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Watching brief report 2017

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Climate change adaptation in the UK (wild capture) seafood industry

SEAFISH

MCCIP Marine Climate Change Impacts Partnership

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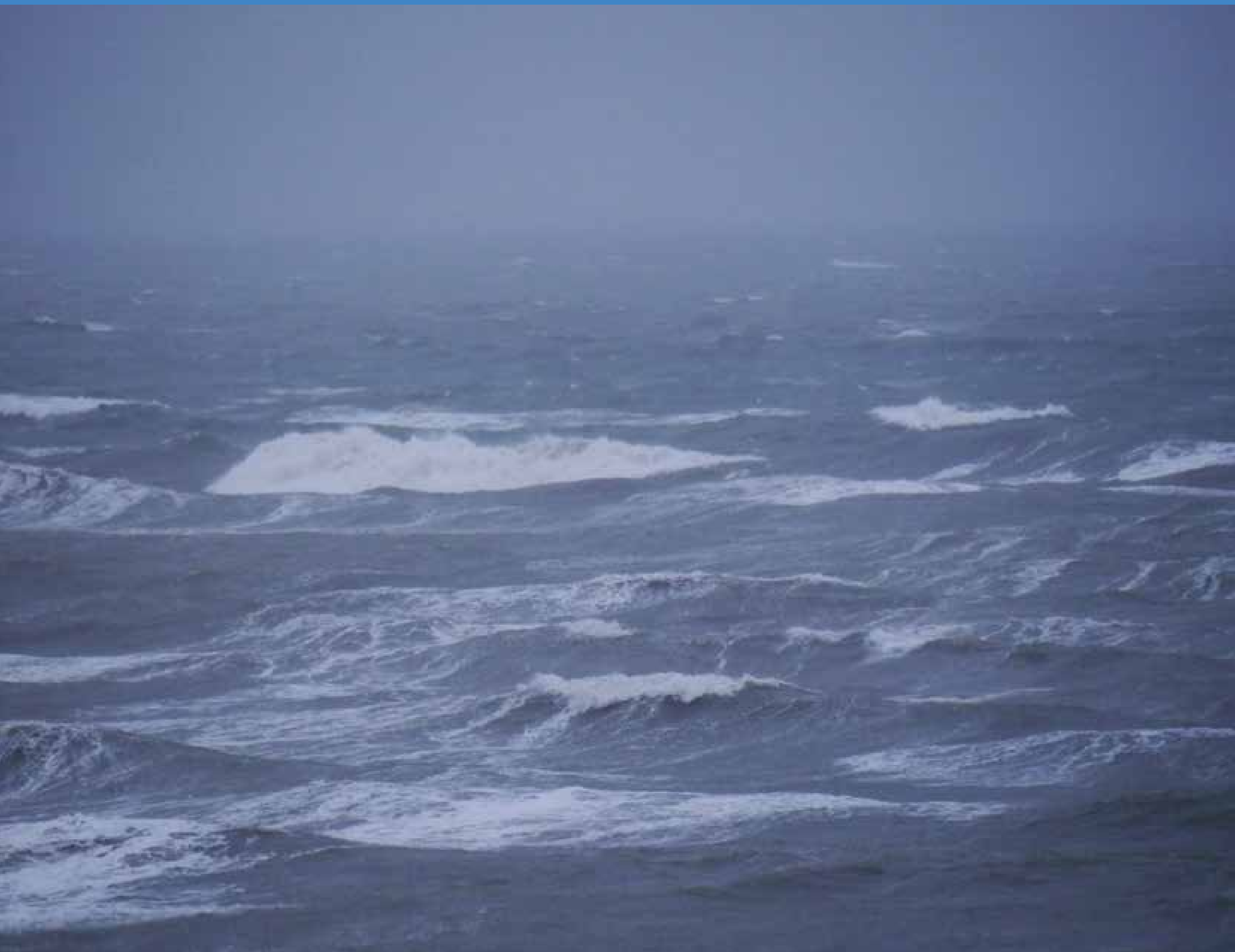

1. Introduction

- Climate change is a strategic challenge across all UK sectors (including UK seafood). In late-2015, Seafish published a review of climate change adaptation for UK domestic and international (wild capture) seafood[1]. This also contributed to the UK Government Adaptation Reporting Requirement on climate change, conducted every five years across a number of sectors.
- The Seafish review concluded that climate change was a challenge for UK seafood, but that industry considers it a 'low priority' relative to other risks. As such a watching brief is to be maintained on climate change developments and their impacts on UK industry. Specifically, seeking regular feedback from industry stakeholders on climate change, impacts and adaptation actions. The findings to be incorporated into Seafish annual horizon reporting.
- This watching brief report considers recent advances in understanding and industry experience of climate change drivers and impacts. Advances in understanding draws on new scientific evidence collated through the MCCIP initiative in 2017, experience of these drivers in 2016 and 2017 is captured through semi-structured interviews with 13 UK industry stakeholders. Findings are provided for domestic and international seafood, and, where appropriate, by major species grouping concerned. This report provides a 'light touch' overview and is indicative only.

