Processing Industry - Climate Change Issues and Challenges

Alex Olsen

December 2021

Key messages

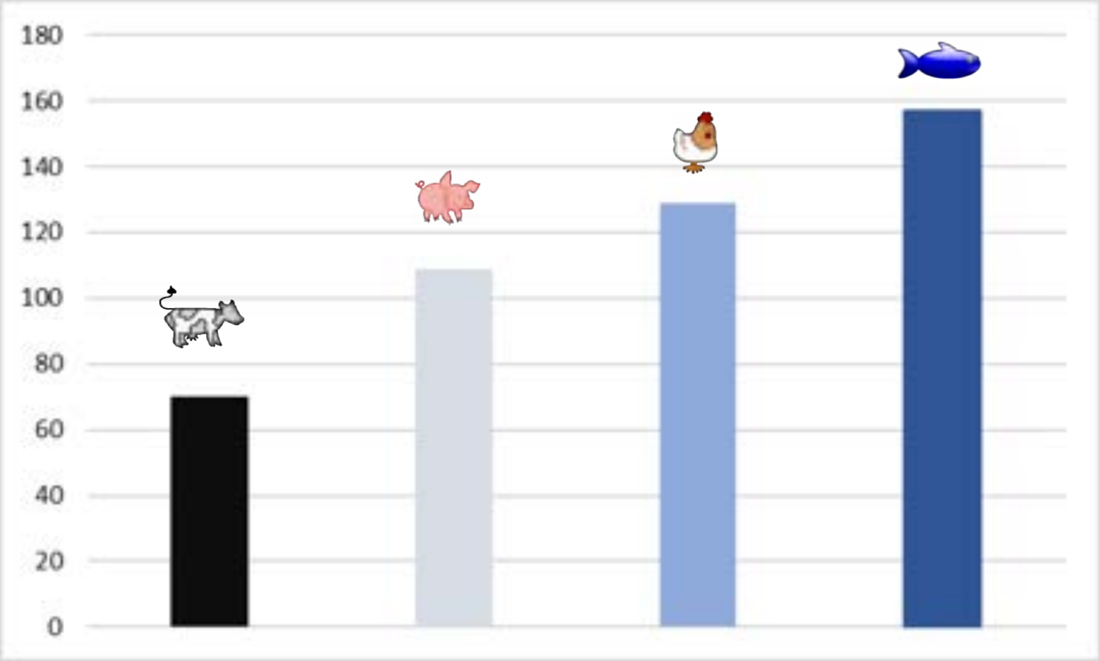
We have a good story to tell.

Still room for improvements

Cooperation and transparency is essential

Estimated animal protein consumption worldwide
by source

Million metric tons



Source: Statista (2020 data)

Why fish is important for the future!

For the people

2
billions more people by 2050

2x
Food supply must double by 2050

70/2
70% is ocean, but only 2% of world food supply

… and for the environment!

	Carbon Footprint* (kg CO2/kg product)	Water Consumption** (litre/kg edible meat)
	3,2	2,000 litre
	5,4	4,300 litre
	6,1	6,000 litre
	67,6	15,400 litre

* Source: Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities; FAO 2013. Cattle is for beef production.
** Source: Mekonnen & Hocckstra 2010 from Animal Society of Animal Science

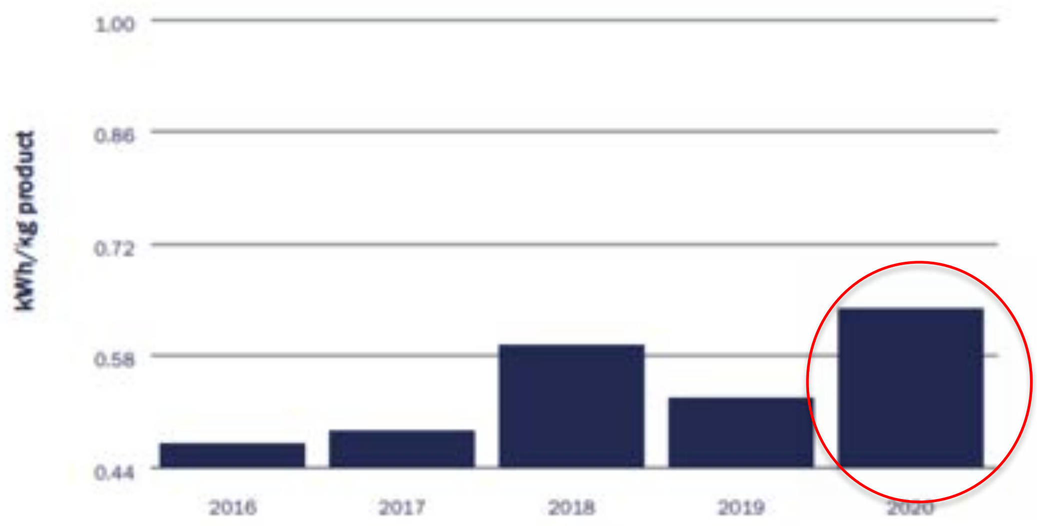
Production - the challenges

1. Reduction of CO_2 emissions as well as water usage & food waste.

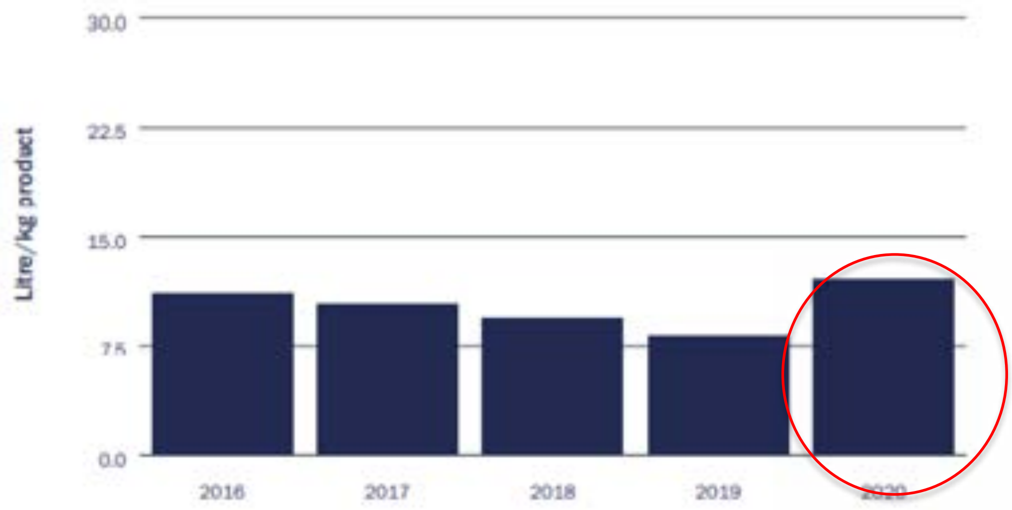
2. Availability of raw material (seafood).

