Seafood Background Document

Climate Change Sectoral Adaptation Plan
Prepared under the National Adaptation Framework

Prepared by the Department of Agriculture, Food and the Marine
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Outline of Impact/Prioritisation process

For the Seafood Sector, an iterative process was undertaken by the Department with significant input from experts from the Marine Institute and Bord Iascaigh Mhara in identifying and assessing the scale of risks. The process was guided by templates (detailed below) provided by Climate Ireland and with guidance from MaREI/UCC, on behalf of Climate Ireland, on process and prioritisation. The significant challenge for the Seafood Sector, in particular, identified in the process is that of quantifying the scale of risks posed by climate change impacts. The areas of particular vulnerability which were identified provided the basis upon which to prepare a series of case studies to examine the challenges faced in greater detail. Research contained within [EPA Report No. 159](#) supported this work.

Tier 1 Assessment of Current Climate Impacts (Trends and Extreme Events) for Seafood Sector

Summary

**Purpose:** Identify the range of climate trends and weather events that currently impact upon your sector.

**Method:** Based on literature review and stakeholder participation

**Outputs:** A list of the sectoral impacts and consequences of observed climate changes (Table 1) and extreme weather events (Table 2). This provides a large list of impacts that informs subsequent prioritisation of impacts for more detailed analysis (Tier 2 Assessment)

**Task Overview**

As part of this task, and for your area of operation, you will provide an overview of the impacts and consequences of observed climatic changes for Ireland and extreme weather events.

This assessment will be conducted in terms of impacts on infrastructure, modes and well-being (staff and passengers). In addition, for each climate trend and extreme weather event, you will provide an estimate of consequence for each of the observed trends and extreme weather events. For extreme weather events, it is also useful to provide the date of an example of each event.

- For information on observed climate changes for Ireland, consult [Climate Ireland’s Essential Climate Information](#) and [Status of Ireland’s Climate Tool](#).
- For a list of extreme weather events, consult [Met Éireann’s database of extreme weather events](#).

**Guidance on Assigning Consequence Level**

Consequence levels employed in the current assessment are based on those employed as part of the UK Climate Change Risk Assessment (2012).

Consequence of impacts of climate trends and extreme weather events can be considered according to economic, social or environmental considerations and can be scored as high, medium and low and in accordance with appendix 1. When rating consequence, input the highest individual score across all three categories.
<table>
<thead>
<tr>
<th>Climatic trend</th>
<th>Observed Impacts – include details of impacts</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperatures</td>
<td></td>
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<tr>
<td>Increasing Ocean temperatures</td>
<td><strong>Fishing Fleet, Harbours and Facilities including aquaculture</strong>: Increasing air temperatures transfer and corresponding rise in ocean temperature, has lead to thermal expansion and consequent rise in sea levels. Sea surface temperature in Irish waters has increased at a rate of approximately 0.6°C per decade since 1994. This has likely lead to an increase in intensity of storms. Increased frequency/intensity of storms is problematic for smaller vessels accessing harbour facilities such as cruise liner transfer crafts, and has the potential to damage fishing vessels while in harbour. <strong>Fish Stocks</strong>: Increasing temperatures conduct to oceans and can disrupt fish distributions and migrations, causing stocks to move north to colder waters. Movement can also be to deeper (cooler) waters leading to non-poleward changes in distribution. There may also be biogeographical changes with southern species coming into Irish waters and northern species leaving. This also has consequences for the spread of Invasive Alien Species. Higher temperatures can lead to higher metabolic rates and hence less energy for growth. Warmer winters are associated with reduced freshwater survival in salmon, and rising temperatures may lead to changes in diadromous fish stock demographics (e.g. growth rate, hatching rate, timing of migration). Changing ocean conditions (related to temperature) are thought to be an important driver of reduced marine survival of salmon. Increased stress to shellfish making them less tolerant to handling during summer months and increased susceptibility to virus due to higher rates of filtration. <strong>Water column and aquifer quality</strong>: Increasing air temperatures transfer to a rise in ocean temperature, also causing thermal expansion and therefore a rise in sea levels. There is evidence that warming sea temperatures are causing earlier onset and longer duration of shelf sea stratification. Recent increases in the relative abundance of the potentially toxic phytoplankton (Pseudo-nitzshia spp.) have been reported in surface Celtic Sea shelf waters; this is related to increases in SST and summer wind speed. Surface water temperatures in lakes are rising, including Irish lakes. Increasing soil temperatures accelerate the rate of decomposition of organic matter in soils, leading to increases in DOC (dissolved organic carbon) export to water. This has implications for the ecology of aquatic ecosystems – the “brownification” of surface waters, and the treatment of drinking water supplies.</td>
<td>Medium</td>
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<tr>
<td>Precipitation and Hydrology</td>
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<tr>
<td>Decrease in mean annual, spring and summer rainfall with increase in</td>
<td><strong>Fishing Fleet, Harbours and Facilities including aquaculture</strong>: Increase in downriver deposits may require increased frequency of dredging in harbours, with resulting difficulties in disposal of dredged material. Heavy winter precipitation leading to decreased water quality status of shellfish waters. Reduced precipitation results in lower river flows and less water available to inland freshwater aquaculture facilities. These facilities provide the juvenile stock for marine fish farms.</td>
<td>Low</td>
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<tr>
<td>Climatic trend</td>
<td>Observed Impacts – include details of impacts</td>
<td>Magnitude of Impact</td>
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<td>autumn/winter heavy precipitation events.</td>
<td><strong>Fish Stocks:</strong> Many fish species have nursery areas in estuaries and coastal areas, and increased river flow may negatively impact on these. Changes in patterns of rainfall, including high winter rainfall and summer droughts may impact on survival and demography of freshwater fish stocks, especially migratory species relying on water level as a cue. Catastrophic flooding can cause high mortality in freshwater fish stocks and reduce spawning success. <strong>Water column and aquifer quality:</strong> Winter increases in rainfall are linked to freshening of coastal waters. May cause an increase in agricultural run-off and diminish salinity levels in coastal areas where rivers discharge into the sea. Increases in rainfall and river discharge will increase dissolved and particulate organic carbon export from terrestrial stores to aquatic ecosystems.</td>
<td>Low</td>
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<tr>
<td>Salinity</td>
<td><strong>Fishing Fleet, Harbours and Facilities including aquaculture:</strong> There are no clear trends in the large-scale salinity patterns within Irish shelf waters. North East Atlantic and Nordic Seas waters becoming slightly more saline after freshening from 1960-1990. <strong>Fish Stocks:</strong> There are no clear trends in the large-scale salinity patterns within Irish shelf waters. North East Atlantic and Nordic Seas waters becoming slightly more saline after freshening from 1960-1990. No major effects on fish stocks have been identified. In marginal areas within bays, shellfish such as mussel are put under stress by increased freshwater run-off. This was witnessed in Wexford during the UISCE project. <strong>Water column and aquifer quality:</strong> There are no clear trends in the large-scale salinity patterns within Irish shelf waters. North East Atlantic and Nordic Seas waters becoming slightly more saline after freshening from 1960-1990.</td>
<td></td>
</tr>
<tr>
<td>Acidification</td>
<td><strong>Fishing Fleet, Harbours and Facilities including aquaculture:</strong> Absorption of CO₂ by the oceans has mitigated climate change but in so doing has increased their acidity. <strong>Fish Stocks:</strong> Absorption of CO₂ by the oceans has increased their acidity, this could have a significant impact on calcifying organisms such as phytoplankton and echinoderms with unknown consequences for top predators such as fish, birds and mammals. Acidification may also affect fish community size structure. Population scale effects of acidification are unknown but there is slight evidence for foodweb effects on zooplankton production and benthic organisms. Possible effects on fish sensory systems leading to behaviour changes. Changes observed in commercial shellfish hatcheries in Pacific NW. Acidic seawater is not necessarily dissolving the shells, but rather the oyster larvae use more of their energy stores at a critical time of their development that causes the larvae to grow slower or even die. Consequences for future water management in controlled environments such as hatcheries and nurseries.</td>
<td>Medium</td>
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<tr>
<td>Acidification (cont.)</td>
<td><strong>Water column and aquifer quality:</strong> Absorption of CO₂ by the oceans has increased their acidity. Surface waters of the Rockall</td>
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<tr>
<td>Climatic trend</td>
<td>Observed Impacts – include details of impacts</td>
<td>Magnitude of Impact</td>
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<td>Trough have acidified at a rate of -0.02pH units per decade between 1991 and 2010, in line with acidification rates at the world’s carbon time series sites.&lt;sup&gt;25&lt;/sup&gt; Acidification was also observed in Labrador Sea Water in the Rockall Trough.&lt;sup&gt;25&lt;/sup&gt; Baseline data on ocean acidification parameters has been published for Irish coastal waters, with low pH and calcium carbonate saturation states measured at selected inshore sites.&lt;sup&gt;26&lt;/sup&gt;</td>
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</table>
| Sea level rise              | **Fishing Fleet, Harbours and Facilities including aquaculture:** Satellite observations indicate that the sea level around Ireland has risen by approx 4-6 cm since the early 1990’s<sup>27</sup>. This has placed increased pressure on existing infrastructure constructed at a time of lower mean sea levels. Sea Level rise has consequences for intertidal aquaculture licensing within the current regulatory regime which does not allow flexibility in structural positioning.  
**Fish Stocks:** Satellite observations indicate that the sea level around Ireland has risen by approx 4-6 cm since the early 1990’s<sup>27</sup>. No known impacts on fish stocks.  
**Water column and aquifer quality:** Satellite observations indicate that the sea level around Ireland has risen by approx 4-6 cm since the early 1990’s<sup>27</sup>. Rising sea levels have the potential to increase saline intrusion in coastal areas and diminish fresh groundwater supplies. Freshwater supplies during low-level events will be prioritised for drinking water, leaving less available for other activities including aquaculture. Evidence from an Irish coastal lagoon indicates a progressive increase in salinity as a result of sea level rise, and resulting changes in the lagoons biology.<sup>28</sup> | Low |
| Sea state and surges        | **Fishing Fleet, Harbours and Facilities including aquaculture:** There is some evidence of increase in significant wave heights during winter months, of up to 30cm<sup>29</sup>. Combined with higher sea levels and storm surges, rises in significant wave heights further threaten existing coastal infrastructure. Also may lead to an increase in injuries/fatalities on, and damage to, fishing vessels and aquaculture structures.  
**Fish Stocks:** There is some evidence of increase in significant wave heights during winter months, of up to 30cm<sup>21</sup>. No known impacts on fish stocks.  
**Water column and aquifer quality:** There is some evidence of increase in significant wave heights during winter months, of up to 30cm<sup>29</sup>. Increased storm surge frequency and extent results in increased saline intrusion of coastal areas potentially impacting on drinking water availability. | Low |
<p>| Phenology                  | <strong>Increasing duration of growing season:</strong> <strong>Fishing Fleet, Harbours and Facilities including aquaculture:</strong> Expansion of the growth season in upper tropic levels&lt;sup&gt;30&lt;/sup&gt;. Unclear the implications, if any for infrastructure in our coastal waters. | Low |</p>
<table>
<thead>
<tr>
<th>Climatic trend</th>
<th>Observed Impacts – include details of impacts</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish Stocks:</strong></td>
<td>Expansion of the growth season in upper tropic levels(^{12}). There is some evidence of phenological changes as a result of changing temperatures e.g. slower growth, changes in spawning season and migration timing(^{4,31}). The implications of this are confounded by fishing pressure. No clear evidence for major population level impacts have been found.</td>
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<tr>
<td><strong>Water column and aquifer quality:</strong></td>
<td>Expansion of the growth season in upper tropic levels(^{30}). Diatom abundance has increased earlier in the year since the late 1990s in all coastal regions; an expansion of the growth season(^{27}).</td>
<td></td>
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</tbody>
</table>