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1 http://www.seafish.org/media/1476673/climate_change_report_-_lr.pdf

2. Scientific evidence – advances in understanding climate change drivers and impacts

2.1 Physical climate change drivers (sea level rise, temperature, storms and waves, ocean acidification and de-oxygenation, changes in terrestrial rainfall).

In 2016/2017 the winter North Atlantic Oscillation (NAO) index was positive (+1.47) for the fourth consecutive winter. When the NAO index is positive, there is an increased chance that seasonal temperatures will be higher than normal in northern Europe. During positive phases of the NAO, winds from the west dominate, bringing with them warm air, while the position of the jet stream enables stronger and more frequent storms to travel across the Atlantic supporting mild and stormy conditions for the UK. By contrast when the NAO is negative, winds from the east and north-east are more frequent, bringing with them cold air, while the adjusted position of the jet stream leads to weaker and less frequent storms.

According to the UK Met Office the year as a whole (2017) was rather warmer than average for the UK. The months from February to June were all warmer than average, whereas the second half of the year saw temperatures nearer to average with the exception of a warm October. UK-average anomalies in February, March, May, June and October were all well in excess of +1 °C, and mid-June saw a significant hot spell. The coolest months relative to average were August and November. Most places were within 10% of the yearly average for rainfall; it was rather drier across central and northern Scotland and many central and southern parts of England, but somewhat wetter in west Wales and north-west England. Notable extreme weather events during the year included Storm Doris in February and flash flooding in Coverack, Cornwall in July; autumn and early winter saw occasional notable storm systems, and widespread snow fell over Wales and central England on 10th of December. The hot spell in June saw the highest temperatures in that month for over 40 years, and, unusually, brought temperatures above 30 °C somewhere in the UK five days in a row (see **https://www.metoffice.gov.uk/climate/uk/summaries/2017/annual**).

The provisional UK mean air temperature for 2017 was 9.6 °C, which is 0.7 °C above the 1981-2010 long-term average, ranking as the fifth warmest year in the historical UK series since 1910. It was about a quarter of a degree warmer than 2016. There were five months which ranked in their respective top ten warmest, and spring was close to being the warmest on record, losing out only narrowly to 2011.

Sea surface temperatures (SST) recorded at Malin Head (north of Ireland) for 2017 were the highest on record at 0.89°C above the 1981-2010 average. Malin Head monthly mean temperatures for 2017 were all above the average. By contrast, for the M3 buoy (Celtic Sea, southwest of Ireland), the mean in 2017 was close to the 2003-2010 average. In the North Sea, monthly SSTs were between 0.1 and 0.9°C above the long-term average for the period 1981-2010. The 2017 annual mean SST, averaged across the whole North Sea of 10.8 °C was slightly lower than in 2016 but with an anomaly of +0.6°C still above the long-term mean (ICES Working Group on Ocean Hydrography 2018).

2.2 Implications (changing catch potential, impacts on offshore operations and assets, impacts on onshore operations and assets).

2.2.1 Domestic system

- In September 2017, researchers from Cefas presented (at the ICES Annual Science Conference) initial outputs from a project looking at "UK fisheries, climate change and storminess: how the harsh winter of 2013/14 can provide insights for the future". This project had been instigated explicitly to address comments raised in the 2015 Seafish climate change report. Meteorologists from the UK Met Office have suggested that winter 2013–14 was the stormiest in the 66-year record, due to unprecedented cyclone intensity and frequency. The UK fishing industry was severely disrupted with severe damage to fishing boats and harbour facilities, especially in the southwest, a lack of fish reaching markets and consequently higher fish prices nationally. A preliminary analysis was carried out of fishery disruption in southwest England using satellite-derived vessel monitoring data to characterise the relationship between weather variables and behaviour of the fleet. Fishing effort was greatly curtailed when wind speed exceeded 10 m/second, but particularly so when winds exceeded 15 m/second. The main focus was on characterising the response among commercial fishing vessels based in Brixham, Plymouth and Newlyn. Projections from climate modellers suggest that extreme wind speeds will increase (in occurrence and severity) over the United Kingdom during the coming century and therefore that UK fisheries will face increasing levels of disruption in the future. This work is now being continued by a PhD student based at University of Exeter.