Electricity & Water usage

Energy



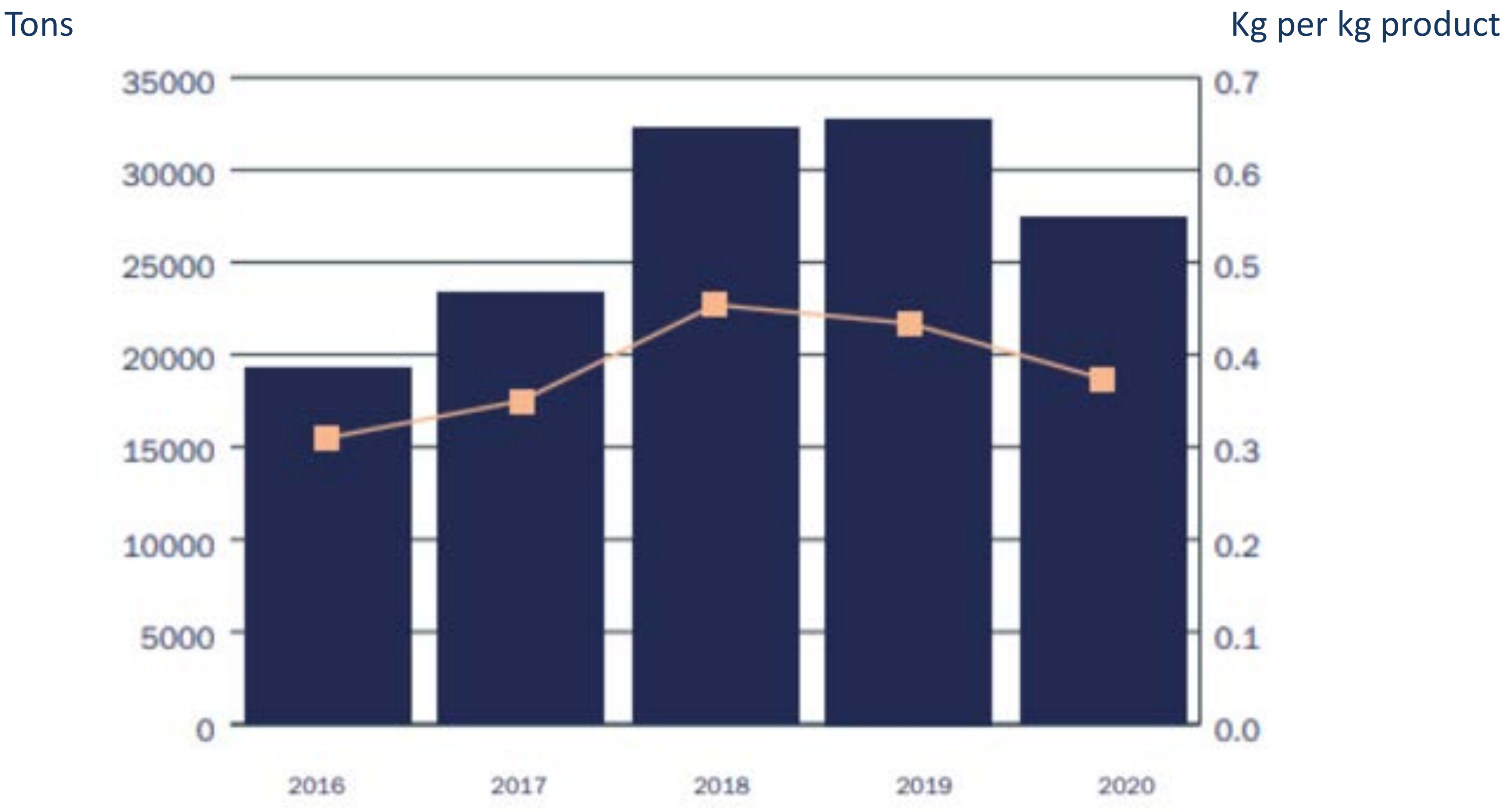
Water



Decouple energy and water use from production

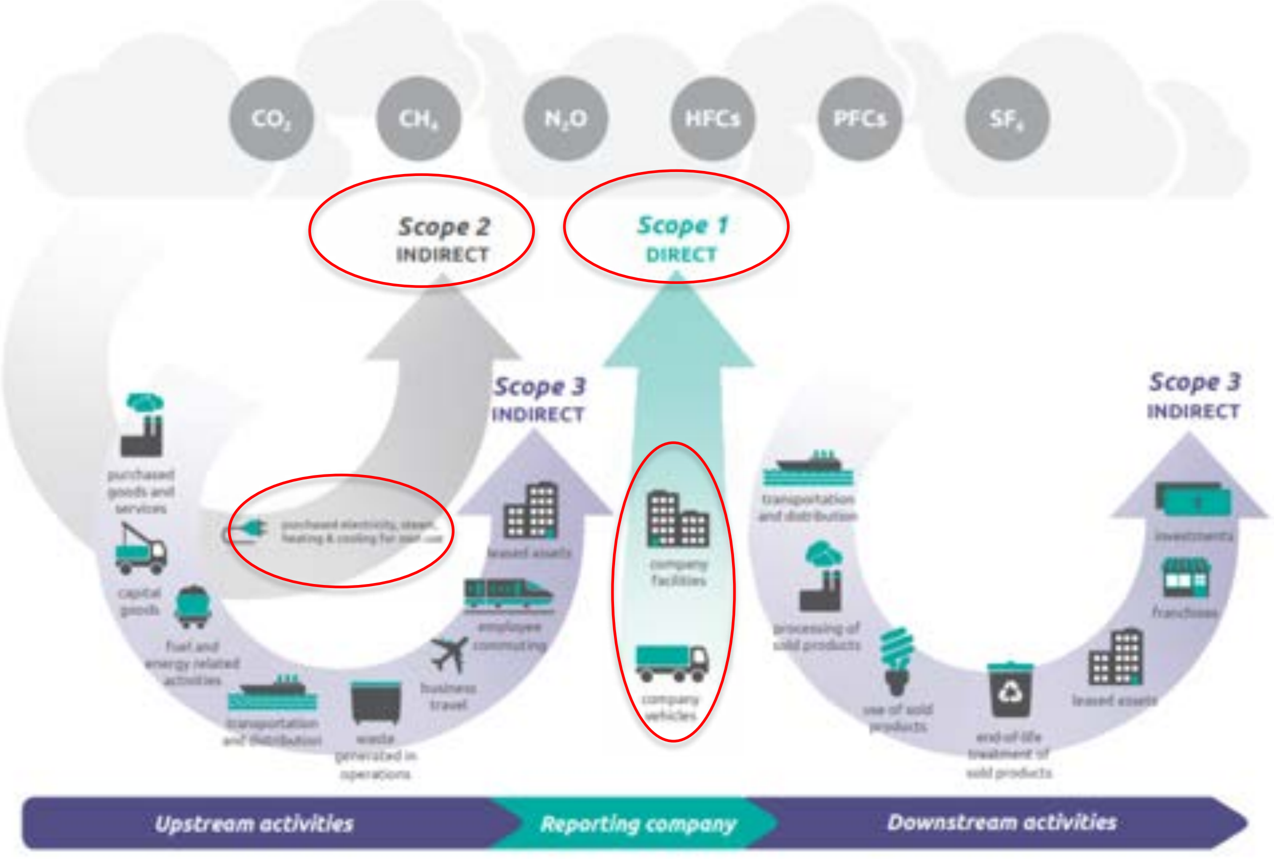
Source: Espersen Sustainability Report 2020

CO_2 equivalent emissions



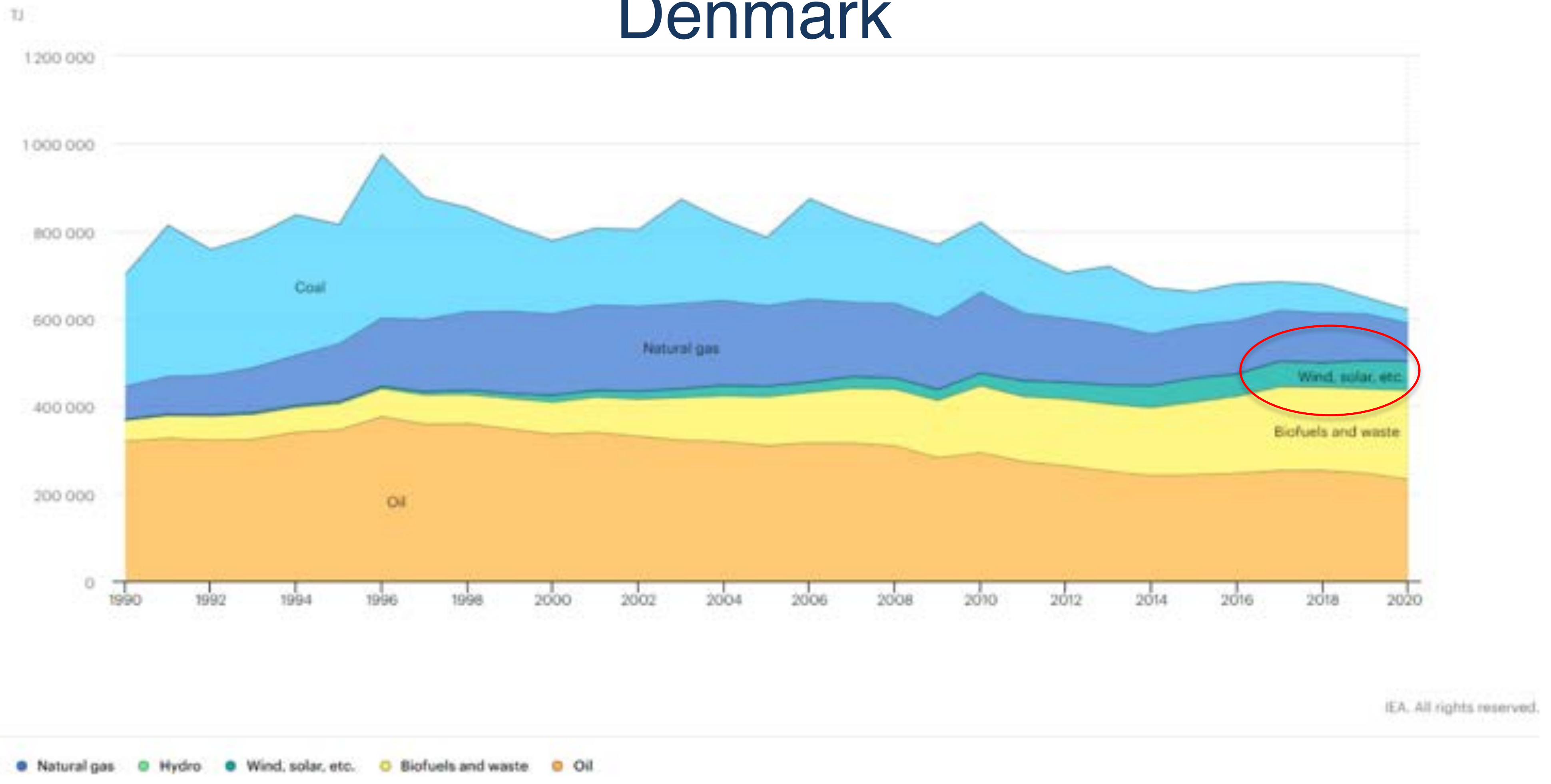
Source: Espersen Sustainability Report 2020

Overview of GHG Protocol scopes and emissions across the value chain

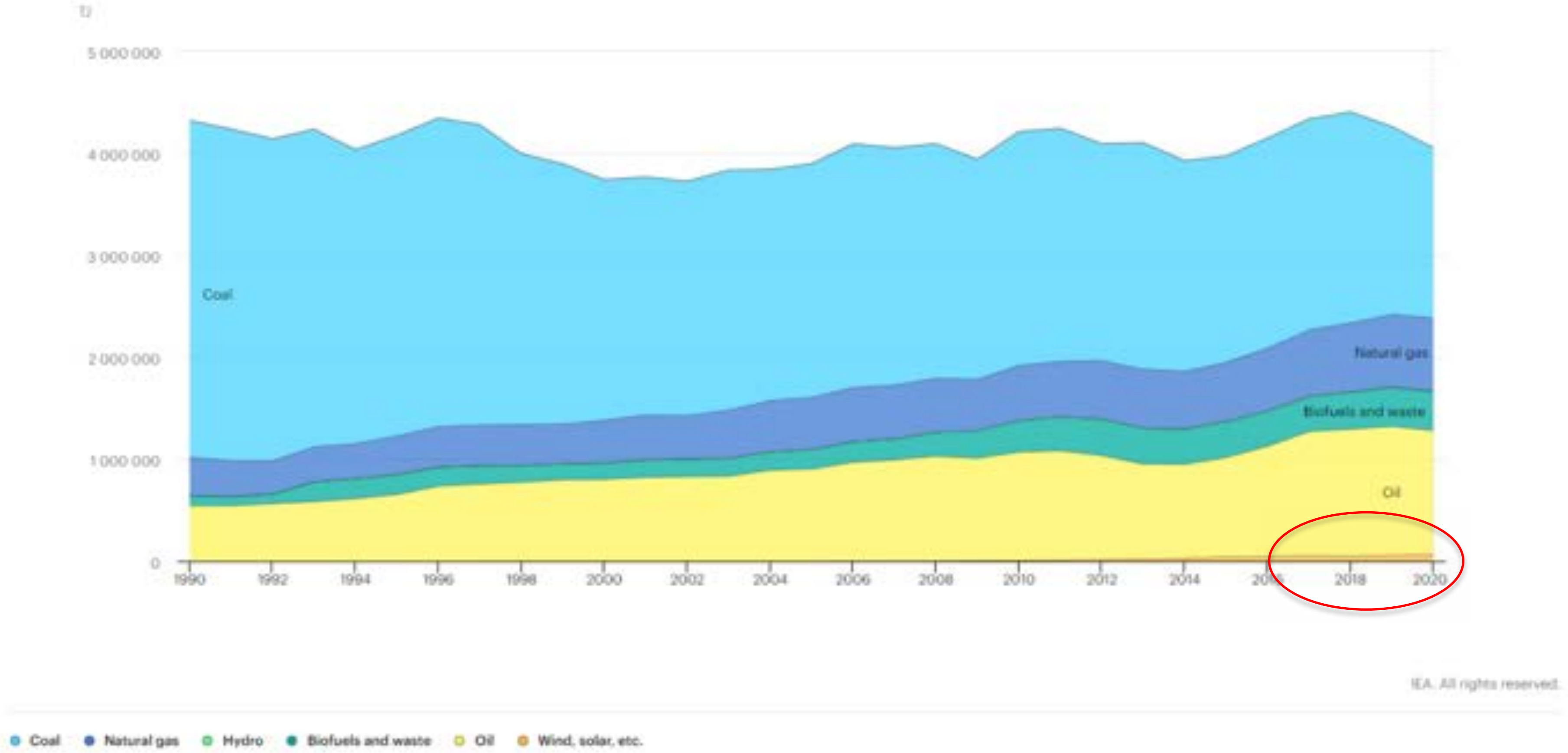


Source: Green Housegas Protocol (WRI)

