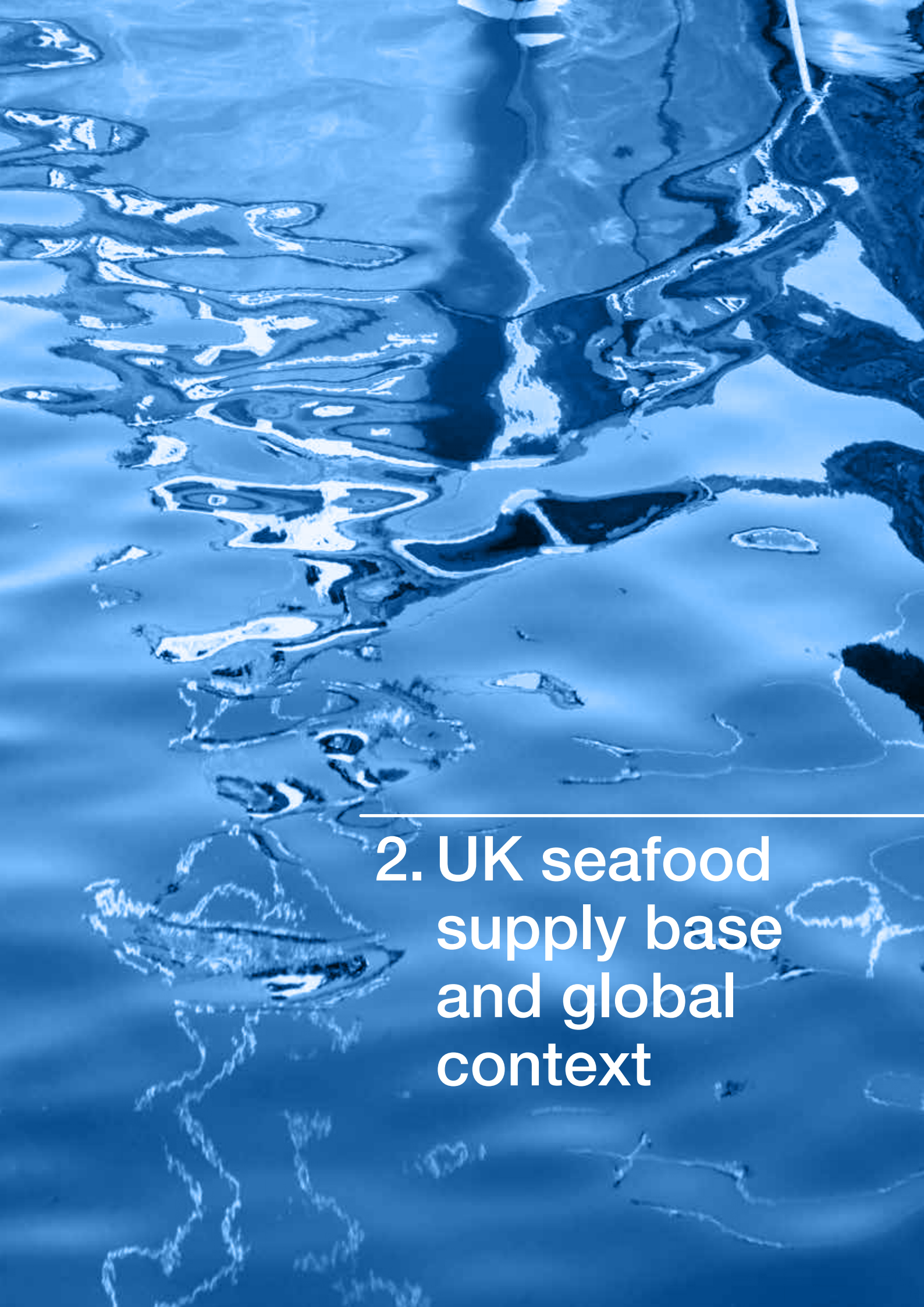
This report aims to support the UK seafood industry in understanding:

- The major characteristics of the UK seafood supply base.
- The new and emerging developments expected to impact on the industry supply base.
- Industry impacts (positive or negative) likely to arise from these developments.
- Action industry (and Seafish) can take in response.

This exercise, conducted in 2017, involved desk research and consultation with Seafish staff and industry operators (see Appendix 2).

The review has limitations. The scope of consultation is not exhaustive. In addition, the review does not consider alternative future pathways (scenarios), but is based on 'business as usual' projections.

This document combines data, opinions and conjecture and is a position paper at the time of press. It is important to bear in mind that evidence today might suggest trends that turn out to be very different in the longer-term.



2. UK seafood supply base and global context

This chapter provides a representation of the seafood industry landscape and the major regional supplies of relevance to the UK. This representation frames the investigation, discussion and agreement on risk developments, impacts and responses.

The term 'seafood' is used broadly in this report and refers to any aquatic food products regarded as food for human consumption or feed for animal consumption. This includes fish, molluscs, crustaceans, echinoderms and other forms of marine and freshwater life.

The UK seafood industry, being reliant on wild capture and aquaculture produced raw material, is diverse, complex and dynamic. The seafood industry is considered here to operate as many subsystems (regional, sectoral), of varying degrees of interdependence, nested within one overarching global system.

In the global context, from a UK perspective, there are at least two major seafood systems that, although overlapping, have distinct characteristics:

- A domestic system – defined as a system reliant on domestically sourced material (material caught from stocks in North Atlantic/UK waters and landed in the UK, material farmed in the UK). Within the 'domestic system', the key UK actors are: producers (farmers/ vessels), agents and merchants in the UK handling material landed/farmed in the UK; UK processors of seafood; and the downstream supply chain in the UK of all of the former including food service companies, retailers and exporters.
- An international system – defined as a system reliant on internationally sourced material (material caught from stocks in the North Atlantic and elsewhere landed outside the UK, material farmed outside the UK). Within the 'international system', the key UK actors are: agents and merchants in the UK importing fish and shellfish that is caught, landed or farmed and possibly processed outside of the UK; UK processors of imported seafood; and the downstream supply chain in the UK of all of the former including food service companies, retailers and re-exporters.

It is notable that from a UK perspective, imported seafood material is largely for UK consumption, whilst material originating in the UK is generally exported for overseas consumption. The UK consumer maintains a robust preference for salmonids (farmed salmon), whitefish (cod, haddock and Alaska pollock), pelagics (tunas) and shellfish (cold-water prawn and farmed warm-water prawn). Meanwhile, UK landings volumes are dominated by mackerel and herring (pelagics), Nephrops (shellfish) and cod and haddock (whitefish).

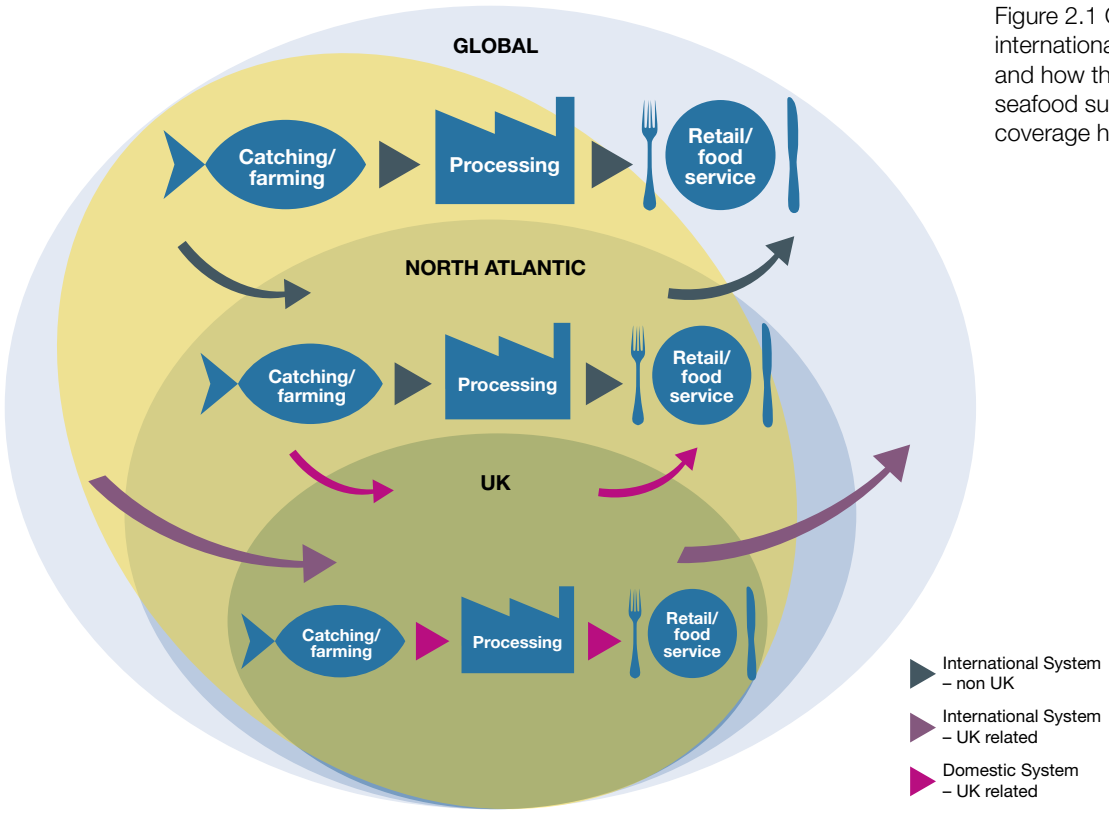


Figure 2.1 Components of the UK international and domestic systems and how they are interrelated (UK seafood supply base to 2030 coverage highlighted in yellow)

2.1 Supply landscape

2.1.1 Major regional markets – Europe, North America and Asia

Major drivers of market demand and consumption are income and population growth. In 2015, world population was 7.3bn with an average GDP per capita of $6,628. Table 2.1 shows the population and income profiles for major global regions in recent years.

Europe and North America are regions with relatively low and stable populations that are comparatively wealthy (with high GDP per capita). In contrast East Asia (including China), South East Asia & Pacific are regions with high and growing population and increasing wealth (GDP per capita).

Protein is an important component of the food necessary to maintain human health. Consumers place high importance on animal meat products as a desirable and convenient means of obtaining protein. Consumers are motivated to consume meats as a quick and efficient means of accessing nutrients (compared to plants) and can be driven to consume certain animal products by strong cultural norms (e.g. consuming red meat as a sign of affluence).

Table 2.2 shows per capita food consumption of the main animal product groups across major global regions. The relatively high consumption of animal products (including seafood) is notable in Europe and North America. The latter has particularly high consumption of red meat and poultry. Meanwhile, the consumption of seafood in Asiatic regions is relatively high.

Table 2.1 Population and GDP per capita for major regions (World Bank, 2013)

	Population (millions)			GDP per capita (US$ per person)		
	2000	2010	2015	2000	2010	2015
Africa South of the Sahara	680	870	982	516	646	711
East Asia	1,482	1,557	1,584	4,584	6,233	7,447
Europe	533	551	557	17,103	19,013	20,630
Former Soviet Union	266	266	268	1,356	2,276	2,927
Latin America & the Caribbean	518	586	618	4,043	4,986	5,480
Middle East & North Africa	381	460	497	3,256	3,717	4,211
North America	316	347	362	34,401	36,764	39,528
South Asia	1,418	1,653	1,770	457	775	960
South East Asia & Pacific	576	651	686	2,236	2,842	3,326
Global	**6,169**	**6,941**	**7,325**	**5,312**	**6,034**	**6,628**

Table 2.2 Per capita food consumption in 2010 (World Bank, 2013)

	kg per capita per year				
	Beef	Pork	Lamb	Poultry	Fish
Africa South of the Sahara	5.7	1.4	2.6	3.3	6.8
East Asia	6.3	35.1	3.1	12.0	35.1
Europe	16.8	39.3	2.6	20.0	20.4
Former Soviet Union	16.8	12.4	2.4	14.3	13.7
Latin America & the Caribbean	25.3	9.8	0.8	25.5	8.4
Middle East & North Africa	7.0	0.1	4.7	16.5	9.3
North America	43.8	28.8	0.6	44.4	23.1
South Asia	2.7	0.3	1.1	1.8	6.4
South East Asia & Pacific	4.9	11.9	1.0	11.0	25.2
Global	**10.0**	**15.1**	**2.1**	**12.2**	**17.2**

2.1.2 UK market

Within the UK, seafood sits within a broad protein landscape that contains a number of substitute proteins. This landscape includes the following protein categories:

- Seafood (whitefish, pelagic, shellfish, salmon, exotic fish).
- White meat (chicken, turkey, gamebirds, etc).
- Red meat (pork, lamb, beef, veal, etc).
- Meat substitutes (*synthetic/cultured meats, mycoproteins* e.g. Quorn, etc, *plant based proteins* e.g. grains, pulses, nuts, seeds, etc, and *insect proteins*).

With each protein category comes a distinct set of attributes that provide advantages and disadvantages in the eyes of the consumer. For example:

- Price – seafood is often relatively more expensive than other proteins.
- Quality – seafood can show greater variation than other proteins in freshness, taste, etc.
- Convenience – compared to other proteins, seafood may offer a more limited product format and be less versatile (the UK consumer can be 'scared of seafood').
- Nutrition – seafood has a number of health benefits relative to, say, red meat.
- Environment – seafood credentials (e.g. sustainability and welfare) can be seen as more complex/uncertain compared to land based proteins.

These can drive consumption levels, but also where products are consumed (in-home or out-of-home). The relative quantities of seafood and selected white and red meats purchased for in-home consumption by UK households is shown in figure 2.2.

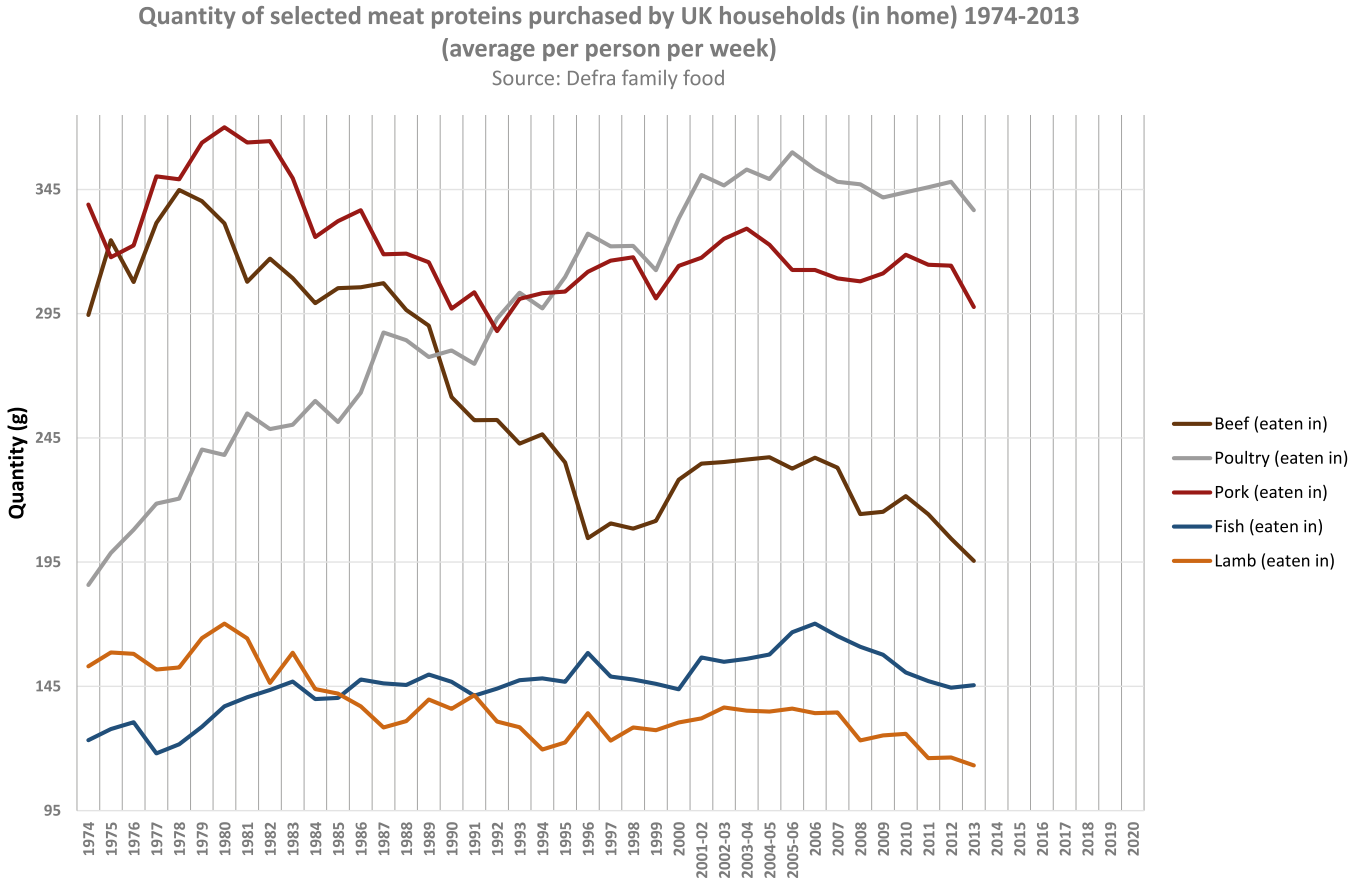


Figure 2.2 Quantity of selected meat proteins for in-home consumption (Source: Defra)

2.1.3 Products and proteins

Within the protein landscape, *products available for direct consumption*, serve specific consumer interests. In serving these interests, proteins are processed to provide convenience (incl. *time saving*) for those storing/preparing/cooking the product (chefs or the consumer). Products offer a spectrum of solutions to the chef or consumer:

- **Customised** solutions (meeting a special/novel requirement e.g. special occasion).
- **Kit/component** solutions (meeting a convenience requirement e.g. quick meal/protein).
- **Off-the-shelf** solutions (meeting a general requirement e.g. meals).

At one end of the spectrum, products provide basic proteins made available in a simple format, to support customised and kit/component solutions. At the other end, products that involve significant transformation of the original protein, can support off-the-shelf solutions.

Primary processed material is largely considered a *fresh product* (chilled never frozen, including live animal). Secondary processed products are mainly *frozen* (including refreshed product) and *ambient* products (including prepared and preserved). Tertiary or composite products (where seafood is one ingredient in the final product) could be fresh or frozen.

Primary products are relatively simple in comparison to secondary, and particularly tertiary, products. Greater product variation can be expected with the latter and in minor/specialised primary products. The typical protein supply landscape for the UK is shown in figure 2.3. This is followed by a brief description of the key characteristics of whitefish, pelagic, shellfish and salmonid products.

In general, seafood products destined for the UK market can be briefly characterised as:

- **UK market products:** A diverse set of products, ranging from sale of live fish to added value seafood products.
- **Species and chain:** A diverse range of species, with product supply chains ranging from short to long (reflecting species but also the time required to cook/consume versus time required to produce seafood products). Variation in the level of control, ranging from vertically integrated chains to market based supply.
- **Major supplying regions:** Origin and main producing countries being both UK and international.

Table 2.3 Types of seafood products

Product format		Extent of processing			
		None	>		Considerable
		Live	Primary	Secondary	Tertiary
Fresh	Chilled never frozen	x	x		x
Frozen	Refresh - chilled previously frozen			x	x
	Frozen			x	x
Ambient	Prepared and preserved			x	

Table 2.4 Example products in seafood sectors (Source: Food Standards Agency, 2008)

Primary	Secondary	Tertiary
Whole	Crabsticks	Curry
Loins	Fish balls	Fishermen's pie
Fillets - skin on	Fish paste	Kedgeree
Fillets - skinless	Roe	Salmon en croûte
Portions - skinless	Taramasalata	Seafood cocktail
Meat in shell	Tuna pâté	Seafood pasta
Meat		Szechuan prawns with vegetables
		Spring rolls
		Prepared pre-school meals (children < 5 yrs)

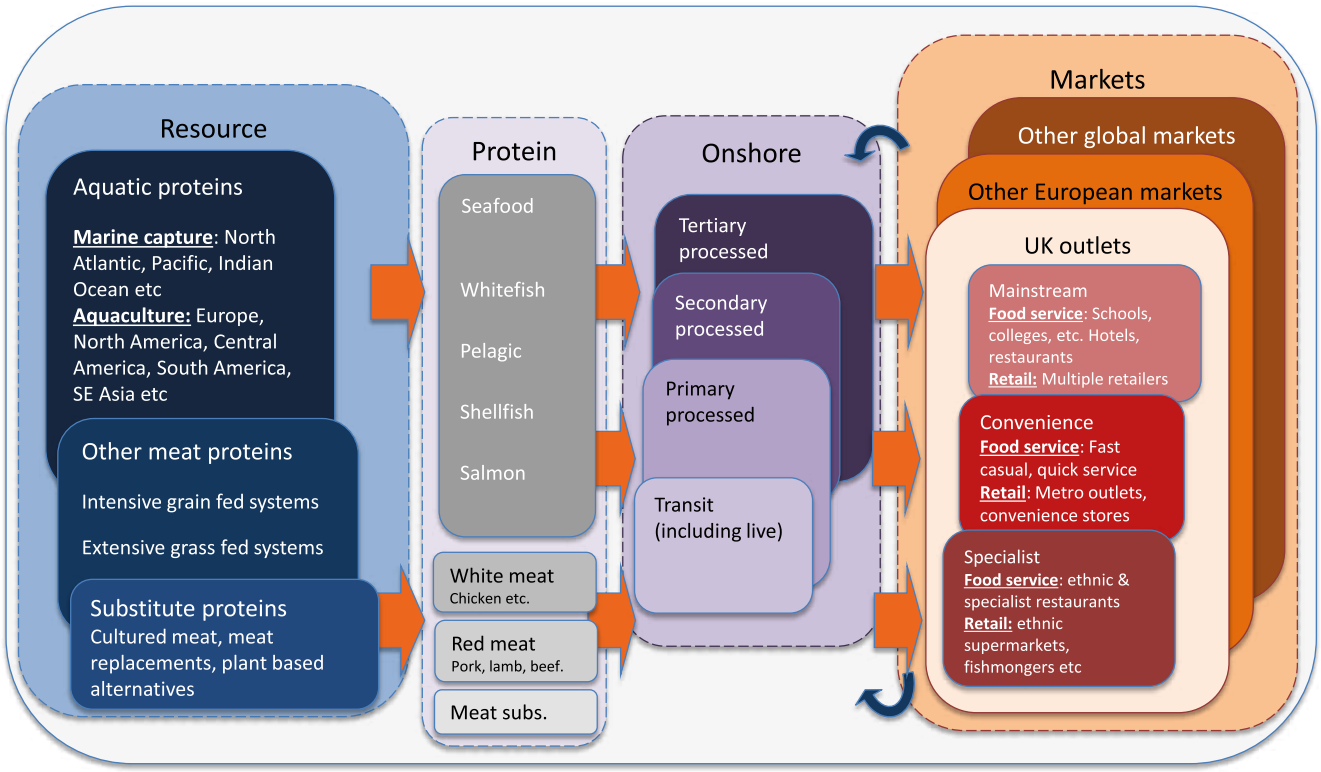


Figure 2.3 Current protein supply landscape

Table 2.5 Key characteristics of whitefish, pelagics, shellfish and salmonids

	Major supplying regions	Species and chain	UK market products
Whitefish	UK domestic sources include UK waters and NE Atlantic. International sources include Arctic/Barents Sea (Norway, Russia, Iceland) and North Pacific/ Bering Sea (USA).	Cod, haddock, whiting, monkfish, sole, plaice, hake, Alaska pollock. UK domestic more fragmented than integrated chains of competitors e.g. Iceland. Fresh product sent direct by truck. Frozen product held in storage, containerised and shipped and sent by truck.	Whitefish products for the UK market include domestic sourced fresh product (lower volume and higher value (£/kg)) and internationally sourced refreshed/frozen product (higher volume and lower value (£/kg)).
Pelagic	UK domestic sources include UK waters and NE Atlantic. International sources include Eastern Atlantic (Spain, Morocco), Indian Ocean, Pacific Ocean, and Atlantic Ocean.	Herring, mackerel, sardine/pilchard, anchovy, tunas. UK fresh product sent direct by truck, overseas fresh material sent by truck and air freight. Frozen product held in storage, containerised and shipped and sent by truck. UK domestic more fragmented than integrated chains of Iceland and Faroe Islands.	Pelagic products for the UK market include fresh product (lower volume and higher value (£/kg)) that is either domestically sourced or internationally sourced and frozen product (higher volume and lower value (£/kg)) that is internationally sourced.
Shellfish	UK domestic sources include UK waters and NE Atlantic. International sources include North Atlantic, and farmed sources in South East Asia and Central America.	Nephrops, cold-water prawn, farmed warm-water prawn. UK fresh product sent direct by truck. Frozen product held in storage, and sent by truck with international material containerised and shipped.	Shellfish products for the UK market include fresh but a sizeable volume of frozen product is also represented from UK and international sources. Fresh domestic product tends to be high value low volume, and frozen product tends to be higher volume and lower value (£/kg).
Salmonids	UK domestic sources include UK waters. International sources include Norway, Chile, USA, and Canada.	Atlantic salmon (farmed), pink and red salmon (capture).	Salmon seafood products for the UK market include domestic sourced fresh farmed product (lower volume and higher value (£/kg)) and internationally sourced refreshed/frozen product (higher volume and lower value (£/kg)) and premium capture product.