- Fernandes et al, (2017) used observational and experimental data, theoretical, and modelling approaches to quantify potential effects of ocean warming and acidification on the fisheries catches, resulting revenues and employment in the United Kingdom under different CO_2 emission scenarios. Standing stock biomasses were projected to decrease significantly by 2050 and the main driver of this decrease was sea surface temperature rise. Overall, losses in revenue were estimated to be in the range 1-21% in the short term (2020–50). Losses in total employment (fisheries and associated industries) may reach approximately 3–20% during 2020–50, with the small vessel (>10 m) fleet and associated industries bearing the majority of the losses. It should be noted however, that this study is based on some fairly 'heroic' assumptions about how individual fish and shellfish species might be impacted by rising temperature and reduced pH in the future, and such assumptions are considered highly uncertain (see https://onlinelibrary.wiley.com/doi/abs/10.1111/faf.12183).
- A study by researchers in Scotland (McQueen and Marshall) published in 2017, examined the inter-annual variation in the timing of Atlantic cod spawning in the northern North Sea, central North Sea and Irish Sea, as estimated by calculating an annual peak roe month (PRM) from records of roe landings spanning the last three decades. A trend towards earlier PRM was found in all three regions, with estimates of shifts in PRM ranging from 0.9 to 2.4 weeks per decade. Temperatures experienced by cod during early vitellogenesis correlated negatively with PRM, suggesting that rising sea temperatures have contributed to a shift in spawning phenology (see https://academic.oup.com/icesjms/article-abstract/74/6/1561/3065349?redirectedFrom=fulltext).
- A study by researchers from Cefas (Townhill et al.) published in 2017, examined the potential impact of reducing oxygen concentrations in the North Sea on commercial fish stocks. Oxygen availability is key in determining habitat suitability for marine fish. As a result of climate change, low oxygen conditions are predicted to occur more frequently and over a greater geographic extent. To assess the potential effects of climate-induced low oxygen on fisheries, physiological data, such as critical thresholds, derived from laboratory experiments on five commercial fish species were integrated with hind-cast and future oxygen projections from a hydrodynamic-biogeochemical model. By using this approach, changes in habitat suitability from the 1970s to 2100 were identified. In the North Sea, the current extent of areas with the lowest oxygen levels is smaller than during the 1970s, with improved oxygen conditions having less impact on species' critical thresholds. Oxygen levels are expected to decrease again in the coming century due to climate change, although not to the minima of previous decades (caused by eutrophication). In affected areas and years, intermediate oxygen levels could have temporary impacts in late summer on swimming, growth, ingestion and metabolic scope of adult fish (see http://www.int-res.com/abstracts/meps/v580/p191-204/)
- In 2017 both commercial and recreational fishers reported seeing large numbers of Atlantic bluefin tuna (ABFT) *Thunnus thynnus*, especially off Devon and Cornwall. Historically this species had been present throughout much of the Northeast Atlantic, including the North Sea where it had previously been a target of commercial fisheries from Norway and France and a sport fishery based in Scarborough. Bluefin tuna largely disappeared from UK waters in the 1970s and the yearly migration of large individuals to northern waters seems to have ceased. However, in recent years tuna have been reported as far north as Iceland and Greenland, possibly shifting their distribution in response to the expansion of mackerel (a major prey item), at least partly influenced by changing climatic conditions. Since 2008, ICCAT has granted a small but rapidly increasing quota share to Norway and Iceland (52.48 and 43.71 tonnes respectively in 2017, rising to 200 and 140 tonnes by 2020) in recognition of the growing abundance of this species in northern waters. It should be noted however, that the United Kingdom has not been allocated a share of the total EU bluefin tuna quota, having never previously had a commercial fishery and therefore a 'track record' of harvesting this species. Currently, the MMO guidance states that: *"(commercial) Vessels* ***must not target bluefin tuna*** *and if caught accidentally they must be returned to the sea, alive and unharmed to the greatest extent possible. Sea anglers* ***must not target bluefin tuna****, any caught as a by-catch when targeting other species must be released immediately and not landed or brought onto the boat".* The only exception to this rule is if recreational catches are part of an ICCAT-approved tagging program. In April 2018 the University of Exeter and Cefas announced that they have embarked upon a two-year scientific study, supported by Defra and the European Maritime and Fisheries Fund (EMFF), to deploy state of the art animal electronic tracking devices to find out where Atlantic bluefin tuna caught in UK waters go, and this follows a similar study in Ireland. Scientists will work with stakeholders including commercial fishers, recreational anglers, wildlife watchers, and NGOs, to share knowledge, and to deploy around 40 tracking devices over the next two years (see https://www.thunnusuk.org/).