Total Energy Supply (TJ) by source 1990 - 2020 Denmark



Total Energy Supply (TJ) by source 1990 - 2020 Poland

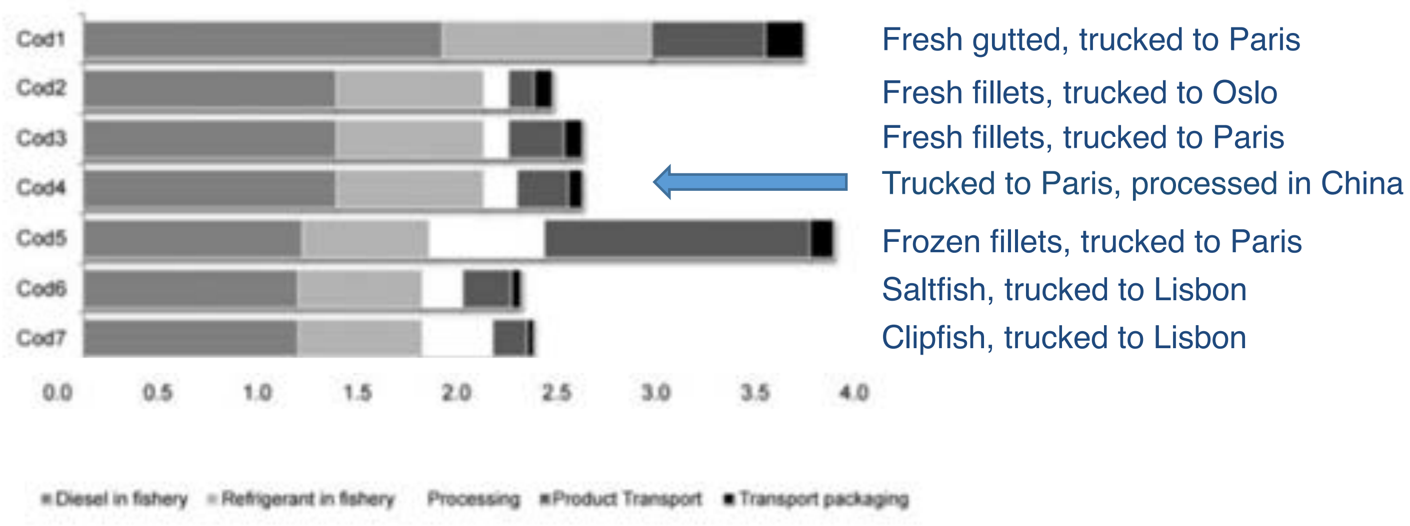


Cod Fillets Carbon Footprint 2015

	Emissions per ton Cod H&G		
Fisheries	970	47,8%	Scope 3
Sea Transport	71	3,5%	Scope 3
Container Transport Truck	590	29,1%	Scope 3
Filleting Operation	398	19,6%	Scope 1 & 2
Totale	2.029	100%	
Emission per kg cod fillet	2,03		

Source: Espersen.

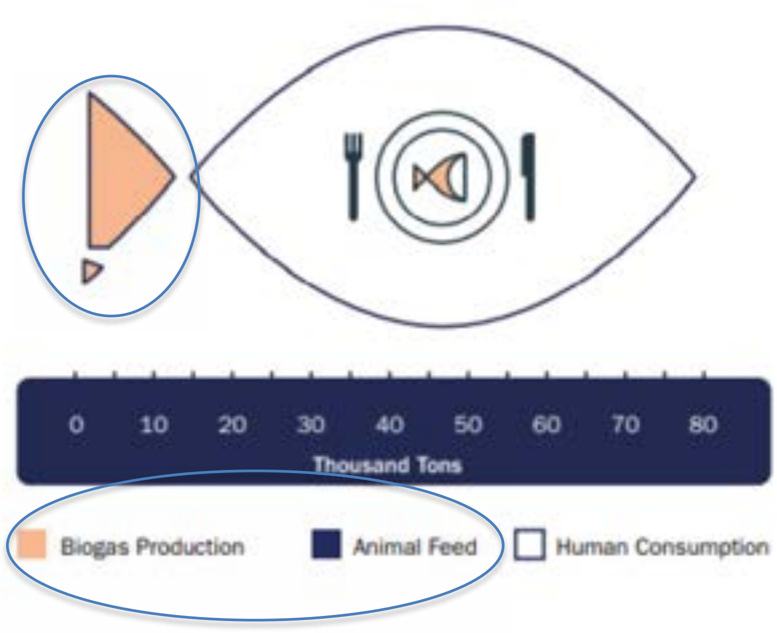
Footprint - cod processed in China ?



Carbon footprint for seafood products from capture fisheries
(kg GHG/ kg edible product)

Source: Ziegler et al., Carbon Footprint of Norwegian Seafood on Global Market, Journal of Industrial Ecology · February 2013

Reduce Food Waste



In 2020 77% of foodstuffs was used for human consumption

Source: Espersen Sustainability Report 2020

Raw material sourcing

Espersen Sustainability Report 2020

Source: FAO

Photo: Per Stale Bugjerde

As Barents Sea temperatures rise, so do cod concerns

Sea water temperature could make some parts of the water inhospitable for the fish.

IntraFish Media
Published: 08.05.2015 10:03 Updated: 08.05.2015 09:57

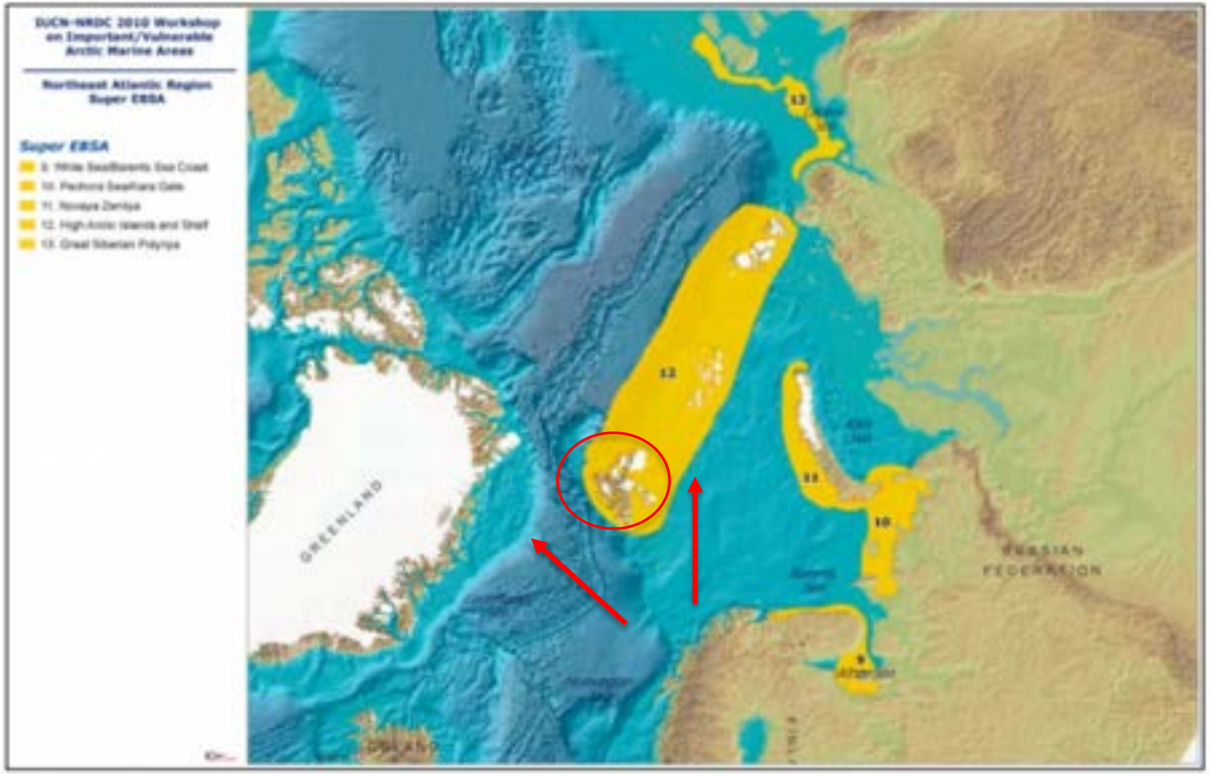
A recent report from Norway's Institute of Marine Research shows Barents Sea temperatures continue to rise and claims a nine-degree increase could make it unlivable for several fish populations, including the Barents Sea's most important fishery -- cod, according to a local paper.

The report is based on temperature projections from the most recent Intergovernmental Panel on Climate Change (IPCC) report, which states average global temperature will rise up to 40.1 degrees Fahrenheit and arctic temperatures may double the global average due to the melting of thin ice sheets.

Associated Articles

- Norway's Barents Sea capelin season ends with 80% higher harvest
- Norwegian cod exports reach all-time high
- Norway ups minimum landing prices for cod, haddock

Vulnerability in the Arctic Marine Environment (Super EBSAs)



Map from IUCN/NRDC Workshop November 2010

Published 2nd March 2016

Partners

Catching Sector:

fiskebåt

NOREBO

eurofish

АТФ

Processors and Manufacturers:

ESPERSEN

Nomad Foods Europe

Birds Eye, iglo & Findus

ICELANDIC SEACHILL

Young's SEAFOOD LIMITED

Retailers and Food Service:

TESCO

Morrisons

ASDA Save money. Live better.

M&S EST. 1884

Sainsbury's

co op

WAITROSE & PARTNERS

We have agreed that from the *2016 season* the catching sector will not expand their Cod fishing activities with trawl gear into those areas where regular fishing has not taken place before. This is a precautionary measure *until* through initiatives such as those mentioned below the fishing activity in future years will be determined by improved knowledge replacing the need for this precautionary approach. ....