Table 1
<table>
<thead>
<tr>
<th>Extreme Events</th>
<th>Weather</th>
<th>Observed Impacts – include details of impacts</th>
<th>Event Example (date and economic impact where available)</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heatwaves</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: Increased temperatures impact the water temperature in rivers and lakes and this can impact on inland aquaculture facilities by stressing fish and increasing probability of water borne diseases and infection. Fish Stocks: Heatwaves at certain times of the year may cause mortality in juvenile salmonids. Water column and aquifer quality: N/a</td>
<td>Summer 1995 – Warmest summer on record</td>
<td>Low/Medium</td>
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<tr>
<td>Extreme Precipitation</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: Extreme precipitation can lead to increased turbidity and suspended sediments in rivers, which can impact on inland aquaculture facilities. Fish Stocks: Mass mortality of juvenile salmonids following a flash flood in July 2009 (MI unpublished data), destruction of salmonid habitat. Possible impacts on nursery areas for flatfish in estuaries. Water column and aquifer quality: Disruption of thermal stratification in lakes, reduced primary production, increased bacterial abundance.</td>
<td>August 1997 – Heavy rain and flooding, Southeast and South July 2009, flood event in North west Mayo.</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Fluvial Flooding</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: N/a Fish Stocks: As above for extreme precipitation Water column and aquifer quality: As above. Potential for sewage infiltration of water supplies and coastal seas. Locally, in marginal areas within bays, shellfish such as mussel are put under stress by increased freshwater run-off. This was witnessed in Wexford during the UISCE project.</td>
<td>December 1998 – River Blackwater</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Pluvial Flooding</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: N/a Fish Stocks: N/a Water column and aquifer quality: Potential for sewage infiltration of water supplies and coastal seas.</td>
<td>February 2002 – Rain and tidal flooding, East and South coasts</td>
<td>Low</td>
</tr>
<tr>
<td>Storm Surge</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture facilities. Reduced accessibility to facilities. Fish Stocks: No known impacts.</td>
<td>February 2002 – Rain and tidal flooding, East and South coasts; Winter 2012/2013 – widespread</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Extreme Events</td>
<td>Weather</td>
<td>Observed Impacts – include details of impacts</td>
<td>Event Example (date and economic impact where available)</td>
<td>Magnitude of Impact</td>
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<tr>
<td>Cold Snaps</td>
<td></td>
<td>Water column and aquifer quality: Saline intrusion of coastal areas.</td>
<td>west coast flooding</td>
<td></td>
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<td></td>
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<td>Fishing Fleet, Harbours and Facilities including aquaculture: N/a</td>
<td>Jan 1987 – Heavy Snowfall</td>
<td>Low</td>
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<td></td>
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<td>Fish Stocks: (see temperature comment above)</td>
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<tr>
<td></td>
<td></td>
<td>Water column and aquifer quality: N/a</td>
<td></td>
<td></td>
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<tr>
<td>Storms/High Wind</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture facilities. Reduced accessibility to facilities. Fish Stocks: Can cause break up of pelagic fish schools with negative consequences for fishing, and possibly for survey accuracy. Water column and aquifer quality: N/a</td>
<td>26th December 1998 – Hurricane force winds over North and Northwest Also December 2013 - February 2014</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Wave Heights</td>
<td></td>
<td>Fishing Fleet, Harbours and Facilities including aquaculture: Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture facilities. Reduced accessibility to facilities. Fish Stocks: No known impacts. Water column and aquifer quality: N/a</td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2
### Appendix 1 – Table of Consequences

<table>
<thead>
<tr>
<th>Class</th>
<th>Economic</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
</table>
| **High** | • Major & recurrent damage to property and infrastructure  
• Major consequences on regional and national economy  
• Major cross sector consequences  
• Major disruption or loss of national or international transport links  
• €100 million for a single event/year | • Major loss or decline in long-term quality of valued species/habitats or landscape  
• Major or long-term decline in status condition of sites of international or national significance  
• Widespread failure of ecosystem function or services  
• Widespread decline in land/water/air quality  
• Major cross-sector consequences  
• 5000 ha lost/gained  
• 10000km of river water quality affected | • Potential for many fatalities or serious harm  
• Loss or major disruption to utilities  
• Major consequences on vulnerable groups  
• Increase in national health burden  
• Large reduction in community services  
• Major damage or loss of cultural assets/high symbolic value  
• Major role for emergency services  
• Major impacts on personal security  
• Million affected  
• 1000’s harmed  
• 100 fatalities |
| **Medium** | • Widespread damage to property of infrastructure  
• Influence on regional economy  
• Consequences on operations & service provision initiating contingency plans  
• Major disruption of national transport links  
• Moderate cross-sector consequences  
• Moderate loss/gain of employment opportunities  
• €10 million for a single event or year | • Important/medium-term consequences on species/habitat/landscape  
• Medium-term or moderate loss of quality/status of sites of national importance  
• Regional declines in land/water/air quality  
• Medium-term or regional loss/decline in ecosystem services  
• Moderate cross sector consequences  
• 500 ha lost/gained  
• 1000 km of river quality affected | • Significant numbers affected  
• Minor disruption to utilities  
• Increased inequality, e.g. through raising costs of service provision  
• Consequences on health burden  
• Moderate reduction in community services  
• Moderate increased role for emergency services  
• Minor impacts on personal security  
• Thousands affected  
• 100s harmed  
• 10 fatalities |
| **Low** | • Minor or very local consequences  
• No consequences on national or regional economy  
• Localised disruption of transport  
• €1 million per event/year | • Short-term/reversible effects on species/habitat/landscape or ecosystem services  
• Localised decline in land/water/air quality  
• Short-term loss/minor decline in quality/status of designated sites  
• 50 ha of valued habitats damaged/improved  
• 100km river water quality affected | • Small number affected  
• Small reduction in community services  
• Within coping range  
• 1000’s affected |

Table 3 Guidance on Classification of Relative magnitude: qualitative descriptions of high, medium and low classes (UK CCRA, 2012)
Citations: (Tier 1 Assessment of Current Climate Impacts (Trends and Extreme Events))


2) Chapter 7, Irish Ocean Climate and Ecosystem Status Report 2009, Marine Institute

3) ICES (2017). EU request on distributional shifts in fish stocks. [http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/eu.2017.05.pdf](http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/eu.2017.05.pdf)


13) Chapter 3, Irish Ocean Climate and Ecosystem Status Report 2009, Marine Institute


19) Le Pape, O., F. Chauvet, et al. (2003). Quantitative description of habitat suitability for the juvenile common sole (Solea solea, L.) in the Bay of Biscay (France) and the contribution of different habitats to the adult population. Journal of Sea Research 50(2-3): 139-149.


22) Table 2.8, Climate Change Research Programme (CCRP) 2007-2013 Report Series No. 1

23) Chapter 4, Irish Ocean Climate and Ecosystem Status Report 2009, Marine Institute


29) Table 2.9, Climate Change Research Programme (CCRP) 2007-2013 Report Series No. 1

30) Table 2.6, Climate Change Research Programme (CCRP) 2007-2013 Report Series No. 1


33) MI Unpublished data


36) Chapter 5, Irish Ocean Climate and Ecosystem Status Report 2009, Marine Institute
## Projected Impacts – Gradual Changes for Seafood Sector

<table>
<thead>
<tr>
<th>Climate Stressor:</th>
<th>Current Magnitude of Impact</th>
<th>Projected Change in Relevant Climate Variables (2041-2060)</th>
<th>Potential Future Impacts</th>
<th>Potential Future Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperatures</strong></td>
<td></td>
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<tr>
<td>Summer Temperatures</td>
<td>Low/Med</td>
<td>↑ (0.9-1.7 deg C)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Reduced water levels during low rainfall periods may impact on accessibility at some sites and availability of water for inland aquaculture facilities. Increasing catchment water temperatures is likely to have knock on effects on the survival and development of juvenile fish populations at inland aquaculture facilities. <strong>Fish Stocks:</strong> Projecting the likely impacts of Climate change is difficult, and likely to miss important factors(^1,2,3,4). However, with a careful and process based approach it may be useful(^5,6). It remains important, however, to remember that “correlation does not imply causation”. Climate change may lead to the decline of traditional fisheries (e.g. cod) and the emergence of new fisheries (e.g. boarfish) and the increased abundance of warm water southern species including Invasive Alien Species. There are also likely to be significant changes to metabolic rates and hence growth in many species(^7,8). Higher temperatures (summer and winter) will likely increase metabolic rates, diverting more energy to metabolism and less to growth and/or reproduction. Distribution and migration changes are likely in many marine fish species. Increasing catchment water temperatures are likely to have strong knock on effects in fresh and transitional waters on the survival and development of juvenile fish populations(^9) including salmonids. Warmer water temperatures leading to increased rates of filtration by shellfish, thereby increasing risks of contamination. Prolonged closure periods due to biotoxin risks result in lost stocks and reduced product quality. Prolonged increased summer temperatures leading to stress on aquaculture species increasing the risks from product handling such as grading activities. <strong>Water Column and Aquifer Quality:</strong> Projected changes in climate are likely to affect a range of water quality parameters, including water temperature, water Dissolved Oxygen (DO) concentrations and Dissolved Organic Carbon (DOC) concentrations(^10).</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Climate Stressor</td>
<td>Current Magnitude of Impact</td>
<td>Projected Change In Relevant Climate Variables (2041-2060)</td>
<td>Potential Future Impacts</td>
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<tr>
<td>Winter Temperatures</td>
<td>Low</td>
<td>↑ (1-1.7 deg. C)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Rising sea levels and increased storm intensity will increase required investment in harbour infrastructure and coastal flood defences. Additionally, increased frequency/intensity of storms is problematic for smaller vessels accessing harbour facilities such as cruise liner transfer crafts and also potential damage to aquaculture facilities and fishing vessels while in harbour. Fish Stocks: For marine species the effects of winter temperature changes will likely have the same ecological outcomes as summer temperatures e.g. distribution, phenology, slower growth, reduced weight at age/length, lower reproduction, and reduced survival etc. Warmer winters are associated with reduced freshwater survival in salmon, and rising temperatures may lead to changes in diadromous fish stock demographics (e.g. growth rate, hatching rate, timing of migration). Water Column and Aquifer Quality: The effects in this area are unclear. If earlier and prolonged stratification of the water column will occur, then a depletion of surface nutrients in shelf seas is likely to result in a decline in phytoplankton biomass. Alternatively, as increased temperature drives primary production and also increased run off from the land will, on occasions, increase nutrients, effects of rising winter temperatures are not so clear. Plus, the increased winds will increase propensity for thermocline breakdown.</td>
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<tr>
<td>Precipitation and Hydrology</td>
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<tr>
<td>Winter rainfall</td>
<td>Low/Med</td>
<td>↑ (0 - 14%)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Increase in downriver deposits may require increased frequency of dredging in harbours with resulting difficulties in disposal of dredged material. Dublin Port has encountered recent difficulties with this issue. Fish Stocks: Increased rainfall leading to an increased risk of contamination of shellfish from stormwater overflows. Also increased stress in shellfish and possible mortality. Probably little effect on marine fish stocks. Increased rainfall increases turbidity and suspended solids in rivers supplying water to inland aquaculture facilities.</td>
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<tr>
<td>Climate Stressor</td>
<td>Current Magnitude of Impact</td>
<td>Projected Change In Relevant Climate Variables (2041-2060)</td>
<td>Potential Future Impacts</td>
<td>Potential Future magnitude of Impact</td>
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<tr>
<td>Water Column and Aquifer Quality:</td>
<td></td>
<td>Winter increases in rainfall are linked to freshening of coastal waters. This may cause an increase in agricultural runoff and diminish salinity levels in coastal areas where rivers discharge into the sea.</td>
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<tr>
<td></td>
<td></td>
<td>Increases in rainfall and river discharge will increase dissolved and particulate organic carbon export from terrestrial stores to aquatic ecosystems.</td>
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</tr>
<tr>
<td>Summer rainfall</td>
<td>Low</td>
<td>↓ (0 - 20%)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Reduced water levels during low rainfall periods may impact on accessibility at some sites. Reduced water available to inland aquaculture facilities which supply juvenile stock to marine sites.</td>
<td>Low/Medium</td>
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<td></td>
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<td>Fish Stocks: Changes in estuarine habitats may have negative impacts on the many marine fish that use these as nursery areas, especially flatfish.</td>
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<td></td>
<td>Water Column and Aquifer Quality: Increased salinity of coastal lagoons and estuarine areas.</td>
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</tr>
<tr>
<td>Salinity</td>
<td>Low</td>
<td>↑ in winter flows (catchment dependent)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: N/a</td>
<td>Low/Medium</td>
</tr>
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<td></td>
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<td>Fish Stocks: There are alternative views regarding effects on fish stocks. No major effects on fish stocks have been identified as yet, with future trends to be determined. Alternatively there is evidence from the Baltic to suggest that salinity can have a significant impact on marine fish stocks, although this would be a very different ecosystem to Irish waters.</td>
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<td></td>
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<td></td>
<td>Water Column and Aquifer Quality: Unknown. Continued observation and monitoring is required to determine any future trends in Irish waters.</td>
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</tr>
<tr>
<td>Acidification</td>
<td>Low</td>
<td>↓ summer flows (catchment dependent)</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: N/a</td>
<td>Medium/High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fish Stocks: Could have a significant impact on calcifying organisms such as phytoplankton echinoderms low down in the food chain and bivalves and crustacea with unknown consequences for top predators such as fish, birds and mammals. Ocean acidification could affect food production, particularly from the shellfish industry. Potential changes in the community structure in response to acidification.</td>
<td></td>
</tr>
<tr>
<td>Climate Stressor:</td>
<td>Current Magnitude of Impact</td>
<td>Projected Change in Relevant Climate Variables (2041-2060)</td>
<td>Potential Future Impacts</td>
<td>Potential Future magnitude of Impact</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Water Column and Aquifer Quality: OA consequences are irreversible. It is projected that there will be an increase in ocean acidity of 170% by 2100 if we continue burning fossil fuels under our “business as usual” scenario and that by the end of the century 70% of all known cold water coral reefs (most of which are in the N Atlantic) will be in water that is corrosive to aragonite. As ocean acidification continues, it may result in changes in metal toxicity and nutrient availability².</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>Low</td>
<td>0.26 – 0.55m</td>
<td><strong>Fishing Fleet, Harbour and Facilities including aquaculture:</strong> As levels continue to rise existing infrastructure may become obsolete or require considerable upgrading/new investment. In particular, pier deck levels will have to be raised and breakwater structures will have to be built to higher levels. This will result in increased costs for future maintenance of these structures and future development in the coastal zone. Effects compounded with storm surges. Flooding of low-lying areas. Sea level rise in combination with increased wave heights will result in greater frequency of wave overtopping of more exposed structures resulting in increased danger of people being washed into the sea. <strong>Fish Stocks:</strong> Unknown future impacts on fish stocks. Changes to salinity in coastal and estuarine areas may impact on local ecology and resulting impact on fish stocks. <strong>Water Column and Aquifer Quality:</strong> Given a projected increase in sea level, it is likely that increasing salinity in sensitive coastal lagoons will continue. Potentially increased salinity of ground water, estuarine areas and further upstream.</td>
<td>Medium</td>
</tr>
<tr>
<td>Sea State and Surges</td>
<td>Low</td>
<td></td>
<td><strong>Fishing Fleet, Harbour and Facilities including aquaculture:</strong> Combined with higher sea levels and storm surges, rises in significant wave heights will further threaten existing coastal infrastructure and aquaculture facilities. Also may lead to an increase in injuries/fatalities on, and damage to, fishing vessels. Storm surges have an impact on inshore shellfish culture, leading to losses of equipment, infrastructure and stock. Prolonged periods of bad weather and high seas/heavy swell conditions may lead to changes in</td>
<td>Medium</td>
</tr>
</tbody>
</table>
### Climate Stressor: Background Document