- In 2016 ICES received a specific request from the EU Commission to investigate long-term distribution shifts of key commercial fish stocks in relation to TAC management areas. This request was addressed through extensive data analysis at the ICES secretariat and a specially-convened WKFISHDISH workshop which took place at ICES headquarters (Copenhagen) on 22-25 November 2016. The resulting ICES advice document was issued in March 2017 (see http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/eu.2017.05.pdf) 19 species were considered: anchovy, anglerfish (two species), blue whiting, cod, common sole, Greenland halibut, haddock, hake, herring, horse mackerel, mackerel, megrims (two species), Norway pout, plaice, pollack, saithe, sprat, spurdog and whiting.

- Based on the ICES analyses and the literature available, all species were found to have exhibited some changes in their distribution to some extent, apart from Greenland halibut, Norway pout and spurdog for which no evidence was found. The main drivers of distribution shift identified were environmental conditions (mainly temperature) for all species, followed by density-dependent habitat selection (seven species), geographical attachment (six species), species interactions (four species), demographic structure (three species), and spatial dependency (two species). Other possible drivers (fishing and colonisation) were also mentioned for four species. 'Big movers', i.e. species where distribution changes are likely to be problematic regarding TAC management areas were identified. Eight species (anchovy, cod, hake, herring, mackerel, plaice, horse mackerel, and common sole) have shifted their distribution in relation to TAC management areas since 1985. Of these, the greatest shifts occurred for hake and mackerel. The following species were identified as 'big movers': anchovy (northward shift in the North Sea), anglerfish (regional changes in the North Sea), blue whiting (increase in the North Sea and west of Scotland), cod (northward shift), hake (expansion in the North Sea), herring (changes across different TAC management areas), mackerel (major changes across northeast Atlantic), megrims (regional changes in the North Sea, Bay of Biscay and Celtic Sea), and plaice (increase in North Sea and Baltic Sea, changes across different TAC management areas). In the ICES advice issued to the EU Commission (in March 2017) it is stated that *"Future changes in distribution are likely, but given the complexity of the mechanisms affecting the spatial distribution of fish stocks, predicting those changes with precision and accuracy is not possible. It is reasonable to assume that these changes will challenge some assumptions underlying the current management of Northeast Atlantic fisheries. Continued monitoring of the spatial distributions of fish stocks is essential to support future management".*

- A collaborative workshop on climate change impacts and fisheries management was held in Copenhagen on 30-31st of August 2017. This event was organized by the Environmental Defense Fund (EDF) and hosted at ICES (but not necessarily endorsed by ICES). The primary aim of this workshop was to explore (through discussion) implications of fish distribution shifts for policy and management. Some of the conclusions contained within the report of this workshop [available at: https://www.edf.org/sites/default/files/documents/climate-impacts-fisheries-NE-Atlantic_0.pdf?_ga=2.35001953.1990209889.1523507540-212745320.1518981706] were:

1. **Scientific and management institutions are not yet fully prepared for the changes under way and still to come.** The long time periods and geographic ranges at which climate change takes place are often in direct conflict with the protocols and rules that guide traditional fisheries management systems. Both science and management institutions must work together to ensure scientific assessments are carried out at the most appropriate geographic and temporal scales so that they are equipped to address the transboundary nature of fish.

2. **The EU's relative stability key has remained virtually unchanged while fish populations continue to move northwards.** Matching catches to quota will therefore be increasingly important, particularly as the EU's landing obligation comes into full effect. Without forging solutions to reduce the increasing lack of alignment between catch (based on total mortality) and quota, EU fishermen will face pressure to either 'tie up' or continue to discard illegally, risking overfishing.

3. **International agreements governing shared stocks are not keeping pace with changes** in the water, with even well-defined international fisheries agreements not resilient to unanticipated change, nor ready to adapt when political interests override sustainability. There are lessons that can be learned, such as the 'mackerel wars' earlier this decade, which aptly demonstrate the risks of mis-management of shifting stocks, and the complex dynamics between different coastal states when there is perceived injustice within the system. This case study can help to signpost areas for innovation and improvement as we move forward.