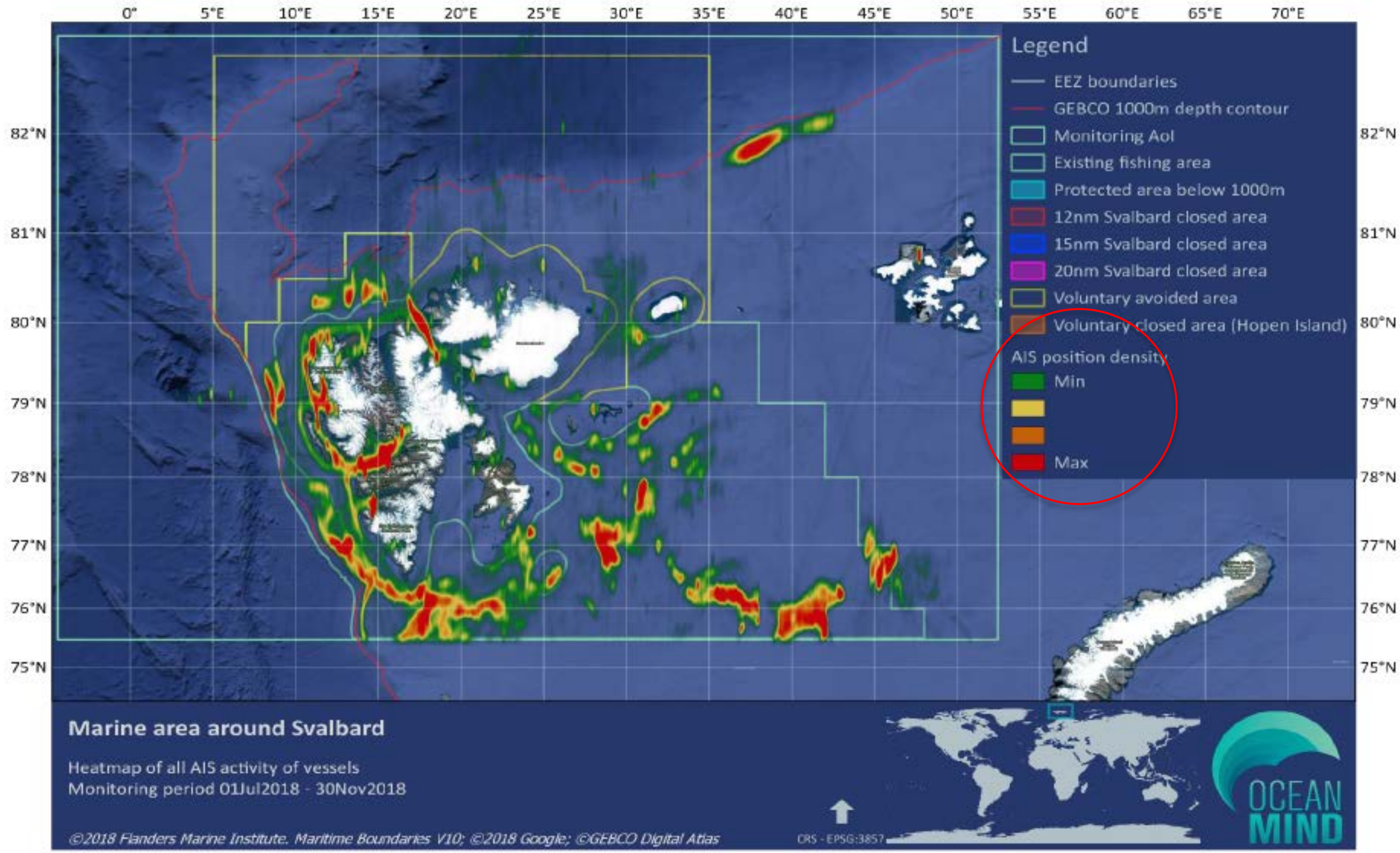


Figure 7 - Heatmap of all AIS activity of vessels at all speeds between July to November 2018

New Norwegian Legislation 2019

Photo: Espersen

Tesco, Espersen, McDonald's-backed Arctic marine project nabs nomination for coveted award

Project aims to help secure a healthy marine ecosystem for the Northeast Atlantic.

Intrafish November 2017

Enters into force July 1st

Establishes 10 closed areas

VICTORY! Bottom trawling scuttled

The end of bottom trawling in the South Pacific is in sight

Feature story - May 14, 2007

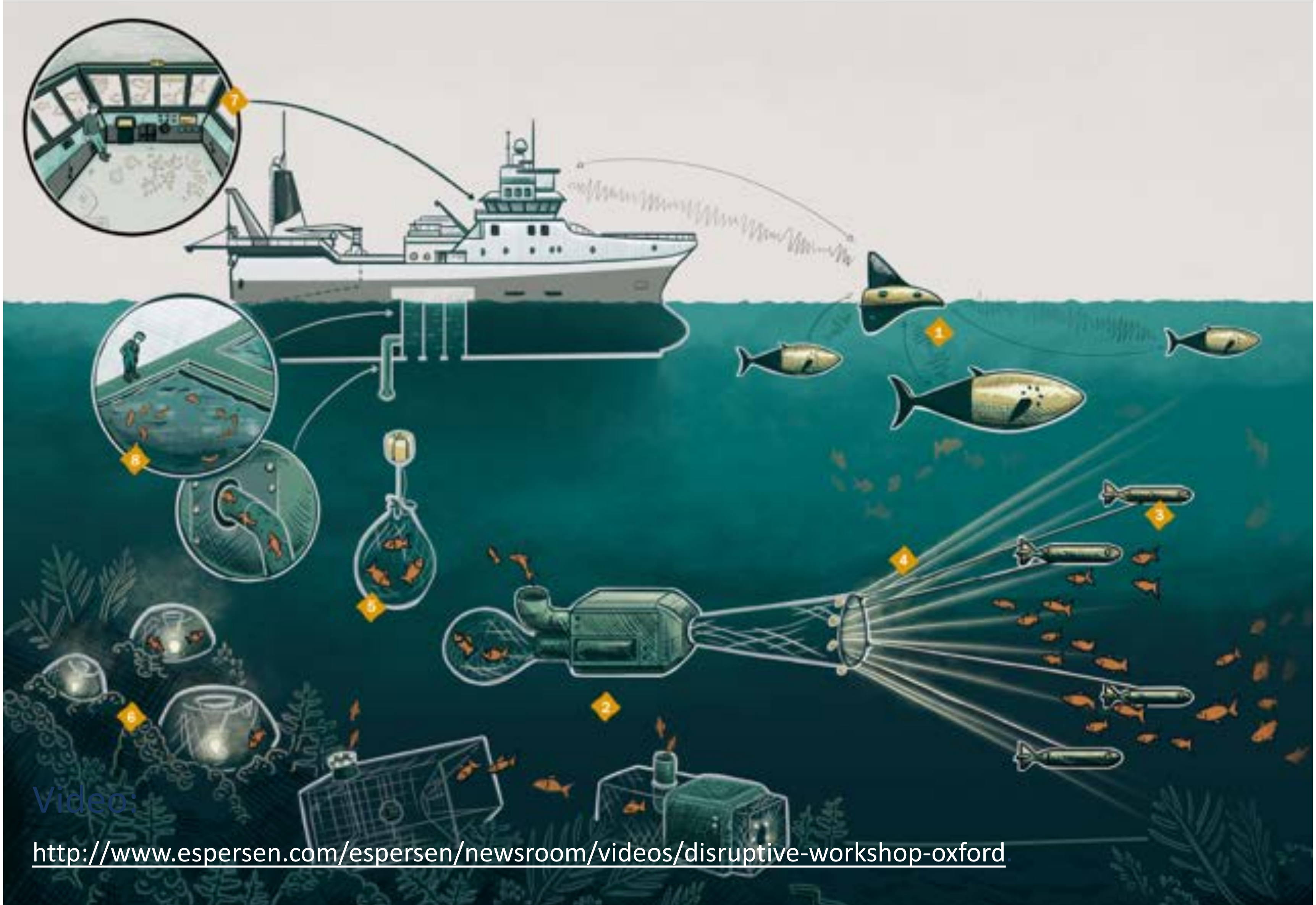
Sustainable fishing gear of tomorrow

Drive international collaboration to invent innovative fishing gear

Minimize the impact on the environment of harvesting whilst providing the benefit of marine fish as a high-quality protein source in the human diet.

.

Usage of laser beams to create ‘virtual nets’ at the front of smaller fish catching devices



Video:

http://www.espersen.com/espersen/newsroom/videos/disruptive-workshop-oxford


We have a good story to tell.
Still room for improvements
Cooperation and transparency is essential
Thank you!
Contact: aeolsen2003@yahoo.dk

International Council for the Exploration of the Sea

SERVICE AWARD

is hereby presented to

Arni M. Mathiesen, Iceland

in recognition of his contribution to ICES as Chair of the Joint ICES/ NMTT Workshop exploring the establishment of a Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA) from 1 January 2021 to 31 December 2021.

William Karp
ICES President

31 January 2022

ICES
CIEM

Norwegian policy to promote a climate smart seafood industry

By Andreas Stokseth, Min of Trade, Industries and Fisheries

Good morning from Oslo everybody!.

My name is Andreas Stokseth. I am working as a Senior advisor in the Section for Marine Research in the Ministry of Trade, Industry and Fisheries.

In our section we are responsible for marine research funding and policy, funding and management of research institutes such as Inst of Marine Research, The Nofima Food Research Institute and Veterinary Institute. Furthermore we are responsible for marine research cooperations with EU, The Fisheries Cooperation under of the Nordic Council of Ministers, and various bilateral partners.

We are also much involved in the UN Ocean Science Decade for Sustainable development, and the work of the High Level Panel for Sustainable Ocean Economy co-chaired by our Prime Minister to name a few central tasks.

As you know we have a new Government in Norway, who has just taken office.
It will take som time for this newly elected government to get to grips with all its responsibilities. Yet I can assure that policies to address the challenges of climate change figures high on the agenda.

In fact the newly appointed Minister of Industry and Trade has clearly stated that industry and the business community will have to play a centre role in the transition to a green economy. A key question in all business development projects should therefore be to what extent it will contribute to cuts in emissions.

Four your information the portifolio of the previous Minister of Fisheries and Seafood has been considerably enlarged beyond fisheries and aquaculture. The portifolio now also includes responsbilities for maritime and coastal affairs, and emergency prepardnes at sea such as oil spill, as well as international coordination of ocean policies. This is reflected in his new title as Minister of Fisheries and Oceans.

For this short presentation I am fortunate to capitalize on a recent adress by the Minister on a marine climate conference. This allows me to present a brief and up to date overview of the integration of the new governments policy on climate change into management of the aquaculture and fisheries industry.

First of all though, would like to point out that Norway will have the honour to hold the presidency of Nordic Council of Ministers next year. We are fully comitted to the vision of the Nordics as the most sustainable and integrated region of the world. This vision also applies to the Nordic seas, which of course is a big and important part of the nordic region. Ocean climate and sustainability issues thus has a firm and central place in the programme for the presidency programme. Norway is keen to bring the big issues of the international ocean agenda into the context of Nordic cooperation.

As an overall domestic goal Norway is committed to a 55% reduction in climate gas emission by 2030, measurede against the level of 1990, and these emissions are to be made nationally. To achieve this target reductions must be made in all sectors of the industry, including of course the seafood industry.

Seafood production leaves a realtively low carbon footprint when compared to most meat production. However, consumers and traders are becoming ever more concerned with the origin of food and the climate and enviromental impact of food production. The seafood industry increasingly has to be able to document sustainability and carbon footprint for import authorities, dealers and consumers. And there are clearly room for improvements. The Norwegian government is therefore comitted to contribute to innovation, and supports new ways to organize production and as well as application of new technology in the seafood industry.