2.1.4 Resources (Global protein, Global seafood, UK available supply)

In 2015, global meat production was 328 million tonnes (carcass weight) and seafood production was 169 million tonnes (live weight equivalent). Table 2.6 shows the global protein profile (red and white meat, fish) across major global regions. It is notable that Europe and North America have a relatively low share of meat and seafood production. The former has a high share of pork production, whilst the latter has a notably high production of red meat and poultry. Meanwhile, the production of meat and seafood in Asiatic regions is relatively high.

Global seafood production derives from both wild capture and aquaculture sources, and involves a large and diverse range of species[1]. Table 2.7 shows fish production by major species group from 2000 and projected for 2030 – this should be taken as indicative[2] and subject to change. For example the latest FAO estimates suggest global fish production will be 200m tonnes (live weight) by 2030.

Key species that make an important contribution to overall production include major demersals, tunas, shrimp and molluscs, and salmon. Projections for key species for 2030 suggest production growth in those species amenable to aquaculture such as tilapia, pangasius, shrimp (such as warm-water prawn), and salmon. Projections for wild capture species are relatively stable and consistent with longer-term trends.

Table 2.6 Total meat and fish production in 2015 (*interpolation* IFPRI, 2017)*

	Million metric tonnes				
	Beef	Pork	Lamb	Poultry	Fish
Africa South of the Sahara	7.4	1.5	3.5	3.3	5.6
East Asia	9.9	50.8	4.3	23.7	68.4
Europe	9.5	25.5	1.7	11.3	10.4
Former Soviet Union	4.5	3.3	0.9	2.5	4.3
Latin America & the Caribbean	23	8.5	0.7	23.1	20.8
Middle East & North Africa	3.5	0	3.1	8.5	5.2
North America	14.8	15.2	0.1	22.9	8.5
South Asia	6.1	0.9	2.9	4.5	15
South East Asia & Pacific	5.3	9.7	1.8	9.3	30.8
Global	**84.1**	**115.3**	**19.1**	**109.2**	**168.9**

*Fish volume is provided as liveweight equivalent, all other meat data is provided as dressed meat or carcass weight.

Table 2.7 Global fish production ('000 tonnes) (World Bank, 2013)*

Major species group		2000	2010	2015	2030
Whitefish	Major demersal fish	19,686	20,667	20,855	21,519
	Tilapia	1,842	3,778	5,065	7,281
	Pangasius / catfish	918	3,539	4,344	5,579
Pelagic	Tuna	3,968	4,559	4,571	4,584
	Other pelagic	35,376	35,098	34,961	34,492
Shellfish	Shrimp	4,263	7,625	7,535	11,218
	Crustaceans	3,441	3,825	4,144	4,540
	Molluscs	17,968	23,043	25,608	29,656
Salmonids	Salmon	2,451	3,376	3,848	4,983
Other	Carp, etc.	34,361	45,618	50,943	62,783
TOTAL		**124,273**	**151,129**	**161,872**	**186,636**

*Actual volume data provided for 2000, projected volume data provided for 2010, 2015, and 2030.

The available supply to UK industry operators (existing seafood supply base) is diverse in species and source region. Table 2.8 shows the supply profile in 2015. By species group and region, the available supply includes an important domestic base and a diverse international base. This includes a relatively small number of wild capture fisheries, in the northern Pacific and Atlantic Ocean basins, as well as equatorial regions. The majority of these fisheries have some form of management (with harvest controls). Available sources of farmed product include North America and northern Europe as well as Central America and South East Asia.

Table 2.8 Available seafood supply to UK industry 2015 by species group and region (Seafish, 2017)

Species group	Region	Production ('000 tonnes)*	Environmental status (score 1 to 5)**
Whitefish	UK EEZ	200	2.7
	NE Atlantic[3]	1,981	1.4
	N Pacific	2,616	1.8
	SE Asia farmed pangasius[6]	2,400	4.0
Pelagic	UK EEZ (small pelagics)[3]	860	2.8
	NE Atlantic (small pelagics)[3]	2,028	2.4
	Atlantic Ocean (tuna)	400	2.4
	Indian Ocean (tuna)[5]	824	2.1
	Pacific Ocean (tuna)[5]	130	2.0
	Sea bass (farmed)	162	3.0
Shellfish	UK EEZ[3]***	116	3.0
	NE Atlantic[3]	416	2.4
	North America[4]	307	2.1
	Latin America farmed prawn[6]	625	4.0
	SE Asia farmed prawn[6]	3,713	5.0
Salmonids	UK farmed salmon[6]	170	1.0
	Norway farmed salmon[6]	1,300	1.0
	Chile farmed salmon[6]	600	2.5
	Canada farmed salmon[6]	120	1.0
	N Pacific wild-caught salmon	912	2.0

* Liveweight equivalent.
** Environmental status based on score of 1 to 5 (where 1 is very good status, 5 very weak status) – note, farmed scores crudely estimated based on certified production as a share of total production.
*** Limited to Nephrops, scallops and brown crab only plus UK mussel production of 20,050t (FAO).

[1] Over 150 species represented 80% of global production volume according to FAO statistics 2009 (faostat.fao.org).

[2] Industrial profiles, reliant on official statistics from many countries, should be viewed as illustrative and with a degree of caution. There is some concern, expressed in the literature and in our interviews, on the limitations of official statistics. For example, there is a view that official statistics, when compared to the real world situation, can substantially misrepresent production. In this regard, there is concern in some quarters that official figures underestimate fishing mortality and that – depending on the country – aquaculture production is overestimated in some instances and underestimated in others (Appendix 4).

[3] ICES landings data. For UK EEZ estimates – see North Atlantic Fisheries College report (Napier, 2017).

[4] NOAA landings data.

[5] ISSF Status of World Fisheries for Tuna (catch/landings).

[6] FAO production data (FishStat).

[7] North Pacific Anadromous Fish Commission Statistical Yearbook.

In well managed fisheries, fishing mortality has decreased such that exploitation is broadly in line with Maximum Sustainable Yield (MSY) objectives (Hilborn et al). There are potential gains from improved fishery management, albeit with regional differences. Further gains in well managed fisheries are likely to be marginal; gains from improving fisheries with weak management could be substantial e.g. equatorial regions in the Indian/Pacific Oceans. Globally, there are a large number of fisheries outwith a management framework where substantial gains may lie if improvements were made (Costello, 2012). For some, however, the conditions of capture fisheries are seriously misrepresented by flaws in official statistics, the challenge to improve fisheries more substantial, with much greater potential to improve yields through better management (Pauly et al).

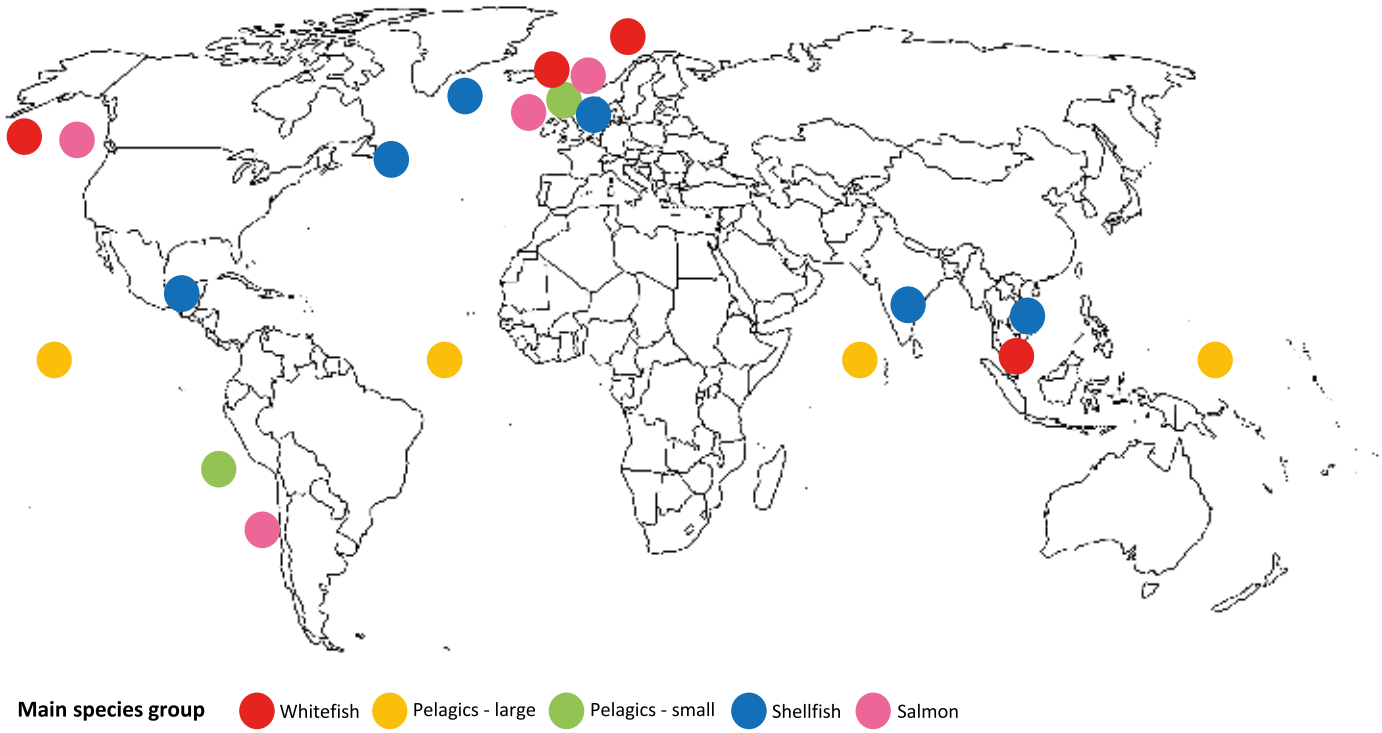


Figure 2.4 UK seafood supply base: main supply regions by species group

2.2 Framing seafood supply risks (definition and dimensions)

Risks to seafood supplies are summarised in table 2.9. Specific risks vary by system (domestic or international), species and production type (capture or aquaculture).

Table 2.9 Dimensions and example risk related to seafood supplies

Dimension	Areas of specific risk	Example risk impact (opportunity/threat)
Availability	Trading conditions	Tariffs, non-tariff barriers, legality, traceability (e.g. IUU) and human rights (e.g. ILO188) requirements that could mean trading and logistics enhanced/impeded.
	Inflexible regulations	Rigid operating conditions.
	Robust/loose fisheries governance	Well managed/data-deficient fisheries.
	Marine user opposition/collaboration	Constrained/expanded production.
	Species characteristics	Volume, seasonality and technical requirements (size grade and specification i.e. whole/fillets/portions/pairs/triples/skin or shell on/off) that could affect species availability.
Affordability	Economy and market conditions	Pricing points vis-à-vis buyers purchasing criteria that can determine UK industry competitiveness.
		Viable catch/aqua production/onshore supply options through existing or new/redundant business models (including operator practices).
	Competing sectors	Shortage of labour.
	Investment/disinvestment	Consolidation, smaller fleet, more efficient/targeted capture, vertically integrated chains.
Nutrition, safety	Industry practice/malpractice	Product quality improved/impaired.
	Composition	Nutritional profile, minimum water/protein content. Loss of product integrity e.g. water addition. Product format (chilled v frozen - single/double, etc).
	Safety	Contaminants, microbiological safety.
Preferences	Certification	Responsible sourcing requirements such that industry reputation weakened/improved.
	Consumer preferences	Tastes/changing tastes.
	Scrutiny/public perception	Social and environmental responsibility assurance such that market access is improved/impeded.
Environmental constraints	Growth conditions	Giving rise to disease.
	Environmental conditions	Contaminants, climate change (e.g. warming waters).
	Natural biological cycles	Overexploited/healthy resource.
	Environmental impact of gear	Impact on seabed/ecosystem.
Outliers/all of above	Gear innovation	New gear e.g. pulse trawling.
	Process innovation	New refrigeration techniques e.g. super-freezing.
	Product/packaging innovation	New formats e.g. Individual Quick Frozen (IQF) product.
	Production innovation	New aquaculture systems e.g. offshore aquaculture, and recirculating aquaculture systems (RAS).

2.3 Supporting seafood supply in the UK seafood and wider protein industry

Institutional and voluntary support to the supply of seafood is summarised in table 2.10.

Table 2.10 Example support organisations and their support functions for UK and wider global seafood supply

Level	Example organisations	Support function	Examples
International (global)	Food and Agriculture Organisation (FAO) – Fisheries and Aquaculture Department	A mission to strengthen global governance and managerial/technical capacities of members, and to lead consensus-building towards improved conservation and utilisation of aquatic resources.	Publish 'State of World Fisheries and Aquaculture' and various 'Codes of conduct'. Works with the Global Partnership Climate, Fisheries and Aquaculture (PaCFA), to raise awareness of climate change issues and to promote a coordinated response from the wild capture fisheries and aquaculture sectors.
	World Bank	A source of financial and technical assistance to developing countries around the world.	Publish future scenarios work on fisheries and aquaculture production.
	WorldFish	An international research organization that harnesses fisheries and aquaculture to reduce hunger and poverty.	Publish future scenarios work on fisheries and aquaculture production. On the ground work with small-scale producers.
	Fisheries and Aquaculture Standards (e.g. MSC, ASC, Global GAP), Global Sustainable Seafood Initiative (GSSI)		
	NGOs (e.g. Greenpeace, WWF, Oceana)		
International (regional)	Regional Fisheries Management Organisations (RFMOs)	International organisations formed by countries with fishing interests in an area or species.	Some have a purely advisory role but most have management powers to set catch and fishing effort limits, technical measures, and control obligations.
	International Council for Exploration of the Sea	Fisheries stock assessment for NE Atlantic. Marine research and information generally.	ICES stock and ecosystem advice.
	European Commission (particularly Directorate-General for Maritime Affairs)	Manages two policy areas: (i) integrated maritime policy; and (ii) common fisheries policy (CFP). Sustainable Fisheries Partnership Agreements allow EU fleets to fish in third countries' Exclusive Economic Zones. Plays active role in bodies established under UN Convention on the Law of the Sea (UNCLOS) and UN Fish Stocks Agreement (UNFSA), and in six tuna and 11 non-tuna RFMOs.	
	Industry networks e.g. Groundfish Forum (whitefish), International Seafood Sustainability Forum (pelagic) International Cold-Water Prawn Forum (shellfish)		
National (UK)	UK Government, administrations, agencies e.g. CEFAS, AFBI, NRW	Fisheries and Marine policy, monitoring research and information (addressing knowledge gaps).	UK and Scottish Marine Bills, stock assessment.
	Regulators and enforcement (e.g. MMO, Marine Scotland, IFCAs, MCA, Royal Navy – in England)		
	Universities/research institutes (e.g. Plymouth Marine Laboratory) and research councils	Research and information (addressing knowledge gaps).	Research.
	Seafish	Industry collaboration, promotion, research and information.	Research, industry groups.
	Industry Associations: SFF, NFFO, SAGB, Seafood Alliance, BFFF	Industry collaboration and policy positions.	Specific projects.
	Industry collaborative ventures e.g. Sustainable Seafood Coalition, Sustainable Fisheries Partnerships	Industry collaboration and policy positions.	Voluntary initiatives, programmes and projects.

3. Drivers and risk developments affecting seafood supplies – the long view

This chapter summarises the main drivers and risk developments affecting the seafood industry over the long-term, with a focus on seafood supply in particular. This draws on developments that are both observed (by third parties) and experienced (by industry operators).

Table 3.1 shows the long view of drivers and risk developments affecting seafood supply, experienced or observed in the period 2000-2015 through to those anticipated in 2015-2030.

Systemic global risk developments, notably food security and climate change, act as **multipliers** to amplify the above risk developments and their impacts (threats and opportunities).

Table 3.1 The long view: 2000 – 2015 – 2030

Driver	Risk developments	
	From	To
Political and trade developments	Weak management of fisheries (with high fishing effort) and aquaculture growth.	Robust management of fisheries (with fishing effort increasingly limited), aquaculture production and supply chain practices.
	Diminishing tariffs (new sources of protein).	Political climate and free trade agreements increasingly uncertain (UK won't run out of food, but higher prices, less choice).
	Sporadic supply disruptions in producing countries.	Competitive pressure to secure supply, more processing in third countries (outside UK control).
Economic developments	UK economic growth, with premiumisation convenience and added value products.	Limited economic growth, expanding overseas markets with greater focus on convenience and added value products.
	Constrained supply in traditional supplies with opening up of new supply sources.	Broadening of species and supply sources with traditional supplies potentially constrained.
	Expanded middle - 'we're all middle class now' (disposable income/debt increasing).	Squeezed middle (low wage economy, reduced disposable income) and savvy shopper.
Social developments	Growing UK population, globalisation, tourism.	Growing population that is diverse and ageing.
	Erosion of family as stabiliser.	Fragmented, greater demands on individual (work, leisure, caring).
	Emergence of celebrity chefs.	Influence of social media (trusted advocates).
	Broadening, and constructive, stakeholder (including NGO) input into marine policy, assurance and certification in Western economies.	Marine policy, assurance, certification challenged by emergence of developing countries with different preferences.
	Introduction/growth in scrutiny (medical community 'don't eat' lists), increased testing.	Forensic testing (allergies, etc) and growing ability to monitor illegal activity in the marine environment.
Environmental developments	Dioxins, PCBs, heavy metals.	Increase in toxins (naturally occurring), pesticides, micro-plastic contamination, sediment residue contamination.
	Fish stocks under fishing pressure.	Pressure on fish stock easing in some areas through managed fisheries, but facing broader pressures on ecosystem (e.g. warming waters, microplastics, etc) and increasing marine use.
Technological developments	Static web information (1st generation).	Dynamic internet (2nd generation) and "internet of things" (3rd generation).
	Technical innovations driving aquaculture (making salmon, prawns, pangasius, available in volume).	Technical innovations (including autonomy) driving improved access to marine resources, including capture and aquaculture in more challenging environments e.g. offshore (making new species available in volume).

3.1 Food security

The main aspects of food security are: a globalised economy; global population increase; and global availability of raw material. Projected economic growth, growth in population (and middle class income), and changing tastes and diets in regions around the world suggest:

- A world economy rebalancing towards Asia.
- An expanding global middle class (squeezed in developed countries).
- Increased protein consumption with regional differences, regions in which per capita fish consumption (Figure 3.1):
  - o high and predicted to grow strongly (China, South East Asia and North America).
  - o high and predicted to grow weakly (East Asia and Pacific, Europe and Central Asia, Japan).
- Global seafood production expected to increase, based on:
  - o wild capture having zero growth with aquaculture expanding at a declining rate.
  - o concentration in Asia (particularly India, South East Asia and China) driven by species amenable to aquaculture (prawn, salmon, tilapia, carp and pangasius).

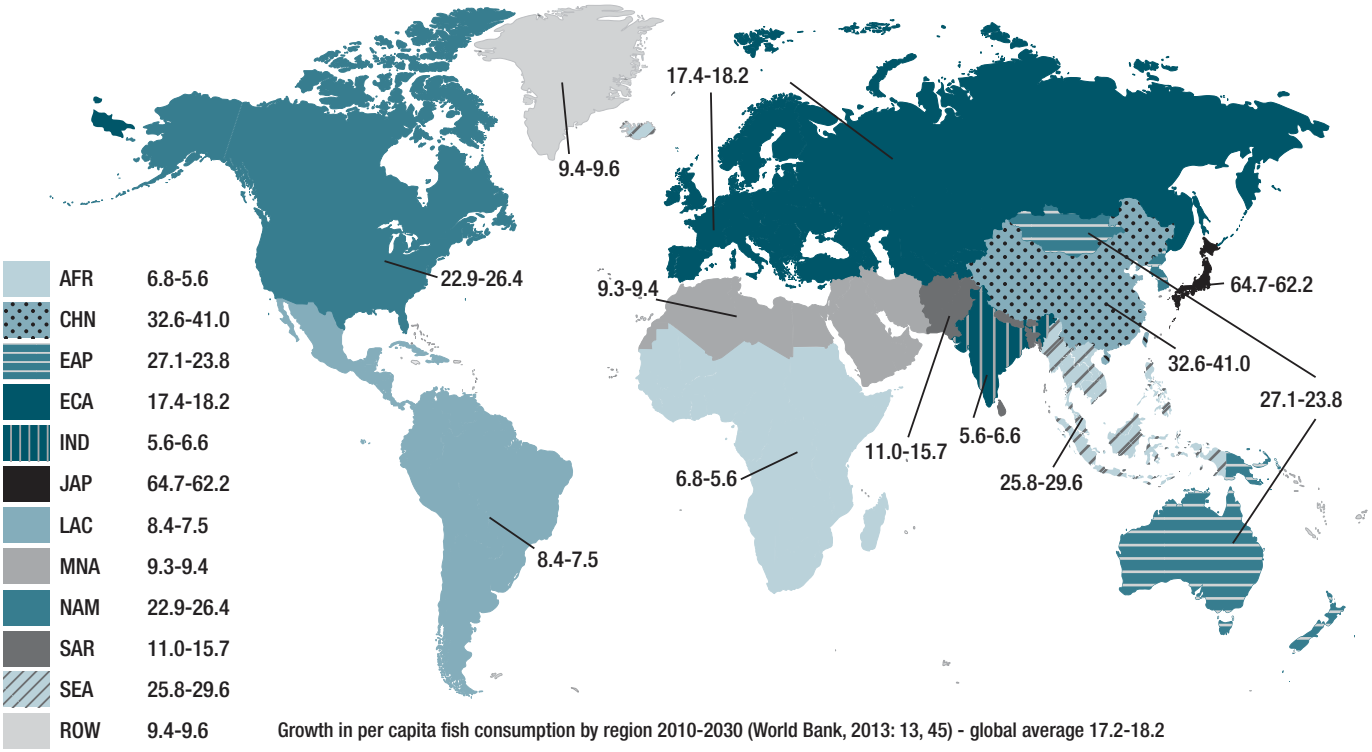


Figure 3.1 Projected growth in per capita fish consumption by region, 2010-2030 (kg/person/year). World Bank (2013:13,45)

3.2 Climate change

The main physical climate change impacts of interest to industry are:

- Sea level rise and extreme water levels.
- Changes in storms and waves.
- Changes in temperature.
- Ocean acidification and de-oxygenation of sea water.
- Changes in terrestrial rainfall (i.e. through surface flooding of land-based infrastructure, plus its role in transferring water, contaminants, and pollutants from land to sea).