4. **Brexit introduces a further layer of complexity,** with the future of negotiations (and therefore future fish allocations and governance for the region) still very much up in the air. There will likely be ramifications of this shifting governance landscape on other bilateral and multi-lateral fisheries agreements in the region, which will require strong governance to ensure fisheries are exploited sustainability during any geo-political transition.

2.2.2. International system

- Barents Sea cod recruitment is known to be heavily influenced by temperature. Due to a favourable climate as well as lower fishing pressure in recent years, the Northeast Arctic cod stock reached record levels in 2013 (spawning stock biomass 2.7 million tonnes), in contrast to elsewhere in the NE Atlantic (such as the North Sea, Celtic Sea and West of Scotland), where populations have been very slow to recover. According to ICES, **the spawning stock biomass (SSB) for northeast Arctic (Barents Sea) cod remained high in 2017** (1.8 million tonnes), as did the cod stock biomass around Iceland (SSB 616,906 tonnes).
- According to ICES, haddock stock biomass in subareas 1 and 2 (Northeast Arctic) are also at very high levels, having witnessed an all-time peak in 2014 (SSB 675,563 tonnes). Estimates of **the spawning stock biomass (SSB) for northeast Arctic (Barents Sea) haddock remained high in 2017** (537,865 tonnes), but stock biomasses are decreasing around Iceland.
- In 2017, overall storm activity in the Barents Sea was very high (the highest since 1981). The number of days with winds speeds >15 m/s was larger than usual, for most of the year. Ice coverage was 20–23% lower than normal. In summer, the ice coverage was 6–15% lower than the long-term average but 4–17% higher than in the previous year. Compared to the first half of 2016, when record high positive seawater temperature anomalies (1.2–1.5°C) were observed, in the second half of 2017, warming was significantly reduced. During most of the observation period in 2017 waters were still 0.8–0.9°C warmer than the long-term average.

3. Industry experience of climate change impacts and relevant responses

Industry experience of climate change within domestic and international systems is described by major fish species grouping. **Note:** *Stakeholders urged **caution** in attributing impacts directly to climate change drivers. Other drivers of relevance include social (e.g. fisheries management) and environmental (biological and oceanic cycles) drivers, so the link between climate change drivers and impact should be considered indicative only.*

3.1 Domestic (see tables 3.1 and 3.2 in Annex 1)

Whitefish

Overall no notable drivers experienced: relatively benign conditions.

- 'Increased storminess and waves':
  - Contributing to poor **weather conditions** with wind and waves resulting in more difficult working conditions – especially for inshore fleet.

Pelagic

Overall no notable drivers experienced: relatively benign conditions.

Shellfish

Overall no notable drivers experienced: relatively benign conditions.

- 'Increased storminess and waves':

- Contributing to poor **weather conditions** preventing inshore vessels from going out and a more difficult working environment.

Progress against adaptation responses

Notable responses in:

- *Fisheries management* include developing **closer science-industry collaboration and engaged research** through:
  - A number completed or continuing Fisheries Science Partnerships e.g. an NFFO-CEFAS partnership focussed on bass, skates and rays, monkfish and brown crab and an ongoing NFFO-Defra partnership through Defra 'Electra' research programme (focussed on elasmobranch species and use of industry data).
  - Quite well established mechanisms in Scotland e.g. Fisheries Innovation Scotland (FIS) and the Marine Alliance for Science and Technology Scotland (MASTS). FIS recently conducted a number of climate change relevant studies (http://www.fiscot.org/projects), investigating 'survival of Nephrops on deck' and 'discard survival' - both related to air and sea temperature. These platforms help advance longer term responses such as the development of a 'more robust strategic fisheries knowledge base' and the review of relative stability ('FIS re-imagined 'relative stability' for example).
- *Quota management* includes pilot projects to **ensure quota swaps / transfers** operate efficiently, for example: the Proteus project - focussed on exchanging information with POs and a Seafish strategic investment funded project looking at the potential of VMS/E-log data pooling system for industry (feasibility and specification).
- *Fishing operations* includes **enhancing operational safety** through:
  - The deployment of Personal Flotation Devices (PFDs), including providing personal locater beacons, with the support of Seafish and others (such as NFFO supplying safety equipment to membership).
  - The continuing trend in new pelagic vessel build that incorporates additional decks/pumping from stern.
- *Port and infrastructure* includes preparation for **damage to site infrastructure** for example through adjusting port infrastructure to cope with storm surges, and – for example - contingency planning for flood threat by a major processor (focussed on how to maintain supply of seafood to customers under a 'worse case' scenario).
- *Processing and markets* for the longer term development of **markets for available domestic seafood** are considered weak, whilst there is the suggestion that climate change is currently translating into the green narrative and thereafter being picked up in buyers' narratives. In UK markets it is noted that, perhaps as a response to supply fluctuation, frozen fish now appears to be a more palatable option in food service. Initiatives concerned with communicating the availability of domestic seafood continue to progress, including the Seafood 2040 initiative in England and the Seafood Scotland run project "Connect Local". The latter provides a domestic/Scottish framework for selling Scottish material locally, and at a Scotland and UK level.