The broad and general picture on Norwegian policies with regard to climate gas emissons in aquaculture and fisheries is that considerable funding will be allocated to three areas of marine research that can have high positive effects on reducing greenhouse gas emissions in the future. The first one is research into alternative and more sustainably produced ingredients for aquaculture fish feed. The second is R&D in green shipping and technology, which in fact have put Norway and the nordics in the forefront of this development. The third is research into cooling and frozen fish techology as an alternative to the fresh fish/airfreigt strategy which has been a major culprit in driving the size of the carbon footprint of the salmon industry.

Turning to the spesifics of Aquaculture - there are already government funds available for the aquaculture industry motivated to reduce emissions:

Aquaculture operator can apply for state support for switching to electric powering of facilities and supply wessels. So far the renewable energy fund Enova has provide support for 130 such projects to aquaculture feed barges. In addition 60 – 70% of ongroing facilities are connected to the national grid. Enova has also supported battery installation in more than a hundred aquaculture supply wessels. The main turning point in this transition was in 2020, when Enova provided support for more than 40 such projects

A major part of the emissions from aquaculture production however happens outside the country: At the current level of salmon production in Norway more than 1,6 mill tons of fish feed, comprizing mostly imported ingredients, is required. More than 70%

of the emissions from the industry can be attributed to feed production and feed transport. In order to reduce emissions alternative, sustainable feed resources have to be identified and developed.

Development of alternative feed ingredients such as mesopelagic fish resources, microalgae, single cell protein, insects, and so forth, can contribute significantly to reducing the carbon footprint of the salmon industry. An additional point is that development of national feed ingredients industry, for instance in replacement of soy imports, will contribute to national employment and increased value adding.

Consequently the ambition of ther government is that all feed to the national industry is based on sustainably produced ingredients by 2030. To achieve this aim current regulations will be revised if necessary, support for research into alternative ingredients will be provided, and a research program for production of sustainable feed based on national resources will be established.

If we turn to fisheries - the picture of emissions are somewhat simpler than for the aquaculture industry. The emissions here primarly stems from the fishing activity of the vessels. As for the domestic shipping a CO_2 – tax applies to the fuel of the fishing fleet

This tax is to motivate for marked based and cost-effective measures to reduce emissions. This is in keeping with the widely accepted polluter pays principle.

The tax is the most important norwegian instrument for cutting emissions, and in order to achieve the climate target the tax will be gradually increased up to 2000 NOK per ton CO_2 by 2033 from the current level of approximately 900 NOK.

Despite ambitious targets we have to face the realities

With regard to the fishing fleet, the adjustment to the green transition has so far been meagre and for certain types of vessels frankly non-eksistent.

A part ot the problem has been that the storage capacity or effectivity of current battery technology has been to low. In addition the high volume of the batteries has been a challenge for many small wessels. Fortunately development in battery technology is rapid. But more research and development is required to establish practical solutions that can provide substantial cuts in solutions from all wessels

Fortunately the technological development is fast. But there's an urgent need for research and development on practical and realistic solutions that can contribute to cut emissions from most fishing vessels.

Thats why we need to take a practical aproach on how to reach the emission target, The policy is to engage in a dialogue with the fishing industry on how to reduce emissions while at the same time maintain the competitiveness of the industry.

The contemporary CO_2 compensation scheme for the fishing fleet will be prolonged, and at the same time one will learn from experience and collect information on technology development and the potential for emission cuts

This will provide the fleet with the time required to adjust to the green transition

In the meantime financial support is available from Innovation Norway and Enova for investments in low and zero emission engines and equipent on board for shipowner ready to make the green transition in their operations.

Thank you for attention!

Understanding and adapting to a changing climate for UK seafood

Dr Angus Garrett, Seafish

Nordic Marine Think Tank / ICES workshop
December 2021

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Here to give the UK seafood sector
the support it needs to thrive.

Contents

Climate change and seafood

- Global climate change recognised as a major challenge for the world, prompting a call for action.
- A warming climate must be addressed, but the world still needs to be fed.
- Food can be an easy target. However, seafood is a relatively low emissions food product.
- We believe seafood is the way forward, a changing climate is expected to disrupt this.

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UK approach

- Adaptation work started several years ago
- Starting a dialogue, maintaining a conversation

Tomorrow

Today

Climate science

Industry experience

Yesterday

2014/15

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UK approach - framing

- Understanding - '*What does a warming world mean for our seafood systems?*' and
- Action - '*What meaningful responses can support adaptation?*'
- Framing seafood: Whole seafood system / domestic and international supply chain

Stocks	Capture / production		Transport and distribution	Trading, processing, storing	Market / sales outlet	Consumption	Waste
Target species	Capture fleets	Landing ports and auctioning markets	Air, sea, and road freight	Primary and secondary processors, importers and exporters, traders	Retail Food Service Wholesale Feed suppliers	'In-home' and 'out-of-home' consumers	Under-utilised product at all stages

- Helping industry <u>make sense</u> of key changes and how they might <u>respond</u> (drawing on scientific expertise and industry experience)

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UK approach - understanding key drivers

The key drivers of climate change relevant to seafood

- Severity of **storminess and waves**.
- Air and water **temperature change**.
- Changes in **terrestrial rainfall**.
- Sea level rise/extreme water levels.
- Ocean acidification (with some uncertainty).

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UK approach - understanding range of impacts

The implications of these drivers - they *may* result in increased:

Now

- **Storminess and waves:** compromising vessel and crew safety, damaging ports and vessels
- **Temperatures:** affecting capture species distribution and could affect the range of farmed species

2040

- **Terrestrial rainfall:** such as flooding of land-based infrastructure, affecting water quality and salinity of nearshore waters

2070

- **Sea level/extreme water levels:** increasing the risk of coastal flooding
- **Ocean acidification:** affecting fish in low oxygen waters, shellfish ability to form shells

UK approach - prioritising impacts

OFFSHORE	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
WHITEFISH					
a) Fishery resources					
i. Alterations in species phenology			🔴		
ii. Impacts on choke species (linked to landing obligations)			🔴 🟢		
iii. Changes to growth rate of target species			🔴 🟢		
iv. Changes to the distribution of target species			🔴 🟢		
v. Changes to year-class strength (including larval survival)			🔴 🟢		
vi. Migration patterns of target species (timing and routes)			🔴 🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
iii. Damage to fleet		🔴			

UK approach - prioritising impacts

OFFSHORE					
	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
PELAGIC					
a) Fishery resources					
i. Migration patterns of target species (timing and routes)			🔴		
ii. Alterations in species phenology			🔴		
iii. Changes to the catchability of target species		🔴	🔴		
iv. Changes to growth rate of target species			🔴 🟢		
v. Changes to the distribution of target species			🔴 🟢		
vi. Changes to year-class strength (including larval survival)			🔴 🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			

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UK approach - prioritising impacts

OFFSHORE	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
SHELLFISH					
a) Fishery resources					
i. Presence of HABs		● (red)	● (red)		● (red)
ii. Presence of pests and diseases					● (red)
iii. Changes to year-class strength (including spatfall)			● (red) ● (green)		
iv. Presence of non-natives / jellyfish			● (red) ● (green)		
v. Changes to the distribution of target species (including squid)			● (green)		
vi. Changes to growth rates of target species			● (red) ● (green)		
b) Offshore operations					
i. Staff physical working conditions		● (red)			
ii. Gear deployment / performance		● (red)			
iii. Damage to fleet		● (red)			

UK approach - prioritising impacts

OFFSHORE					
	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
ONSHORE					
a) Ports and harbours					
i. Damage to site infrastructure	●	●			●
ii. Boat damage in ports / harbours		●			
iii. Integrity of electricity supply					●
b) Employment and fishing communities					
i. Integrity of housing and local amenities	●	●			
ii. Days at sea		●			
c) Transportation of catch					
i. Disruption to ferry service		●			
d) Processing of catch					
i. Damage to site infrastructure	●	●			●
ii. Integrity of electricity supply					●

UK approach – impacts with consequences

Temperature change:

- ..changes in the abundance and distribution of commercial fish stocks so influencing catch potential with implications for quota management:

Storminess/waves, changes in rainfall, sea level rise:

- ..dangerous working conditions, damage to property, disruption to transport.

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UK approach: areas of adaptation, now & longer term*

- Fishery:
  - Enhancing fisheries science
  - Flexibility in fisheries management regimes (changing/new fisheries)*
- Fleet operations
  - Enhance operational safety
  - Review vulnerability of fleet*
- Onshore
  - Building port resilience
  - Assessing transport vulnerability
  - Develop seafood marketing strategies/organisations
  - Review need for relocation*
- Adaptation principles:
  - industry demand-led actions; maintain ‘watching brief’; integrate into corporate planning

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UK approach: examples of adaptation actions

- Storminess/waves:
  - Improved vessel design and operating practices e.g. crew enclosures and covered areas, pelagic vessels pumping from stern rather than side
  - Investment in port infrastructure e.g. defence against storm surges
  - Preparing for potential flood events e.g. contingency planning for worse case scenarios

- Temperature change:
  - Investment in fisheries research e.g. understand how temperature affects fish, fishing practices and prospects for the UK fleet

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Lessons and pointers

Climate change and adaptation is not straightforward:

- Climate impacts are uncertain
- These uncertain problems compete with other, immediate challenges
- Adapting relies on working with others

Lessons and pointers

Climate change and adaptation is not straightforward:

- Role of institutional drivers
- Cross boundaries:
  - Consider the whole system and engage early with stakeholders.
  - Taking climate change into industry conversations (not the other way around)
- This is about the real world:
  - Climate change often amplifies existing concerns
  - Drivers for action are wider than climate change
- Adaptation framework rather than centralised plan.