<table>
<thead>
<tr>
<th>Climate Stressor</th>
<th>Current Magnitude of Impact</th>
<th>Projected Change In Relevant Climate Variables (2041-2060)</th>
<th>Potential Future Impacts</th>
<th>Potential Future magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Waves</td>
<td>Low/Med</td>
<td>↑ intensity and duration</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Low water levels may reduce accessibility in some sites and availability of water for inland aquaculture facilities.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fish Stocks: Heat waves at certain times of the year will potentially cause mortality in salmonids and other species in estuaries, inshore bays and lagoons. Possibility of stratification and deoxygenation leading to mortality.</td>
<td></td>
</tr>
<tr>
<td>Phenology</td>
<td></td>
<td></td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: N/a</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>↑ length of growing season</td>
<td>Fish Stocks: N/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: N/a</td>
<td></td>
</tr>
</tbody>
</table>

**Projected Impacts – Extreme Events**

<table>
<thead>
<tr>
<th>Climate Stressor</th>
<th>Current Magnitude of Impact</th>
<th>Projected Change (2041-2060)</th>
<th>Potential Future Impacts</th>
<th>Potential Future magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Waves</td>
<td>Low/Med</td>
<td>↑ intensity and duration</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Low water levels may reduce accessibility in some sites and availability of water for inland aquaculture facilities.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fish Stocks: Heat waves at certain times of the year will potentially cause mortality in salmonids and other species in estuaries, inshore bays and lagoons. Possibility of stratification and deoxygenation leading to mortality.</td>
<td></td>
</tr>
<tr>
<td>Event Type</td>
<td>Impact</td>
<td>Fish Stocks</td>
<td>Water Column and Aquifer Quality</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Cold Spells</td>
<td>Low</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: No anticipated impact.</td>
<td>Low/Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish Stocks: See comment above on heat waves.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: Unknown impact.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme Precipitation</td>
<td>Low/Med</td>
<td>Fishing Fleet, Harbour and Facilities including Aquaculture: Increase in downriver deposits may increase the cost and frequency of required dredging. Extreme rainfall events increase turbidity and suspended solids in rivers supplying water to inland aquaculture facilities.</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish Stocks: Increase in mass mortalities of juvenile salmonids and destruction of salmonid habitat and inshore aquaculture as extreme precipitation events become more frequent. Dissolved and particulate matter impacting on shellfish quality. Impacts on estuarine nursery grounds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: Freshening of coastal waters, increase in agricultural runoff, diminished salinity levels in coastal areas where rivers discharge into the sea, increased dissolved and particulate organic carbon export from terrestrial stores to aquatic ecosystems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought</td>
<td>Low</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: Low water levels may reduce accessibility in some sites. Reduced water available to inland aquaculture facilities which supply juvenile stock to marine sites.</td>
<td>Low/Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish Stocks: Droughts leading to low water levels can result in delayed downstream migration of smolts and also present difficulty for adult salmonids to return to freshwater from the sea.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: Reduced river flow may increase salinity of coastal lagoons and estuarine areas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluvial Flooding</td>
<td>Low/Med</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: N/a</td>
<td>Low/Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish Stocks: As for extreme precipitation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: N/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pluvial Flooding</td>
<td>Low</td>
<td>Fishing Fleet, Harbour and Facilities including aquaculture: N/a</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish Stocks: N/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water Column and Aquifer Quality: Increase in events of sewage infiltration of water supply and coastal seas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event Type</td>
<td>Event Description</td>
<td>Impact on Fishing Fleet, Harbour and Facilities including aquaculture</td>
<td>Impact on Fish Stocks</td>
<td>Impact on Water Column and Aquifer Quality</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Storm Surge</td>
<td>Low/Med</td>
<td>in intensity of surges + SLR</td>
<td>Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture structures and reduced accessibility to facilities. Prolonged periods of bad weather and high seas/heavy swell conditions may lead to changes in fishing patterns as fishing fleets would be forced to tie-up for lengthy periods.</td>
<td>Unknown future impacts. Continued monitoring required.</td>
</tr>
<tr>
<td>Growing Season</td>
<td>Low</td>
<td>length (35-40 days)</td>
<td>N/a</td>
<td>Unclear future impacts. Continued monitoring required.</td>
</tr>
<tr>
<td>Storms/ High Winds</td>
<td>Low/Med</td>
<td></td>
<td>Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture structures and reduced accessibility to facilities. Prolonged periods of bad weather and high seas/heavy swell conditions may lead to changes in fishing patterns as fishing fleets would be forced to tie-up for lengthy periods.</td>
<td>Potential increase in breaking up of pelagic fish schools with associated negative impacts on fishing. Depending on the frequency and duration of such storms this has the ability to reduce annual effective fishing effort and potentially fishing mortality, particularly for inshore stocks.</td>
</tr>
<tr>
<td>Wave Heights</td>
<td>Low/Med</td>
<td></td>
<td>Danger to life and infrastructure in coastal areas. Risk to fishing fleets, infrastructure damage to harbours and aquaculture structures as well as reduced accessibility to facilities. In particular, aquaculture structures and mooring systems will have to be designed and certified accordingly to ensure they are capable of withstanding the larger forces generated as a result of increased wave heights. Prolonged periods of bad weather and high seas/heavy swell conditions may lead to changes in fishing patterns as fishing fleets would be forced to tie-up for lengthy periods.</td>
<td></td>
</tr>
</tbody>
</table>

---

**Water Column and Aquifer Quality:**

- Storms/ High Winds: Increased wave ‘overtopping’ and storm induced surges may result in saline intrusion.
- Wave Heights: Increased wave ‘overtopping’ and storm induced surges may result in saline intrusion.
Wave Heights (cont.)

patterns as fishing fleets would be forced to tie-up for lengthy periods.

**Fish Stocks:** Largely unknown future impacts. Physical stress on aquaculture species causing mortalities and stock losses. Depending on the extent and duration of increased wave heights this has the ability to reduce annual effective fishing effort and potentially fishing mortality.

**Water Column and Aquifer Quality:** Increased wave ‘overtopping’ may result in saline intrusion.

9) *Irish Ocean Climate and Ecosystem Status Report 2009*, Marine Institute


17) MCCIP 2013 Report card


20) Ref Special report on emission scenarios – IPCC 3rd and 4th Assessment report

### Appendix 1 – Table of Consequences

<table>
<thead>
<tr>
<th>Class</th>
<th>Economic</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
</table>
| High   | • Major & recurrent damage to property and infrastructure  
         • Major consequences on regional and national economy  
         • Major cross sector consequences  
         • Major disruption or loss of national or international transport links  
         • €100 million for a single event/year | • Major loss or decline in long-term quality of valued species/habitats or landscape  
         • Major or long-term decline in status condition of sites of international or national significance  
         • Widespread failure of ecosystem function or services  
         • Widespread decline in land/water/air quality  
         • Major cross-sector consequences  
         • 5000 ha lost/gained  
         • 10000km of river water quality affected | • Potential for many fatalities or serious harm  
         • Loss or major disruption to utilities  
         • Major consequences on vulnerable groups  
         • Increase in national health burden  
         • Large reduction in community services  
         • Major damage or loss of cultural assets/high symbolic value  
         • Major role for emergency services  
         • Major impacts on personal security  
         • Million affected  
         • 1000’s harmed  
         • 100 fatalities |
| Medium | • Widespread damage to property of infrastructure  
         • Influence on regional economy  
         • Consequences on operations & service provision initiating contingency plans  
         • Major disruption of national transport links  
         • Moderate cross-sector consequences  
         • Moderate loss/gain of employment opportunities  
         • €10 million for a single event or year | • Important/medium-term consequences on species/habitat/landscape  
         • Medium-term or moderate loss of quality/status of sites of national importance  
         • Regional declines in land/water/air quality  
         • Medium-term or regional loss/decline in ecosystem services  
         • Moderate cross sector consequences  
         • 500 ha lost/gained  
         • 1000 km of river quality affected | • Significant numbers affected  
         • Minor disruption to utilities  
         • Increased inequality, e.g. through raising costs of service provision  
         • Consequences on health burden  
         • Moderate reduction in community services  
         • Moderate increased role for emergency services  
         • Minor impacts on personal security  
         • Thousands affected  
         • 100s harmed  
         • 10 fatalities |
| Low    | • Minor or very local consequences  
         • No consequences on national or regional economy  
         • Localised disruption of transport  
         • €1 million per event/year | • Short-term/reversible effects on species/habitat/landscape or ecosystem services  
         • Localised decline in land/water/air quality  
         • Short-term loss/minor decline in quality/status of designated sites  
         • 50 ha of valued habitats damaged/improved  
         • 100km river water quality affected | • Small number affected  
         • Small reduction in community services  
         • Within coping range  
         • 1000’s affected |

Table 4 Guidance on Classification of Relative magnitude: qualitative descriptions of high, medium and low classes (UK CCRA, 2012)
Seafood Background Information

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1. Ireland’s Ocean Economy

1.1 Overview

Taking the seabed area into account, Ireland is one of the largest EU states; with sovereign or exclusive rights over one of the largest sea to land ratios (over 10:1) of any EU State. This ocean territory supports a diverse economy, with further potential to tap into the global market for seafood, marine tourism, ocean energy, and innovative applications for health, medicine and technology. Ireland’s position in the North East Atlantic has additional benefits in the form of the mild climate which supports terrestrial and marine biodiversity.

In June 2019, NUI Galway’s Socio-Economic Marine Research Unit (SEMRU) published Ireland’s Ocean Economy Report 2019. The report indicates that in 2018, Ireland’s ocean economy had a turnover of €6.2 billion. The direct economic contribution, as measured by gross value added was €2.2 billion or 1.1% of GDP. Ireland’s ocean economy provided employment for 34,132, full time equivalents. Compared to 2016, 2018 saw a 13% increase in turnover, an 11% increase in gross value added and a 13% increase in employment. The indirect GVA that is generated from ocean related activity in Ireland in 2018 amounts to a €1.96 billion, with a total GVA (direct and indirect) of €4.19 billion, which represents 2% of GDP.

Of particular note in terms of Ireland’s ocean economy, is the growth experienced in the seafood sector, as reported by Bord Iascaigh Mhara (BIM) in The Business of Seafood 2018. The report shows that the value of the Irish seafood sector increased by 3.4% on the 2017 figure, contributing €1.25 billion to Ireland’s GDP.

A further report from NUI Galway’s SEMRU in 2018, Valuing Ireland’s Blue Ecosystem Services, highlights the significant contribution that provisioning, regulation and maintenance, and cultural marine ecosystem services make to our welfare, health and to economic activity. On an annual basis, recreational services provided by Irish marine ecosystems are estimated to have an economic value of €1.6 billion. Fisheries and aquaculture are estimated to be worth €664 million in terms of output value from Irish waters, carbon absorption services (which help to mitigate climate change) are valued at €819 million, waste assimilation services €317 million, scientific and educational services €11.5 million, coastal defence services of €11.5 million and seaweed harvesting €4 million. Even though not all of the ecosystem services provided by the marine environment can be monetized, the report indicates that the value of those that can is substantial.

1.2 Management of Marine Resources under the Common Fisheries Policy

The Common Fisheries Policy (CFP) established certain principles such as shared access which created the concept of ‘community waters’ and the principle of relative stability whereby each Member States’ share of each Community quota remains constant over time. The share allocations are based on catch records and reflect the fishing levels by the Irish fleet at that time (mainly the early 1980s). The percentage shares held by each Member State have remained the same under the principle of relative stability. Under these arrangements, other Member States have enjoyed access to the fishing grounds in the Irish Exclusive Economic Zone (EEZ), as illustrated in Figure 1.