The two main climate change drivers that lead to priority risk developments for wild capture seafood are *increased storminess and waves* and *air or sea temperature change*. In shellfish an additional driver is *changes in rainfall/land run-off*. For whitefish and pelagic fisheries, this has contributed to changing distribution of target species (in an international context long-term catch potential is expected to alter significantly as species move away from lower latitudes/tropical regions towards higher latitudes/polar regions, for the UK domestic context some traditional species may move away and warmer water species move in) whilst in shellfish fisheries there are changes in the prevalence of non-native species/jellyfish. In all fisheries, offshore operations will be impacted with challenges to safe working conditions and gear deployment/performance.

Climate change may also have implications for aquaculture supplies, especially those originating in estuarine areas. There may be impacts from *increased storminess and waves, air or sea temperature change, changes in rainfall/land run-off,* and *acidification*. In salmonid production this could exacerbate disease, parasites and harmful algal blooms. In freshwater finfish (pangasius, tilapia) production this could impact in multiple ways including loss of water and mass mortality events, change in water quality from flash flooding and river discharge, whilst exacerbating parasite challenges. In shellfish (warm-water prawn) production impacts could, in addition to freshwater impacts, extend to include altering the 'active period' of pathogens.

Onshore, the above risk developments are compounded by *sea level rise* and *extreme water levels*. This can give rise to impacts affecting onshore operators:

- Damage to site infrastructure (port and processors).
- Integrity of electricity supplies.
- Transport distribution (including ferries).
- Integrity of housing and reduced employment.

4. UK seafood supply - recent and anticipated developments, impacts and response

This chapter provides an industry perspective on the UK seafood supply base. It sets out stakeholder views on how the UK supply base might look in 2030. This is followed by a description of the main risk developments recently experienced (in the last 15 years) and anticipated (in the next 15 years) relating to the UK seafood supply base. These are described in terms of whitefish, pelagics, shellfish, and salmon supply and, in each case, relate to major supply region, species and chain, and markets (retail/food service) serving the UK. Actions are suggested by way of response to anticipated developments.

In securing supply, all sectors (whitefish, pelagics, shellfish, salmon) share common exposure to key risk dimensions: **availability; affordability; preferences; nutrition/ safety; environmental constraints;** and **innovation**. The UK seafood industry may share these concerns, but the domestic and international operators have exposure in different ways - explored below.

4.1 UK supply base in 2030

Table 4.1 shows industry stakeholder perspectives on future production levels to 2030.

Table 4.1 Anticipated seafood supply availability to UK industry 2030 – industry perspective

Domestic sources		
Species group	**Species**	**Future production**
Whitefish	Cod	
	Haddock	
	Saithe	
	Whiting	
	Flat fish	
Pelagic	Mackerel	
	Herring	
Shellfish	Nephrops	
	Scallops	
	Mussels	
	Brown crab	
Salmonids	Atlantic salmon	
International sources		
Species group	**Species**	**Future production**
Whitefish	Cod, haddock (Norway)	
	Cod, haddock (Iceland)	
	Cod (Canada)	
	Alaska pollock (USA)	
	Tilapia	
	Pangasius	
Pelagic	Tuna	
Shellfish	Warm-water prawn	
	Cold-water prawn	
Salmonids	Atlantic salmon (Norway)	
	Salmon (N. America)	
	Atlantic salmon (Chile)	

Much Lower **Lower** **No change** **Higher** **Much Higher**

Domestic supplies

Table 4.2 Anticipated risk developments for domestic supply and selected impacts (opportunities - green/threats - red).

Domestic	Supplies impact	Supplies risk dimension					
		Availability	Affordability	Preferences	Nutrition & safety	Environmental constraints	Outliers
SUPPLY REGIONS							
All sectors	i) UK industry competitiveness	🔴🟢	🔴🟢				
WHITEFISH							
a) Seafood resource							
UK fisheries (cod, haddock, whiting, saithe, monkfish, sole, plaice, rays)	i) Flexible operating conditions	🔴🟢					
UK fisheries (cod, haddock, whiting, saithe, monkfish)	i) Flexible, pragmatic, operating conditions	🟢		🔴🟢			
UK fisheries (cod, haddock, whiting, saithe, monkfish)	i) Species availability (catching restrictions)	🔴🟢				🔴	
PELAGIC							
a) Seafood resource							
UK fisheries (mackerel, herring)	i) Species availability	🔴🟢					
SHELLFISH							
a) Seafood resource							
UK fisheries (Nephrops)	i) Species availability unchanged	🟢					
UK fisheries (scallops)	i) Tightened operating conditions, ii) Species availability	🔴🟢					
UK aquaculture (mussels)	i) Expanded production but constrained	🟢				🔴🟢	🟢
UK fisheries (brown crab)	i) Tightened operating conditions	🔴🟢				🔴	
SALMON							
a) Seafood resource							
UK aquaculture (Atlantic salmon)	i) Expanded production but constrained	🔴🟢				🔴🟢	
SPECIES AND CHAIN							
FISHERY/PRODUCTION OPERATIONS							
b) Whitefish fishery operations							
UK fisheries (cod, haddock, whiting, saithe, monkfish)	i) Smaller consolidated fleet		🔴				
UK fisheries (cod, haddock, whiting, saithe, monkfish, sole, plaice, rays)	i) More efficient/targetted capture						🔴🟢
b) Pelagic fishery operations							
UK fisheries (mackerel, herring)	i) Smaller consolidated fleet continues ii) Species availability	🟢	🟢				
b) Shellfish fishery operations							
UK fisheries (Nephrops)	i) Shortage of labour ii) New/redundant business models to ensure viable catch		🔴				
UK fisheries (Nephrops)	i) Tightened operating conditions ii) Industry reputation		🔴	🟢			
UK aquaculture (mussels)	i) Expanded production		🟢				
b) Salmon production operations							
UK aquaculture (Atlantic salmon)	i) Expanded production		🟢				🟢
ONSHORE OPERATIONS							
All Sectors	i) Improved product quality						🟢
c) Ports, harbours and markets							
Pelagic	i) Supply viability with new/redundant business models		🔴🟢				
d) Transporation of catch							
Whitefish	i) Trading/logistics impeded	🔴	🔴				
Shellfish	i) Trading/logistics impeded	🔴	🔴				
e) Primary processing							
Pelagic	i) Supply viability with new/redundant business models	🟢	🟢				
f) Secondary processing							
Shellfish (scallops)	i) Supply viability with new/redundant business models		🔴🟢	🟢			🟢
Shellfish (mussels)	i) Supply viability with new/redundant business models		🟢	🟢			🟢
g) Tertiary products							
MARKETS (SALES OUTLETS)							
Pelagic	i) Market access improved/impeded	🔴🟢	🔴🟢	🟢			
Shellfish (scallops)	i) Market access improved/impeded	🔴	🔴				
Shellfish (mussels)	i) Market access improved/impeded	🔴	🔴				
Shellfish (brown crab)	i) Market access improved/impeded	🔴	🔴	🔴	🔴		
Atlantic salmon	i) Market access improved/impeded		🔴🟢				
h) Retail							
Whitefish	i) Market access improved/impeded		🔴	🔴			
Whitefish	i) Industry reputation		🔴	🔴			
i) Food service							
j) Wholesale							
k) Feed suppliers							

4.2 Whitefish

4.2.1 Recent developments

- Major supply regions: Domestic whitefish supply has been challenged primarily in terms of reduced **availability**, driven by robust fisheries governance (e.g. cod recovery, quota cuts) that has restricted supply. Latterly, this governance has been criticised as being rigid and inflexible particularly being coupled with increasing whitefish abundance as natural biological cycles (for example hake and monkfish) have suggested a healthier resource i.e. easing of **environmental constraints** on the supply base. Criticism of governance centres on inappropriate scrutiny and assurance e.g. scientists reaching for a perfect equilibrium in what is a dynamic ecosystem and NGO influence shaping (arguably dogmatic) **preferences**.

- Species and chain: Whitefish fishery operations have seen their **reputation** tarnished as a consequence of sourcing practices (blackfish) but then improve as a result of sustained responsible sourcing. Cod, in particular, is now coming out of a prolonged period of poor reputation. Restrictions on supply availability (above) and the need to maintain **affordability** has led to a smaller fleet. This was the result of disinvestment (decommissioning and switching to shellfish fisheries) and investment (modernising and investing in new vessels, growing number of state-of-the-art boats), and challenging market conditions (e.g. high fuel prices) forcing a change in business models to ensure viable supply. **Innovation** in gear technology has enabled the fleet to move from catching volume (gutting and landing what it could), to bulk fishing (that maximised catch and threw away unwanted fish supported by conveyors, hoppers, etc) to a fleet that is more selective (in which half the vessels have improved ability to catch, with gear to avoid species). However, technology creep has opened up other consequences; working down the food chain (industrial fishing) and questionable new gear e.g. pulse trawling.

- Markets: Domestic whitefish supply has been challenged in the UK market by **affordability** (on price points) and **preferences** (scrutiny and public perception around environmental responsibility) particularly in retail. Retailer preferences (e.g. on certification - Marine Stewardship Council, Responsible Fishing Scheme, etc) has meant barriers for some processors with lack of understanding by retailers creating tensions and adding costs for processors. Scrutiny and certification can be positive for incentivising improvements (e.g. fisheries improvement projects – FIPs) but a barrier if taken too literally by retailers. Preferences, and scrutiny in particular, has also played a role in accessing export markets; for example data deficiency, on monkfish, has been a barrier in some overseas markets.

4.2.2 Anticipated developments

- Major supply regions: Domestic whitefish supply is expected to face opportunities primarily in terms of **availability**. Given EU Exit, and the review of the regulatory framework, there may be greater availability for key finfish and a better economic outcome if fisheries are managed under an alternative management regime e.g. zonal attachment (rather than relative stability). EU Exit also affords the opportunity to look at current **preferences** and 'inject some Norwegian realism into fisheries governance' to make it more flexible; working with dynamic ecosystems rather than current crude decision-making. More flexible questions could be put to scientists (and ICES) recognising that industry may have to pay for science requirements (employing their own scientists) with NGO scrutiny likely to increase. It is expected by some that **environmental constraints** may tighten in the next 5-10 years for some species e.g. condition of haddock stock and effect of climate change on cod availability.

- Species and chain: Whitefish fishery operations are expected to face challenges in **affordability**. Given the current generation of fishermen will retire and the next generation are not available, investment sources will change; investment will tend to come from commercial companies rather than passing on from the previous generation. There are opportunities for gear **innovation** to shift technology towards truly 'smart' gear that can improve selectivity. However, new techniques must demonstrate benefits with evidence to back it up e.g. pulse fishing. With EU Exit, onshore operations supplying European markets could face non-tariff barriers and delays (that could include blockades) affecting **availability** of live and perishable, fresh product to those markets.

- Markets: Domestic whitefish supply will continue to be challenged in the UK market by **affordability** (on price) and **preferences** (around environmental responsibility but also on new aspects such as fish welfare).

4.3 Pelagic

4.3.1 Recent developments

- Major supply regions: The challenges to domestic pelagic supply centre on the interplay of **availability** and **environmental constraints**. Some 15 years ago availability was supported by weak governance. Weakness in the domestic arena coincided with a period of over quota landings (blackfish). When domestic governance strengthened and availability restricted, weak governance was seen in the international arena: the fishery experienced a lot of pressure from northerly coastal states (Iceland/ Faroe Islands/Russia) making use of autonomous quota and expanding the number of vessels prosecuting the fishery. This dynamic coincided with changing **environmental constraints**; stronger domestic fishing controls meant less pressure on pelagic stocks and fish pushing northwards (e.g. for food) into international areas. However weak international governance introduced greater risk to stock exploitation. In recent years, mackerel and herring stocks appear to be reasonably healthy. The UK (particularly Scotland) benefits from very strong access e.g. mackerel fished entirely in UK waters. The seasonal access to the fishery fluctuates only marginally year-on-year.

- Species and chain: Those operators engaged in landing, as well as those processing, pelagic species have faced pressures on **affordability** and **availability**, whilst a period of over quota landings in the UK undermined industry reputation challenging **preferences**. Over the longer-term, investment and disinvestment has seen the fleet move from a high number of smaller vessels landing to domestic shore factories (or Russian vessels) across a longer and steadier season towards a more consolidated fleet fishing for short periods. This fleet, of 20 or so vessels, is highly efficient and lands much higher volumes (to both home ports and abroad) during much shorter fishing seasons. Onshore production has had to reflect the change in available supply (i.e. production moving from longer seasons across the year to specific periods). Securing available supply is key to survival; to maintain viable supply, business models are now based on family business (with close family links to catching sector), vertical integration (catching and onshore operators), market competition (best paying markets offer catchers highest price e.g. Norwegians selling into Japan), or government regulation (obligation to land to domestic operators). In an effort to maintain affordability, there is much more consolidation in the onshore sector with fewer and fewer independent companies. The acute challenge for UK primary processors has been market and economic conditions that are challenging current supply options, specifically the ability to match Norwegian prices for landed material (volume and critical mass are a big driver for this as the lack of volume undoes the contribution to overheads). More positively, mackerel continues to see strong product development and **innovation** in the ambient (ready-to-eat) sector.

- Markets: In UK markets, pelagic products enjoy the advantage of **affordability** and recognised **nutritional** benefits. Mackerel products capitalise, for example, on having high levels of omega-3 and a competitive price point compared to other competitor products e.g. salmon. **Availability** of pelagic products in export markets have been affected by adverse trading conditions. Political relations closed export markets (e.g. Russia, Ukraine, etc) and economic conditions, such as the oil and gas downturn, pressured others (e.g. Nigeria). This has led to the search for new markets and increased challenge for **affordability** e.g. Far East markets (very competitive) and European markets (with higher costs).

4.3.2 Anticipated developments

- Major supply regions: It is expected that EU Exit, and with it the review of the regulatory framework and its emphasis of managing fisheries under zonal attachment, could enhance **availability**.

- Species and chain: In the absence of any change in governance, continued pressure on **affordability** will mean the existing consolidated fleet continues and the available supplies secured. Further consolidation in catching is unlikely unless there is significant investment in one business model and divestment from another e.g. unless a very large company buys out a family based operation. Profitability in the catching sector may be challenged if there is consolidation elsewhere i.e. onshore buying power increases as a result of consolidation. In the onshore sector, further consolidation is expected as a response to **affordability** pressures and also to secure **availability**. With buyers having more power, this could mean more robust pricing points and improved profitability for processors.

- Markets: The **availability** and **affordability** of pelagic products in export markets is likely to remain a continued challenge. The recent closure of historical export markets (eg Russia, Ukraine, etc) is unlikely

to be reversed; and European markets may be challenged with EU Exit. However, new markets in the Far East, despite remaining competitive, represent an opportunity to relook at international marketing (and compare with Norway and Iceland) in response to **preferences** in these markets.

4.4 Shellfish

4.4.1 Recent developments

- Major supply regions: The **availability** of Nephrops has been broadly stable with some fluctuations in volume coupled with **environmental constraints** arising from natural biological cycles of the species. Scallops **availability** has been stable (a move away from a species regarded as 'self-managing', towards a data deficient fishery and a gradual tightening in governance with the combination of Marine Conservation Zones, effort control, and inshore bye-laws) and responsive to **preferences** (with efforts to improve industry reputation, for example through the MSC led initiative in the English channel). Brown crab supply has seen increased **availability** resulting from data deficiencies and weak fisheries governance and supported by apparently benign **environmental constraints** where no obvious deterioration has been seen in the stock. Mussel production has seen a gradual increase in **availability** (slow increases in available volumes in the face of seed availability problems, inflexible regulations, Scotland aside, and discord amongst marine users), increasingly rigorous **preferences** (scrutiny on environmental impact) given **environmental constraints** (available and disparate sites) and **innovation** in production systems (offshore exploration particularly notable).

- Species and chain: All operators engaged in landing shellfish, as well as those producing mussels, have responded to pressures on **affordability**. The Nephrops fleet has seen disinvestment (decommissioning) and investment (switching from whitefish and a growing number of state-of-the-art boats) but suffers crewing problems due to unpleasant operating practices (at sea processing). The scallop fleet has seen consolidation with vessels in the 10-15m sector increasing with higher quayside prices supporting fleet investment. The brown crab fleet has developed as a localised fleet plus the emergence of modest sized, mobile and fast, super crabbers (landing higher volumes). Meanwhile mussel production has increased where there have been favourable conditions for shared costs and consolidation (e.g. in the Shetland Isles). Onshore processors have also been challenged on **affordability**, Nephrops and scallops have enjoyed high prices as demand outstrips supply; the former seeing investment in processing facilities to expand output, and the latter reaching a premium product status. Mussel processing dealing with live in-shell product into premium markets have faced challenges centring on potential food **safety** concerns (not arising from any inherent problems with mussels but because filter feeders are exposed to coastal bacterial conditions – coastal and offshore harmful algal blooms, potential new threats from micro-plastics, etc).

- Markets: Domestic shellfish products have been challenged in the UK market by **affordability** (for scallops and mussels, market conditions have supported viable supply through existing business models; in scallops a premium position has been achieved with UK retail consumers coming to terms with the higher price whilst mussels have seen slight growth). For mussels the European export markets have remained static yet important (with UK production filling the gap in variable EU production).

4.4.2 Anticipated developments

- Major supply regions: Shellfish **availability** could be enhanced primarily through improvements in fisheries governance. EU Exit offers the opportunity for reform and more flexible fisheries governance. Nephrops availability would benefit from flexibility but managing under zonal attachment is unlikely to mean substantial change. Flexibility could potentially be advantageous for scallops, for example having a system of voluntary closures could allow the natural environment to produce greater amounts of raw material. However, EU Exit could affect some parts of the scallop sector e.g. international swaps on effort most notably with France. For brown crab, there is potential for stronger governance, e.g. Defra could introduce regional management where higher minimum landings sizes and pot limits are in place - whilst withdrawing unused latent licences - to ensure higher production is not the result of increased effort. Meanwhile **environmental constraints** could both impede availability (in brown crab as a result of reduced access to the seabed; wind farms, pipeline excavations and 2nd round of MPAs) and enhance availability (in mussels, co-locating with other marine users e.g. windfarms could lead to significant increase in production particularly if supported with **innovation** - new offshore production, combined offshore/inshore production and the application of new technology, research and science).

- Species and chain: Shellfish fishery operations, and mussel producers, are expected to face challenges in **affordability**. For Nephrops vessels, regulatory 'burden' will mean it becomes more challenging to recruit crew and this may mean quota is not fully taken i.e. existing business models will struggle to maintain current supply. For mussel producers, further consolidation offers the opportunity to share and reduce cost burden. Expect industry to respond to **preferences** through initiatives that support scrutiny - improving responsible sourcing through fishery improvement projects, for example in Nephrops bringing processing onshore to address malpractice (high grading) at sea. With EU Exit, onshore operators could face the **availability** of material to EU markets through export impacted by non-tariff barriers, delays and blockades. Live and perishable fresh product - particularly Nephrops, mussels, and brown crab - are significantly exposed in this regard. Onshore operators are expected to invest in product development to support **affordability**. Areas of opportunity include **innovation** in new added value products (in scallops) and the development of new products focussed on convenience (in mussels).

- Markets: Shellfish products can expect availability and affordability challenges in markets. **Availability** of Nephrops, scallops, mussels and brown crab in exports markets are expected to be affected by changing trading conditions arising from EU Exit. The **affordability** of exports to the EU could suffer from direct increases in cost through tariffs and indirectly through non-tariff barriers (if there are tariffs then these will either fall on the customer, or the operator, or a combination of both). UK mussels filling the gap in variable EU production may not remain as a viable trade. Shellfish could face additional challenges centred on **nutrition**, arising from contamination and, in brown crab, acceptable cadmium levels (e.g. if political relations deteriorate and shape **preferences** in EU and Chinese markets).

4.5 Salmon

4.5.1 Recent developments

- Major supply regions: Farmed salmon has experienced a general increase in **availability** in which rapid volume expansion has been constrained by market conditions, with production capacity now severely limited by a regulatory regime reluctant to increase the number of sites. Limitations are aggravated further by **environmental constraints** (increase in disease issues; lice and gill disease being problems), and limited advances for **innovation** in alternative production systems (e.g. the recent closure of a closed containment system).

- Species and chain: With fluctuating volumes, operators have faced the challenge of **affordability** – in response to changing market conditions and inefficient business models (where aquaculture production levels were no longer viable), investment and disinvestment has led to a more consolidated sector with fewer operators.

- Markets: Salmon has benefitted from **affordability** in UK and export markets (market conditions supporting a premium position). Scottish salmon matches market **preferences** occupying a premium segment in the UK market vis-à-vis Norwegian salmon, with export growth (particularly exports to the US and Far East e.g. growing Chinese demand).

4.5.2 Anticipated developments

- Major supply regions: Expect **availability** of salmon to increase as regulatory conditions change; specifically a shift to offshore production due to marine spatial planning (emphasising aquaculture). However, increases will be subject to inshore regulatory change (e.g. lifting a moratorium on farm size limits) and **environmental constraints** (where biology and temperature conditions can limit growth).

- Species and chain: Expect salmon producers to maintain **affordability** of supply by increasing production volumes. However, this will be through incremental (rather than radical) **innovation**. For example closed containment production may be more attractive in the face of biological challenges compared to radical shift to deep sea offshore production (Norwegian producers being better placed).

- Markets: Expect UK salmon products to be challenged by **affordability** in the UK market, where economic conditions put pressure on price-points vis-à-vis substitute products (salmon sourced from elsewhere and other seafood species).

4.6 Example response to anticipated supplies risk (domestic)

Anticipated risk developments in the UK seafood supply base over the near- and longer-term present opportunities as well as threats. These will affect individual businesses, supply chains and industry as a whole. For each industry sector (domestic), anticipated risks are shown by dimension (availability, affordability, preferences, nutrition/safety, environmental constraints and innovation) together with a number of suggested actions from stakeholders by way of response.