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Looking forward

- Seafood is the way forward
- Part of the solution helping to address climate change and food security
- We all play a part in seafood, and all have a part in responding to climate impacts
- We should be prepared:
  - Keep an eye on climate change
  - Working together to respond to changes we see coming
- Join us in this conversation
  www.seafish.org/climate-change-seafood

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Thank you

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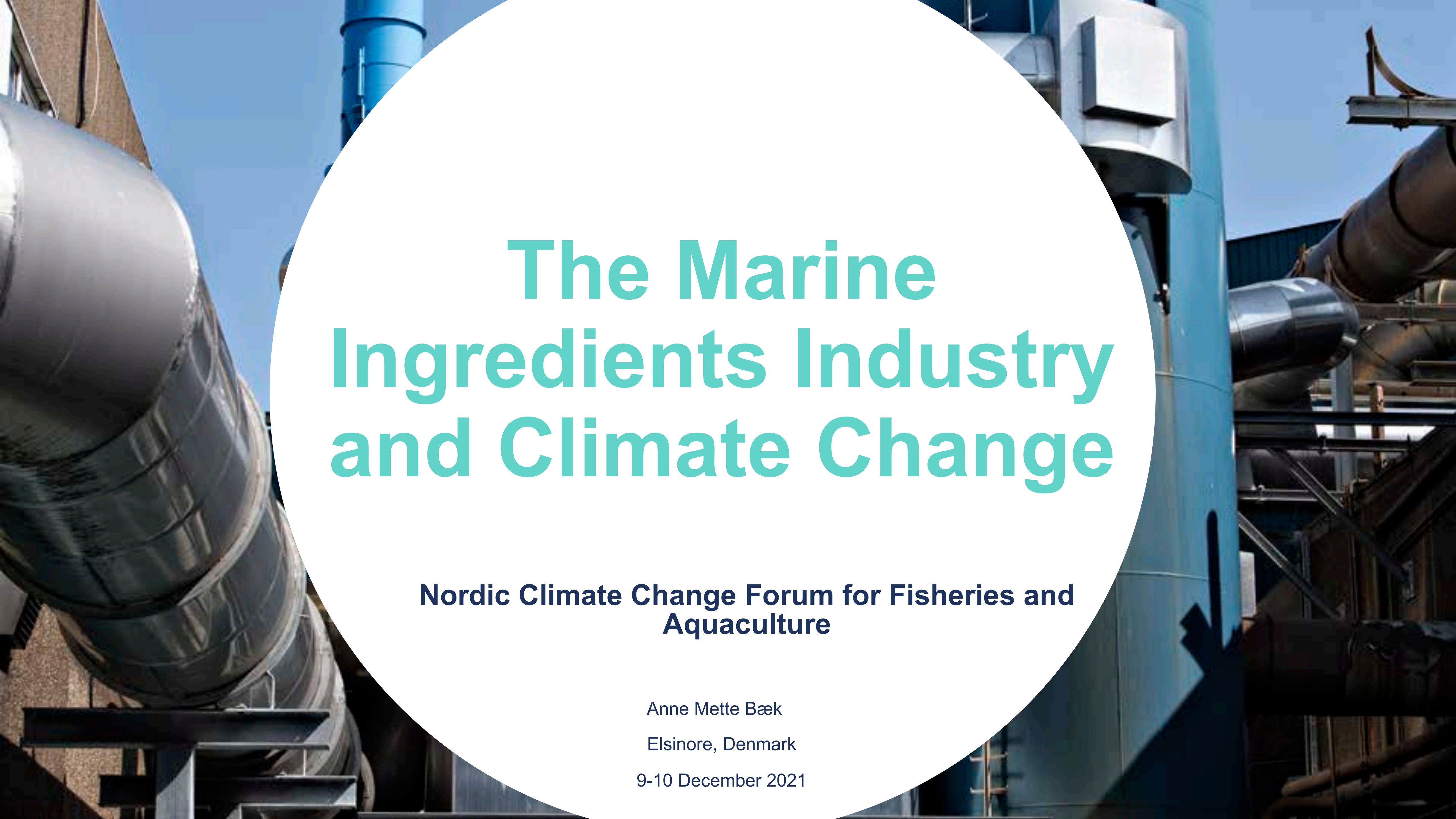
Here to give the UK seafood sector
the support it needs to thrive.



The Marine Ingredients Industry and Climate Change

Nordic Climate Change Forum for Fisheries and Aquaculture

Anne Mette Bæk

Elsinore, Denmark

9-10 December 2021

Agenda

- Presentation
- Marine Ingredients: production, usage and responsible sourcing
- Marine ingredients in the global food system
- Consequences of global warming for Marine Ingredients production
- New raw materials
- The industry´s role in climate change mitigation
- Questions

Presentation

EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

Marine Ingredients Denmark

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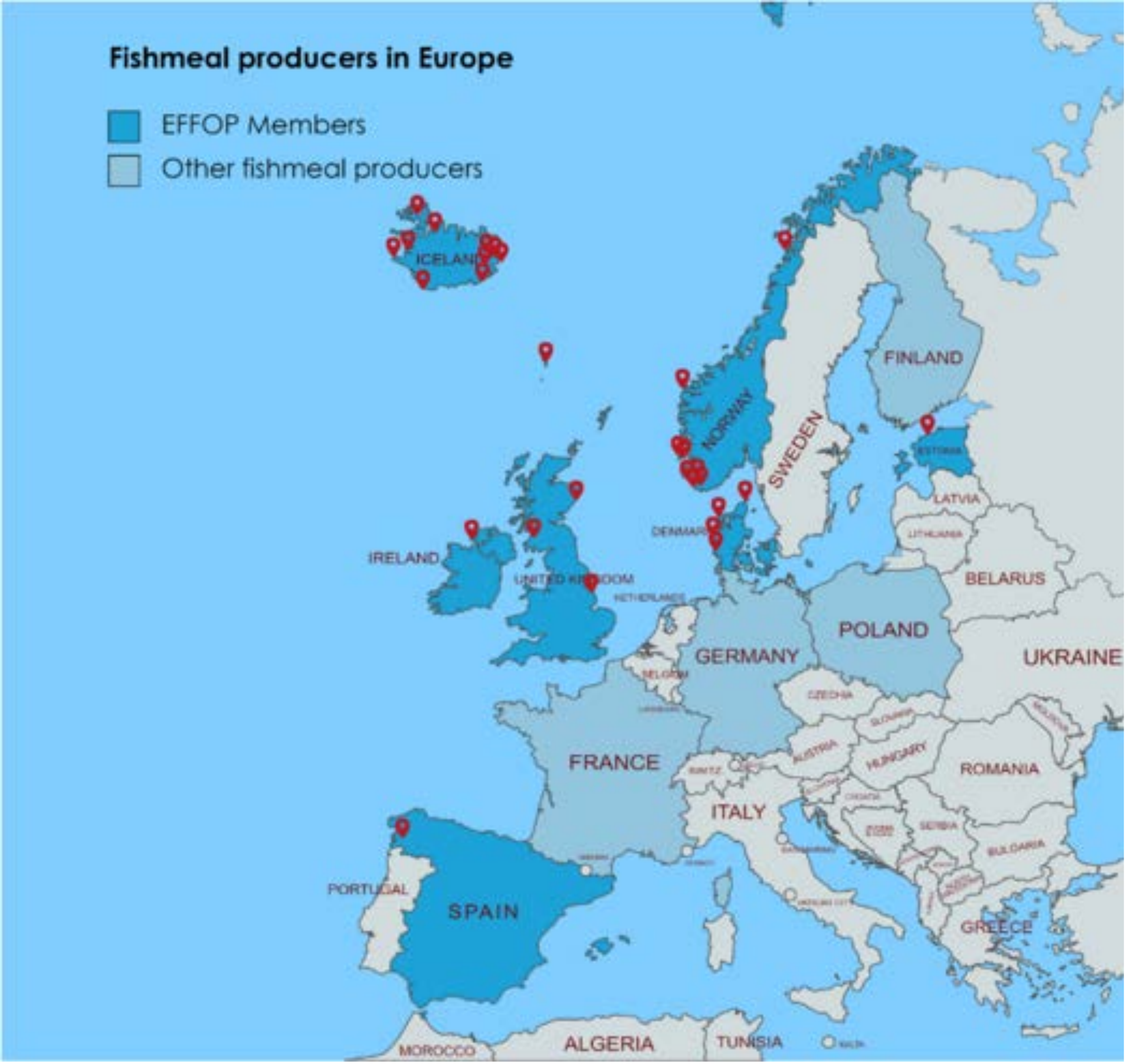


European producers are based in

- Denmark
- Faroe Islands
- Iceland
- Norway
- United Kingdom
- Ireland
- Germany
- France
- Spain
- Estonia
- Poland
- Finland

EFFOP production sites:

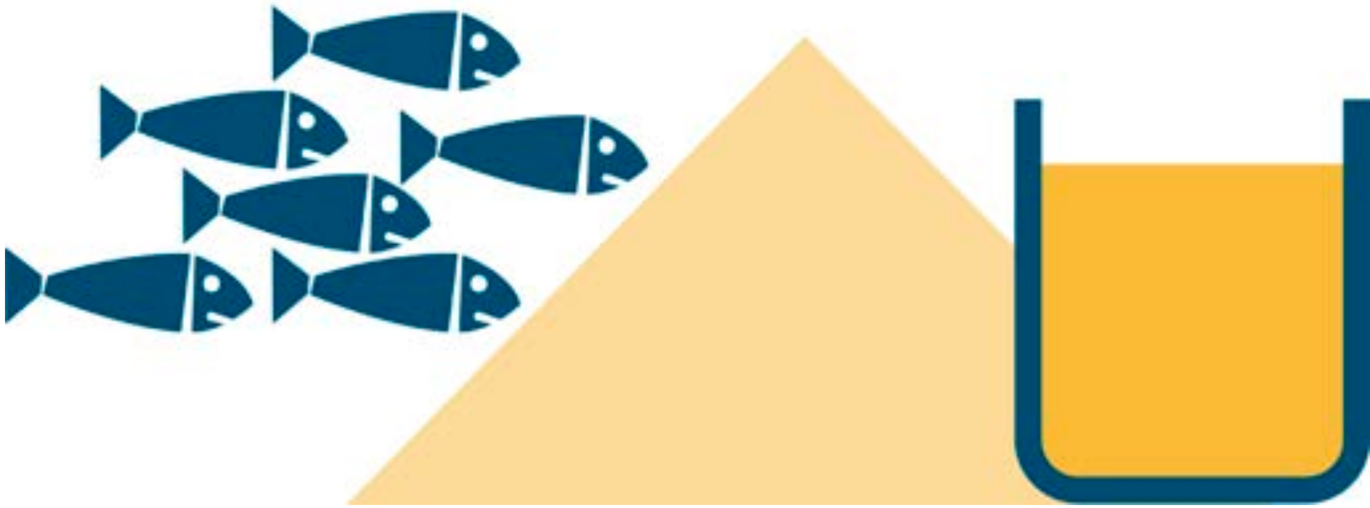
EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