The current Common Fisheries Policy, introduced in 2014, provides a robust framework to deliver stocks to Maximum Sustainable Yield (MSY) levels by 2020 at the latest and also includes other significant reforms, such as regionalisation of certain aspects of fisheries management and the phased introduction of the Landing Obligation (discards ban) to eliminate discards. The landing

---


3 Valuing Ireland’s Blue Ecosystem Services, SEMRU 2018
obligation applies to all species under EU catch limits from 2019. Under the CFP, all Member States are now required to manage fleets so that fleet capacity and fishing opportunities are stable and in balance. An annual report must be submitted to the Commission, along with an action plan where overcapacity is apparent. Failure to carry out the action plan may result in suspension or interruption of European Maritime and Fisheries Fund (EMFF) funding.

Article 34 of the Common Fisheries Policy Regulation requires Member States to prepare multi-annual national strategic plans for aquaculture. Ireland’s National Strategic Plan for Sustainable Aquaculture Development was submitted to the European Commission on 23 October 2015 and subsequently published in December 2015.

Ireland has the third-largest sea area and the largest maritime area to land mass ratio in the EU, but only derives approximately 1 per cent of gross domestic product from the maritime economy.

![Map of the Irish Exclusive Economic Zone](image)

**Figure 1.** Map of the Irish Exclusive Economic Zone

The extent of Ireland’s marine territory can been seen in Figure 1.
1.3 **European Maritime and Fisheries Fund**

Ireland’s European Maritime and Fisheries Fund (EMFF) Operational Programme 2014-2020 provides for €239.4 million of investment in Ireland’s seafood industry. The Programme, which was formally launched in January 2016 and co-funded by the Exchequer and European Union, supports the sustainable development of Ireland’s aquaculture, fishing and seafood processing sectors. The Programme, organised around six Union Priorities, supports the general reform of the EU’s Common Fisheries Policy (CFP) as well as the development of its Integrated Maritime Policy (IMP) in Ireland. Ireland’s European Maritime and Fisheries Fund Operational Programme aims to contribute to the EU cross-cutting objectives of environment, innovation, and climate change mitigation and adaptation by reducing Europe’s carbon footprint—e.g. ocean renewable energy, low-emission maritime transport, exploiting the Atlantic’s seafloor natural resources.

The Multiannual Financial Framework 2014-2020 proposes to ensure that at least 20% of the European budget is climate-related expenditure. This includes both adaptation to and mitigation of climate change.

Climate change mitigation and adaptation projects/measures within operational programmes include all those that support sustainability (such as fishing at MSY) and reduce the impact of fishing on the environment thus increasing the resilience of ecosystems and fish stocks. In that respect, climate change considerations are seen in a very broad context.

1.4 **The Atlantic Strategy**

The EU Commission, following extensive consultation, published a Maritime Strategy for the Atlantic Ocean Area in November 2011. The purpose of the Atlantic Strategy is to develop a coordinated programme of actions across the economic, environmental, research, innovation, governance, safety and security dimensions of the Atlantic maritime region involving Ireland, Spain, Portugal, France and the UK. The Strategy is intended to promote cohesive development by promoting Blue Growth and will be linked to Agenda 2020 and its flagship initiatives, cohesion policy and Integrated Maritime Policy objectives.

The Atlantic Strategy identifies five overarching, and inter-linked, themes:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Common Fisheries Policy</th>
<th>Marine Strategy Framework Directive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing Europe’s carbon footprint</td>
<td>Ocean renewable energy</td>
<td>Low-emission maritime transport</td>
</tr>
<tr>
<td>Sustainable exploitation of the Atlantic seafloor’s natural resources</td>
<td>Marine raw materials for food, fuel and pharmaceuticals</td>
<td>Marine knowledge</td>
</tr>
<tr>
<td>Responding to threats and emergencies</td>
<td>Maritime safety</td>
<td>Maritime crisis management</td>
</tr>
<tr>
<td>Socially inclusive growth</td>
<td>Training and re-training</td>
<td>Clustering of industries</td>
</tr>
</tbody>
</table>

Table 5. Atlantic Strategy Themes

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Implementing the Atlantic Strategy – The Atlantic Action Plan

In May 2013, the EU Commission published the Action Plan for a Maritime Strategy in the Atlantic area5 (known commonly as the Atlantic Action Plan). The Action Plan aims to deliver on the themes set down in the Strategy (as outlined above). The Action Plan contains four priorities, with Priority 2 focussing on protecting, securing and enhancing the marine and coastal environment. Agreed actions within this priority include extending cooperation in the Atlantic region in the field of oceanic research in order to better assess climate change impacts.

The Atlantic Action Plan makes specific reference to ocean observation, in that mapping and forecasting are critical for the sustainable growth of economic activity in the Atlantic area and furthering our understanding of the oceanic processes in the Atlantic which play an important role in determining our climate. It goes on to state that making this information widely available is critical in developing a European Atlantic ocean observing and predictive capability. Specific objectives also include contributing to the development of tools and strategies to address global climate change issues, including mitigation and adaptation strategies (see Box 1 below).

The priorities set out in the Atlantic Action Plan are to:

1. Promote entrepreneurship and innovation;
2. Protect, secure and develop the potential of the Atlantic marine and coastal environment;
3. Improve accessibility and connectivity;
4. Create a socially inclusive and sustainable model of regional development;

Priority (2) includes specific objectives linked to developing a European Atlantic Ocean observing and predictive capability, based on existing structures, platforms and mechanisms to support the implementation of EU policies, reduce costs for industry, public authorities and research institutions, stimulate innovation and reduce uncertainty in the behaviour of the Atlantic Ocean and the impact of climate change by:

(a) using existing systems and mechanisms to develop and maintain a sustainable integrated programme for surveying and observing the coasts, seabed and water column, covering the waters of EU Member States, Outermost Regions and Overseas Countries and Territories from the coasts to the deep ocean;
(b) developing new instruments and platforms for ocean observation and ecosystem monitoring (including seabed mapping) that increase the number of parameters that can be measured automatically, lower the costs of observation and accelerate the dissemination of data to users;
(c) contributing to a more effective stewardship, cataloguing and distribution of interoperable marine data and a multi-resolution seabed map through contributions to a European Marine Observation and Data Network;
(d) developing a network of coastal oceanographic forecasting systems (including risk assessments) that build on the Copernicus marine service.

Priority (2) also aims to contribute to the development of tools and strategies to address global climate change issues, including mitigation and adaptation strategies by:

(a) supporting an assessment of the carbon footprint of the blue economy in the Atlantic area;
(b) developing a platform for exchanging best practice on emissions reduction and energy efficiency;
(c) developing co-operative partnerships to identify and monitor the impacts of global climate change on marine activities, ecosystems and coastal communities in the Atlantic area, including developing better predictive and risk assessment capabilities.

---

Box 1: Atlantic Action Plan

A mid-term review of the Atlantic Action Plan\(^6\) was completed in 2018 which noted the following main achievements across the four priority areas:

**Enabling smart growth in the Atlantic**

About 500 projects related to the promotion of entrepreneurship and innovation in the Atlantic area, accounting for investment of around €750 million;

**Cleaner and more predictable Atlantic**

Around 500 projects related to the protection, security and development of the environment in the Atlantic area representing investment of around €2.1 billion;

**A better connected Atlantic**

About 100 projects, worth €2.4 billion, were aimed at improving accessibility and connectivity. These mainly targeted port developments in Spain and Ireland;

**A socially inclusive Atlantic**

Around 100 projects were aimed at socially inclusive regional development, with €360 million of investment in tourism infrastructure in Wales and remote health monitoring in Ireland, for example.

In addition, the stakeholder community in the Atlantic Ocean area has arguably grown stronger and more competitive when it comes to obtaining funding for marine and maritime projects, particularly when one looks at the success rate of the regular grant schemes financed through the European Maritime and Fisheries Fund. Weaknesses were identified in relation to strategy design, implementation and governance structure. Following the mid-term review a number of lessons learnt were put forward which could serve as a basis for discussion on the way forward for maritime cooperation the Atlantic sea-basin.

---

**Assistance Mechanism**

The Support Team for the Atlantic Action Plan was set up by the European Commission in August 2014. The Team consists of a network of National Hubs operating in Ireland, France, Portugal, Spain and the United Kingdom, coordinated by a Brussels-based central management team. Their role is to communicate and provide updated information on the Plan, including research and investment priorities. The Support Team also provide a "match-making platform" to assist with potential project partners and advise on the use of EU and national or regional financial instruments for projects implementing the Action Plan. In July 2018, a new service contract to operate the assistance mechanism of the Atlantic Action Plan was awarded.

In monitoring the Action Plan, the Support Team estimates in excess of €19.5m has been awarded across a range of EU funding instruments to marine related climate adaptation projects across the five Member States, funded from a range of EU funding instruments. An estimated €4.9m awarded to Irish partners.

The priorities of the Atlantic Action Plan are also supported by the Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate). JPI Climate is a pan-European intergovernmental initiative gathering European countries to jointly coordinate climate research and fund new transnational research initiatives that provide useful climate knowledge and services for post-COP21 Climate Action. With cofunding from the EPA a number of marine related climate adaptation projects have been awarded funding.

The ongoing rollout of the Action Plan for the Atlantic Strategy has been a focus for Ireland at EU level, with active participation through the Atlantic Strategy Group which oversees the implementation of the Action Plan and assisting in the smooth operation of the accompanying Assistance Mechanism.

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\(^6\) Mid-term review of the Atlantic Action Plan, 2018
**Atlantic Co-operation**

Following the publication of the Atlantic Action Plan, the European Union, the United States and Canada in 2013 signed the Galway Statement on Atlantic Ocean Cooperation\(^7\). The goal is to better understand the Atlantic Ocean and promote the sustainable management of its resources through sharing the ocean observation efforts of the three partners. A particular focus of the work is to study the interplay of the Atlantic Ocean with the Arctic Ocean, particularly in relation to climate change.

The Atlantic Ocean Research Alliance Coordination and Support Action (AORA-CSA) project, coordinated by the Marine Institute, an initiative of the European Commission’s Blue Growth Strategy, is tasked with supporting the implementation of the Galway Statement. Updates and further details are available on [www.atlanticresource.org](http://www.atlanticresource.org).

AtlantOS\(^8\) is an EU Horizon 2020\(^9\) Blue Growth 8 (Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources) research and innovation project that proposes the integration of ocean observing activities across all disciplines for the Atlantic, considering European as well as non-European partners. AtlantOS significantly contributes to trans-Atlantic cooperation by integrating existing observing activities established by European, North and South American, and African countries and by filling existing gaps to reach an agile, flexible Integrated Atlantic Ocean Observing System (IAOOS) and associated ocean information systems around the Atlantic. The Marine Institute is a member of the Atlantic Ocean Observing System Blueprint Core Group. The Atlantic Blueprint will propose a strategy for building an Integrated Ocean Observing system in the Atlantic. The document will help policy makers and the oceanographic community to move towards a more sustainable, coordinated and comprehensive ocean observing system. It aims to integrate existing ocean observing activities into a sustainable, efficient and fit-for-purpose system.

### 1.5 Harnessing Our Ocean Wealth

Harnessing Our Ocean Wealth\(^10\), Ireland’s Integrated Marine Plan (IMP), sets out a roadmap for the Government’s vision, high-level goals and integrated actions across policy, governance and business to enable our marine potential to be realised. Implementation of this Plan continues to see Ireland evolve an integrated system of policy and programme planning for our marine affairs.

Implementation of the Plan is being delivered within the over-riding medium-term fiscal framework and budgetary targets adopted by the Government.

This IMP covers the following key areas:

- Governance
- Maritime Safety, Security and Surveillance
- Clean – Green – Marine
- Business Development, Marketing and Promotion
- Research, Knowledge, Technology and Innovation
- Capacity, Education, Training and Awareness
- Infrastructure
- International and North/South Cooperation

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\(^7\) [https://ec.europa.eu/research/iscp/pdf/galway_statement_atlantic_ocean_cooperation.pdf](https://ec.europa.eu/research/iscp/pdf/galway_statement_atlantic_ocean_cooperation.pdf)

\(^8\) [Atlantic Ocean Observing System](https://ec.europa.eu/programmes/horizon2020/en)


Harnessing Our Ocean Wealth Targets:

- Double the value of our ocean wealth to 2.4% of GDP by 2030.
- Increase the turnover from our ocean economy to exceed €6.4bn by 2020.

In Ireland responsibility for marine matters is spread across a number of Government Departments. In recognition of the need for better coordination and the broad scope of the sector, the Inter-Departmental Marine Co-ordination Group (MCG) was established in 2009. The MCG provides oversight of each of the government departments to ensure cross-government delivery and implementation. The Group, chaired by the Minister for Agriculture, Food and the Marine and convened by the Department of the Taoiseach, meets on a regular basis to bring together senior officials of Departments with an involvement in marine issues to drive forward the Government’s marine strategy and coordinate issues that require cross-departmental action.

<table>
<thead>
<tr>
<th>Inter-Departmental Marine Coordination Group</th>
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<tr>
<td><strong>Chair</strong></td>
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**Table 6. Composition of the the Marine Coordination Group 2017**

Implementation is based upon the following mechanisms:

1. Individual departments implementing relevant policy and strategy programmes;
2. Improved cross-government communication and engagement;
3. Ongoing updates to the MCG;
4. Focused task forces with broad participation that address specific actions; and
5. Annual reviews of progress, with feedback to stakeholders.