3.2 International (see tables 3.3 and 3.4 in Annex 1)

Whitefish

Notable drivers experienced include:

- *'Increased storminess and waves'*:
  - Contributing to poorer **weather conditions** in Norway and Iceland according to some stakeholders. However, there is no clear signal on this as others feel conditions are not worsening particularly. Nevertheless, as vessels are robustly built to withstand these conditions, fishing has not been disrupted.
- *'Temperature change'*:
  - Clearer signal that this is affecting **fish distribution** in the Barents Sea/Arctic. Also in the North Pacific (Alaska and Bering Sea) with the general drift northwards of Alaska Pollock spawning or catching patterns impacting on fishing and **catch potential of target species**, adding uncertainty to seasonality and continued evidence of smaller fish size (the late season in 2016 saw lots of stock being frozen down (by Russia) impacting further on price).

Pelagic

Notable drivers experienced include:

- *'Temperature change'*:
  - Affecting **fish distribution and fisheries productivity** (alongside other factors) in oceans of particular interest (Indian ocean and Western pacific) and elsewhere. Impact is unclear but fleets becoming increasingly less profitable – a desire to change from long-line to purse-seine and price rises above normal price fluctuations for Indian ocean tuna.

Shellfish

Notable drivers experienced include:

- *'Temperature change' and 'acidification'*:
  - Believed to be the primary drivers (in combination with cod predation) affecting **catch potential** of target species (cold water prawn) in the North Atlantic and Western Atlantic. Suffering from ice-break up in the Arctic and more icebergs off Newfoundland. Increased sunlight through thinner ice believed to affect algae and the salinity of water. The fishing season of other species of cold water prawn on the West coast of the USA also believed to be impacted by temperature.

Progress against adaptation responses

Notable responses in:

- *Fisheries management* include **management regimes embracing the concept of climate change adaptation** through the upholding of the recent negotiated agreement between Government/industry/NGO stakeholders concerning international access and governance rights in the Arctic. Recent progress includes:
  - Broad adherence to the limiting of fishing to traditional fishing areas.
  - Norwegian scientists assessing risks of new marine ecosystem by extending existing research (the Mareano project).
  - Industry setting up a satellite system to monitor catch infringements of the agreement, whilst the Norwegian Government is discussing the need for regulatory control.
- *Fishing operations* include new boat building in the UK (pelagic) and Norway with vessels making themselves more weather independent to **maintain ability to catch** in the North Atlantic. This may be a result of recognising more storms but may just be technological advances.
- *Processing and markets,* in **maintaining a watching brief on climate change** and potential response overseas, highlights the arrival of super-frozen tuna and its acceptance in the UK market. Acceptance of new formats and sources previously rejected (in favour of fresh formats) supports consistent supplies in the face of changes in distribution of catch potential of the target species.

4. Conclusion

- A range of impacts continue to be experienced in the last 12-15 months, although climate change drivers appear less noticeable in this review – particularly in the UK domestic system.
- Brexit negotiations are likely to advance the timescales on a number of potential adaptation responses. These include, for example, close science-industry collaboration and engaged research; developing a more strategic fisheries knowledge base; and review of ‘relative stability’. As an illustration, for science-industry collaboration, Brexit negotiations offer opportunities to progress towards a fit-for-purpose collaborative arrangement that, if focussed on zonal attachment for example, could enhance understanding and response to changes in the fishery.
- Significant geo-political developments have the potential to force a change in the speed of response. For example, Brexit has the potential to advance the requirement to ‘review relative stability’ from a long term response (of over 15 years) to a nearer term action.

Annex 1 – Tables.