Table 4.3 Suggested actions in response to anticipated supplies risk (domestic)

Sector	Dimension	Anticipated risk	Suggested action	Example owner*
General	Innovation		Continued insight on the possible impacts of EU Exit.	Seafish
			Help with strategic planning. This could include bridging activity between RASS and HS. E.g. mackerel distribution shifting up to Iceland could have been more proactive with discussions and plans.	Seafish
			Move from a vague to a clear Seafish offer: i) Provide an overall watching brief (like this horizon work), provide data to answer questions where industry has to react to situations coming out of the blue (support arguments) ii) Offer platforms/facilities that can save operators money.	Seafish
			Improve industry stakeholder engagement e.g. hold more industry supply meetings in appropriate regions of the UK rather than London.	Seafish
Whitefish	Availability	Fisheries governance	Use UK legislation to improve governance/enforcement.	
			In the face of increasing supply ensure there are enforced controls to avoid flooding the domestic market.	
	Affordability	Investment	Expanding availability needs to be gradual with onshore having to grow with higher volumes so as not to crash the market.	
		Market conditions	Focus on improving domestic consumption of UK fish.	Seafish
	Nutrition, safety	Industry practice/ malpractice	Improving knowledge transfer between fishermen and processors (e.g. factory visits) to highlight importance of product quality (e.g. focus on chilled chain, not days at sea).	
	Innovation	Gear innovation	Industry could set an ambitious standard for using smart gear. Could aim to get mesh size up, for example 5mm every five years, so that a level of responsible fishing is reached that is reasonable for businesses. Could have 3rd parties (NGOs/multiples) tagging gear being used (e.g. larger mesh size than required). Seafish could play a role in smart gear technology (as this has waned in recent years).	
	Preferences	Scrutiny/public perception	Improve resources to get people new to the industry (particularly in retail) quickly up-to-speed with issues, reducing misunderstanding and supply chain tensions.	
Pelagic	Availability	Volume	Explore the options for more UK fish landed in UK ports.	Seafish
		Regulations	Adopt a regulatory approach to securing fish - address the lack of political will to review the economic link in fisheries licensing (as agreed in the 2012 concordat and the Defra Seafood 2040 report). At present, in England, there is not the industry critical mass to deliver.	
		Operating practices	Explore how the pelagic industry can be match fit from the new supply portfolio.	
	Affordability	Market conditions	Adopt a market approach to securing fish: • Encourage UK processors to participate in the international auction in Norway. • Assist processors expand infrastructure/capacity (bring operators up the standard of Norwegians).	
	Preferences	Scrutiny/public perception	Review international marketing of pelagic material, especially in comparison to Iceland and Norway (posing big questions for Scot Govt, Seafood Scotland, Seafish).	

Shellfish		Trading conditions	Consider future trade conditions. In Scotland, industry is working with Scot Govt on EU Exit trade scenarios. NFFO/SAGB have initiated a trade group to explore the evidence needed to define and quantify the various product journeys in the shellfish sector vis a vis exports and the customs union.	
			Industry is looking for EU Exit to result in a reasonable redistribution of fish allocation. Governance reform to see a shift from 'Relative Stability' to 'Zonal Attachment' as the basis for informing coastal state negotiations on fishing shares. A balance between what is reasonably due to the UK and onshore capacity/adjustment to: 1. Process additional volume. 2. Find markets for material.	
	Availability	Fisheries governance	Industry should track where Defra goes on regional management of crustacea. Whether via effort limitation, or technical measures, once UK becomes a coastal state, regional industry groups will need to take part in realistic and perhaps rapid responses if Defra loses interest, or makes inappropriate proposals.	NFFO Shellfish Committee and SAGB
			Industry lobbying support to maintain shellfish studies and data collection. This may be critical if shellfish research, stock assessment and advice are threatened with any attrition of Government staffing and funding (e.g. if the post-EU Exit demands on the finfish side become all encompassing).	
			There is a lot of good work underway, e.g. Fishery Improvement Plans (FIPs), driven by industry or NGOs or Seafish. Given the risk of duplication, Seafish could provide a useful platform to collate all relevant information on improvements in shell fisheries.	Seafish
		Inflexible regulations	Seafish, having a good identity/objective position, could translate industry messages upwards to overcome bureaucratic blockages, and keep mussel site approvals process moving (not to cut down or avoid).	Seafish
	Affordability	Investment	Arrange finance/credit for mussel producers. As assets in the water are not recognised by banks, a financing regime for shellfish farmers would be helpful.	
	Nutrition, safety	Safety	Prepare and manage the media if microplastics are identified in mussels.	
		Consumer preferences	Seafish can support awareness, maintaining campaigns of broad species; increasing the popularity of fish with prime time exposure with celebrity chefs/ internet based campaigns so people can understand the product.	Seafish
			Industry can increase visibility of fishermen e.g. fishermen's blogs a few years ago, connecting with industry communications on social media to a wider audience and to target millennials.	
	Preferences		Develop apps that can support people going to counters (level of cooking experience, e.g. beginner), promote monthly species, menu options, print out ticket for counter staff, also protein chart to compare cost of protein against pork/lamb/beef (e.g. chicken versus fish).	
		Scrutiny, public perception	Blue Planet and social media focus on marine plastics, yet the industry has been collecting refuse for years. Seafish could help raise awareness of this good work.	Seafish
			Position seafood in the UK food strategy. Highlight healthy food, ecosystem services (public good), highly efficient foodstuff. Sits with the circular economy.	Seafish
	Innovation	Product innovation	New product development in mussels to increase UK consumer take-up – there may be opportunities around shell-off product rather than current shell-on.	
Salmon			At market end, move beyond maintaining premium segment and maintaining reputation.	Scottish Salmon Producers Organisation
	Preferences	Scrutiny/public perception	In production standards, the likes of BAP and ASC are becoming more important. Scottish salmon is not a leading voice in ASC. Early ASC development did not reflect Scottish production (heavy NGO influence, so didn't have a champion) a disadvantage to the industry.	Scottish Salmon Producers Organisation
	Innovation	Production innovation	Investment in step-change e.g. sub group on site innovation – how do we grow much more fish? Do we have offshore cages/closed cages?	Scottish Aquaculture Innovation Centre

*stakeholder suggestion (to be agreed)

International supplies

Table 4.4 Anticipated risk developments for international supply and selected impacts (opportunities - green/threats - red).

International	Supplies impact	Supplies risk dimension					
		Availability	Affordability	Preferences	Nutrition & safety	Environmental constraints	Outliers
SUPPLY REGIONS							
WHITEFISH							
a) Seafood resource							
NE Atlantic fisheries (cod, haddock)	i) Species availability ii) Industry reputation	🟢		🔴🟢		🔴🟢	
NW Atlantic fisheries (cod)	i) Species availability	🔴🟢		🔴🟢		🔴🟢	
Global aquaculture (tilapia)	i) Expanded production	🟢	🟢			🟢	
SE Asia aquaculture (pangasius)	i) Constrained production	🔴🟢	🔴🟢			🔴	
PELAGIC							
a) Seafood resource							
All tunas	i) Stock over exploited, ii) Species availability	🔴	🔴			🔴	
Asian aquaculture (bluefin tuna)	i) Constrained production	🔴🟢	🔴🟢			🔴	🟢
SHELLFISH							
a) Seafood resource							
N Atlantic fisheries (cold-water prawn)	i) Species availability	🔴				🔴	
Shellfish aquaculture (warm-water prawn)	i) Expanded/volatile production	🔴🟢	🟢			🔴🟢	🟢
SALMON							
a) Seafood resource							
NE Atlantic aquaculture (Atlantic salmon)	i) Expanded production but constrained	🟢				🟢	🟢
E Pacific aquaculture (Atlantic salmon)	i) Uncertain/volatile production	🔴🟢				🔴🟢	
NE Pacific aquaculture (wild pink/red salmon, Atlantic salmon)	i) Constrained production	🔴🟢				🔴🟢	
SPECIES AND CHAIN							
FISHERY/PRODUCTION OPERATIONS							
b) Whitefish fishery operations							
All wild capture fisheries (NE Atlantic and N Pacific)	i) Catch viability with new/redundant business models ii) Managed exploitation iii) Industry reputation		🔴🟢	🔴🟢		🔴	
All wild capture fisheries (NE Atlantic and N Pacific)	i) Catch viability with new/redundant business models (Global)		🟢	🟢			🟢
NE Atlantic fisheries (cod, haddock)	i) Catch viability with new/redundant business models (Norwegian)		🟢	🟢			🟢
NE Atlantic fisheries (cod, haddock)	i) Catch viability with new/redundant business models (Icelandic)		🟢				🟢
NW Atlantic fisheries (cod)	i) Catch viability with new/redundant business models (Canadian)		🔴🟢	🔴🟢			
N Pacific fisheries (Alaskan pollock)	i) Catch viability with new/redundant business models (Alaskan)		🔴🟢				
b) Pelagic fishery operations							
All tunas	i) Stocks over exploited, ii) Catch viability with new/redundant business models	🔴	🔴			🔴	
All tunas	i) Industry reputation and malpractice	🔴		🔴	🔴		🟢
Indian ocean fisheries (tunas)	i) Catch viability with new/redundant business models	🔴	🔴	🟢		🔴	
b) Shellfish fishery operations							
N Atlantic fisheries (cold-water prawn)	i) Catch viability with new/redundant business models	🔴	🔴			🔴	
Shellfish aquaculture (warm-water prawn)	i) Expanded production but constrained ii) Industry reputation	🔴🟢		🔴🟢		🔴	🟢
b) Salmon fishery/production operations							
NE Atlantic aquaculture (Atlantic salmon)	i) Expanded production	🟢	🟢			🟢	🟢
E Pacific aquaculture (Atlantic salmon)	i) Uncertain/volatile production	🔴🟢	🔴🟢			🔴🟢	
NE Pacific aquaculture (wild pink/red salmon, Atlantic salmon)	i) Constrained production	🔴🟢					
ONSHORE OPERATIONS							
c) Ports, harbours and markets							
d) Primary processing							
Whitefish (cod and haddock)	i) Supply viability with new/redundant business models (Norway)		🟢				🟢
Whitefish (cod and haddock)	i) Supply viability with new/redundant business models (Iceland)		🟢				🟢
Whitefish (cod and haddock)	i) Supply viability with existing business models (Canada)		🔴🟢				🟢
Pelagic (tuna)	i) Supply viability with existing business models (threat)	🔴	🔴	🔴		🔴	
Shellfish (cold-water prawn)	i) Supply viability with new/redundant business models (Canada, Iceland, Norway etc)		🔴🟢				
Shellfish (warm-water prawn)	i) Supply viability with new/redundant business models	🔴🟢	🔴🟢	🔴🟢	🔴		🟢
e) Transporation of catch							
f) Secondary processing							
g) Tertiary products							
Whitefish (cod, haddock)	i) Supply viability with new/redundant business models (Iceland, Norway, Russia etc)		🔴🟢				
MARKETS (SALES OUTLETS)							
Global aquaculture (tilapia)	i) Supply viability with new/redundant business models in UK		🟢	🟢			
Pelagic (tuna)	i) Supply viability with new/redundant business models, ii) Trading costly/impeded	🔴	🔴	🔴		🔴	
Shellfish (cold-water prawn)	i) Supply viability with new/redundant business models	🔴🟢	🔴🟢			🔴🟢	
Salmon aquaculture	i) Supply viability with existing business models		🟢		🟢		🟢
h) Retail							
Shellfish (warm-water prawn)	i) Market access improved/impeded ii) Supply viability with existing business models	🔴🟢		🔴🟢			
i) Food service							
Whitefish (cod, haddock)	i) Supply viability with existing business models		🟢	🟢			
Shellfish (warm-water prawn)	i) Supply viability with existing business models		🔴🟢	🔴🟢			
j) Wholesale							
k) Feed suppliers							

4.7 Whitefish

4.7.1 Recent developments

- Major supply regions: International whitefish supply has been driven primarily by **availability**, preferences and environmental constraints. The availability of **whitefish in the NE Atlantic** has been driven by concerns over the robustness of fisheries governance. Better management control (undertaken jointly by Norway and Russia) reducing illegal fishing, and quota setting more aligned with science/evidence (e.g. Norwegian Research Institutes), allowed Total Allowable Catch in the Barents Sea to expand, for example cod peaked at over a million tonnes. Likewise Icelandic fisheries have adhered to a strict harvest control rule. **Environmental constraints** have been eased with natural biological cycles contributing to healthier more abundant resources. The Barents Sea fishery has seen significant growth in the cod stock to 2013, though now showing a downward trend, whilst the haddock stock similarly peaked in 2013 but remains at a high level. The Icelandic cod stock has grown steadily since 2011 due to a strong spawning stock. After growth running to 2010, the Icelandic haddock stock has stabilised at a lower level for several years now reflecting the long-term average. However environmental conditions are introducing new constraints; climate challenge in the Barents Sea fishery, particularly increasing temperature and melting sea ice, are potentially changing feed availability, fish movement, and subsequent changes in texture of the fish meat. **Preferences** for NE Atlantic fisheries have been shaped by scrutiny and public perception (focussed on sustainability and the consumer interest in this). Some 15 years ago cod was the fish to avoid. However, around five years ago it was becoming clear that Barents Sea and Icelandic whitefish fisheries were being managed to a high standard (volume varying with biological cycles - patterns that are well established) and this has resulted in growing confidence in supply. More recently, scrutiny has highlighted climate change, melting sea ice and protection of the marine environment in the Barents Sea; Greenpeace campaigned against extending fishing activity in the area around Svalbard and the Arctic circle. The **availability** of **whitefish in the NW Atlantic** has long been restricted since the introduction of the cod moratorium in 1992. Robust fisheries governance is in place protecting potential supply off eastern Newfoundland and Labrador, allowing only a small annual catch volume. The resource is **environmentally constrained** with cod stocks having remained at low levels for a prolonged period. Around five years ago there was a good year of spawning/newer fish; however there is uncertainty on the growth trajectory of this year class. **Preferences** for cod in the NW Atlantic are strongly influenced by public perception (the collapse of the cod stocks and industry reputation) and scrutiny (currently the fishery has a FIP monitoring the condition of the resource). The **availability** of **Alaska pollock** in the North Pacific has been supported by the high standard of management in the Alaskan fisheries (also underpinned by MSC certification). This management has ensured quota setting is more aligned with science/evidence (e.g. North American Association). Robust fisheries governance has helped manage scrutiny and public perception. This has provided confidence in this supply, helping industry respond to market **preferences**. However, scrutiny has also involved environmental concerns, attracting attention from NGOs campaigning for protection of the marine environment e.g. Greenpeace campaign to protect the Bering Sea canyons. The **availability** of **pangasius**, much of which is farm produced in SE Asia (Vietnam), has increased considerably. Resources grew rapidly several years ago but recently have been more constrained. Much like salmon, this species encountered many challenges such that regulation was increased and improved. Regulation, and the confidence this has given to grow the sector, has helped this species in the face of scrutiny and public perception. Meanwhile the **availability** of **tilapia** has also grown globally; farmed volumes have grown, particularly in Latin America and China, as this species has been able to respond to **preferences** in world markets (although less well in UK and EU – see below).

- Species and chain: Fishery operations and onshore operators in the whitefish sector have been challenged to maintain **affordability** given **nutritional requirements, preferences** and **environmental constraints**. Economic and market conditions have driven vessel owners towards new business models to ensure catch viability. Fleets are seeing vessel investment worldwide; with increased investment in trawlers and weaker investment in line catching vessels. Attention to product quality, industry reputation and environmental impact of trawling has driven innovation towards lower impact trawl gear.

    - Norwegian vessels are now much more technology oriented, operating as highly efficient floating factories. Research has focussed on smoothing seasonal Norwegian catch and investment in ranching live fish.

- The Russian catching sector has invested in the refreshed sector, increasing 'at sea' production and less headed and gutted (H&G). Improvements in the freezing processes and thawing techniques and technologies.
- In Iceland, the catching sector has seen investment and consolidation with vessels part of larger vertically integrated seafood companies. New builds are replacing older vessels, with investment in new technology to super-chill fish (reducing ice requirement), collect by-products and automate storage (reducing crew).

- Similarly, economic and market conditions are driving operators towards new business models to ensure supply is viable to the market[9].
  - In Norway, freezing and processing technology is being developed to support domestic, rather than offshore (e.g. China), fish processing.
  - In Iceland, a combination of political support, a competitive exchange rate (following the Icelandic crash), investment and technology breakthrough has advanced domestic processing such that throughput has increased by 100% - effectively doubling the output of three or four years ago.
  - In Canada, infrastructure is much reduced with limited onshore processing reflecting the catching constraints (cod moratorium).
- Pangasius producers (largely in Vietnam) have supported the **affordability** of this species, with economic conditions driving business models (vertically integrated and reduced operational costs) and investment supporting expanded production. Meanwhile, pangasius has been supported to meet market **preferences** through regulation, progressively introduced and enforced, that has led to better management practices, together with certification such as ASC. Pangasius has also benefitted from relatively benign **environmental constraints**. Produced in non-industrialised part of the world with good feedstuff and without industrial pollution. Although there are issues over antibiotics, these are considered much smaller scale than in agriculture. This species has positive growth conditions with advantages over others: being without the parasite issues that salmon experience, fewer disease issues, and prevalent feed sources containing a smaller percentage of wild capture.
- The **affordability** of tilapia has been supported through investment in farm operations, particularly in China and Latin America (although not at a lower cost than pangasius). Tilapia farms in the UK were established when there was a view that cod would become unavailable; however with continued cod availability the farms folded. In meeting **preferences**, certification and production **innovation** has played an important role in securing market access. China is the largest tilapia producer/exporter (exporting frozen product at low prices to the world market – with good quality certified product) whilst Latin American farms have developed to produce high quality chilled product to make entry into US markets (white cloth dining).
- Markets: International whitefish has been challenged in the UK market by **affordability** and **preferences**. Some 15 years ago there was a shift from **cod and haddock** towards Alaska pollock then pangasius. For cod and haddock, economic and market conditions mean UK consumers resist price rises, so existing business models have had to absorb fluctuations in availability (for example adjusting portion sizes at price points) to ensure supply is viable. In retail, market conditions have also meant refreshed product has been favoured to ensure supply is viable (refreshed product being almost as good as fresh product and is more convenient to use) whilst scrutiny and public perception has driven a general preference for, and shift towards, line-caught product. In food service, market conditions have meant viable supply relies on commodity whitefish at a low price. Chinese double frozen has gained favour in this regard. With market conditions, **pangasius** gained a foothold in the UK mainly as a result of its low price point. Market entry was supported by a robust response to scrutiny (with reputation management, presenting facts and challenging myths). However, meeting **preferences** has been challenging; for some, this species - having an earthy taste - does not match UK consumer preferences particularly well. Now, however, pangasius is no longer just affordable but matches consumer preferences (desirable, able to carry flavours, etc). In contrast, **tilapia** has a relatively weak position in the UK (and EU) market being largely confined to ethnic communities. UK is resistant to this species on the basis of price points (more expensive than cod or haddock) and consumer preferences (the UK consumer is resistant to it being a relatively flavourless farmed product without much appeal). Historically, the

9 For example, some operators are now receiving processed cod and haddock from China that is cheaper than it was to produce three or four years ago. Such a price reduction is indicative of global competition but also, in the face of higher labour costs in China, can indicate malpractice - see Seafood Strategic Outlook Product Integrity (www.seafish.org/media/1644236/product_integrity_lr.pdf).

UK introduction of tilapia suffered from poor marketing ("farmed fish from Asia", negative perceptions of farming, animal welfare and environmental standards) and was a contender only if both cod and haddock were unavailable.

4.7.2 Anticipated developments

- Major supply regions: International whitefish supply is expected to face challenges primarily in terms of availability but also preferences and environmental constraints. Notwithstanding year to year variation, the **availability** of **whitefish in the NE Atlantic** is expected to centre on stability in Barents Sea and Icelandic fisheries rather than major volume increase or reduction. Icelandic cod will see a slight increase in the next five years, Icelandic haddock to remain stable at current levels. There is a small risk that Barents Sea management will struggle if geopolitical relations (between Norway and Russia) deteriorate and also if new negotiating agreements (Norway/UK/EU) founder. **Preferences** are expected to increase the focus on stock management and sustainability in the Barents Sea (limited further contribution given the fishery is already well managed) but **environmental constraints** may tighten with conflict between environmental management (temperatures rising), harvesting (fish moving north into new areas) and access (closed areas). Robust fisheries governance could lead to significant increase in the **availability** of **whitefish in the NW Atlantic** if the biological condition of Canadian cod off Newfoundland is favourable and **environmental constraints** are eased (if the cod year class can get past year six, then this could be a significant future source of supply). Canadian cod may prove superior in terms of **preferences**; with a much sweeter taste than NE Atlantic cod, this could potentially be preferable to the UK consumer.

- **Pangasius** and **tilapia** could see expanded production increase **availability** of farmed species with a much larger share of the market being supplied by an aquaculture product like tilapia. However this will be shaped by **affordability** and **environmental constraints**. Pangasius has growth potential with favourable economic and market conditions (sector is new, labour cost is low, water is available) but constrained by environmental conditions (inland farming will face space constraints). Expect pangasius to be a strong competitive force vis-à-vis NE Atlantic cod and haddock (more so than increased supply of Canadian cod). Tilapia resources could grow significantly due to favourable conditions, especially in the developing world and particularly fresh water production in Africa.

- Species and chain: Fishery operations and onshore operators in the whitefish sector are expected to face challenges centred on **affordability**. Expect vessels in the Atlantic and the Pacific to travel further to find fish i.e. longer (more expensive) fishing trips as fish move north. Given levels of availability, expect to see market competition intensify across a number of supply regions (e.g. South America, Asia, and potentially higher value markets prepared to pay more - potential for USA to increase seafood consumption) and some vessel owners pursuing new business models to ensure catch viability, others being less able to do so. Operators will face tensions between **preferences** (different levels of scrutiny and challenge to industry reputation) and **environmental constraints** (biological pressure and exploitation rates with environmental impact). Expect **innovation** to drive smart technology that can maximise fishing opportunity whilst limiting impact (expect the exploration of low impact trawl through transformative technology e.g. transfer of pelagic pumping technology as a potentially useful technique and selective gears that can better target sizes and year classes).

  - In Norway, expect much more efficient vessels doing more production on board, with aspirations to supply further up the supply chain, the potential re-emergence of fish farming of cod and other whitefish (introducing competition for wild capture whitefish), and delivery of fresh whitefish products year round.

  - In Iceland, catching consolidation will continue but slow as industry runs out of companies to buy.

  - In Canada, however, restrictions on cross ownership between the catching sector and onshore sector may limit new business models and keep costs high.

- Expect onshore operators in primary and secondary processing to develop new business models to ensure supply is viable to the market. Given the level of investment in whitefish source regions, and investors seeking a return on that, expect a shift in sourcing for the market. The split in market preferences (premium cuts close to source - fresh and refreshed - versus other cuts) drives changes in sourcing; with increased focus on premium cuts from Iceland/Norway/Russia, challenging the sourcing and utilisation of other cuts.