The annual review of progress is published at an annual Our Ocean Wealth Conference. The annual Conference brings together representatives from a wide range of relevant bodies, both public and private sector, to discuss marine-related matters. In tandem with the Conference, the MCG has, since 2015, with support from the Marine Institute and other state agencies, organised SeaFest, Ireland’s national maritime festival. The festival aims to promote an awareness of Ireland’s vast

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11 [https://www.ouroceanwealth.ie/about-us](https://www.ouroceanwealth.ie/about-us)
12 Updates and related reports are available on [www.ouroceanwealth.ie](http://www.ouroceanwealth.ie)
marine resource and showcases the extensive work that is being carried out in the sector. The annual Our Ocean Wealth Summit forms a key part of the IMP by bringing together national and international speakers, industry experts, business development agencies and the Irish business and marine research communities.

As part of the implementation of HOOW, two Task Forces were established - the Enablers Task Force (ETF) and the Development Task Force (DTF). The reports of both Task Forces were submitted to the Government and were published at the annual Our Ocean Wealth Conference in 2015. The aim of the Enablers Task Force was to develop an appropriate maritime spatial planning framework (MSP) for Ireland and, in its report, the Task Force recommends such a framework. On foot of the report, in 2016, the Government designated the now Department of Housing, Planning and Local Government (DHPLG) as the lead Department with responsibility for the implementation of marine spatial planning, with the support of the Marine Institute in terms of technical and scientific advice. The Department of Agriculture, Food and the Marine is actively engaged on Marine Spatial Planning, with DHPLG, particularly in the context of the seafood sector. In addition, DAFM provides funding through Ireland’s European Maritime and Fisheries Fund Programme to the Marine Institute to undertake a series of data and evidence projects to support the implementation of MSP in Ireland. Further details of the projects are available here: https://emff.marine.ie/blue-growth.

The second task force, the Development Task Force, was established to identify ways of promoting economic developments in the marine sector. Its report set out what it described as a cohesive and integrated set of changes required to realise the HOOW objectives in the medium (to 2020) and longer (to 2030) terms. A key recommendation, which has subsequently been achieved, was the establishment of an Integrated Marine Development Team among the key State marine and industrial development agencies: the Task Force saw this as critical for driving implementation of the development aspects of HOOW and for instigating and supporting private sector investment.

1.6 Seafood Sector Policy Context

According to The Business of Seafood 2018, published by BIM, Ireland’s Seafood sector contributed €1.25 billion to the Irish economy in 2018. This is an increase of 3.4% on the 2017 figure. The total value of seafood landed into Ireland’s main fishing ports was €370 million, the aquaculture sector was valued at €176 million and Irish seafood exports were worth €653. 14,359 people are employed around our coast both directly and indirectly. Ireland’s proximity to the rich productive seas of the North East Atlantic provides an ideal resource on which to continue to develop the seafood sector.

Food Wise 2025, the successor to the Food Harvest 2020 strategy, sets out a ten year plan for the agri-food sector. It underlines the sector’s unique and special position within the Irish economy, and it illustrates the potential which exists for this sector to grow even further.

Food Wise 2025 has five cross-cutting themes: sustainability, human capital, market development, competitiveness and innovation. Sustainability is key to the strategy, which states that: “environmental protection and economic competitiveness are equal and complementary – one cannot be achieved at the expense of the other”. The plan sets out three priorities for the seafood sector; 1) Expand the raw material base, 2) Enhance the industry’s structure and skills and 3) Optimise product added value, export markets and environmental sustainability. A number of threats are identified for the seafood sector including stock depletion in wild fisheries, slowness/uncertainty of aquaculture licence determination and failure to protect and measure the impact on the natural environment. Actions for the seafood sector included the commissioning of

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14 https://www.agriculture.gov.ie/foodwise2025/
an independent review of the existing aquaculture licensing system and improving the environmental sustainability of the sector. The Review of the Aquaculture Licensing Process\textsuperscript{16} was subsequently published by the Independent Aquaculture Review Group, in May 2017.

National plans have been developed to address sector-specific challenges including climate change. The National Strategic Plan for Sustainable Aquaculture Development, required under the CFP, takes account of “Harnessing Our Ocean Wealth”, Food Wise 2025 and the European Maritime and Fisheries Fund Operational Programme. Within the aquaculture sector, Co-ordinated Local Aquaculture Management Systems (CLAMS) is a long established voluntary process which enables co-ordination among existing aquaculture operators and this process will undoubtedly provide important information to the policy and strategy programmes.

\section*{1.7 \textbf{Marine Environmental Protection Policy Context}}

Ireland’s vision for biodiversity as set out in Ireland’s National Biodiversity Plan 2017-2021\textsuperscript{17} is “that biodiversity and ecosystems in Ireland are conserved and restored, delivering benefits essential for all sectors of society and that Ireland contributes to efforts to halt the loss of biodiversity and the degradation of ecosystems in the EU and globally”. There are a number of key areas where the Department of Agriculture, Food and the Marine is expected to pursue more targeted actions which are relevant in the current context. Moving beyond awareness to the mainstreaming of biodiversity in the decision-making process for the seafood sector is crucial to ensure protection and restoration of biodiversity. Similarly, up to date scientific knowledge is essential for an informed assessment of the status of biodiversity, conservation management and sustainable use. In order to achieve the Plan’s goals, it will be important to ensure that incentives and subsidies do not contribute to biodiversity loss.

The Marine Strategy Framework Directive\textsuperscript{18} is a major piece of EU legislation that requires Member States to achieve good environmental status (GES) in the marine environment by the year 2020 at the latest. Good environmental status in the marine environment means that the seas are clean, healthy and productive and that human use of the marine environment is maintained at a sustainable level.

Protection of designated conservation sites under the EU Birds and Habitats Directives has been mainstreamed in decision-making for aquaculture and for management of sea-fisheries opportunities in inshore waters. An extensive dataset of habitats and species around the coast has been compiled and a programme of assessments compatible with Article 6 of the Habitats Directives (including appropriate assessments and risk assessments where fitting) is underway. The outcomes from the assessment process include adaptive management measures which respond to ongoing management and change of the Natura 2000 sites over time.

\section*{2. \textbf{Climate Change Research}}

\subsection*{2.1 \textbf{Adaptation Research and Development}}

Through research Ireland can better prepare for the climate-related challenges ahead. The Marine Institute and the third level institutions have a wide range of research underway which will inform the preparation of all aspects of adaptation. The right research will be essential in monitoring climate-change indicators, in preparing to respond to the challenges of climate change and in


\textsuperscript{18} https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056
identifying appropriate adaptive mechanisms based on scientific evidence and socio-economic assessments.

<table>
<thead>
<tr>
<th>Policy/Strategy</th>
<th>Research Requirements</th>
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| **Harnessing Our Ocean Wealth** | Scientific, technical and economic advice to inform all aspects of the Blue Economy  
  e.g. to identify consumer attitudes to seafoods and marine nutraceuticals  
  to develop marine socio-economic indicators, modelling and scenario development |
| **Common Fisheries Policy** | Scientific, technical and economic advice to inform fisheries management and aquaculture development  
  e.g. to support decision making based on the ecosystem approach  
  to develop conservation measures,  
  to address selectivity in mixed fisheries  
  to increase productivity and output of aquaculture in an environmentally sustainable way |
| **Marine Strategy Framework Directive** | Scientific, technical and economic advice to inform environmental protection  
  e.g. to identify research to relevant to MSFD objectives  
  to provide tools to policy makers to implement MSFD measures  
  to inform the efficacy of GES indicators |

Table 7. Policies/Strategies and Research Needs

2.2 **Marine Research Gap Analysis**

The Marine Institute and reports such as The Status of Ireland’s Climate, 2012 have undertaken gap analysis in existing research and observation programmes regarding climate change monitoring and impact identification. The following gaps have been identified:

**Climate monitoring**

- No long-term national observation programmes exist for a number of the relevant Essential Climate Variables (ECV) such as ocean acidification, pCO₂, ocean currents, and phytoplankton.
- Lack of long term baseline environmental monitoring stations corresponding to biological monitoring stations.
- Lack of high frequency time series of marine ECVs collected in an integrated manner to assess variability and trends over a range of time scales.
- Compartmentalised research and monitoring can make it difficult to provide a coherent evidence base on environmental changes and ecosystems responses.

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19 [http://www.epa.ie/pubs/reports/research/climate/CCRP26%20-%20Status%20of%20Ireland%27s%20Climate%202012.pdf](http://www.epa.ie/pubs/reports/research/climate/CCRP26%20-%20Status%20of%20Ireland%27s%20Climate%202012.pdf)
• Continuous GPS at the selected tide gauge stations to account for isostatic variability and accurate measurement of long-term changes in sea-level together with building capacity in the use, and validation, of satellite information for sea level.

• For climate change purposes it is vital that at least two, and preferably more, Irish tide gauges are upgraded to Global Sea Level Observing System (GLOSS) standards.

• The Earth Observation (EO) research community is highly fragmented in Ireland and the focus has been too much on commercialisation of EO data rather than also realising the potential benefit of EO data for research and environment, including climate monitoring applications.

• The lack of a long term current monitoring system in Irish waters represents a significant gap in the Northeast Atlantic.

Fisheries

• The main gap identified is the need to examine a range of changes in many aspects of fish biology; distribution, migrations, abundance, fish communities, growth, age structures.

• Testable hypothesis based linking of major climate related changes in physical, chemical and biological oceanography linked to changes in the, migration, growth, fecundity and recruitment of fish, and other commercially or ecologically important species is important.

• Lack of long term baseline data on salmon stocks (>50 years).

Lower trophic level species

• Currently, there is no operational climate change programme in place to monitor changes in phytoplankton community assemblages in Irish waters.

• The role of advection (transport) from the offshore in seeding blooms in coastal areas requires further attention.

• Limited work has been performed in modelling the different HAB species and their monitoring/modelling studies in shelf areas.

• Impact of increasing ocean acidification on Irish HAB species is largely unknown.

• Investigations into ichthyotoxic species such as Karenia mikimotoi to be to a level that will allow a proper evaluation of their impacts on the marine ecosystem.

Ocean chemistry

• Dedicated ocean chemistry monitoring programme is required with regard to monitoring of ocean acidification and ocean carbon flux.

• High uncertainty as to the potential effects and ecosystem vulnerability of ocean acidification and other changes in biogeochemical cycling.

• No coherent near shore / offshore monitoring of biogeochemistry on a meaningful temporal and / or spatial basis.

Projecting the future ocean climate

• National capacity for ocean climate and earth system modelling, which allows for the linking of model outputs with observed changes in indicators such as fish stocks and communities should be developed.

• This not only requires a joined up capacity building programme for developing coupled ocean-atmosphere and biogeochemical models at high resolutions but also towards data assimilation.
Further the national High Performance Computing (HPC) infrastructure is not adequate to meet the demands of the level of modelling required to adequately support climate impact and adaptation.

2.3 **Future required research/infrastructure for marine climate change**

The Marine Institute published the National Marine Research and Innovation Strategy for Ireland 2017-2021\(^\text{20}\) in June 2017. Climate change is highlighted as a key area with the following recommendations for funding focus:

- **Supporting inter-institutional collaborative research** through dedicated funding calls. Research on climate change is highly inter-disciplinary with impacts on a range of other research themes and topics in the marine, e.g., ocean observation, marine biodiversity, modelling, and the delivery of policy advice.

- **Establishing a research programme of scale in Ireland.** Such a programme should integrally link to sustained investments in an integrated ocean observing system (infrastructure). This is underpinned by key international, European and national policy drivers (COP21, IPCC, G7 Science and Technology Ministers, European Marine Board, JPI Oceans, EPA).

- **Increase strategic engagements with key European and international infrastructures and networks in order to add specific value to national investments.** This will increase collaborations with the wider global community and contribute to global goals on monitoring climate change impacts and mitigation strategies.

More specific scientific requirements for adequate monitoring of climate change impact and providing support for effective adaptation planning and potential mitigation include:

**A national marine climate observing system**

- An integrated observing system should be established for core physical, chemical, and biological variables (Essential Ocean Variables) which should include high frequency stations (e.g. moorings).

- Establishment of a network of long term baseline monitoring stations in coastal waters to detect change in water biology, chemistry and physical quality, contaminants, phytoplankton, zooplankton, microbiology, macro- algae, benthic invertebrates, fisheries, alien and non-native species as indicators of climate change.

- It is critical that an observing network is not seen simply as an infrastructure project as without core experts using the data and taking ownership the necessary data quality will not be ensured.

- Estuarine and coastal areas, as well as the deep ocean should be adequately monitored.

- An observing network should consider how to maximise synergies with other activities, (MSFD, WFD, MSP) to add value. Whatever we do will be resource limited but if we start by considering our preferred network, and then what we already have, we can prioritise to maximise use of resources

- Coordinated national engagement with the (GCOS) with designated coordinator for Essential Ocean Variables.