Marine ingredients: Fishmeal and fish oil

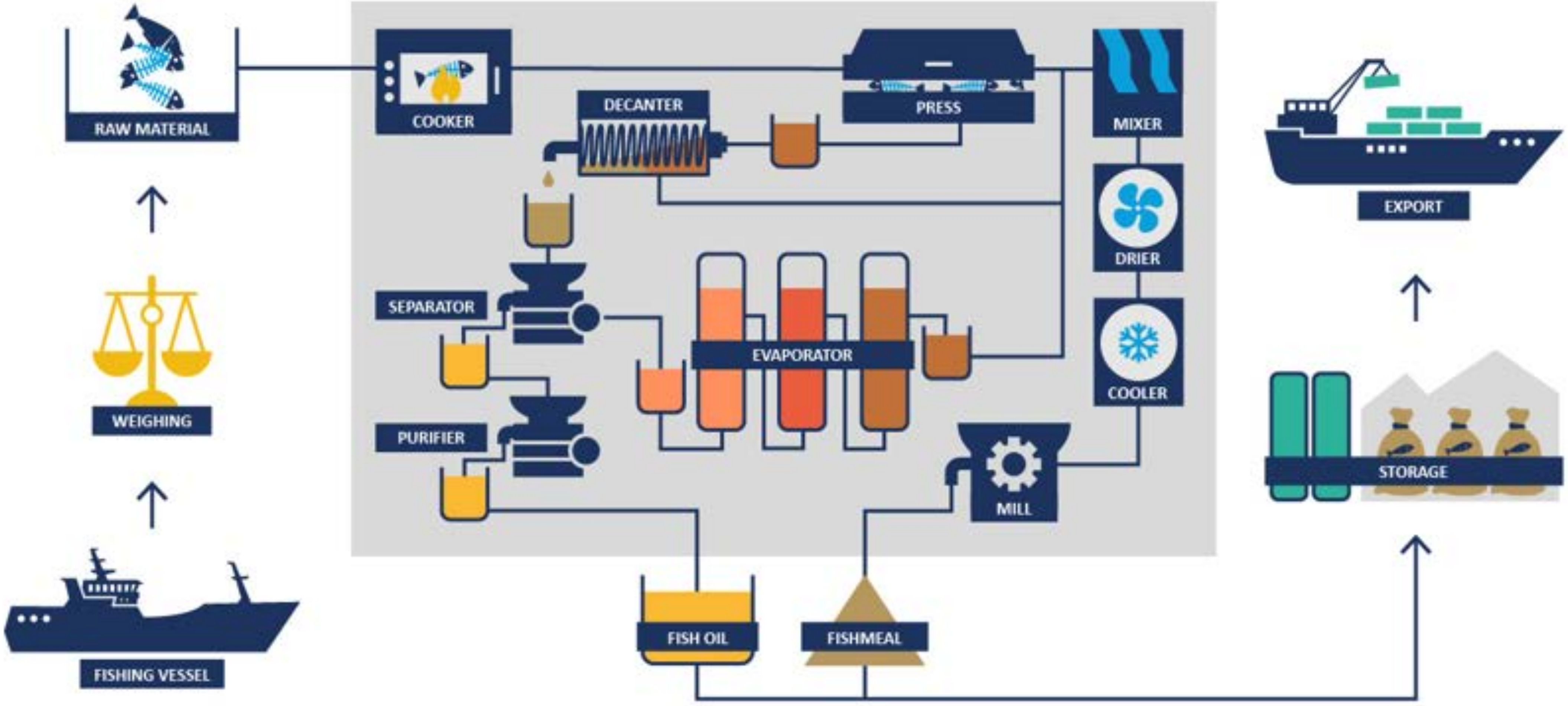
Produced from small pelagics and trimmings.

Fishmeal is a dried marine powder that holds several nutritional qualities, which makes it very attractive as a protein supplement in feed for aquaculture and agriculture

Fish oil is 100 % marine oil with a high content of the essential omega 3 fatty acids. Fish oil is mainly used for the production of feed for farmed fish and as refined fish oil for human consumption (fish oil capsules)



Production of fishmeal and fish oil



How we work with traceability

EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

The marine ingredients industry relies on a low carbon value chain, from fishing methods

The impacts within the fishing sector are primarily driven by fuel use

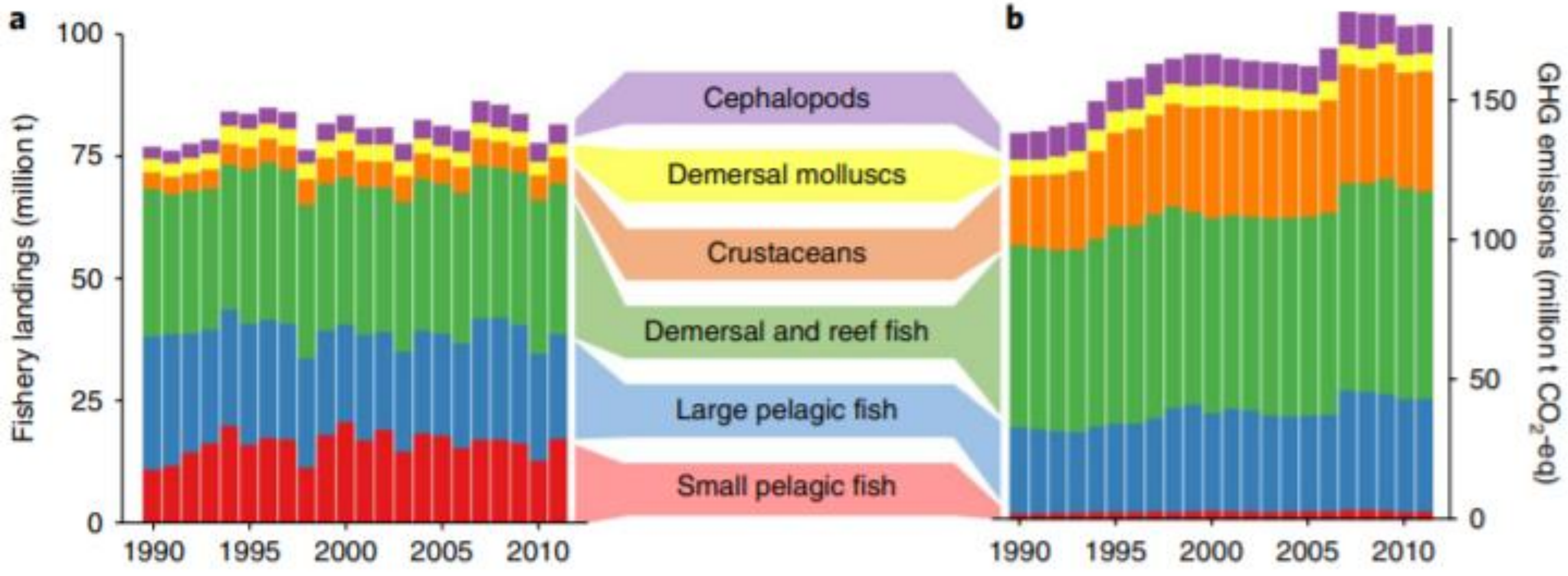
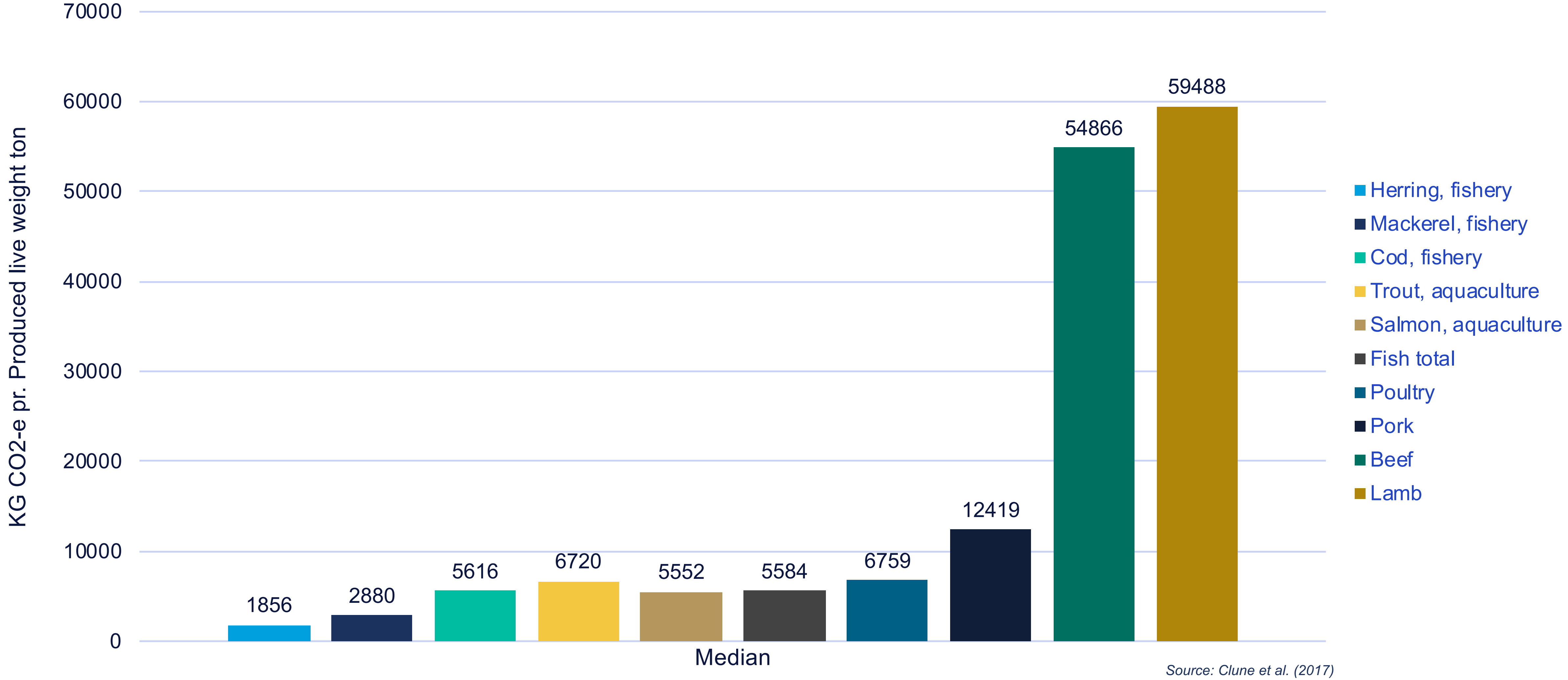


Fig. al marine fishery landings and GHG emissions for 1990–2011 categorized by species groups. a, Global marine fishery landings. **b**, Global GHG emissions from marine fisheries.

Source: Fuel use and greenhouse gas emissions of world fisheries, Robert W.R. Parker et al, in Nature Climate Change, 2018

Carbon footprint



Source: Clune et al. (2017)

EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

Marine ingredients in the global food system

Oceans make up

70%

of our planet

but fish accounts for...