- In Norway, with supplies stabilised at the catching end, expect existing supply chains (that process in Eastern Europe and China) to be challenged if technology supports freezing and Norwegian processing of fish (through reduced reliance on labour).
- Expect consolidation in Icelandic processing to continue at a slower rate. Given the focus on exporting fresh fillets, expect Icelandic operators to respond to Norwegian/Russian investment in the refreshed sector. EU Exit is a concern; depending on the UK/Iceland deal it could have a large impact on how much supply will go to the UK.
- In Canada, expect several years before production can take advantage of any increased availability. However, expect availability to unlock significant investment to upgrade infrastructure and difficulty with securing vertical integration/optimisation (given restrictions on operator practices) keeping costs high.
- In secondary processing there is continued pressure to fully utilise fish material e.g. use of fish block material (for fish fingers/ready meals, etc) may diminish, and other cuts may have to be developed to maintain value.

- Markets: International supply will continue to be challenged in the UK market by **affordability** (on price) and **preferences** (scrutiny/public perception). For example, expect the food service market for **cod and haddock** to retain a focus on price and favouring Chinese double frozen (rather than Icelandic single frozen) product. It is expected that any shift in the market (from a commodity/low price to premium market) will only take place in the long-term where preferences compel operators to communicate sourcing credentials e.g. if claims need to be put on menus. Affordability is also expected to weigh heavily on whether **tilapia** can succeed in the UK market. Expanding tilapia in the UK is unlikely whilst there are alternatives (cod, haddock, pollock, and pangasius in food service). Entry would have to be slow burn and hit mid-price range (rather than compete with low price pangasius), possibly through food service and association with street food and ethnic cuisine and championed by celebrities and celebrity chefs.

4.8 Pelagic

4.8.1 Recent developments

- Major supply regions: International supplies of tuna, from all regions but particularly (for the UK) the Indian and Pacific Oceans, have been challenged primarily by availability, affordability and environmental constraints but also preferences and nutrition/safety. **Availability** is partly influenced by seasonality of this tropical species but has also been driven by weak fisheries governance, with tuna stocks managed to the cusp; fished to maximum sustainable yield (MSY) or beyond that. Ideally management would be based on science, however existing fisheries governance under regional fisheries management organisations (RFMOs) has proved somewhat inadequate (not all tuna stocks are quota managed, and some RFMOs governance is weak). **Affordability** is driven by economic and market conditions such that buyers price-points make tuna a high value species. This value and the business models underpinning it, make tuna of great political importance to coastal and port states. This political standing has undermined science based management. Furthermore, being a high value species heightens sensitivity over **nutrition/safety** (growing suspicion of illegal activity - both in terms of IUU and slavery) and alignment with **preferences** (scrutiny and certification). Weak **environmental constraints** undermine natural/biological cycles: there is little scope to improve stocks when fished so hard. In practice stock status fluctuates at maximum/overfished/just underfished. Tuna from the Indian Ocean, for example, is challenged by availability (monsoon season and Ramadan), affordability (market conditions driving price fluctuations across the season) and market preferences (NGO scrutiny includes the Marine Conservation Society giving tuna a red rating - fish to avoid e.g. due to IOTC implemented rules not being followed with landings volumes, especially yellowfin, being much higher than advised). **Innovation** in production has meant farmed tuna availability has advanced, albeit at a very small scale (farming in Japan and Australia). Bluefin aquaculture has turned a corner and managed to go full circle in breeding fish in captivity, although feeding the fish remains a problem.

- Species and chain: In recent years, concerns have grown over **availability** in the face of **environmental constraints** (stock biomass declining in a lot of cases and exploitation increasing). Tuna fishery operations have maintained **affordability**, through **innovation** that has, in turn, affected environmental constraints.

Smart technology has maximised the purse seine fishing opportunity. The purse seine net fleet (principally targeting skipjack for the canned tuna market, as well as targeting larger tunas seasonally) has become very efficient by developing sophisticated techniques for spotting/tracking (IT and satellite skills) and catching fish (using fish aggregating devices (FADs)). These are considered so numerous that some think it is affecting tuna migration. This contrasts with the long-line fleet that has seen fewer technology advances and are typically quite old. The long-line fleet can super freeze and stay at sea for long periods, but with challenging market conditions it would appear these vessels are being run down or converted to purse seine. In addition, some countries are sponsoring the exploitation of smaller fisheries from source countries that have less viable and less fished stocks (keeping a steady flow by increasing the catch areas). Onshore operators, securing material across the above supply bases for the UK, have been challenged on **affordability** with prices having escalated due to increasing pressure from third countries accessing supply; and more recently by the worsening exchange rate since the EU Exit referendum. Market conditions drive particular business models to ensure supply viability. For primary processors, an important source of fresh tuna coming into the UK is yellowfin from the Indian Ocean. Viability of this supply is being challenged as, over several years, the price ceiling in the post summer period has steadily increased and now moving into a new high-price era. In recent years, new business models have been developed using processing **innovation** (super freezing technology) to secure viable supplies from further afield (the Pacific Ocean) for the UK market. For secondary processors, most of the canned tuna (mainly skipjack, but some bigeye and yellowfin) is sourced from the Indian Ocean and, more recently, the Pacific Ocean to meet market **preferences**, customers sustainability requirements; typically MSC-certified fisheries (many pole-and-line and non-FAD), cooperation in FIPs and with competitors to address IUU). A proportion of Atlantic tuna comes into the UK via Ghana as canned tuna. It is likely that fresh and frozen tuna from the Atlantic goes into Spain and from there into the rest of the EU; where **nutrition/safety** concerns have been raised recently relating to product integrity and use of red colouring (beetroot juice) and treatment with antioxidants to enhance the colour of lower grade tuna.

- Markets: The supply of tuna to the UK market has been shaped by **affordability** given **availability** and **preferences**. In food service, for example, viable supplies are increasingly relying on frozen tuna (an advantage for super-frozen supplies) driven by market conditions and regulatory conditions (in accordance with EU law, all fish intended to be eaten raw has to have been previously frozen, to a specific temperature and time period, before serving). In retail, supply has remained viable with existing business models as market conditions sustain a high demand for tuna from responsible sources. However, increasing pressure on price has driven a notable decline in volume (particularly canned).

4.8.2 Anticipated developments

- Major supply regions: The anticipated supply of tuna will be shaped primarily by availability, affordability and environmental constraints and innovation. In wild capture, **availability** will be driven by a combination of continued weakness in fisheries governance and trading conditions (fishing effort may be maximised, IUU fishing may worsen, and concerns over human rights issues) as tuna continues to be a high value species (with wealthier populations meeting the challenge of **affordability**). Tuna will face tightening **environmental constraints** in terms of the biological condition of stocks (increased competitive pressure for a finite stock as countries become wealthier with sustained stock improvement remaining elusive) and longer-term deterioration in growth conditions (given a growing focus on harvesting meso-pelagic stocks - feed material for tuna stocks) and environmental conditions (global warming of the oceans likely to affect tuna fisheries). Production **innovation**, **affordability** and **environmental constraints** are expected to impact ranched and/or farmed **availability**. The availability of farmed tuna could increase but constraints will limit volumes. The affordability of bluefin will improve as aquaculture is made more efficient, but it is unlikely to commercially viable within the next 15 years. Remaining difficulties in feeding the fish - even with feed innovation - would suggest bluefin resources will grow rather than thrive. Expect bluefin to remain a very exclusive product.

- Species and chain: Fishing operators and onshore operators will be challenged by availability and **affordability** in tension with preferences, nutrition/safety and environmental constraints. Given pressures on supply, expect affordability to challenge vessel owners with market conditions making the catch less viable (alongside the supporting business models). With buyers in rapidly developing countries having different **preferences** to western buyers markets (some of their market demands being years away

from a 'western approach') this competitive pressure could result in further challenges for western buyers. This includes increased malpractice, impaired product quality and unethical practices, leading to concerns over **nutrition/safety** and falling short of **preferences** (e.g. failures in certification and scrutiny). Although this is expected to be addressed over time through **innovation** (e.g. increased transparency such as greater visibility of vessel tracking data and the use of blockchain technology), expect IUU fishing and unethical practices to worsen in the next several years, before technology makes illegal activity very difficult towards 2030. For onshore operators, **affordability** will be a major challenge given preferences and environmental constraints. Economic and market competition will intensify (as developing countries become wealthier and eat more high value fish), competition to purchase fish will increase and the cost to produce the fish will rise. In the Indian Ocean, for example, the **availability** of tuna could be damaged if trading conditions worsen (with real difficulties if EU Exit results in a no deal (WTO) situation where the UK loses the current preferential trade arrangements between the EU and third countries). Expect further effort to meet **preferences**. For example through certification initiatives to get all Indian Ocean purse seiners to MSC level. Expect efforts to address **environmental constraints** - the impact of purse seiners being potentially 'choked' by their impact on unsustainable fish such as juvenile larger tunas if caught as a bycatch in the mature skipjack fishery, and the MCS red rating of tuna-producing countries. The red rating could remain in place but, once proven to work and improvement made, may be removed. Expect these developments to impact on **affordability**: yellowfin is expected to see an upward price trend whilst the price/availability of skipjack is expected to be problematic. Market conditions will challenge the viability of Indian Ocean tuna and the supporting business models as a supply option for UK fresh and canned tuna.

- Markets: Expect tuna to be challenged in the UK market on a number of fronts: availability, affordability, preferences and environmental constraints. Expect **affordability** to be a key challenge with market conditions for tuna and weaker trading conditions (trade agreements and weak exchange rate) driving price increases across tuna products. Expect this inflationary pressure to lead to a further reduction in volume demanded, particularly for canned material (where tuna bulk buys are not perceived as being as good value by consumers) and a search for substitute for large pelagic material (e.g. amberjack, trevally, yellowtail).

4.9 Shellfish

4.9.1 Recent developments

- Major supply regions: **Cold-water prawn** material has experienced major fluctuations in **availability** changing from growth to long-term decline. Some 15 years ago, prawn stocks (in Canada, Greenland, Iceland and Norway) were strong and supported sizeable supply growth. From around 2003/4 a decline in biomass has resulted in a continuous decline in supply. The political climate, and fisheries governance, has been reasonably steady with lessons being learned from other fisheries e.g. discussions on management of stocks, catch avoidance, etc. The downturn has been associated with **environmental constraints**, specifically natural/biological cycles of prawn abundance (the decline has been linked to increasing cod predation) and environmental conditions (suspected effects of climate change and increasing water temperatures, and the distribution of certain stocks moving north). For Norway, Iceland and West Greenland stocks continue to be poor - the primary reason appears to be cod predation (rather than the suspected effects of climate change). **Warm-water prawn** has experienced major changes with an explosion in **availability**. However, **environmental constraints** mean production, and availability, has been volatile. Prawn is susceptible to disease that can spread quickly along difficult-to-protect coastlines – notable outbreaks include White Spot Syndrome Virus (WSSV) and Early Mortality Syndrome (EMS). Overall, production volumes have expanded worldwide as a result of **affordable** farmed production, in Latin America and the Far East in particular supported by **innovation** in production: switching to a species with more advantageous characteristics. Some 15 years ago the dominant species sourced was the wild-caught black tiger prawn (slower growing and more disease prone) and this was substituted for, the faster growing and more disease resistant, vannamei prawn more amenable to farming. Now farmed species are dominant (~75% of farmed production is vannamei) whilst wild-caught black tiger is a minority.

- Species and chain: In response to the availability of **cold-water prawn** and market conditions, fishery operations have adjusted their business models to ensure viable catch and maintain **affordability**. In the period of growth to 2008/9, the main focus was on production efficiencies; securing yield rather than quality. More recently, with volumes reducing as catches/quotas get smaller each year, this business model is beginning to be challenged. Onshore primary

processing operations (Canada, Iceland, Norway, etc), under similar conditions, have also sought to ensure a viable supply to maintain **affordability** through appropriate business models; high volume/ low price with very tight margins. The downturn in stocks has seen processors adjust their business models to maintain affordability; lower volumes/higher price with improved operator margins compared to 10 years ago. Adjustment includes a reduction in primary processing: mothballing of plants (to return when stocks recover) in the likes of Northern Norway and Icelandic peeling plants, with high social costs; consolidation (significant in Norway, but also vertical integration - Greenland purchased a Canadian operator to secure catch). In **warm-water prawn** production, investment has led to a huge increase in supply sources with the rapid increase in Far East production contributing to **affordability**, particularly in India (having large areas dedicated to the production of this prawn). Generally farming is more intensive in SE Asia (>100 per square metre) compared to Latin America (10-15 per square metre), the latter typically attracting a price premium. However affordability has been undermined by disease outbreaks and poor management. Production suffered in the early 2000s with WSSV whilst four years ago the outbreak of EMS devastated production in Thailand, and reduced crops in Vietnam and South America. This disrupted world production and produced substantial price spikes. More recently market conditions (demand from rapidly developing countries) has seen a shift in the supply base. Domestic supply from Vietnam and Thailand has been exported to China, with Vietnam and Thailand now importing prawn from India. Prawn operators have experienced mixed fortunes in relation to **availability** (of product specification) and **nutrition/ safety** (product composition and quality). Product quality has improved through innovation in product specification (shift from all frozen block/headless product towards selling IQF/peeled product), and the build-up of primary processing in developing countries. However, in some instances, product quality has been undermined by industry malpractice and the system of industry packaging. Many operators use packaging systems where products are bought on a net weight basis. Others (e.g. in some EU countries and in the Middle East) use alternative systems that are inferior in that they can undermine product integrity (demand for cheap product can result in product carrying a higher percentage of water content)[10].

- Markets: **Cold-water prawn** in the UK market has had mixed fortunes with changes in **preferences** fuelling fluctuation in popularity. **Environmental constraints** (limited stock productivity) and recent tightening of market conditions has seen UK market demand rising and a steady increase in prices, challenging **affordability** (maintaining viable supply). **Warm-water prawn** has secured its position in the UK market as a staple product in retail (ready cooked products and as head-on product on fish counters) and in food service. This has been supported by **innovation** (expanded production volumes) and **affordability** (viable supply). Securing access to the market has meant responding to **preferences**; responsible practices and assurance are a growing condition driven by increased scrutiny and certification (with concerns over product quality), largely in the retail sector such that no UK retailers are knowingly selling adulterated prawn. Food service cannot impose strict specifications on their supply in the way retail can. Food service customers are very much focussed on price and there is a market for lower quality product (including product that has been phosphated to allow added water). Over the last few years, stories on bad social/ethical practices have come to the fore, with slavery in the supply chain a substantial concern. With social issues having been less of a driver in shaping current certifications, these issues are covered only to a limited extent[11]. This new ethical aspect, is becoming more significant, with all the large catering companies starting to require third-party certification as a condition of purchase (as it provides a safety net).

4.9.2 Anticipated developments

- Major supply regions: The **availability** of **cold-water prawn** is expected to continue its decline over the long-term as a result of **environmental constraints** (natural/biological cycles of abundance, cod predation) before normalising at a stable level. At some point the decline of prawn stocks should stabilise and harmonise with cod stocks.

10 It is common practice amongst operators in some EU countries to use a packaging system based on glaze and 'weight and counts'. This inflates consumer prices (can mean products are sold carrying a higher percentage of water content) and supply costs (as supplying countries - such as India - have to establish new weights/counts systems for the EU over and above existing net weights systems for other markets). Efforts have been made to reform the packaging system in the EU but without success (requiring unanimity and a number of countries refusing the reform did not pass). Demand for cheap product leads to increased risk of adulteration (e.g. glaze) and fraud.

11 See *Standards and the Blue Economy* report (http://www.iisd.org/ssi/standards-and-the-blue-economy).

12 For example Asian countries with available land (both Malaysia and Indonesia have substantial tracts of land), can switch production from agriculture to prawn cultivation very easily. Further production opportunities are likely in India, Latin America (Brazil and Ecuador) and the Middle East. There are also farm developments at temperate latitudes, including those producing at particular times of the year, and development of geothermal ponds in Iceland for indoor prawn production.

- The supply of **warm-water prawn** in the near-term will be challenged by **environmental constraints** (growth conditions mean disease is an ever present risk e.g. *Enterocytozoon hepatopenaei* is a new, particularly virulent, disease) and **availability** (species specification and political developments affecting conditions of trade). In trade, there is ongoing dialogue between the EU and several source countries (e.g. India, Vietnam, Bangladesh, Thailand) regarding regulatory requirements and trade arrangements. These countries account for a disproportionate share of supply to the EU and the UK, so adverse trade conditions would impact availability. Longer-term, warm-water prawn **availability** is likely to improve considerably with expanded production driven by **affordability** (market conditions), **innovation** (production innovation) and easing **environmental constraints** (more favourable growth conditions as disease is better managed). Expect resources to grow significantly due to favourable conditions and collaboration, with a wide range of countries capable of producing (with a mix of responsible production and those producing cheaply/poorly)[12].

- Species and chain: Offshore operators fishing for **cold-water prawn** are facing **environmental constraints** (downturn in the natural/biological cycles of abundance and environmental conditions) and changing **availability** (northerly shift in distribution, quota being reduced and closures affecting the fishery). This is challenging **affordability** with market conditions, and having to move activity with the fishery, meaning new business models are required to maintain current catches and catch viability. Expect **affordability** to also challenge onshore operators in Canada, Iceland, Norway, etc with market conditions driving price rises and new business models to ensure viable supply; broadening the species under the cold-water prawn envelope (wild northern prawn), broadening supply sources to include a range of other fisheries e.g. North American Pacific fisheries, taking a slightly different approach in each species e.g. peeling. For example, expect to see *Pandalus jordanai* coming into the UK from the Pacific due to a shortage of *Pandalus borealis* and *Pandalus montagur* prawns from the Atlantic. **Warm-water prawn** production is expected to expand considerably despite a range of constraints. In the near term, however, **environmental constraints** (outbreaks, containment, and disease mitigation) will be important challenges to expanded production, and coupled with potentially adverse trading conditions (including those arising from EU Exit), likely to affect **availability**. Large producers, such as those in Thailand and Vietnam currently facing challenges, are expected to better manage environmental constraints through **innovation** (e.g. production sites lining ponds with rubber, and more recirculating aquaculture systems (RAS)). Expect an improved response to **preferences** (improving industry reputation with a continued focus on industry problem solving e.g. sustainable shrimp task force handling the reputation over feed). In the near term, expect onshore trade and processing operators to face challenges to **availability** on account of trade developments (e.g. current discussions between EU and India – a significant supplier of prawn to the EU and the UK – and the ability of India to produce prawn in compliance with EU requirements). Given reliance on key source countries, short-term political shocks that tighten trade can challenge prawn **affordability**. For those operators sourcing certified product (largely for retail markets), loss of supply would be significant as there are few alternative sources in the short-term. Exacerbated by tightening **preferences** (the requirement for certified product placing additional constraints on supply), additional strain will be placed on other production (in Ecuador and Indonesia); driving price increases. Other operators (e.g. those supplying into food service) face fewer constraints but may be exposed to adulterated material finding its way back into the EU raising **nutrition/safety** concerns (industry malpractice). Longer-term, **affordability** will improve with investment in producers, market conditions driving production efficiencies and **innovation** in production (improvements to aquaculture feeds; such as using marine worms (*polychaetes*), traceability (e.g. DNA sampling) to allow brood stock identification, and new technology to help increase stocking densities (see 'Green House Shrimp Farms') such that, in principle, prawn could be grown anywhere. **Affordability** and viable supplies may be eased for onshore trade and processing operators through new business models supported by product/packaging **innovation**: a reformed system of industry packaging. For operators adopting a reformed packaging system (using net weight), sourcing could expand to include a host of countries set up to trade based on that system.

- Markets: Environmental constraints, and the availability and affordability of **cold-water prawn** will challenge its presence in the UK market. In 15 years, expect cold-water prawn in the UK market to be much rarer (although it won't disappear). Given limited **availability**, expect to see a broadening of the species specification under the 'cold-water prawn' envelope,

perhaps redefined as 'Wild Northern Prawn'. To ensure **affordability**, new business models may be required to ensure viable supply in the face of adverse trading conditions (trade agreements, non-tariff barriers: EU Exit could lose the ~11% tariff reduction from CETA as of Sept 2017 - currently half the cold-water prawn is sourced from Canada) and market conditions (what the UK pays versus what Asia pays - particularly China as the biggest competition to UK supply). **Warm-water prawn** in the retail market will be challenged by **preferences** and **availability**. In the near term, increasing pressure for certification and assurance (see the buying power of Walmart and its commitment to third-party certified seafood by 2025), coupled with incentives for less stringent assurance requirements (the influence of China on producer behaviour) could reduce **availability** of certified product for other businesses. Longer-term, this commitment to assurance is a significant, and positive, move towards more responsible prawn production. However, the trend towards increasing assurance/certification may slow and could reverse as the pressure on producers to certify is falling (as China's demand for prawn does not have the same certification requirement). In food service, the demand for farmed prawn is expected to grow with the market staying very much focussed on price, being price competitive for the next 10 years. This will be driven by a relatively fixed approach to **preferences** and **affordability**; as long as there is not a requirement to declare prawn additives on menus and recipes, operators are likely to continue buying adulterated product. Nor is any change expected in addressing **affordability**; market conditions are expected to drive viable supply through existing business models. In a climate of rising costs, it is unlikely consumers will pay the additional cost for improved practices.

4.10 Salmon

4.10.1 Recent developments

- Major supply regions: The supply of salmon has experienced a general increase with enhanced **availability** (increased volumes largely due to favourable conditions for farmed salmon), **affordability** (market conditions in which, with the exception of the last few years, salmon prices have performed favourably against competitor proteins) within **environmental constraints** (limitations in wild salmon abundance, and growth/environmental conditions restricting farmed operations). **Norwegian farmed Atlantic salmon** has seen **availability** increase as a result of robust regulation supporting volume expansion. Volume reached some 1.3m tonnes in 2016 (growth a result of the broadening of geographic sites) but no further in the last few years due to limited availability of production licences, **environmental constraints** (growth conditions that result in sea lice) and **affordability** (reducing volume in response to market conditions - where an increase in salmon volume combined with an expected increase in global demand that failed to materialise to force a drop in market prices). The supply of **Chilean farmed Atlantic salmon** has experienced challenging **environmental constraints** (environmental conditions giving rise to algal blooms) and dramatic swings in **availability** (major fluctuations in volume with weak regulatory conditions suffering from enforcement and policing problems). In **North American wild-caught pink and red salmon** has experienced benign **environmental constraints** (natural/biological cycles suggest a healthy stock status for pink and red salmon) and has seen **availability** increase with volume increasing within robust regulatory frameworks in Alaska (although not without a political dimension) and Canada (due to the influence of NGOs and high levels of scrutiny).

- Species and chain: **Norwegian farmed Atlantic salmon** producers have supported **affordability** (as a result of investing in expanded production, and managing production to maintain price in changing market conditions, production reached 1.3m tonnes in 2016, and has been static over the last three to four years) whilst addressing **environmental constraints** (growth is hindered with salmon being prone to disease – sea lice – accounting for a sizeable production loss) and facing limitations in **availability** (limited number of production licences). **Chilean farmed Atlantic salmon** producers have been challenged by **affordability** (fast and volatile industry growth with investment and market conditions fostering business models that struggle to support viable supply, e.g. lacking the required operating measures in area based management, fish health control systems, etc) and **environmental constraints** (production reduced significantly by adverse growth conditions - the outbreak of infectious salmon anaemia virus or ISA disease) with environmental conditions (an outbreak of algal blooms prolonged because of nutrient addition) taking out significant volumes overnight undermining **availability** (where several cycles of production volume crashing and then recovering have been further fuelled by opaque operating standards). North America has seen an

increase in the **affordability** and **availability** of **North American farmed Atlantic salmon** (farmed largely by Canadian producers, production has increased on both east and west coasts although not as dramatic as in Norway or the UK) and **'wild-caught' pink and red salmon** (Alaskan salmon harvest volume has trended higher over an extended period 2002-2016). In the face of changes to availability, onshore operators have been challenged on **affordability**. To ensure viable supplies, operators are changing business models switching supply sources dramatically this has forced sustained price increase[13].