- Establishment of long-term monitoring stations in the deep ocean west of Ireland to examine long-term changes to thermocline, intermediate and deep water masses.

- Support for development of advanced observation technologies including gliders and Argo floats.

\(^{20}\) [National Marine Research and Innovation Strategy for Ireland 2017-2021](#)
Sea level rise, storm surge and coastal flooding

- Upgrade completion and maintenance of Malin Head and Castletownbere tide gauges at Global Sea Level Observing System (GLOSS) standards for long term sea level monitoring.
- Provide analyses of these data with historical records from established, reliable tide gauges and link these to regional satellite derived information on sea-level change effectively utilising the new era of earth observation data.

Modelling and High Performance Computing

- Improved national modelling capacity (including downscaled coupled biogeochemical models) to support ecosystems studies and future projections.
- Support for development of national capacity for data assimilation to improve model performance.
- Improved HPC national infrastructure to support climate research (coupled and earth system modelling) and vulnerability, impact and adaptation planning (high resolution regional downscaling and coastal ocean models).

Ocean Chemistry

- There is a need to better understand current Ocean Acidification (OA) and climate conditions, variability and biogeochemical processes in coastal, shelf and off-shelf waters through a dedication and sustained observation programme.
- Key habitats such as cold-water coral reefs which are expected to be particularly sensitive to reducing aragonite saturation states warrant particular study.
- Research into potential impacts of rapid OA at all levels of ecological organisation is a relatively young field with a poor understanding of how it may impact in concert with other stressors such as warming. The capacity for evolutionary adaptation is only beginning to be addressed.
- Development of wider carbon cycle observation and monitoring to support earth system modelling and mitigation activities.

Lower trophic levels

- The continuous plankton recorder (CPR) surveys have taken place in the deep water North Atlantic since the 1940s. These surveys should be extended to fill gaps in Irish near-shore waters.
- Range extension of toxic phytoplankton leading to novel and emerging toxins in shellfish will require additional resourcing to ensure the monitoring of seafood safety is not compromised.
- Prediction studies on the response of different HAB groups and genera to the influences of climate change.
- Modelling climatic changes on phytoplankton communities and changes in primary productivity impacts cascading through marine food webs.
- Major floods could affect coastal water quality and the performance of waste-water treatment plants, leaving some shellfish waters potentially exposed to elevated levels of pathogens; Research into waste water treatment and impacts.
- Carrying out sanitary baseline surveys need to be prioritised.

Integrated, transdisciplinary research and climate service development

It is vital that all marine climate change activities are coordinated within a wider national climate programme as we increasingly move to an earth system approach. This will require funding.
mechanisms that promote transdisciplinary infrastructure, research and climate service development together with the potential to engage closely with all relevant international programmes and initiatives. On the national level, close co-ordination between Departments, Agencies, Higher Education Institutions (HEIs) and the private sector will be vital to addressing the challenges of the impacts of climate change on Irish waters.

The Marine Institute’s Strategic Plan 2018-2022, Building Ocean Knowledge-Delivering Ocean Services, was developed to ensure the provision of fit-for purpose research, advice and services for the department of Agriculture, Food and the Marine, other government departments and agencies as well as a broad range of national and international stakeholders. There are four strategic focus areas: 1) Scientific Advices and Services, 2) Forecasting Ocean and Climate Change, 3) Research and Innovation and 4) Ireland’s Ocean Economy.

Strategic focus area 2 – forecasting ocean and climate change:

Strategic Intent - “To provide world-leading regional and localised forecasting outputs and services that support Ireland’s challenge in responding and adapting to changes in our oceans and climate. This will support Ireland’s effort to meet EU and international climate action targets. We will strengthen our partnerships in climate action, mitigation and adaptation to deliver integrated earth and ocean science, technical solutions, predictive capabilities and expert advice.”

Strategic Initiatives under focus area 2 include: 1) Advancing ocean and climate observation monitoring, 2) Deepening our knowledge and 3) Forecasting ocean and climate change.

BIM’s Statement of Strategy 2018-2020, Enabling Sustainable Growth, aims to enhance the competitiveness of the Irish seafood sector focusing on five key strategic priorities; sustainability, skills, innovation, competitiveness and leadership. Highly disruptive external factors, such as climate change, informed, shaped and influenced the development of this strategy for BIM.

BIM published an Environmental Sustainability Atlas in July 2017 which highlights the considerable amount of work undertaken to ensure a sustainable future for the country’s fisheries, aquaculture and processing businesses. BIM ensures that good environmental practices are embedded in every activity that it supports.

2.4 Immediate Fisheries Research Priorities

Fisheries

Research programmes should be developed to support impact and adaptation studies, together with support for the necessary observation infrastructure, on the following areas:

Migration routes and spawning

- Temperature affects the migration, distribution and onset of spawning of large pelagic stocks such as Blue Whiting (Hatun et al. 2009) and NEA mackerel (Reid et al. 2001, Jansen et al. 2012, Hughes 2013). This can affect availability of stocks to particular fisheries. It can also have implications for fisheries managements across international boundaries and significant implications for the design and conduct of stock assessment surveys which need to be appropriate for the current population structure and distribution

Recruitment and productivity

- Sea surface temperature can significantly affect the recruitment success of gadoids in the Irish Sea, Celtic Sea and west of Scotland (Drinkwater 2005, Brunel & Boucher 2007). Stocks at the extreme limits of their distribution show higher dependency on optimal temperatures

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21 The Marine Institute’s Strategic Plan 2018-2022
22 BIM Statement of Strategy 2018-2020
23 BIM Environmental Sustainability Atlas, 2017
than stocks in the centre of their distribution for successful recruitment (Planque & Fredou 1999). In the waters around Ireland, many fish stocks of commercial importance are at the extreme limits of their species' geographical distribution.

- In the Celtic Sea, there have been marked changes in the proportion of herring spawning in autumn and in winter, with the proportion of autumn spawners drastically declining since its peak in 1990. The change is attributed to both local (i.e. averages autumn SST and winter salinities) and global (i.e. the NAO and AMO indices) environmental factors (Harma et al. 2012).

**Change in fish biodiversity**

- In the Celtic Sea, species richness (number of species) increased due to increases in the number of warm-favouring Lusitanian species. In the area west of Scotland, species richness decreased because the number of cold-favouring Boreal species decreased (Ter Hofstede et al. 2012).

**Research commencing in these areas:**

In December 2018, the Minister for Agriculture, Food and the Marine announced investment of over €0.7 million in the Marine Data Buoy Network. The additional funding provides for both ongoing operations and a significant upgrading of the existing infrastructure. The Marine Data Buoy Network is managed by the Marine Institute, an agency of DAFM, in collaboration with Met Éireann. The Network provides crucial data for weather forecasting, risk management for shipping, the fishing community and coastal towns and villages with advanced warnings as well as oceanography research and data on Ireland’s deep waters.

- The Marine Institute is providing funding for a Post-Doctoral Fellow to specifically examine the topic of the Impacts of Climate Change on Commercial Fish Stocks in Irish Waters over a 3-5 year period, commencing this year. The research will be based around obvious pressures such as temperature and acidification, as well as expected changes in salinity, sea level and extreme weather events and second order effects such as changes in the plankton abundance etc. impacting on the food web. Research conducted on species diversity in Irish waters in 2009/2010 will be revisited and the findings of that time which included that in NW waters Boreal (northern) species were declining, with no accompanying rise in Lusitanian (southern) species observed.

- Given the progression of climate change effects, it is important to revisit this work, map any changes that have occurred since, and then use IPCC climate projection scenarios to determine what is likely to happen, to aid possible adaptation planning. Work undertaken will include carrying out habitat suitability analyses to identify the current ecosystem preferences by species, and then project these into the climate change scenarios for the near to medium term. Risk analysis will be conducted to identify the most impacted species and fisheries and where appropriate identify adaptation mechanisms.

- It is expected the role will be supported by close collaboration with the oceanographic modellers working in the Institute as well as involving collaboration with other national and international research organisations including the Centre for Environment, Fisheries and Aquaculture Science (CEFAS).

In December 2018, the announcement was made of €2 million in funding, from the Marine Institute and the European Regional Development Fund, for a major project on Atlantic Climate Change led by Dr Gerard McCarthy of the ICARUS Climate Research Centre and Department of Geography at Maynooth University. Guided by the goals of the Government's national marine strategy 'Harnessing Our Ocean Wealth' and the 'National Marine Research and Innovation Strategy 2017 – 2021', the international 'A4 Project' marks a substantial investment by the Marine Institute in physical oceanography and climate change research in Ireland, and aims to
improve the understanding of the links between trends in Atlantic temperatures and climate change.

3. Climate Change Challenges and the Seafood Sector

3.1 Adaptation of the Seafood Sector

3.1.1 Challenge: Sustainable Management of Ireland’s Marine Resources under CFP

Fishing activities in EU waters are managed under the Common Fisheries Policy at a European level. The introduction of reform measures to address the challenges of adapting fishing opportunities and techniques presents both challenges and opportunities to take climate change adaptation into account.

Recommended Adaptation Actions

- Work with other Member States under regionalisation to agree common measures for the North Western Waters Region.
- Facilitate, in accordance with CFP rules, modernisation of the fleet. Modernisation can have a positive impact on the carbon output of the fishing fleet.
- Continue the programme of risk assessment of sea-fisheries in compliance with the Birds and Habitats Directives and adopt mitigation strategies where required.
- Work with the industry to develop long-term management measures for inshore fisheries to support adaptation by managing exploitation patterns on a sustainable basis.
- Ensure that the European Maritime and Fisheries Fund Operational Programme facilitates schemes which improve the sustainability of the seafood sector, including decommissioning of excess capacity, adaptation of more selective/environmentally friendly fishing gear, responding to storm events, etc.

3.1.2 Opportunity and Challenge: Adapt to Changes in Stock Distributions

Climate change may result in a shift in distribution patterns for certain fish stocks to the north as the temperature of the sea increases. This shift may mean greater fuel costs for vessels which continue to target these species. However other shifts may result in different species becoming more abundant in the waters around our coast bringing key resources nearer to the Irish coast and offering new fishing opportunities.

Increased sea temperatures may also result in a reduction in biomass in some commercial species due to decreased recruitment but recruitment in other species may be enhanced leading to improved opportunities for fisheries that target these expanding populations.

Recommended Adaptation Actions

- Support adaptation of the seafood sector to changing stock distributions through appropriate research

3.1.3 Challenge: Monitor Shellfish Quality and Harmful Algal Blooms

Improving the quality of coastal and offshore marine water bodies while increasing commercially profitable fish and shellfisheries are objectives set out in “Harnessing our Ocean Wealth”. To realise these twin objectives it will be necessary to take account of changes in projected climate patterns outlined in the Met Éireann Report “Ireland’s Climate - the road ahead”24. Harmful algal blooms (HABS) in Irish waters already cause significant economic damage to wild fisheries and aquaculture on an annual basis by making shellfish unsafe to eat and by causing mortalities from high biomass blooms. Being prepared for significant range expansions and increasing biotoxin problems due to changing marine environments call for increased vigilance and possible adaption in seafood-biotoxin

24 http://edepositireland.ie/handle/2262/71304
and HAB monitoring programmes.

A review of the response of HABs to ocean climate change identified the parameters that oceanic climate change poses to phytoplankton blooms. The key factors are changes in temperature, salinity, surface stratification, alteration of ocean currents, alteration to nutrient upwelling, elevated CO2 levels (leading to increased photosynthesis), reduced calcification from ocean acidification and changes in land runoff and micronutrients.

These factors individually or together may lead to:

- Range expansion of warm-water species at the expense of cold-water species, which are driven pole-ward. This may lead to the introduction of more toxic species into Irish waters that are at the northern limit of their distribution.
- Species specific changes in the abundance and seasonal window of growth of HAB taxa. This could result in a smaller period of time when shellfish are non-toxic, or a longer high risk period for fish kills due to blooms than is currently experienced.
- Earlier timing of peak production of some phytoplankton. This could have knock on impacts for recruitment and growth of fish and shellfish species due to a mismatch or insufficient prey species required for growth.
- Secondary effects for marine food webs, notably when individual zooplankton and fish grazers are differentially impacted ("match-mismatch") by climate change. The marine food web is an intricate connection of species that grow and decline in a prey/predator cycle. Disruption to this from climate change may lead to collapse of economically important stocks.

In addition recent research also identifies microbiological contamination threats emerging in response to climate change. These include major floods affecting coastal water quality and the performance of waste-water treatment plants; heavy rains and floods leading to the re-suspension of contaminants and droughts which reduce re-absorption of contaminants in watercourses.

The spread of HAB species is of particular concern and the poor knowledge of the distribution of these and other pathogenic microorganisms in the marine environment must be a priority area for future investigation. Investigations of existing data sets have already shown some evidence of concern in Irish water (Nolan et al. 2010). These include increases in the annual numerical abundance of diatoms and dinoflagellates evident in all Irish coastal regions since 1998 with a significant increase in diatom abundance particularly during the early part of each year. An expansion of the growth season has been observed and an increase in phytoplankton biomass is evident in the northern Celtic Sea, based on Continuous Plankton Recorder data, since 2000. While the total annual abundance of harmful and toxic species varies greatly between years, the percentage occurrence of some harmful species during the winter months has increased since 2000.