OFFSHORE	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
WHITEFISH					
a) Fishery resources					
i. Alterations in species phenology			🔴		
ii. Impacts on choke species (linked to landing obligations)			🔴 🟢		
iii. Changes to growth rate of target species			🔴 🟢		
iv. Changes to the distribution of target species			🔴 🟢		
v. Changes to year-class strength (including larval survival)			🔴 🟢		
vi. Migration patterns of target species (timing and routes)			🔴 🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
iii. Damage to fleet		🔴			
PELAGIC					
a) Fishery resources					
i. Migration patterns of target species (timing and routes)			🔴		
ii. Alterations in species phenology			🔴		
iii. Changes to the catchability of target species		🔴	🔴		
iv. Changes to growth rate of target species			🔴 🟢		
v. Changes to the distribution of target species			🔴 🟢		
vi. Changes to year-class strength (including larval survival)			🔴 🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
SHELLFISH					
a) Fishery resources					
i. Presence of HABs		🔴	🔴		🔴
ii. Presence of pests and diseases					🔴
iii. Changes to year-class strength (including spatfall)			🔴 🟢		
iv. Presence of non-natives / jellyfish			🔴 🟢		
v. Changes to the distribution of target species (including squid)			🟢		
vi. Changes to growth rates of target species			🔴 🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
iii. Damage to fleet		🔴			
ONSHORE					
a) Ports and harbours					
i. Damage to site infrastructure	🔴	🔴			🔴
ii. Boat damage in ports / harbours		🔴			
iii. Integrity of electricity supply					🔴
b) Employment and fishing communities					
i. Integrity of housing and local amenities	🔴	🔴			
ii. Days at sea		🔴			
c) Transportation of catch					
i. Disruption to ferry service		🔴			
d) Processing of catch					
i. Damage to site infrastructure	🔴	🔴			🔴
ii. Integrity of electricity supply					🔴

Table 3.1 Summary of key domestic offshore and onshore threats (red dots) and opportunities (green dots)

Speed of response (inertia)		System	Adaptation response	Owner	Scale of resource			
					Minor	Moderate	Significant	Major
	Underway	**Fishery**	Scientific advice and data collection through partnership working	Fisheries Science Partnerships				
	Underway	**Fishery**	Development of training and education modules for fishermen	Fishing into the Future (with Seafish)				
	Underway	**Operations**	Enhance operational safety (raised decks)	Industry				
	Underway	**Operations**	Enhance operational safety (Personal Flotation Devices)	The Fishing Industry Safety Group				
	Underway	**Operations**	Enhance operational safety (Safety at Sea training)	Seafish-approved training providers				
	Underway	**Ports**	Build port resilience	Port / harbour authorities / Department of Transport				
	Underway	**Processing**	Develop markets for available domestic seafood	Seafood Scotland				
	Immediate (<2 years)	**Ports**	Ensure berth allocations for vulnerable vessels	Port / harbour authorities		■		
	Immediate (<2 years)	**Processing**	Develop marketing strategies for seafood in rest of UK	Industry trade organisations		■		
	Short term (2-5 years)	**Fishery**	Develop close science-industry collaboration and engaged research	Industry trade associations / scientists		■	■	
	Short term (2-5 years)	**Fishery**	Ensure quota swaps / transfers	Industry		■		
	Short term (2-5 years)	**Operations**	Keep a watching brief on climate change and potential responses	Industry trade associations	■			
	Short term (2-5 years)	**Ports**	Improving port risk management	Port / harbour authorities	■	■		
	Short term (2-5 years)	**Transport**	Assess vulnerability of freight ferries	Government			■	
	Short term (2-5 years)	**Processing**	Establish specific seafood marketing organisations for rest of UK	Industry trade organisations (e.g. Fishmongers Hall)			■	
	Medium term (5-15 years)	**Fishery**	Developing a more robust, strategic fisheries knowledge base.	Scientists / industry / Govt			■	
	Medium term (5-15 years)	**Fishery**	Review of domestic quota allocation	EU / UK Govt / Fisheries scientists / industry			■	■
	Medium term (5-15 years)	**Operations**	Review of fishing seasons in response to disruptions	Industry / Government			■	
	Long term (>15 years)	**Fishery**	Review 'Relative stability' (Governance) arrangements	EU / UK Govt / Fisheries scientists / industry				■
	Long term (>15 years)	**Operations**	Assess vulnerability of fleets across the EU	EU research				■
	Long term (>15 years)	**Processing**	Re-locate processing sites inland	Processors and planning inspectorate				■