- Markets: Over many years salmon has benefitted from **affordability** in UK markets where market conditions support viable supply and very competitive price points. Salmon matches market **preferences**, responding well to scrutiny and the push for certification, positioning farmed **Atlantic salmon** as a very reasonable option in the UK market - the 'chicken of the sea' - whilst **wild-caught pink and red salmon** generally attracts a more premium position. These positions have been established as a result of sustained **availability** (through strong volume growth). However, in recent years, the fit with **preferences** is coming into question with consumer expectations being challenged on **affordability**. After continuous price rises (as available supply got hit by climate change and sea lice) consumers are being turned off and cutting back unwilling to pay high prices for 'chicken of the sea'.

4.10.2 Anticipated developments

- Major supply regions: Expect the supply of salmon to improve as **availability** is supported with increased volume that is better managed and production **innovation** eases **environmental constraints**. Expect the supply of **Norwegian farmed Atlantic salmon** to improve as **availability** increases with volumes expanding through a sensible, managed approach. There is a political willingness to grow production but only if it is environmentally and economically stable and regulated in a progressive way – e.g. there is a standard licence and a green licence (in which operations satisfying impact models are permitted higher fish production). The likely supply of **Chilean farmed Atlantic salmon** is uncertain. **Availability** of salmon is supported by Chile's huge natural resources - given the range of inlets it could produce over a million tonnes very quickly - however, regulatory conditions in Chile are opaque, with volumes unpredictable. This is likely to be exacerbated by any recurring **environmental constraints** (see above). The supply of **North American farmed Atlantic salmon** and **wild-caught pink and red salmon** is unlikely to increase as **availability** is restricted (Canada is unlikely to increase production significantly due to constraints on natural resources and levels of scrutiny) and broad changes in harvest levels are not anticipated in Alaska's wild capture fisheries. Alaska also faces **environmental constraints** (with stock biology supporting an inelastic supply).
- Species and chain: Expect **Norwegian farmed Atlantic salmon** producers to focus on radical **innovation**, maintaining **affordability** of supply by expanding production. Technology could potentially breach the offshore production frontier in the next five to seven years, radically increasing production in the next 20 years. Offshore underwater cages seem to be viable and will augment existing production. Innovation is also expected to address **environmental constraints** (with new frontiers in finding a cost effective means of managing sea lice; potentially in the next few years). Expect **availability** to be enhanced as operators collaborate more closely with regulators to expand production. Large operators are already establishing in-house teams of environmental modellers and working with regulators; moving away from a 'tick box' approach to environmental standards to a more proactive stance (beyond compliance). In the near-term, expect **Chilean farmed Atlantic salmon** producers to be challenged by **affordability** (production is likely to see continued uncertainty and volatility affecting the viability of supply) and **availability** (the regulatory environment is uncertain with disagreement amongst industry stakeholders on which way to go). With this uncertainty, **environmental constraints** (e.g. algal blooms) and growth conditions (disease) will be a continued threat. Longer-term, in theory, Chilean production should pick up again with volatility more manageable, driven by industry rather than regulators. Expect **North American farmed Atlantic salmon** and **wild-caught pink and red salmon** producers to maintain **availability** rather than expand production.

13 For example, as Chilean production imploded due to algal blooms (removing significant volumes overnight - ~8,000t in some areas) suppliers in North America switched to Norwegian salmon to maintain salmon as a staple on US tables reducing salmon volume and increasing the price significantly.

- Markets: Expect salmon products in the UK market to maintain **affordability** with efforts to manage market conditions (demand continuing to rise, with some sources having limited capacity to increase) to ensure viable supply through existing business models. **Innovation** in production will support volume increase in a managed fashion targeted at maintaining equilibrium in the market, and maintaining a steady price (to suit **preferences**).

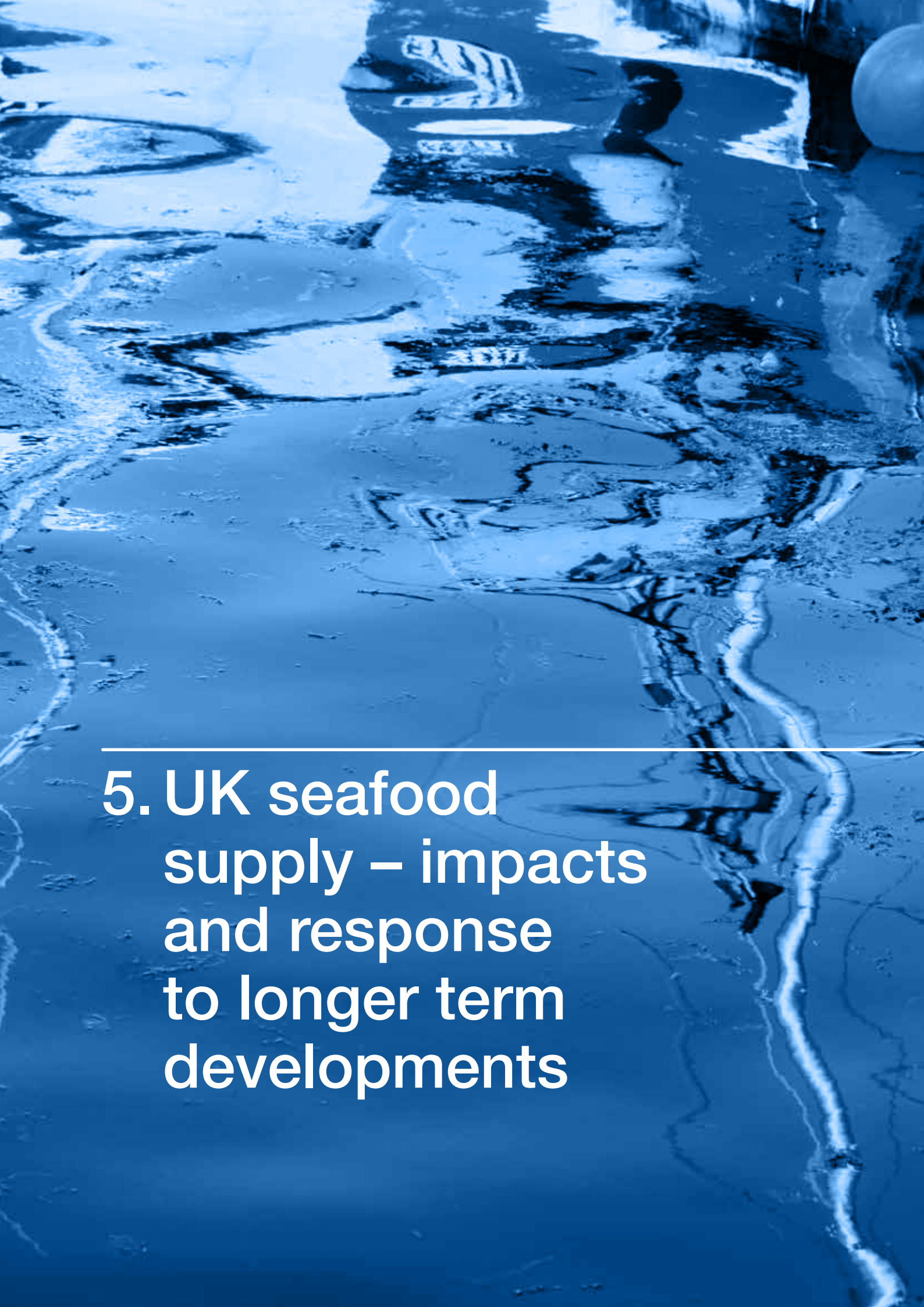
4.11 Example response to anticipated supplies risk (international)

Anticipated risk developments in the UK seafood supply base over the near and longer-term present opportunities as well as threats. These will affect individual businesses, supply chains and industry as a whole. For each industry sector (international), anticipated risks are shown by dimension (availability, affordability, preferences, nutrition/ safety, environmental constraints and innovation) together with a number of suggested actions from stakeholders by way of response.

Table 4.5 Suggested actions in response to anticipated supplies risk (international)				
Sector	Dimension	Anticipated risk	Suggested action	Owner*
General	Preferences		With the Defra Seafood 2040 strategy focus on consumption, understand the theory of change, the price points and different categories of consumer to help focus strategy.	Seafish
	Innovation		Help with strategic planning. This could include bridging activity between RASS and HS (e.g. the response to the mackerel distribution shifting up to Iceland could have been more proactive with discussions and plans).	Seafish
			Continued insight on the possible impacts of EU Exit.	Seafish
			Review the implications of growth in recirculating aquaculture systems (RAS) systems on Seafish levy. Growth in RAS suggests the levy income, being based on sea water systems, will be static with no increase.	Seafish
			Improve supply chain knowledge transfer on onshore risks (and best practice) around product integrity issues.	Seafish
Whitefish	Availability	Fisheries governance	Given the importance of certain fisheries to the UK (e.g. cod and haddock), the UK has a duty to engage with government in these producing areas and in UK fisheries.	Industry/Govt
			Seafish need to ensure we play our role in scientific institutions supporting fisheries management and work collaboratively with countries bordering our fisheries/sharing stocks. Need relationships at fisheries management and government (policy) levels (where we link our trade flows with management of these stocks).	Govt, Seafish, industry
		Specification	Review quality of fish and any changes arising from changes in availability (e.g. soft fish) using data at factory level.	Industry
			With Icelandic production focussing on fillets, Hull/Grimsby/Iceland collaboration should review and explore the balance of opportunities across formats (e.g. whole/fillets/fresh/refreshed).	Industry
			Canada could be an additional source of new material for the UK. Norwegians and Icelanders are willing to assist Canadians and Greenlanders upgrade their production rather than risk damage to markets.	Industry
	Nutrition, safety		Need small group of first movers to establish standards for whitefish product integrity.	Industry
	Preferences	Certification	Improved collaboration is needed to meet requirements of fisheries management e.g. MSC accreditation, etc.	Industry
		Consumer preferences	Industry operators and Seafish should take the lead in engaging with the consumer, understanding future preferences, and setting industry standards.	Industry/Seafish
		Scrutiny	Industry need to be alert and engage NGOs, emphasising, multi-stakeholder approach to governance (change from 'no fishing' to 'change how we fish') to address challenge of environmental management and harvesting (potential conflict).There is more that can be done e.g. taking customers up to Svalbard (Arctic Circle).	Industry
			Concerted action is needed by Seafish and industry operators in order to come up with solutions to the issues raised by NGOs.	Industry/Seafish
			For UK market entry, the pathway for tilapia would have to be through food service and be championed by celebrities and celebrity chefs. Engage chefs trying to make their name, coming in at the low end and trading up. Associating with street food and ethnic cuisine would be a pathway. Requires supply to follow best practice including certified sources/ethical practice.	Industry
	Innovation	Gear innovation	Smart technology to support low impact fishing and fishing in different areas. Need innovation in engines to support longer fishing trips and reduce trawl drag.	

Pelagic	Availability		Risk Assessment (RASS) to expand scope to include more fisheries (e.g. sardine, more tuna fisheries, etc).	Seafish
		Species specification	If tuna producing countries remain red-rated, industry has the option to: i) Look at alternative supply from same source ocean ii) Source from oceans elsewhere. iii) Look at pre-frozen (has the advantage of a wider supply base/consistency and meeting the legal requirements for sale of raw fish).	Industry
		Fisheries governance	More cohesive/joined up/collaborative work on improving fisheries management, including senior levels in government and RFMOs. There are already moves to work together and improve tuna management e.g. Global Tuna Alliance. Think/talk more honestly about what's for the best; the future good of tuna as a species and of tuna markets. Shift conversations from vested, to enlightened interests.	Industry
			Seafish to continue good facilitation role and convening groups (e.g. Ethics Common Language Group). However, can Seafish play a stronger leadership role, to avoid the frustration of building a common industry approach on certain issues?	Seafish
	Preferences	Scrutiny	More of the same: helpful facilitator, convening collective view, the Ethics Common Language Group on the crew side. Seafish ability to help is limited, being constrained (e.g. not able to levy on canned tuna, or lobby/ advocate). To help further Seafish would have to be in the international arena; would need introducing to key players and freedom to participate in international groups.	Seafish
	Environmental constraints		Highlight exploitation of meso pelagic stocks into Seafish horizon mapping as a red risk and get a presentation to Seafish Directors.	Seafish
		Growth conditions	Explore mortality rate of meso pelagic stocks: under what conditions can you take a million tonnes from the biomass and this not adversely affect the stock?	Seafish
Shellfish	Availability	Trading conditions	WWP – In the context of trade legislation, improve the risk assessment of imports (for example through recognition of third party certification).	Seafish
		Specifications	CWP - Broaden the offer from a single species to a species group and establish a brand…wild northern prawn… like ASMI or NSER. Seafish to fill in some of the information gaps, and help industry in their response and getting them to commit.	Industry, Seafish
		Fisheries governance	CWP - Given the importance of certain fisheries to the UK (e.g. cold-water prawn), the UK has a duty to engage with Government in producing areas and in UK fisheries.	Industry/Govt
	Nutrition, safety	Composition	WWP - With EU Exit, there may be an opportunity to influence the packaging system in key parts of the warm-water prawn trade (where weights/count is used). It's an intractable problem; net weight is the hinge, it needs i) Political will – to be a legal requirement ii) Seafish to highlight/ raise awareness iii) Compliance - Seafish should be stronger on this, acknowledging it can't dictate to industry.	Govt, industry, Seafish
	Preferences	Certification	WWP – Given aquaculture growth, need a major push by certification bodies to get prawn aquaculture sites certified.	Industry
		Scrutiny, public perception	CWP - Need a code of conduct that could cover quality and sustainability, for example: i) Quality - Glaze levels for northern wild shrimp. ii) Sustainability – responsibility in the fishery including ethics code on practise such as bonded labour. iii) Industry collaboration. There is more willingness for collaboration now compared to three years ago. Seafish to fill in some of the information gaps, and help industry in their response (to point i to iii above) and commitment.	Industry, Seafish
			Continue invaluable Issues groups (social-ethics group). i) Working group focused on fishing gear technology would be useful ii) RASS good as it is, works well and provides useful background information iii) More collaboration, Seafish to provide further facilitation of key issues.	Seafish

			WWP - The key is 3rd party certification as a safety net given bad stories on social/ethical practices. Easier with retail, however the biggest challenge is food service - somehow we need to engage more and achieve some movement. Seafish needs to work on this, for example: i) Start with contract catering companies (although large operators, feeding a lot of consumers, they are not generally recognisable so brand sensitivity and CSR exposure is quite low). ii) Engage through the 2040 initiative (e.g. Marketing group) that could get 'more understanding' and 'stories out'. The chefs' portal could be a practical way of starting the conversation. Later, a food service conference at which attendees could see the opportunities and level of understanding. iii) Concerted action from lead operators with Seafish facilitation focussed on certification and best practice.	Industry, Seafish
Salmon	Availability	Inflexible regulations	The Chilean industry is open to collaboration with scientists. Useful action includes running workshops on basic principles (e.g. carrying capacity, what are good and bad sites, etc.) to improve practices.	Industry, academia
		Inflexible regulation	Given the importance of certain sources to the UK (e.g. Norwegian salmon), the UK has a duty to engage with government in producing areas and in the UK.	Industry/Govt
			Industry has a shared interest in setting common standards in area management. Salmon is quite well vertically integrated (a large share of operations in Scotland are Norwegian owned) so, having direct influence, agreement should be easier.	Industry
	Innovation	Production innovation	Invest in feed alternatives, such as opportunities being explored in Ocean Harvest Tech or Marine Aqua probiotics.	Industry



5. UK seafood supply – impacts and response to longer term developments

For the UK seafood supply base, industry stakeholders provide a cautiously optimistic view of volumes available to 2030. The broad view is that supply volumes will improve generally across both wild capture and aquaculture production. There are important exceptions, however:

- Tuna and cold-water prawn are expected to remain vulnerable; the former as a result of insufficiently robust management and the latter a result of biological and environmental conditions affecting the stock.
- Warm-water prawn production and UK domestic mussel production could increase considerably.
- Canadian cod and farmed salmon could produce significant additional supply volumes, but this is highly uncertain. This new volume depends on specific advances in the near term: sustained improvement in stock (Canadian cod), and successful deployment of offshore production (farmed salmon).

The impact of longer-term developments on UK seafood supply is multiplied by food security and climate change challenges:

- There are various scenarios under which the global food system could ensure food security. The food security challenge, a growing world population and middle class offers opportunities for protein suppliers in an enlarged global market but also the considerable challenge of intensified competition. Longer-term trends suggest global demand growth will increase the prices of meat protein, including seafood (with the projected changes dependent on how aquaculture develops). However, achieving *sustainable* food security will require changes across the system: in supply (improved production); efficiency gains in the chain (reduced waste); and in market demand (reduced consumption)[14]. Included in these changes will be a growing awareness of the merits and demerits of various proteins in the market place, and a shift in investment appetite across the protein portfolio. This includes growing awareness of, and investment interest in, meat substitutes (particularly synthetic/cultured meats) that could have major long-term consequences. In seafood, overall estimates of seafood requirements for direct human consumption by 2030 are 228-238 million tonnes, but with marked differences in the predicted geographic distribution of demand, especially for China[15]. According to the ***business as usual*** projections of seafood production for direct future consumption there is a potential global shortfall of 62 million tonnes. Given this shortfall, three responses have been identified; reducing waste (15 million tonnes), enhancing fisheries (8 million tonnes), and sustaining aquaculture (39million tonnes). Beyond these improvements, those seeking to secure seafood supply will have to respond to the developments and competitive challenges of the marketplace – some of which have been highlighted in this review.
- By 2030, the effects of climate change are expected to begin reducing (business as usual) growth of global meat production with more marked growth reduction by 2050. By 2030 reductions in growth are mainly expected in developing countries, with reductions also felt in developed countries by 2050. In seafood, the projected increase in global production by 2030 would be slightly reduced. Capture production would see a reduction and changing distribution (with catch potential in high latitude regions increasing, and in tropical regions decreasing). This reduction would be partly compensated by enhanced production increases in aquaculture.

Food security and climate change therefore amplify risks and impacts in both domestic and international domains of the UK seafood supply base. Note these are 'business as usual' projections; alternative future pathways (more extreme scenarios) could amplify risks and impacts significantly.

UK domestic supply

A central challenge for the UK domestic industry is long-term competitiveness in securing **available** and **affordable** supplies from UK waters, and how this has changed over the last 15-20 years. For some, competitiveness has been compromised by excessively open trading conditions, for example with an open licence regime that has facilitated:

- UK flagged vessels fishing the grounds and landing into non-UK ports.
- The buy-out of UK operators by non-UK operations, with operations then consolidated in the owners' home country.

14 See Roos et al (2017) for example.

15 See Getting to Eden (www.fishingfuture.org).

This has contributed to the decline of fleets, coastal auctions, and coastal businesses in the UK. Although the need to strengthen the licence regime was recognised by all UK devolved administrations in 2012[16], there has been limited action on this to date. As the industry has evolved over the last 15 years under open trading conditions, many have lost sight of the industry (as a national asset) and how this has gradually changed.

At a general level, throughout the chain, there is recognition that market **preferences** - demands for responsible sourcing, certification, scrutiny, etc - play a key role in market access (both in the UK and export markets). Industry practices and product quality are expected to improve further over the next 15-20 years. This will be driven by innovation building on improvements already seen in technology (e.g. Blockchain), traceability (e.g. Quick Response codes), product testing and refrigeration.

UK international supply

In the international domain, a strategic challenge centres on the interaction between **availability**, **affordability**, **preferences** and **environmental constraints**. The availability of seafood resources is seeing pressure in wild capture but opportunity in farmed production. Wild capture is constrained by relatively finite biological resources, whilst advances in farmed production are expanding aquaculture resources. Although there is robust regulation of wild capture fisheries in some areas, the industry continues to suffer from weak governance in others. The availability of farmed seafood has provided some respite, providing new supply options, but has brought additional uncertainties around assurance and safety for example. The trading of seafood products has tightened, although remains weak in some areas giving license to malpractice.

Increasing presence in the global market of emerging economies, particularly China, is challenging affordability, preferences and environmental constraints. This has a number of impacts:

- With growing wealth, and lower processing costs, the likes of China can afford to buy; driving an increase in competition for seafood resources.
- Without the requirement for standards (e.g. water addition), this removes a cost burden for suppliers. Although certification is much more prevalent, with major stocks certified by the MSC in recent years and the development of aquaculture certification driven by western markets; it is not a requirement for all buyers e.g. those in developing countries.
- Higher prices and lower cost burden can be attractive to supplying regions, increasing pressure on exploitation rates in areas suffering weak fisheries governance.

Innovation to support this strategic challenge can be seen in recent technology investments in, for example, Norway and Iceland. This has the potential to reshape supply chains; for example replacing Eastern supply chains with domestic supply chains so some supply regions have greater assurance for product integrity.

EU Exit is a major disruption in both domestic and international domains, with opportunities and threats primarily affecting availability and affordability. Domestic operators face a major opportunity to redesign governance and address imbalances in supply availability. Importantly, however, affordable exports to the EU are threatened, this could challenge underlying businesses models designed for accessing EU markets. For international operators there is a threat to sourcing affordable seafood. Additional costs could arise from a disruption in trade conditions (the UK moves away from EU trade arrangements, UK-EU standards diverge, etc) and adverse market conditions (for example with disadvantageous currency position).

The industry and Seafish have a choice as to whether or not to respond to this emergent landscape at this stage. Responding could involve a range of defensive or offensive actions, across the seafood system, initiated in advance. Deciding not to respond at this stage would mean industry and Seafish are subject to events as they unfold, requiring strong capabilities to react quickly. If there is an appetite to respond at this stage, this review exercise has highlighted the following conclusions and requirements:

1. The breadth and reach of the UK seafood supply base is considerable and the range of challenges facing industry operators no less so. The response to these challenges is similarly wide ranging: **all operators emphasise the need to respond to availability and market preferences, with domestic operators' further emphasising affordability.**

16 See *'A Subject Specific Concordat between Defra, Marine Scotland, Welsh Government, and DARD On Management Arrangements for Fishing Opportunities and Fishing Vessel Licensing in the United Kingdom'*. This concordat, signed by all UK devolved administrations in 2012, specified an urgent review of UK wide licensing conditions with a view to strengthening 'the economic link'.

2. Given the wide ranging responses to these challenges by a number of stakeholders, the **Seafish role and offer must be clear. Ongoing Seafish support to help industry respond in a timely fashion is valued and should continue.** Examples include Seafish being a good facilitator of industry issues groups, the Seafish risk assessment support is valued (and could be extended to cover more species) whilst platforms that can collate and harness relevant information are particularly valuable, e.g. providing clarity on fishery improvements in key fisheries, or supporting awareness by maintaining broad species campaigns.