If current global climate models are correct in their predictions that earlier and prolonged stratification of the water column will occur then a depletion of surface nutrients in shelf seas around Ireland is likely to result in a decline in phytoplankton biomass. This type of change will cascade through the food web with many unknown consequences. As most of the toxic and harmful algae recorded in Irish waters prefer stratified waters it is possible that an increase in the frequency of harmful events will be a symptom of such changes. Increased flood events and rainwater discharge will lead to new threats and require adaptive strategies in design and capacity of wastewater treatment plants in shellfish production areas. Harmful algal blooms have the potential to temporarily close aquaculture sites and can lead to a loss in income. There can be serious impacts on human health if contaminated shellfish is consumed.

Recommended Adaptation Actions

- Support the inclusion of harmful algal bloom species in monitoring programmes.

### 3.1.4 Opportunity: Sustainable Growth of Aquaculture
Climate change and higher sea temperatures will put aquaculture and fisheries under increased threat from algal blooms, amoebic gill disease, invasive species considerations and others. This will have to be carefully considered and husbandry practices adapted. Marine scientists, biologists and vets will have a key role to play with significant input required from Bord Iascaigh Mhara and the Marine Institute and other relevant agencies.

Pursuant to Article 34 of the CFP Regulation (EU 1380/2013), Ireland published a National Strategic Plan for Aquaculture Development in December 2015. The multi-annual national plan proposed 24 actions to be implemented over the period up to 2020. The plan addresses the following potential climate-related impacts on aquaculture:

From a seafood perspective:

- Sea level rise leading to problems with site suitability, access and general site management
- Increase in storm frequency and intensity leading to structural damage, associated financial losses and burdens, also potential escapes of farmed fish and its consequences for biodiversity
- Increase in water temperature leading to -
  - Changes in seasonality, resulting in changes in typical growth patterns, affecting timing of spawning and harvesting
  - New/different disease challenges
  - Expansion in range of alien invasive species
- Increased frequency/severity of harmful algal bloom events as a result of changes in ocean and coastal stratification and increasing temperatures

Of greater importance is the introduction of new species able to survive in areas that they were not able to survive in previously and change in behaviour of existing species. This can have both negative and positive consequences for both aquaculture and the natural environment. New species can threaten existing wild and cultured species by displacement, disease etc.

Ocean acidification in the long term may lead to a decrease in suitability of the waters as a habitat for shellfish. Consequences of this have already been documented in the East Coast America where there are problems with the survival of oyster seed unable to grow shells in waters with reduced ph. The decreases in the availability of carbonate ions force marine organisms to spend more energy building and maintaining their shells, resulting in less energy available for other biological processes such as growth and reproduction.

It will also be important to ensure the physical infrastructure associated with aquaculture such as fin fish cages and other containment structures as well as shell fish longlines and their associated mooring systems are designed constructed and maintained to withstand the increased forces generated by wind wave and current forces. Marine Finfish Licence Applications (and currently licensed finfish Operators) are subject to the Department’s published Protocol for Structural Design of Marine Finfish Farms (2016)

The current worst case conditions to be designed for (as per the protocol) are to include storm waves (and currents) from various incident directions which (individually) have a 2% (1/50) probability of being exceeded in any particular year.

From a fresh water perspective:

- Increase in storm frequency and intensity -Increased flood risk
- Changes in seasonality
- Reduced freshwater availability

Impacts on the freshwater environment can have consequential impacts on the marine seafood sector such as a reduction in freshwater inland smolt production due to climate change impacts directly impacting on marine finfish production.
In contrast, increased water temperature may also result in benefits for the Irish aquaculture industry, e.g. faster growth rates, resulting in decreased costs and conditions more conducive to the growth of new species.

**Recommended Adaptation Actions**

- Continued funding of projects concerning Knowledge Innovation and Technology, under the European Maritime and Fisheries Fund Operational Programme which are relevant to climate change adaptation by the aquaculture sector

**3.1.5 Opportunity: Energy and Waste Management**

Without either formally or directly addressing climate change as a single issue, a number of measures across a range of environmental aspects, for example, fuel efficiency, resource efficiency and waste management; have been adopted by the fishing and aquaculture sectors in recent years. Such measures contribute to climate change mitigation and allow the sector to adapt to the changing environment as a consequence of change already experienced. The adoption of Environmental Management Systems and independently and accredited certification schemes for quality, eco and organic production requires, in all cases, that members review their existing operations across a range of environmental aspects and take action to address any issues identified through a documented process of continual improvement. The associated improved environmental performance leads to ongoing and varied mitigation of climate change impacts by the sector. All the Irish Seafood Standards are independently and internationally accredited to ISO65/EN45011 and currently have been linked with the Bord Bia Origin Green programme which covers all Irish food producing sectors.

**Recommended Adaptation Actions**

- Promote and support research to adapt aquaculture technologies and species for climate change.

**3.1.6 Challenges: Competitive, efficient seafood processing**

The aim of the BIM pilot Green Seafood Business programme was to reduce water and energy costs within the seafood processing sector by better monitoring and management of those utilities. The seafood processing sector had, generally, not effectively managed their environmental systems which resulted in high environmental inputs which add significant overhead costs to the sector. These higher costs put the sector at a competitive disadvantage and needed to be addressed to reduce environmental input costs, to establish a sustainable green seafood processing sector.

Following on from the successful pilot scheme in 2011 where a number of companies reported savings of between 10% and 20% in operating costs, the programme was successfully rolled out and is available to all seafood processors. Through the programme BIM has assisted businesses across the seafood sector save money and improve their local environmental imprint through reduced energy, water consumption, and waste prevention management.

Consideration of the potential for these or similar programmes to contribute to climate adaptation was taken into account in the preparation of the European Maritime and Fisheries Fund Operational Programme, which provides for the development of the seafood industry in line with EU and national policies.

**Recommended Adaptation Actions**

- Ensure the European Maritime and Fisheries Fund Operational Programme facilitates schemes which improve the sustainability of the seafood processing sector.

**3.2 Adaptable Governance**

**3.2.1 Challenges: Ensure governance structures can respond to climate-related changes**

Appropriate governance systems can support the seafood industries through climate change by
assisting in identifying potential challenges and responding to emerging opportunities. The integration of water quality, biodiversity and environmental protection into the existing decision making processes for fisheries and aquaculture provides the potential to improve the quality of the environment in which these activities take place. A more robust environment will be better equipped to respond to climate-induced changes.

Changes in sea water temperatures and pH levels have been observed and are recognised as a consequence of human-induced climate change. The extent of the impact of these factors in Irish waters is under research. Governance systems will need to be reviewed to ensure that adaptations such as changes in catch species migration patterns, culture of novel species and planning for the management of invasive/alien species can be facilitated. The design of coastal infrastructure in particular will need to take account of meteorological, flooding and sea-level rise predictions.

Recommended Adaptation Actions

- Ensure that climate change adaptation is included in sea-fisheries, aquaculture and seafood governance systems.

3.2.2 Challenge: Continue to Provide Inclusive Governance

The Aarhus Convention, which Ireland has ratified, places an imperative on public authorities to proactively provide information and to allow meaningful public participation. Programme design, policy review or regulatory reform to respond to climate challenges will need to continue to be inclusive processes, taking in scientific and technical advice, industry experience and other stakeholder concerns. In some circumstances consultative structures may need further enhancement to optimise effectiveness of engagement.

<table>
<thead>
<tr>
<th>Seafood Development Operational Programmes</th>
<th>Monitoring Committee – wide range of membership inc. state bodies, industry, ENGOs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategic Environmental Assessment</td>
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<tr>
<td></td>
<td>Scheduled public consultation</td>
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<td></td>
<td>Publication of Programme and Schemes</td>
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<td></td>
<td>Notification of Grants Awarded</td>
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<td></td>
<td>FLAGs- Fisheries Local Action Groups around the coast</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>National Sea-Fisheries Legislation and Decision Making</th>
<th>Publication of Register of Irish Sea-Fishing Boats</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Publication of Fisheries Management Notices in print and online</td>
</tr>
<tr>
<td></td>
<td>Right of reply to decisions on consents – authorisations and permits</td>
</tr>
<tr>
<td></td>
<td>Monthly Quota Management Meetings with industry</td>
</tr>
<tr>
<td></td>
<td>Public consultations on management of fishing opportunities, published online</td>
</tr>
<tr>
<td></td>
<td>Article 6 assessments of Natura 2000 species and habitats</td>
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<tr>
<td></td>
<td>Regional and National Inshore Fisheries Forums which include representatives of marine stakeholders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea-Fisheries Conservation and Seafood Safety</th>
<th>Sea-Fisheries Protection Consultative Committee - 14 representatives from the Irish Marine Community</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Code of Practice and Molluscan Shellfish Safety Committee for Live Bivalve Classifications</td>
</tr>
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</table>

| Aquaculture Legislation and Decision Making | Application process includes either a compulsory Environmental Impact Statement/Environmental Impact Assessment Report followed by an Environmental Impact Assessment by the Consent Authority or, in some cases, carrying out of an Environmental Impact Assessment screening process |
Table 8. Existing Participative Governance Structures in the Seafood Sector

Recommended Adaptation Actions

- Continue to support inclusive governance structures of sea-fisheries

### 3.2.3 Challenge: Ensuring best practice in the Aquaculture Licensing Process

Aquaculture licensing is administered through the Aquaculture and Foreshore Management Division (AFMD) of the Department of Agriculture, Food and the Marine. The remit of AFMD is largely regulatory in character, the core responsibilities are:

- Licensing and regulation of Aquaculture in accordance with the Fisheries (Amendment) Act 1997 as amended.
- Management of the foreshore through a system of leasing and licensing in respect of the Fishery Harbour Centres and fishery related activities. All other foreshore licences/leases is the responsibility of the Department of Housing, Planning and Local Government (DHPLG).
- Responsibility under certain EU Environmental Directives.

In practice, expert advice is sought on application both internally from the Marine Engineering Division of the Department and the Marine Agencies and externally from a range of other specialist areas of the public services.

Aquaculture Licences are currently granted for a time period of 10 years. The Minister may, on the application of the licensee made at any time after the expiration of a period of three years commencing on the granting of the licence or its last renewal under section 19, review an aquaculture licence. These provisions are supportive to allowing appropriately timely review of licences as the impacts of climate change develop.

Scientific assessments and environmental concerns (that are constantly evolving) are taken into consideration in the monitoring and assessment work carried out in bays, and as part of the EIA/EIS submission that accompanies Aquaculture Licence Applications and Reviews.

Intensive monitoring and assessment work carried out jointly by the National Parks and Wildlife Service and the Marine Institute over the past decade, in combination with the extensive monitoring work carried by the finfish industry and the third level institutions, should ensure that future screening and appropriate assessment processes are equally rigorous but less onerous than in the past. Additionally ongoing research underway both in the Marine Institute and in the third level institutions should provide timely warnings as to the degree to which the critical issue of climate change is affecting aquaculture areas along the Irish coast.

Through its role as licensing authority for aquaculture, the Department is committed to adopting best practices in relation to complying with key environment directives and achieving identified Greenhouse Gas (GHG) targets. There are already an extensive number of actions in place in this regard.

Recommended Adaptation Actions

- Continue to apply best practice procedures in the environmental assessment of applications
for aquaculture licences

3.3 Providing Fisheries Infrastructure

3.3.1 Challenges: Prepare for long-term sea-level rise scenarios

Ireland has a number of strategically important Fishery Harbour Centres, as well as essential facilities at a range of smaller ports and harbours around the coastline. Under statute the Department of Agriculture Food and the Marine owns, manages, maintains and develops the six designated Fishery Harbour Centres (FHC’s) located at Howth, Co. Dublin; Dunmore East, Co. Waterford; Castletownbere, Co. Cork; Dingle, Co. Kerry; Ros an Mhil, Co. Galway; and Killybegs, Co. Donegal.

The six FHCs play a key part in the sustainable development of the economic and social fabric of the regions in which they are located. Due to the aggressive marine nature of the environment in which the FHC’s are located and the industrial scale and type of the activity that takes place at the ports on an ongoing basis, annual maintenance of the piers, and their associated furnishings and fitting including fendering, bollards, ladders, surfaces, water mains, electrics and the like is vital.

Straight line prediction trends (rather than exponential) indicate that mean sea level could rise by up to 0.6 metres by 2100. In order to provide for this increase, coastal infrastructure developments, including piers and other such infrastructure will have to be designed to ensure that deck levels are constructed high enough to account for this predicted sea level rise.

Increased pressures due to higher waves will result in higher forces which will have to be taken into account in the analysis and design of marine Infrastructure. All of this will result in increased costs particularly in major marine infrastructure projects which will have design life spans of 50 to 100 years. In order to limit overtopping of coastal defence structures such as breakwaters due to the larger waves and increased sea levels as a result of climate change higher and more robust structures will have to be designed and constructed.

If say sea level rise started to follow exponential projections we could be in the realms of a mean sea level rise of a metre or more in the next hundred years. This would have major implications for infrastructure in low lying areas and particularly island nations. These considerations can be taken into account at design stage for coastal infrastructure. However, wider application and acceptance through the Planning System taking in Building Control will be essential to successful adaptation.