Table 3.2 Adaptation responses for the domestic system

OFFSHORE					
	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
Wild capture (general)					
i. Changes in species distribution and fisheries productivity (+ve and -ve effects)			Red, Green		
ii. Loss of fisheries production at lower latitudes			Red		
iii. Enhanced fisheries production at high latitudes			Green		
iv. Impact on international fisheries governance and access rights			Red		
WHITEFISH					
a) Fishery resources					
i. Changes in distribution or catch potential of target of species (general)			Red, Green		
- Arctic fisheries			Red, Green		
- North Atlantic Fisheries			Red, Green		
- North Pacific (Alaska and Bering Sea) fisheries			Red, Green		
- Mid Atlantic – offshore Senegal, The Gambia, Sierra Leone, Ghana			Red		
b) Offshore operations					
i. Gear deployment / performance		Red			
PELAGIC					
a) Fishery resources					
i. Changes in distribution or catch potential of target species (general)			Red		
- Tuna fisheries			Red		
- Pacific Ocean anchoveta and sardine fisheries			Red		
SHELLFISH					
a) Fishery resources					
i. Changes in distribution or catch potential of target species				Red	
ii. Introduction of non-native species			Red		
b) Offshore operations					
i. Staff physical working conditions		Red			
ONSHORE					
a) Ports and harbours					
i. Damage to site infrastructure	Red	Red			Red
ii. Vessels / gear damage in ports / harbours		Red			
c) Onshore processing					
i. Disruption or damage to coastal processing facilities	Red	Red			Red
SOCIO-ECONOMIC CONDITIONS					
i. Impact on national economies of changes in fisheries			Red, Green	Red	
ii. Impact on food security of changes in fisheries			Red	Red	

Table 3.3 Summary of key international offshore and onshore threats (red dots) and opportunities (green dots)

Speed of response (inertia)		System	Adaptation response	Owner	Scale of resource: Minor	Moderate	Significant	Major
	Underway	**Offshore**	IMO convention on standards of training and certification of 'watchkeepers' (fishing sector)	IMO				
	Immediate (<2 years)	**Fishery**	Review of key sources of existing supply and available options	UK Industry - especially integrated supply chains / UK Govt / scientists		■	■	
	Short term (2-5 years)	**Fishery**	Monitoring and assessing the impact of changes in specific regional supplies	UK industry bodies / Support organisations / Govts / scientists		■	■	
		Fishery	Promoting an awareness of climate change in the North Atlantic pelagic fishery	UK Industry / UK Govt / scientists		■		
		Fishery	Ensure management regimes embrace the concept of climate change adaptation	International industry bodies / Govts / scientists		■	■	
		Fishery	Ensuring international fisheries management regimes provide early resolution on 'rights to fish'	Industry bodies / RFMOs / scientists / Govts.		■	■	
		Offshore	Maintain ability to catch	UK and international industry / marine engineers and designers		■	■	
		Offshore	Ensure capacity for enhanced productivity of whitefish fisheries at higher latitude	UK and international industry / scientists		■		
		Processing	Improve resilience and capacity of overseas facilities	UK and international industry / Govt / RFMOs / scientists		■	■	
	Medium term (5-15 years)	**Fishery**	Assessing the viability of enhanced regional productivity	UK industry / Govt / scientists		■		
		Fishery	Developing much closer science-industry links to understand climate driven regional changes	UK industry / Govt / scientists		■	■	
		Offshore	Engagement with overseas stakeholders to support climate change adaptation	UK industry / industry bodies / investors / RFMOs / scientists / Govts		■	■	■
		Processing	Maintain a watching brief on climate change and potential responses overseas	UK industry / Govt / scientists		■	■	
	Long term (>15 years)		-					

Table 3.4 Adaptation responses for the international system

Consultees

1. David Anderson, Aberdeen Fish Producers Organisation.
2. Lucy Blow, New England Seafood Ltd.
3. Will Clark, Wilsea Ltd.
4. Karen Galloway, Xenosophy Ltd.
5. Ian Gatt, Scottish Pelagic Fishermen's Association.
6. Malcolm Morrison, Scottish Fishermen's Federation.
7. Alex Olsen, Espersen.
8. David Parker, Young's Seafood Ltd.
9. Dale Rodmell, National Federation of Fishermen's Organisations.
10. John Rutherford, Frozen At Sea Fillets Association.
11. Robert Stevenson, Lunar Fish Producers Organisation Ltd.
12. Brian Young, British Frozen Foods Federation.
13. Laky Zervudachi, Direct Seafoods Ltd.

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