3. **However, there is a requirement for additional Seafish support to help industry respond to longer-term challenges, where a number of strategic level responses are required:**

   - With government, these include strategic positioning of seafood within the UK food strategy, supporting UK collaboration with countries bordering fisheries of UK interest (UK trade policy as well as fisheries management).
   - With industry, these include a stronger leadership role in 'issues groups' (re-examine constraints on facilitator role), in pushing for integrity solutions and activating industry operators (warm-water prawn for example), and in international marketing (develop a broader brand for cold-water prawn for example, and a strategic review of export marketing of domestic supply vis-à-vis Norway and Iceland)
   - For Seafish itself, there is a need to review long-term levy trends and their implications, given the increasing share of aquaculture production, and share provided by recirculating systems (where no levy can be secured).

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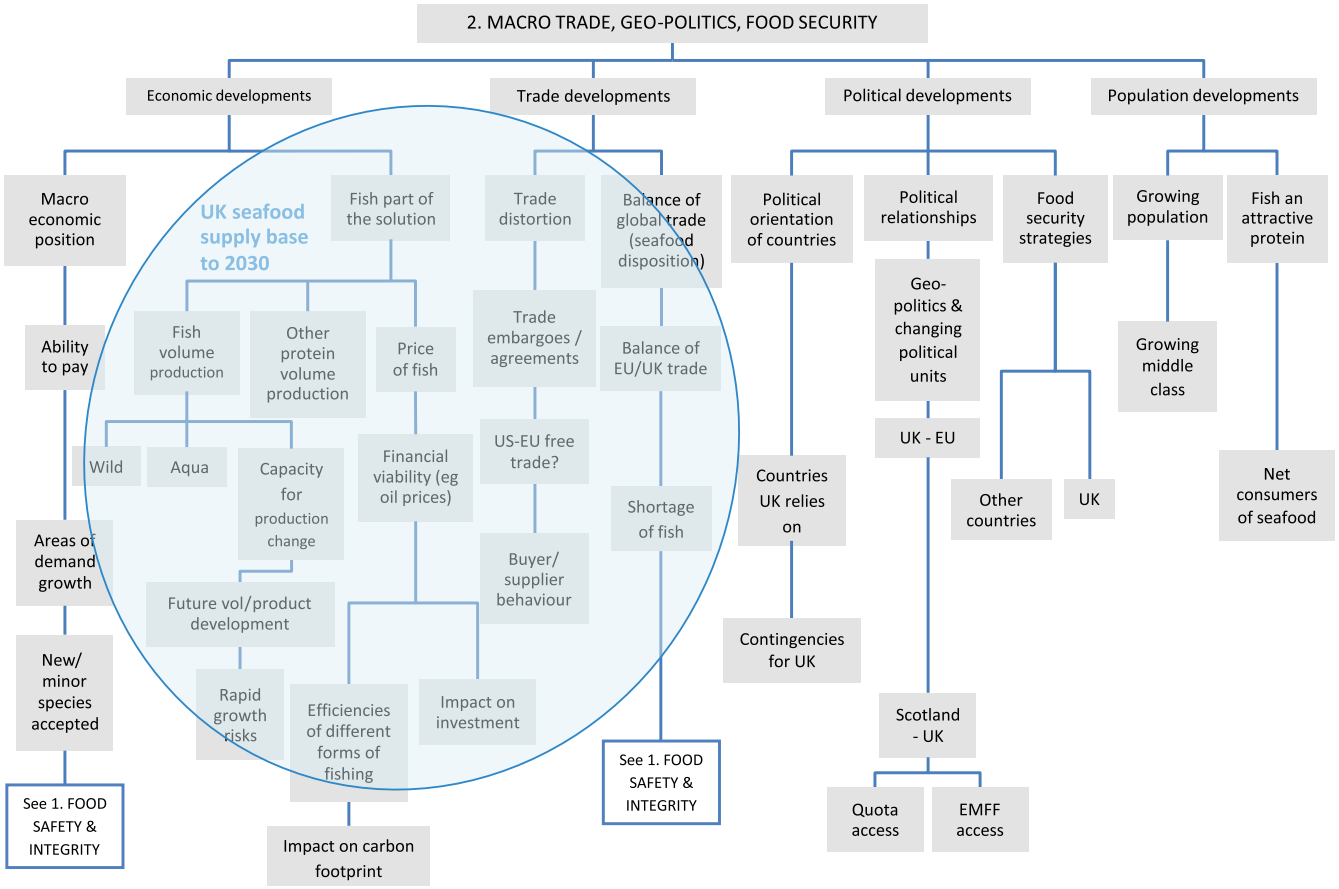
Appendices

Appendix 1 – Locating UK seafood supply base to 2030 in seafood risk landscape



Appendix 2 – Consultees

1. David Anderson, Aberdeen PO Ltd
2. Sarah Johnson, Alaska Seafood Marketing Institute
3. Mike Berthet, Aquaesea Ltd
4. Dr Stephen Hall, Avalerion Capital
5. Andrew Matchett, Coombe Fisheries
6. James Wilson, Deepdock Mussels
7. Laky Zervudachi, Direct Seafoods Ltd
8. Bill MacKenzie, Don Fishing Co Ltd
9. Alex Olsen, Espersen
10. Billy Dickson, Falfish
11. Edward Polley, Falfish
12. Anton Dietschel-Buehler, Flatfish
13. Richard Stansfield, Flatfish
14. Andrew Pillar, Interfish
15. Stephen Brown, Landauer Seafoods
16. Robert Stevenson, Lunar PO Ltd
17. Estelle Brennan, Lyons Seafood
18. Adam Green, Lyons Seafood
19. Jonas Vidarsson, Matis
20. Lucy Blow, New England Seafood
21. Hans Frode Kielland Asmyhr, Norwegian Seafood Council
22. John Angus, Pelagia Shetland Ltd
23. Chris Shearlock, Princes Seafoods
24. Dr Colin Bannister, Advisor to SAGB
25. Dr Adam Hughes, SAMS
26. John Anderson, Scottish Fishermen's Organisation
27. Lesley Jenkins, Scottish Salmon Producers Organisation
28. Jamie Smith, Scottish Salmon Producers Organisation
29. Nigel Edwards, Seachill
30. Sarah Hussey, Seafarms
31. Ivan Bartolo, Seafish
32. Craig Burton, Seafish
33. Lee Cocker, Seafish
34. Malcolm Large, Seafish
35. Bill Lart, Seafish
36. Phil MacMullen, Seafish
37. Richard Watson, Seafish
38. Professor David Little, Stirling University
39. Professor Trevor Telfer, Stirling University
40. Edward Whittle, Whitby Seafoods
41. Andrew Nicholson, Two Sisters Food Group
42. Karen Galloway, Xenosophy Ltd

Appendix 3 – UK seafood industry – main systems, functions and activities (Source: Seafish, Defra)

Broad species grouping	System	Species	Species distribution (and main producing countries)
Whitefish	Domestic	Cod, haddock, whiting, monkfish, sole, plaice	UK waters/NE Atlantic (UK)
Whitefish	Domestic	Cod, haddock, pollock	UK waters/NE Atlantic (UK)
Whitefish	Domestic	Sole, plaice, rays	UK waters/NE Atlantic (UK)
Pelagic	Domestic	Herring, mackerel, sardine/pilchard, blue whiting	UK waters/NE Atlantic (UK)
Pelagic	Domestic	Mackerel	UK waters/NE Atlantic (UK)
Shellfish	Domestic	Crabs, lobsters, Nephrops, whelks	UK waters/Eastern Atlantic (UK)
Shellfish	Domestic	Nephrops	UK waters/NE Atlantic (UK)
Shellfish	Domestic	Mussels, scallops	UK waters/Eastern Atlantic (UK)
Shellfish	Domestic	Mussels, oysters	UK waters/NE Atlantic (UK)
Salmonids	Domestic	Atlantic salmon, Rainbow trout (NE Atlantic small pelagic, waste and some imported fisheries (anchovy, sardine) input as feed in stage 2)	UK waters/NE Atlantic (UK)
Exotics	Domestic	Carp, bream	UK
Whitefish	International	Cod, haddock, hake, halibut, plaice	NE Atlantic/Barents Sea (Norway, Russia, Iceland)
Whitefish	International	Alaska pollock	North Pacific/Bering Sea (USA)
Whitefish	International	Pangasius	South East Asia (Vietnam)
Pelagic	International	Tunas (yellowfin, albacore, skipjack, swordfish)	Indian Ocean (Spain/France/Sri Lanka) Pacific Ocean (Philippines/Mexico) Atlantic Ocean (Spain/France/Ghana)
Pelagic	International	Anchovy, sardine/pilchard	Eastern Atlantic (Spain, Morocco) Eastern Pacific (Peru)
Shellfish	International	Northern/cold-water prawn	North Atlantic (Denmark/Greenland/ Iceland/Norway/Canada)
Shellfish	International	Warm-water prawn	South East Asia (Indonesia/India/Thailand), Central America (Ecuador/Honduras)
Cephalopods	International	Squid, octopus, cuttlefish	Mixed (Eastern Pacific, Mediterranean, North & South Atlantic, Indian Ocean)
Salmonids	International	Pacific salmon	Pacific Ocean (USA/Canada/Russia)
Salmonids	International	Atlantic salmon	NE Atlantic (Norway)
Exotics	International	Kingfish, parrotfish, groupers, snappers	Asia, Africa

	Source method	Capture method	Transportation	Format and processed form
	Capture	Whitefish & flatfish (bottom trawl)	Road, container	Fresh - whole, fillets/loins, smoked, prepared
	Capture	Whitefish (gillnets) Whitefish (minority line-caught)	Road, container	Fresh - whole, fillets/loins, smoked, prepared Whole, fillets/loins, smoked, prepared
	Capture	Flatfish & rays (beam trawl)	Road, container	Fresh - whole, fillets/loins, prepared
	Capture	Small pelagic (purse seine & mid-water trawl)	Road, container	Fresh/frozen (including frozen at sea) - whole, fillets/loins, smoked, fishmeal, preserved, aqua feed
	Capture	Small pelagic (line-caught)	Road, container	Fresh - whole, fillets/loins, smoked, prepared
	Capture	Crustaceans (pots)	Road, air freight	Live Fresh/frozen - whole, prepared
	Capture	Prawn (trawl)	Road	Live Fresh/frozen - whole, shelled, preserved
	Capture	Molluscs (dredged)	Road, air freight	Live Fresh/frozen - preserved
	Aquaculture	Molluscs (rope grown/longlines) Molluscs (bottom grown)	Road, container, air freight	Live Fresh - preserved
	Aquaculture	Marine cage farming Freshwater ponds/raceways	Road, container, air freight	Fresh/frozen - whole, fillets/loins, prepared, smoked Fresh/frozen - fillets/loins smoked, prepared
	Capture	Demersal fish (bottom trawl)	Road, container, air freight	Fresh/frozen - fillets/loins, smoked, prepared
	Capture	Whitefish (pelagic trawl)	Road, container	Frozen - fillets/loins, smoked, prepared
	Aquaculture	Freshwater pond culture	Road, container	Frozen - whole, fillets/loins, prepared
	Capture	Tunas (long-line) Tunas (purse seine) Tunas (pole & line/handline)	Air freight, container	Fresh/frozen - whole, fillets/loins, preserved Preserved Whole, fillets/loins, preserved
	Capture	Small-pelagics (purse seine)	Road, container	Fishmeal, fish oil, canned, aqua feed
	Capture	Prawn (trawl)	Road, container	Frozen - whole, shelled, preserved
	Aquaculture	Shrimp farming (intensive > extensive)	Road, container	Frozen - whole, shelled, preserved
	Capture	Cephalopods (jigging, trawl in North Atlantic)	Road, container	Frozen – prepared, brined
	Capture	Salmon (nets)	Road, container	Frozen - whole fillets/loins, smoked, prepared
	Aquaculture	Marine cage farming	Road, container, air freight	Fresh/frozen - whole, fillets/loins, prepared, smoked Fresh/frozen - fillets/loins smoked, prepared

Appendix 4 – Global and regional production overview

A4.1. Global fisheries and aquaculture production

- The Food and Agriculture Organisation (FAO) promotes the international classification and the standardization of data submission procedures. This is to ensure that fisheries and aquaculture statistics collected are comparable across countries and allows for summation and analyses at a regional and a global level.
- In order to convert landed catches (which likely will have been processed to some degree) back into the live weight the FAO Coordinating Working Party on Fisheries Statistics provides guidance on conversion factors. From herein catches and landings will be assumed to equal the live weight.
- It is the responsibility of fisheries administrations in each member state to report landings statistics to the FAO. In the UK this would be the responsibility of the Marine Management Organisation (see MMO, 2016).
- However, it should be noted that the capacity of countries to reliably report their fisheries statistics varies, with underreporting likely for many countries with a few exceptions (notably China[17]). A recent study using 'catch reconstruction[18]' suggests that global catches between 1950 and 2010 were 50% higher than data reported to the FAO suggest, and are declining more strongly since catches peaked in the 1990s (Pauly and Zeller 2016) (see section A4.2).

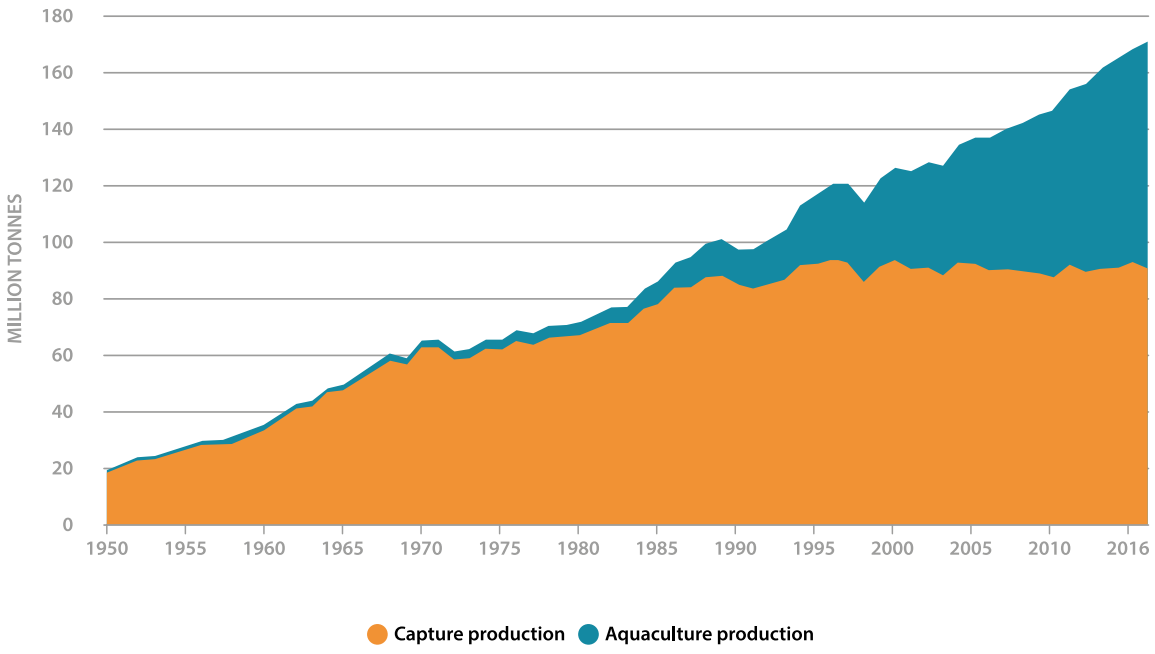


Figure A4.1 World capture fisheries and aquaculture production (FAO 2018)

Global fisheries production

According to the FAO (FAO 2018):

- With capture fishery production relatively static since the late 1980s, aquaculture has been responsible for the impressive growth in the supply of seafood for human consumption (Figure A4.1).
- Global total capture fishery production in 2016 was 90.9 million tonnes, of which 79.3 million tonnes from marine waters and 11.6 million tonnes from inland waters. Global marine fisheries catches increased to 86 million tonnes in 1996, then slightly declined.

17 Watson, R. & Pauly, D. Systematic distortions in world fisheries catch trends. Nature 414, 534–536 (2001).

18 'Catch reconstruction' utilises utilizes a wide variety of data and information sources to derive estimates for all fisheries components missing from the official reported data (e.g. subsistence and recreational fisheries, discarded bycatch, IUU catch, etc) (Pauly and Zeller 2016).

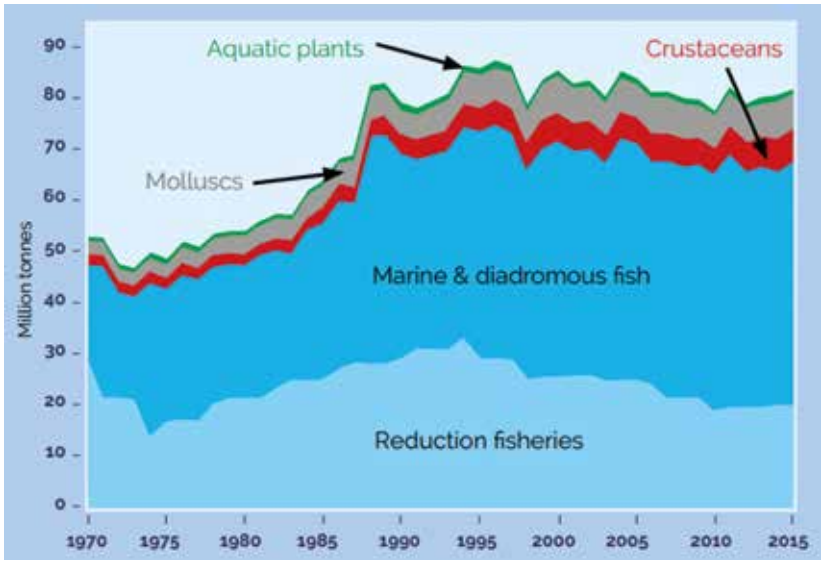


Figure A4.2 Global marine landings and mariculture production. Reduction fisheries consist mostly of small pelagic plankton-feeding fish such as anchovies, sardines and herrings, which are processed into fishmeal and oil (FAO, 2017, from SAPEA 2017).

Global fisheries stock status

According to the FAO (FAO, 2018):

- The world's marine fish stocks have not improved overall, despite notable progress in some areas. Based on FAO's analysis of assessed commercial fish stocks (~20 percent of global catch), the share of fish stocks within biologically sustainable levels decreased from 90 percent in 1974 to 66.9 percent in 2015 (See Figure A4.3). Thus, 33.1 percent of fish stocks were estimated as fished at a biologically unsustainable level and therefore overfished. Of the total number of stocks assessed in 2015, fully fished stocks accounted for 59.9 percent and underfished stocks 7 percent.
- It should be noted that there are strong regional differences in the effectiveness of fisheries management, and the proportion of sustainably managed stocks is actually increasing in some regions due to a reduction in fishing pressure.

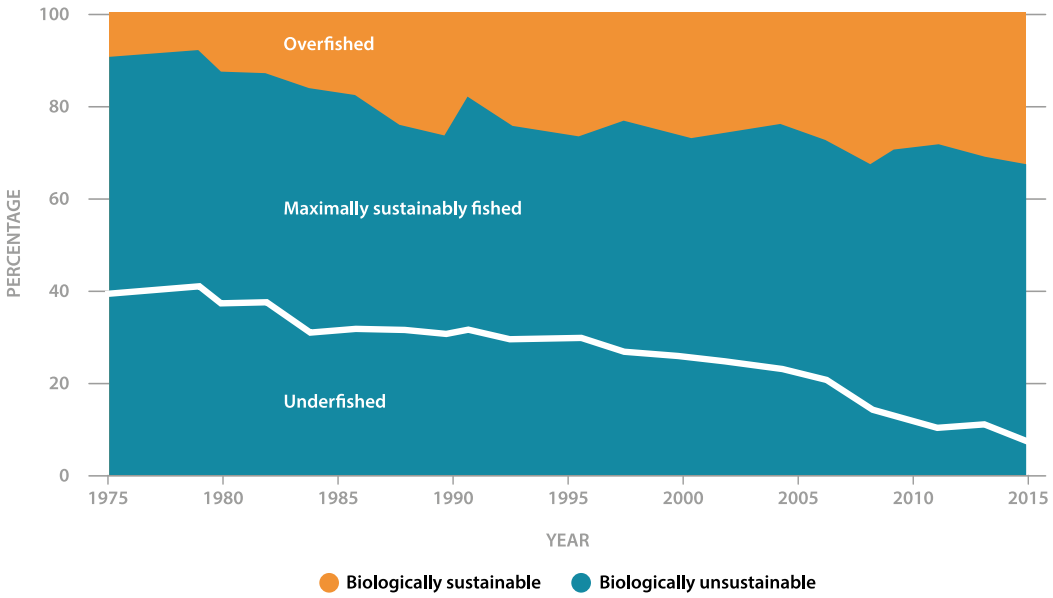


Figure A4.3 Global trends in the state of the world's marine fish stocks, 1974-2015.

Aquaculture production

According to the FAO (FAO, 2018):

- World aquaculture production of fish accounted for 46.8 percent of total production (including for non-food uses) from capture fisheries and aquaculture in 2016.
- China has played a major role in this growth as it represents more than 60 percent of world aquaculture production.
- Feed is widely regarded as becoming a major constraint to the growth of aquaculture production in many developing countries. However, by volume, just under half of world aquaculture production in 2016, including seaweeds and microalgae (27 percent) and filter-feeding animal species (15 percent), was realised without feeding.

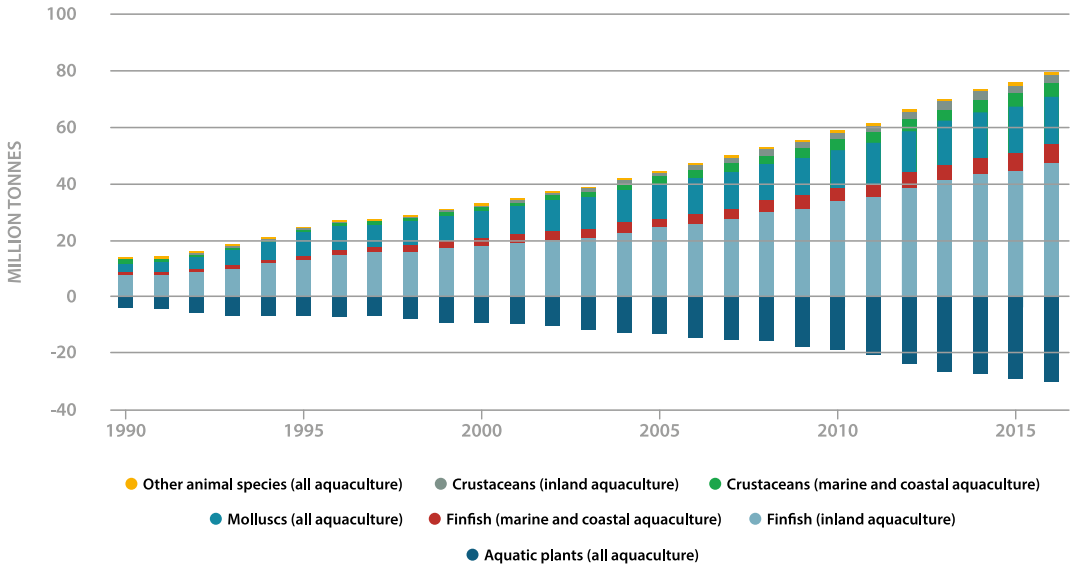


Figure A4.4 World aquaculture production by volume (1990 – 2016) (FAO 2018).