Planning for sea level rise will be a primary objective for adaptation of Fisheries Harbours and Coastal Infrastructure. It will be important that consultants and designers engaged in the future for coastal infrastructure design work are suitably equipped and experienced to take account of these changes and design coastal structures with adequate factors of safety to withstand the worsening conditions.

It will be essential that the codes of practice and design standards for maritime structures are adapted to take account of the effects of climate change and that guidance on planning design, construction and maintenance of such structures is kept under review in the light of climate change.

It is also recommended that any funding this department provides to local authorities such as grant aiding of any harbours, piers, slipways or the like, particularly the more substantial infrastructure is conditional on the planning, design and construction being adequate to cater for the factors due to climate change outlined above.

Terrestrial planning legislation currently requires that flooding is taken into consideration. It will be important for the future in so far as coastal infrastructure is concerned that fluvial flooding with increased runoff due to more intense rainfall and the more intense elements from the marine side mentioned above are factored into the planning and design of coastal infrastructure.

Higher sea temperatures will also have an impact on rates of bacterial corrosion on steel immersed in such water and adequate protection will be required to limit corrosive effects.

Research is vital in these areas and it is essential that Met Éireann, the Marine Institute and other
agencies working in this area are given the resources to continue to monitor climate change carefully so as to give greater certainty as to how trends are progressing.

The Office of Public Works completed a National Coastal Protection Strategy Study in 2013. The Study provides strategic current scenario and future scenario (up to 2100) coastal flood hazard maps and strategic coastal erosion maps for the national coastline. The flood risk mapping will be a useful tool to support decision making about how best to manage risks associated with coastal flooding and coastal erosion.

In January 2019, the Minister for Agriculture, Food and the Marine announced a €35.7million Capital Investment Package for the Six Fishery Harbour Centres and other fisheries related marine infrastructure. The €35.7 investment will build on the €96m invested in the Fishery Harbour Centres since 2010 and the €27m invested in the Local Authority infrastructure over the same period. Improving the standards of facilities at our Fishery Harbour Centres and other public harbours around our coast attracts increasing and additional economic activities, benefitting a broad range of current and future harbour users including the fishing industry, seafood processing sector and the wider rural coastal communities. Measures already undertaken which will help the seafood sector adapt to climate change include the construction of a new harbour entrance at North Harbour, Cape Clear, with an automated gate which can be shut in severe storms or when sea swell threatens the harbour basin.

Recommended Adaptation Actions

- Ensure that the assessment of funding applications under the Fishery Harbour and Coastal Infrastructure Development Programme consider the impact of climate change on proposed structures

### 4. Seafood Sector: Current Measures to address vulnerabilities

#### 4.1 Management of Fishing Activities

As identified in section 1, the reformed Common Fisheries Policy introduces a number of actions to be taken by all Member States in order to put the exploitation of marine resources on a more sustainable path. These actions will form an important part of the adaptation of the Irish catch fleet:

- Multi-annual management plans will move from the current single-stock plans to fisheries-based plans
- Stocks will be managed through fixing fishing opportunities in line with Maximum Sustainable Yield levels, and other conservation and technical measures which are part of the toolbox of instruments available.
- The ban on discarding in pelagic stocks came into effect on 1 January 2015. The landing obligation was extended to certain demersal species from the 1st January 2016 and has applied to all TAC species since 1st January 2019. Maintain a balance between fleet capacity and the available fishing opportunities. An annual report must be submitted to the Commission, along with an action plan where overcapacity is apparent.

#### 4.2 Adapting Aquaculture

Ireland’s National Strategic Plan for Sustainable Aquaculture Development, published in 2015, identifies 24 actions to be implemented over the period up to 2023 to foster the sustainable growth of the sector and enhance its environmental sustainability. Actions to promote Innovation and technological development in the sector, supported by funding under Ireland’s European Maritime and Fisheries Fund Operational Programme, may be relevant to climate change adaptation by the aquaculture sector, such as actions to mitigate the spread of invasive species and studies concerning impacts of raised water temperature on fish health etc., while actions concerning capital investment
in the sector may support investment in on-site renewable energy such as turbines, or in equipment to enhance the capacity of salmon sites in more exposed locations to withstand increased storm intensity.

The Department has developed an aquaculture licence template “Aquaculture Marine Multi-Method/Species” which allows for multiple species to be grown on aquaculture sites. The Marine Institute is carrying out research, using a research site in Bertragh Buí Bay, on Integrated Multi-Trophic Aquaculture [IMTA] allowing a number of species including finfish, seaweed and crustaceans to co-exist and benefit from their various culture types. Research on IMTA has also been undertaken in third level colleges such as NUIG which worked on the EU/ERDF INTEGRATE project with contributions from MED, MI and others - see link http://integrate-imta.eu/.

BIM Technical work on novel species includes work on developing hatchery technology for the cultivation of native Irish seaweed species. The next step in this process is to look at commercial hatcheries. Further research, and on-growing trials, on the higher value red seaweeds are also due to be undertaken. A project on identification, extraction and testing of anti-methanogenic compounds from Irish seaweeds continues.

BIM is working to develop and demonstrate a commercial scale perch farm on cut away bogs using Recirculating Aquaculture Multi-trophic Pond Systems (RAMPS). Bioremediation of wastes from freshwater farms is ongoing.

BIM is developing an app for use by aquaculture farmers providing them with information on key high-risk species, which includes a photo reporting and query function for unknown species on their sites. It also allows alerts to be sent out to users if a new species is reported and confirmed. This is currently in the test phase with a planned roll out to the aquaculture sector in Q4 2019.

An Invasive Alien Species and Aquaculture working group composed of members from BIM, MI, DAFM, DHPLG, EPA and DCHG, along with a representative from the Biodiversity Data Centre:

- Agrees and periodically reviews high risk species relevant to the natural environment and aquaculture sector in Ireland.
- Establishes and periodically reviews procedures for action to be taken in the event that a high-risk species arrives in Ireland.
- Identifies and manages resources to support actions to be taken in the event that a high-risk species arrives in Ireland.

### 4.3 Adapting Seafood Businesses

From dealing with seafood processors on the Green Seafood programme BIM has found that Industry awareness about the issue of energy and water efficiency needs to be increased. With this in mind, BIM deliver green awareness training onsite to management and staff of the seafood processors which have taken part in the Green Seafood Programme. To aid in these presentations BIM has made two short awareness videos which will help to get the point across. The 2 videos which focus on the efficient use of water and efficient refrigeration systems were shot on-site and they demonstrate good and bad practice throughout the industry.

The table below is an example of some of the actions and recommendations which would be outlined in the assessment report for seafood processing facilities.

<table>
<thead>
<tr>
<th>Area</th>
<th>Main Actions and Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>✓ Background water use check to identify any leaks onsite</td>
</tr>
<tr>
<td></td>
<td>✓ Calculate total water use and generate process based indicators for internal benchmarking</td>
</tr>
<tr>
<td><strong>Seafood Sector: Background Document</strong></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
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</tbody>
</table>

### Crab cooker – water usage reduction
- Reduce water used in cleaning of the crab cooker and associated conveyor belts
- Cascade water use within the main processing area
- Reduce flow rates from taps and hoses across the site
- Increase the use of squeegeeing prior to final clean throughout the site
- Fit a number of strategic water meters to allow greater understanding of current areas where costs are incurred (hook these up to online metering system)

### Electricity
- Review the reasons as to why the import capacity has been exceeded on a number of occasions in 2012
- Investigate and cost benefit the use of LEDs (or induction lamps) in the cold rooms and blast freezes where metal halides are currently used
- Fit and commission Wattics system to optimise refrigeration operation and identify key electricity using systems

### Energy
- Insulate all hot water and steam pipes in the plant room and beyond
- Greater control of steam usage to maintain temperature requirement should be a priority
- Potential recovery of heat from dumped crab cooker hot water to be investigated
- Repair of the cooling coil, to reduce the quantity of ice being used for cooling purposes.
- Investigate the reinstatement of the diesel generator with a soft start system in place
- Further investigate the benefit of using quick response roller doors on the external freezers
- Cost an economiser for the boiler as well as optimising water pretreatment and boiler blowdown

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**Table 9. Example of Green Seafood Business Actions**

It is important to note that the companies which have made the biggest savings are the ones which have a strong management commitment to improve the environmental performance of the plant. When management commits to going green this then filters down to staff and a culture change begins to happen which forms the basis for the continuous improvement of the environmental performance of the plant.

BIM’s Statement of Strategy “Enabling Sustainable Growth 2018-2020” outlines its five strategic priorities: sustainability, skills, innovation, competitiveness and leadership. One of the many initiatives highlighted in the strategy is that BIM will “provide the sector with effective technical programmes that reduce environmental impact and increase competitiveness”.

Bord Bia’s Origin Green Programme aligns with nine of the seventeen United Nations’ Sustainable Development Goals (SDGs) including climate action, life below water and affordable and clean energy. Members of the Origin Green Programme make sustainability commitments. Commitments include energy reduction, responsible sourcing and water conservation and management.

As an Origin Green partner, BIM assists companies at each step along the way to achieve their sustainability goals. Working with companies from initial application to supporting companies in devising sustainability plans, setting achievable targets, and tracking progress each year over their...
Seafood Sector: Background Document

five-year plans. BIM’s expert staff deliver technical workshops at vessel and processor level to specifically assist the catching sector with sustainable raw material sourcing e.g. through membership in the Responsibly Sourced Seafood Standard and the National Fisheries Improvement Projects.

<table>
<thead>
<tr>
<th>Energy</th>
<th>Emissions</th>
<th>Waste</th>
<th>Water</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduction initiatives</td>
<td>• Reduction of GHG emissions</td>
<td>• Initiatives to reduce packaging</td>
<td>• Reduce consumption</td>
<td>• Development and conservation of ecosystems on site</td>
</tr>
<tr>
<td>• Renewable Investment</td>
<td></td>
<td>• Packaging reduction</td>
<td>• Minimise contamination</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Prevent Pollution</td>
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![Table 10. Origin Green Manufacturing Sustainability Charter – Targets](image)

Plans must include at least three target areas that address the three key areas of water, waste and energy. Biodiversity and emissions will continue to be encouraged as additional targets.

Independent verification and accreditation are an integral element of Origin Green across all levels of the programme. Companies are required to deliver a progress report on an annual basis. This annual review is audited by Mabbert, a leading inspection, testing, verification and certification body, to ensure progress is being achieved against targets set. The audit is carried out through a mixture of both on-site and desktop based audits.

Highlighting the benefits of better environmental management should in turn, develop a green image for the Irish seafood processing sector which will assist in achieving market opportunities in exports consistent with the government’s agri-food policy ‘Food Wise 2025’ while also reducing the environmental impact of seafood processing plants.

4.4 **Fisheries Harbours and Coastal Infrastructure**

The Department of Agriculture, Food and the Marine, through its Marine Engineering Division, intends to carry out a strategic review of infrastructure at the six Fishery Harbour Centres (FHCs). The review will have as its focus the development of a masterplan which will regenerate the six Fishery Harbour Centres and will have an embedded goal of reducing their carbon footprint.

The review will be performed in addition to review of the Business Plans that already exist for each Fishery Harbour Centre to ensure that:

- The infrastructure meets the demands of the fleet and that steaming between Fishery Harbour Centres due to congestion as a result of lack of landing space will be minimised.

New and refurbished offices at the harbours will be designed and constructed paying particular attention to energy performance and BER.

New Pier lighting and upgrading of existing lighting systems will be upgraded using energy efficient bulbs.

Electrical infrastructure will be brought up to standard to ensure energy efficiency. New and existing water and power outlets will be metered in line with current standards.

Water mains at the Fishery Harbour Centres will be well maintained to avoid water leakage and conserve water.

Where possible, cement replacement products such as GGBS will be used in concrete construction.

Existing Harbour infrastructure particularly older more exposed harbour walls and breakwaters will be examined to ensure they can withstand extreme wave forces and wave overtopping looking at 50 to 100 year timeframes.
Designs for all new quays will be carried out bearing in mind design life and the probability of sea level rise during the design life period and beyond.

As there is a substantial set down area at Killybegs Fishery Harbour Centre adjacent to very deep berthage import and export of Wind Turbines and other renewable Energy equipment will be facilitated as far as possible.

**Fishery Harbour and Coastal Infrastructure Development Programme**

The Fishery Harbour and Coastal Infrastructure Development programme is administered by the Sea Fisheries Administration Division of the Department of Agriculture, Food and the Marine. The programme funds capital development projects at the six designated Fishery Harbour Centres and also co-funds projects at regional fishery harbours which are the responsibility of Local Authorities.

Guidance to Local Authorities for funding towards the development of coastal infrastructure will be conditional particularly, where funding is sought for more substantial infrastructure such as quays or breakwaters, that the design must take into consideration sea level rise and associated increases in wave heights and forces.

The Fishery Harbour Centres accommodate increasing commercial diversity in rural coastal locations generating much needed employment and economic benefits. Continued investment is required to continue to develop this strategically important infrastructure to meet international best standards, providing opportunities for further economic expansion in coastal communities.