Future projections

The recent 'Getting to Eden' initiative reviewed global projections for seafood provided by the World Bank/ International Food Policy Research Institute (IFPRI) as well as the FAO:

- Under the most recent assessment (World Bank 2013)[19], projections to 2030 under a business-as-usual scenario estimate total seafood supply to be 186.8m tonnes of which supply for direct human consumption of 151.8m tons.
- Using an alternative method, the FAO estimate the supply for direct human consumption under a business-as-usual scenario to be 187.9 million tons (Cai 2011). The FAO model described by Cai (2011) provides an alternative means for obtaining a baseline estimate, using historical relationships between fish production, per capita estimates of fish consumption and gross domestic product (GDP) for each country to project future trends.
- Using the business-as-usual scenarios from the World Bank and FAO, approximately 152-188 million tonnes of seafood will likely be produced by 2030 for direct human consumption[20].
- Overall estimates of fish requirements for direct human consumption by 2030 are between 228 and 238 million tons, but with marked differences in the predicted geographic distribution of demand, especially for China (figure A4.4). According to the business as usual projections and projected levels of fish for direct future consumption there is a potential global shortfall of 62 million tons (figure A4.5).
- To meet this shortfall in production, three things need to be achieved; reducing waste, enhancing fisheries, and sustaining aquaculture.

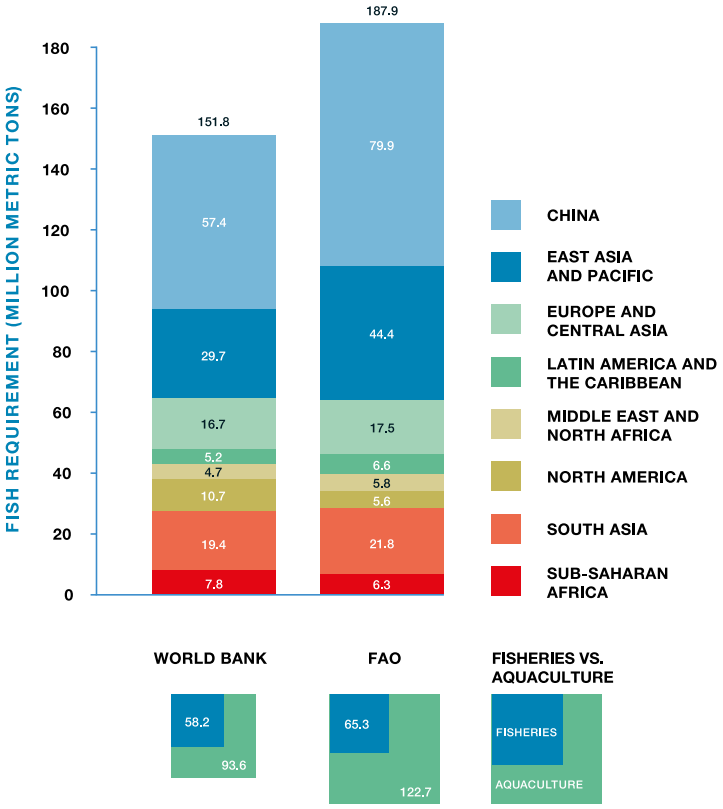


Figure A4.5 Business-as-usual projections to 2030[20]

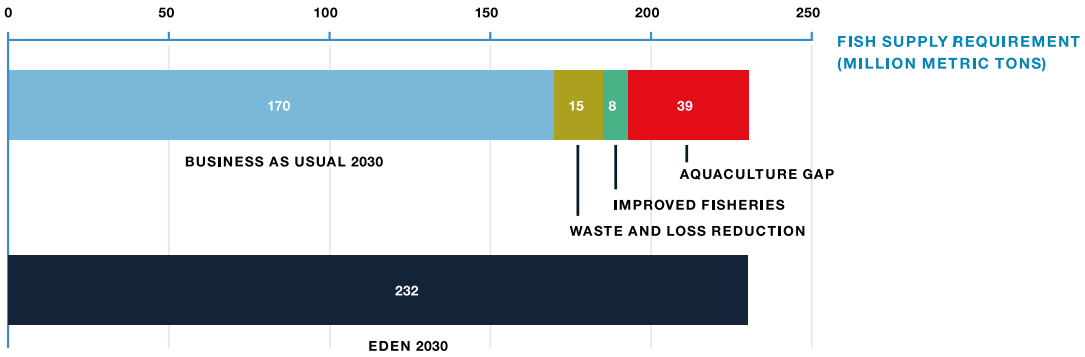


Figure A4.6 World fish requirement/ supply (million tons) [20]

19 The report presents the results of an econometric analysis that relates information on supply and demand responses and trade to changes in price. These responses are then combined with predicted growth in population, income, fish production and feed conversion ratios.

20 Getting to Eden, www.fishingfuture.org

A4.2. Regional analysis of fisheries and aquaculture production

- Fish production is projected to increase but varies by species (figure A4.6) and region. If properly managed, fisheries could potentially contribute to increased production. However there is uncertainty over the level of this contribution. The two key uncertainties cited in the Getting to Eden study in realising the upside to production (including aquaculture below) are 1) climate change and other environmental pressures, and 2) economic growth and the openness of markets[20]. Another source of uncertainty not specified in the Getting to Eden study is the precision of underlying data reported to the FAO (Pauly and Zeller 2016), and the coverage of stocks that are formally assessed.
- Using official statistics:
  - Fishing mortality (at least in some management areas) is shown to have declined, and now at sustainable levels (Hilborn and Ovando 2014). See figure A4.7.
  - The estimated opportunity for increasing the global wild capture using a 'perfect' maximum sustainable yield approach across the globe is 10-12 million tons. As the entire potential is unlikely to be realised, the estimated gain of 8 million tons from fisheries improvement, suggested in the previous section, seems possible[20]. See figure A4.8.
- However, this may be over optimistic given the potential for flaws in official statistics:
  - In most FAO areas, actual catches of marine fish are significantly higher than those reported (Pauly and Zeller 2016). See figure A4.9
  - The status of stocks that lack a formal stock assessment, which comprise >80 percent of global catch (Costello et al 2012). Using species' life history, catch, and fishery dependent data, Costello found that small unassessed fisheries are in substantially worse condition than assessed fisheries, but that large unassessed fisheries may be performing nearly as well as their assessed counterparts. Both small and large stocks, however, continue to decline; 64% of unassessed stocks could provide increased sustainable harvest if rebuilt. Their results suggest that global fishery recovery would simultaneously create increases in abundance (56 percent) and fishery yields (8 to 40 percent).

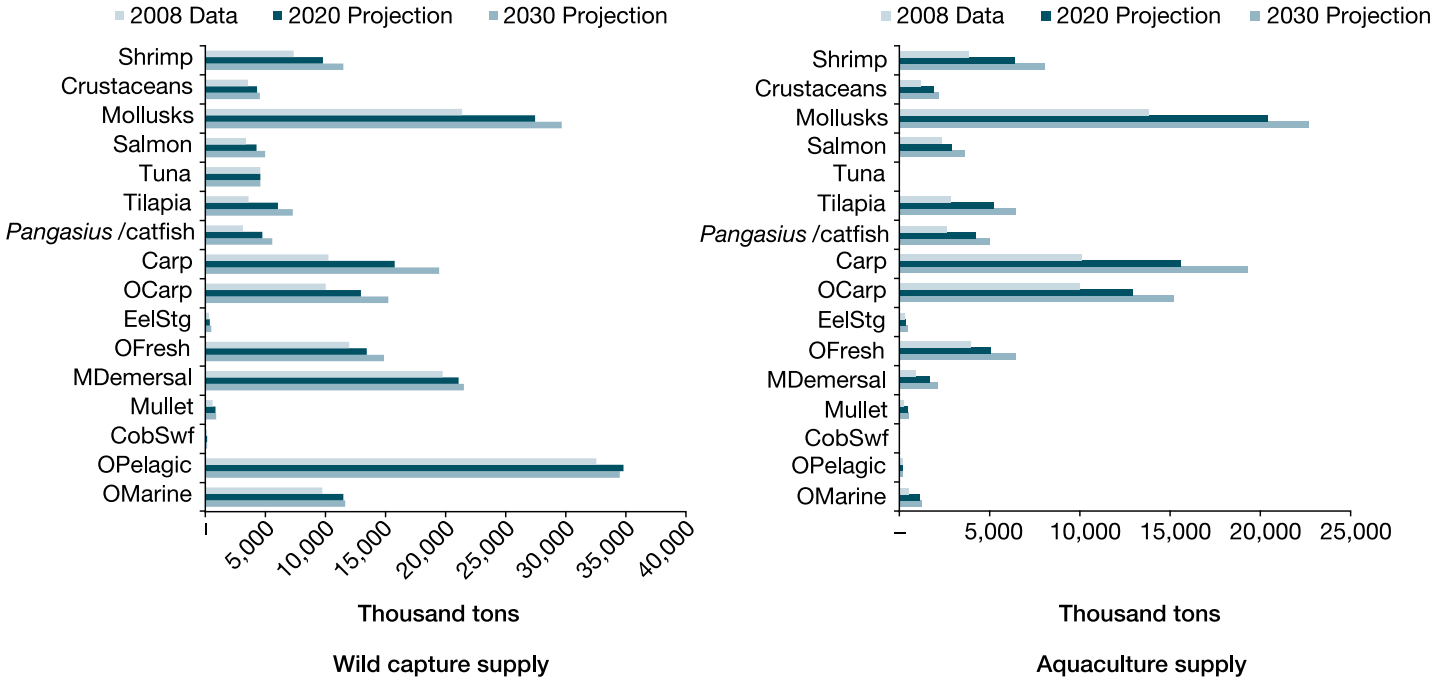


Figure A4.7. Projected wild capture and aquaculture fish supply by species (World Bank, 2013)

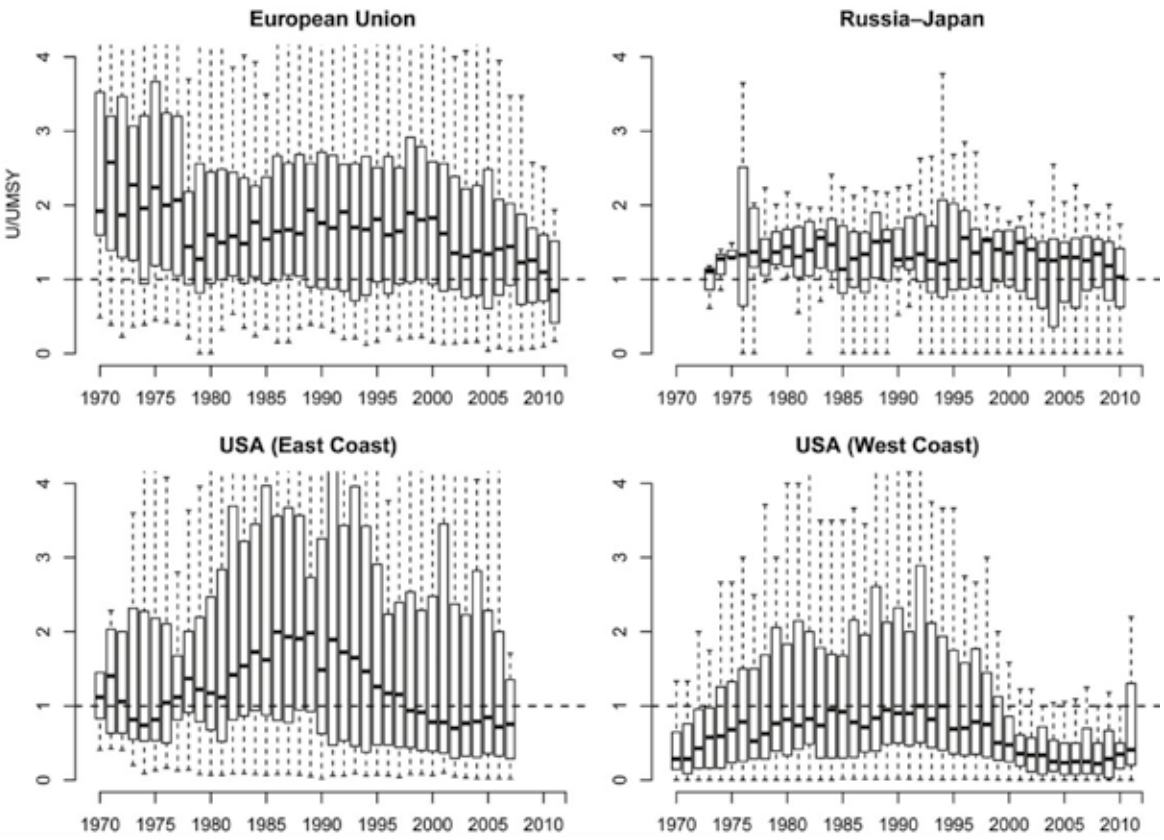


Figure A4.8 Boxplots of fishing mortality rate (U) scaled relative to the level that would achieve MSY (UMSY) in the EU, Russia–Japan, USA (West Coast) and USA (East Coast) over time. Black horizontal lines indicate the median U/UMSY in a given year; the box areas represent the interquartile range, and the whiskers the 95% confidence intervals (Hilborn and Ovando 2014).

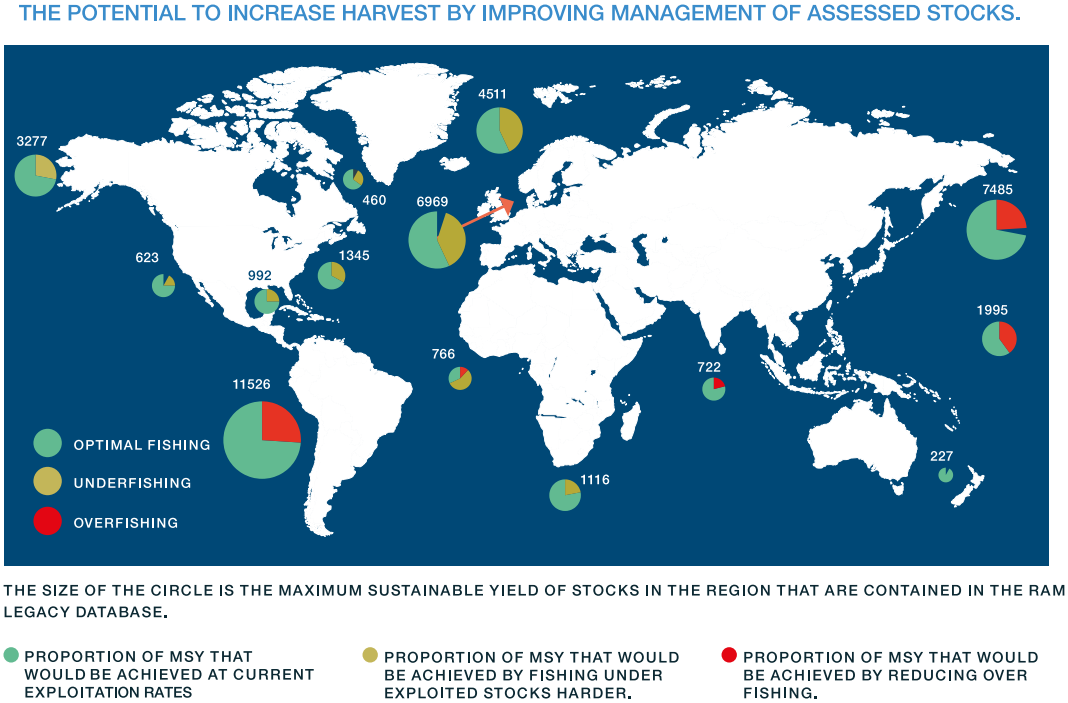


Figure A4.9 Potential to increase harvest by improving management of assessed stocks[20]. Note the RAM Legacy Database is not comprehensive, with significant data gaps from fisheries in the developing world.

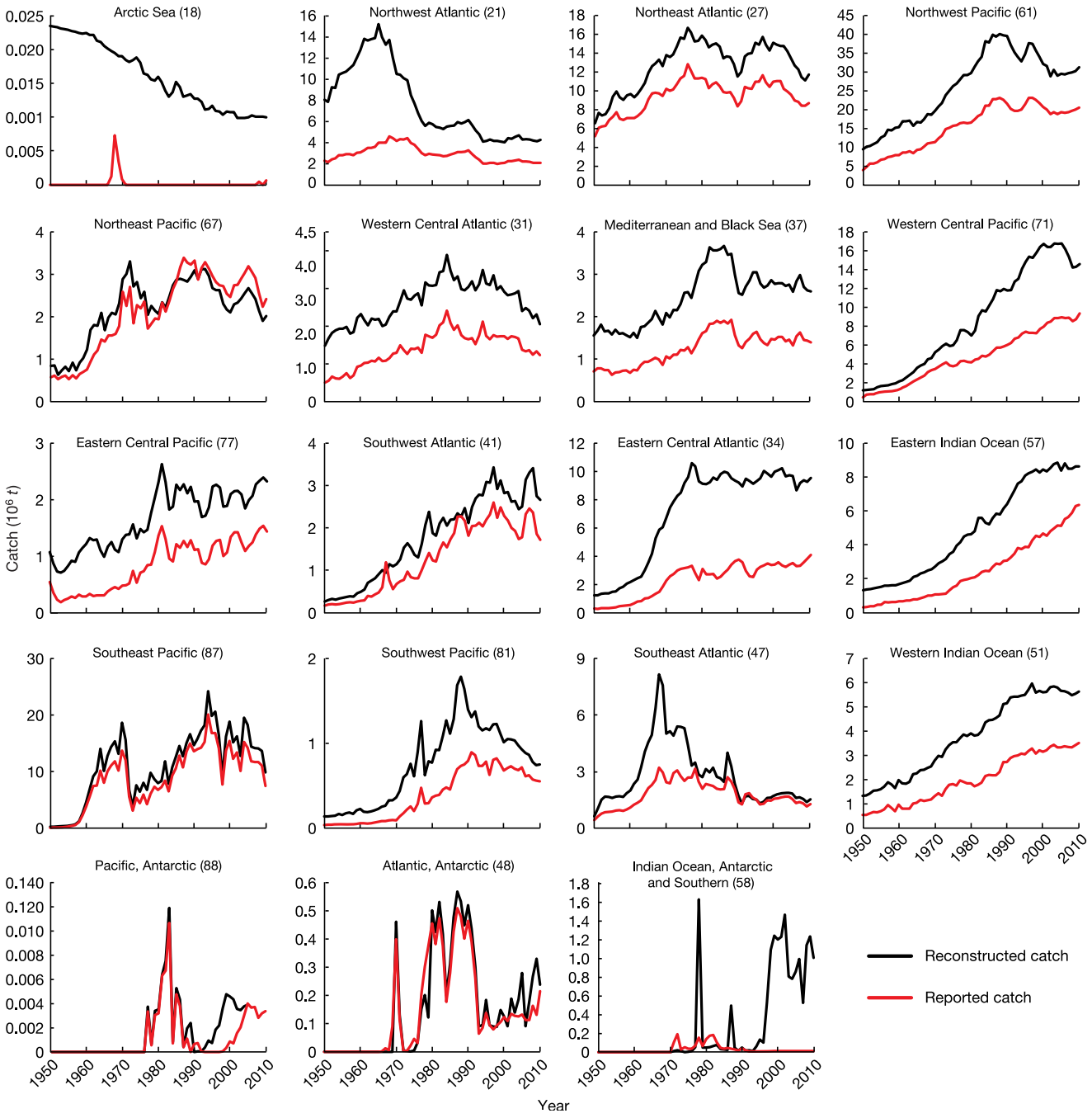


Figure A4.10 Reconstructed and reported catches by FAO areas. Contrasting reconstructed and reported catches in the 19 maritime 'Statistical Areas' which FAO uses to roughly spatialize the world catch. Note that for Area 18 (Arctic), the reported catch by the U.S. and Canada was zero, while only Russia (former-USSR) reported a small catch in the late 1960s, even though the coastal fishes of the high Arctic are exploited by Inuit and others (from Pauly and Zeller 2016).

Appendix 5 – Example products in seafood, white, red, and substitute meat sectors

Table A5.1 Example products in seafood, white, red and alternative meat sectors (Data sources include Food Standards Agency, 2008)

	Primary	Secondary	Tertiary	
Seafood	Whole Loins Fillets - skin on Fillets - skinless Portions - skinless Meat in shell Meat	Crabsticks Fish balls Fish paste Roe Taramasalata Tuna pate	Curry Fishermen's pie Kedgeree Salmon en croute Seafood cocktail	Seafood pasta Szechuan prawns with vegetables Spring rolls Prepared pre-school meals (<5yrs)
Chicken	Whole Dark meat Light meat Meat Breast Roasted Skin	Burger/grillsteak Chicken nuggets Chicken roll Meat spread Pate Chicken in white sauce Chicken wings	Chicken pie Chicken chasseur Chicken chow mein Chicken curry Chicken satay Chicken tandoori Chicken tikka masala Chicken stir-fry	Sweet and sour chicken Coronation chicken Coq au vin Spring rolls Prepared pre-school meals (<5yrs)
Pork	Bacon Ham Belly joint Diced Fillet strips Leg joint Loin chops Steaks	Frankfurter Luncheon meat Meat spread Pate Salami Sausages Savaloy Faggots in gravy	Pork pie Sausage rolls Scotch eggs Pork casserole Sausage casserole	Sweet and sour pork Spring rolls Prepared pre-school meals (<5yrs)
Lamb	Neck cutlets Breast Leg Loin chops Mince Neck fillet Shoulder Stewing lamb	Donor kebabs Shish kebab	Lamb curry Lamb kheema Lamb hotpot with potatoes Irish stew Lancashire hotpot	Moussaka Spring rolls Prepared pre-school meals (<5yrs) Meat samosas
Beef	Braising steak Rib roast Mince Rump steak Silverside Stewing steak Topside	Burger/grillsteak Corned beef Meat spread Pate Sausages	Cornish pastie Beef pie/steak and kidney Stewed steak with gravy Beef bourguignon Beef casserole Beef chow mein Beef curry Beef stew Beef stir-fry Bolgnese sauce (with meat)	Chilli con carne Cottage/shepherds pie Goulash Beef hotpot with potatoes Lasagne Meat samosas Moussaka Pasta with meat and tomato sauce Spaghetti bolognese Prepared pre-school meals (<5yrs)
Substitute	Eggs Tofu Beans Lentils Chick peas Unsalted nuts Seeds	Omelette Egg mayonnaise sandwich filler Marinated tofu Soya mince Quorn pieces, minces, slices and fillets Baked beans in sauce Mixed beans in sauce Bean burgers Hummus Flavoured/salted nuts and seeds	Vegetarian quiche Vegetarian mini eggs Egg sandwiches Vegetarian soya-based sausages Vegetarian soya-based burgers Quorn burgers, sausages, fishless fingers, escalopes	Quorn pasties, sausage rolls, pies Quorn stir-fry Quorn/soya mince lasagne Quorn/soya mince bolognese Quorn curry Chick pea/bean/lentil curry Nut cutlets, roast or burgers

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