17%

of total animal protein

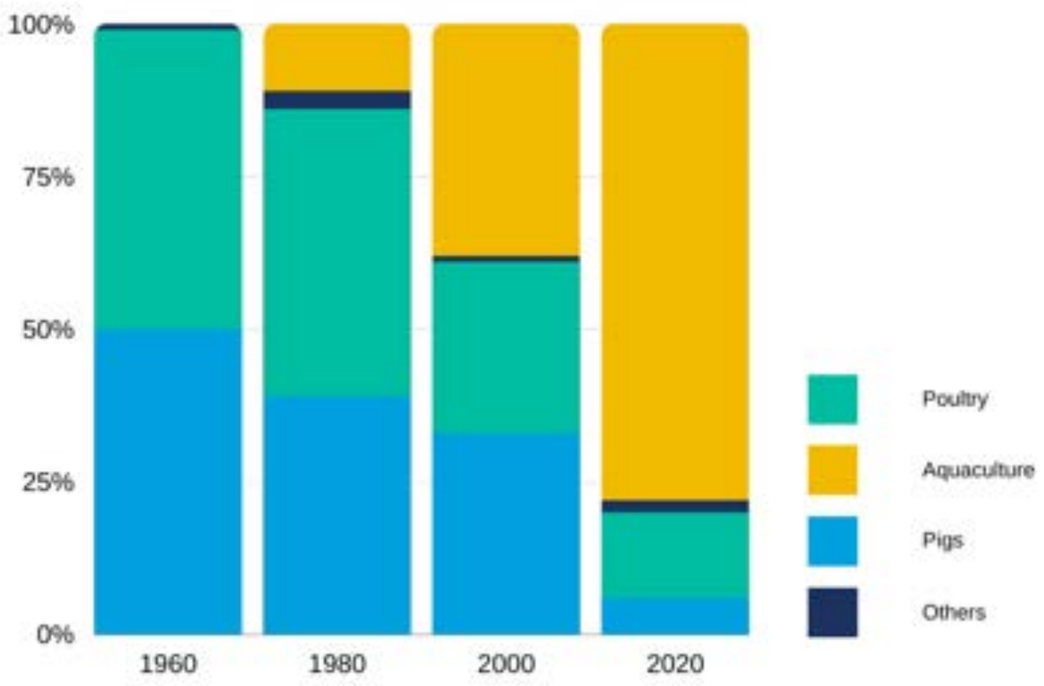
7%

of all proteins

Source: FAO, State of the World Fisheries, 2020

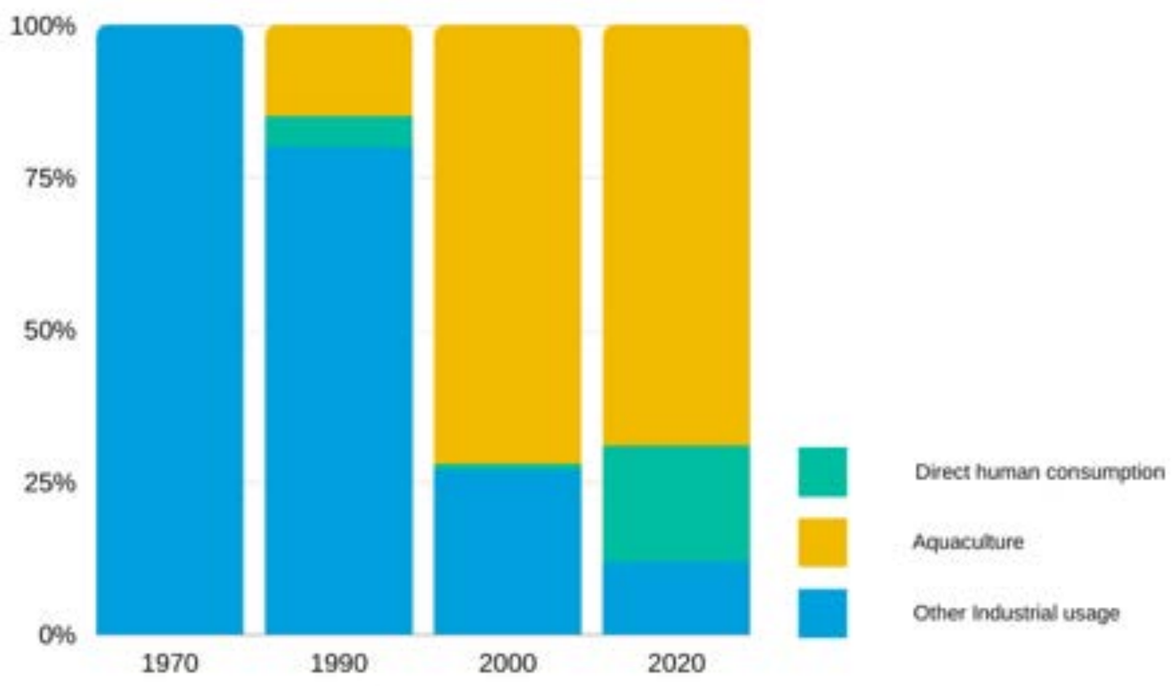
Strategic ingredients to support the growth of aquaculture

Fishmeal use



Source: IFFO

Fish oil use



Source: IFFO

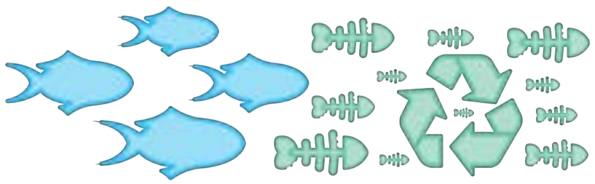
EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

The Marine ingredients sector has a role to play in climate change mitigation - by helping produce five times more farmed fish than it has been using raw material to produce fishmeal and fish oil

IFFO
THE MARINE INGREDIENTS ORGANISATION

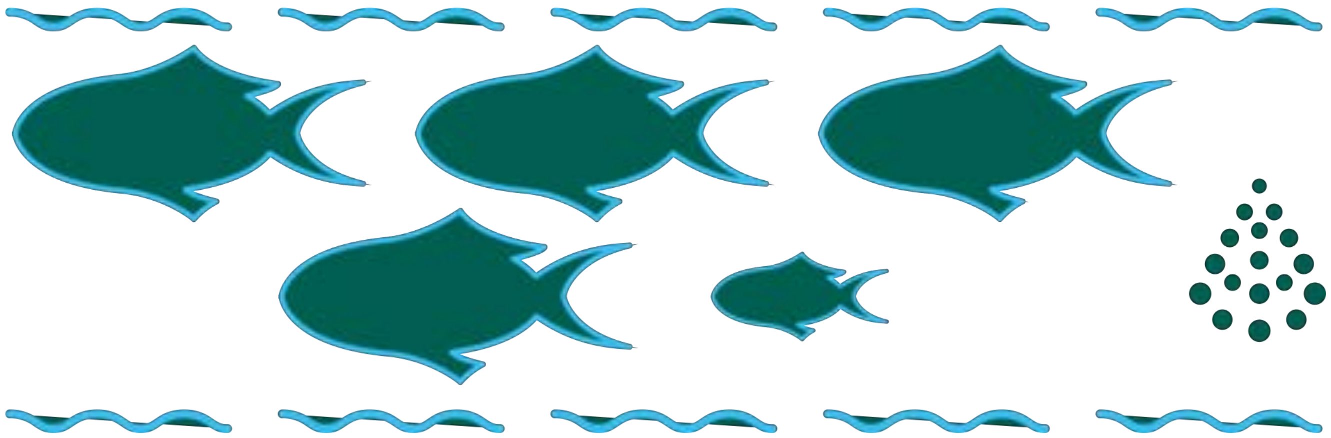
MARINE INGREDIENTS HAVE A MULTIPLIER EFFECT

1kg



Raw material used to produce fishmeal and fish oil

5kg



Farmed fish

Source: Kok et al., 2020

Climate change drivers impacting the marine ingredients industry

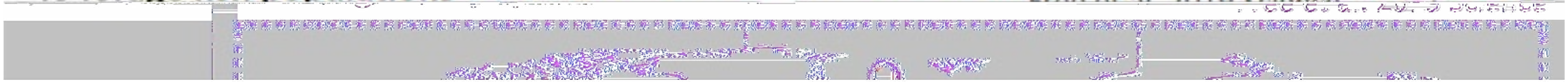
- Warming sea temperatures
- Change of pH in Seawater
- Global Sea Level Rise
- El Niño & La Niña

EUROPEAN FISHMEAL AND FISH OIL PRODUCERS

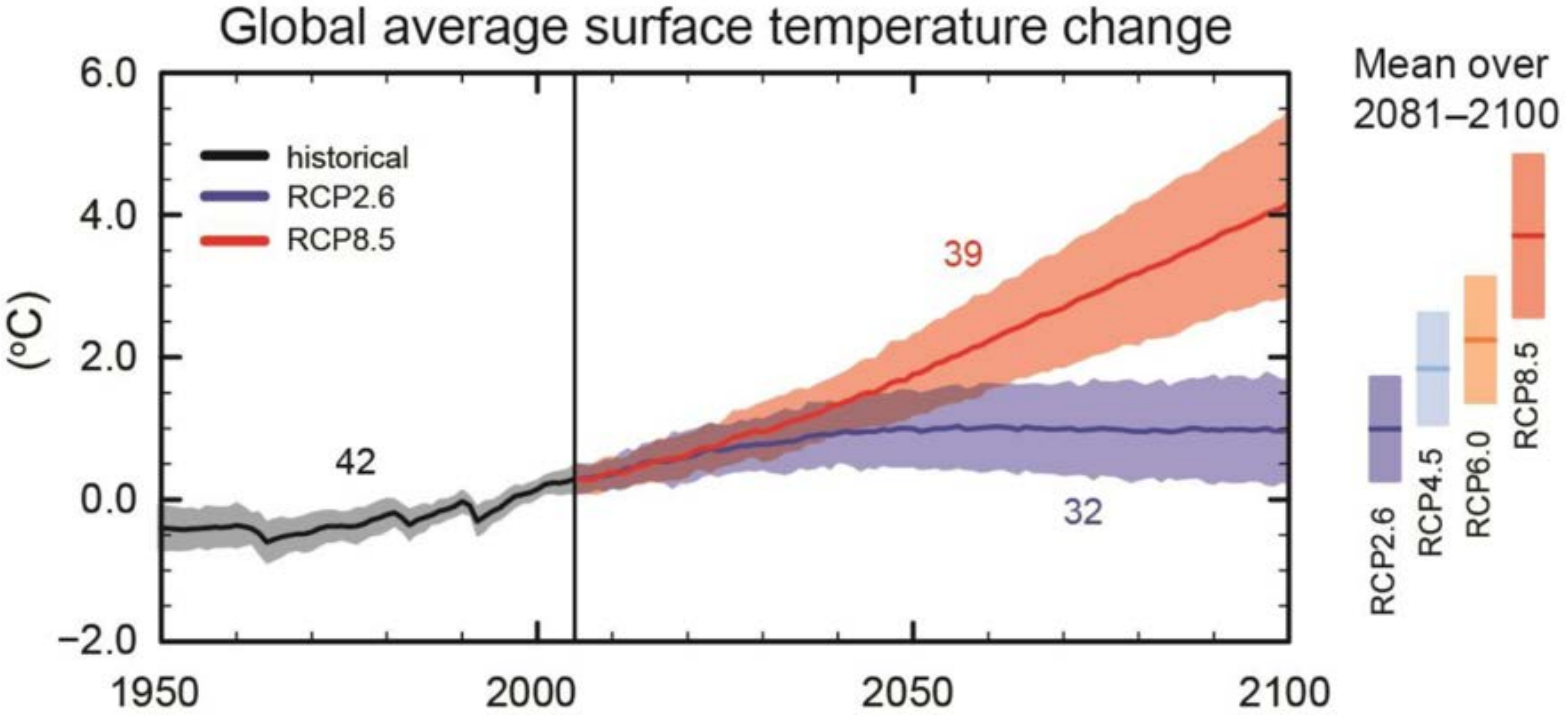
Warming has already affected reduction fisheries

40 forage fish populations

Free et al. 2019 Science



More warming is expected for the future



Developing Management Strategy Evaluations (MSEs)

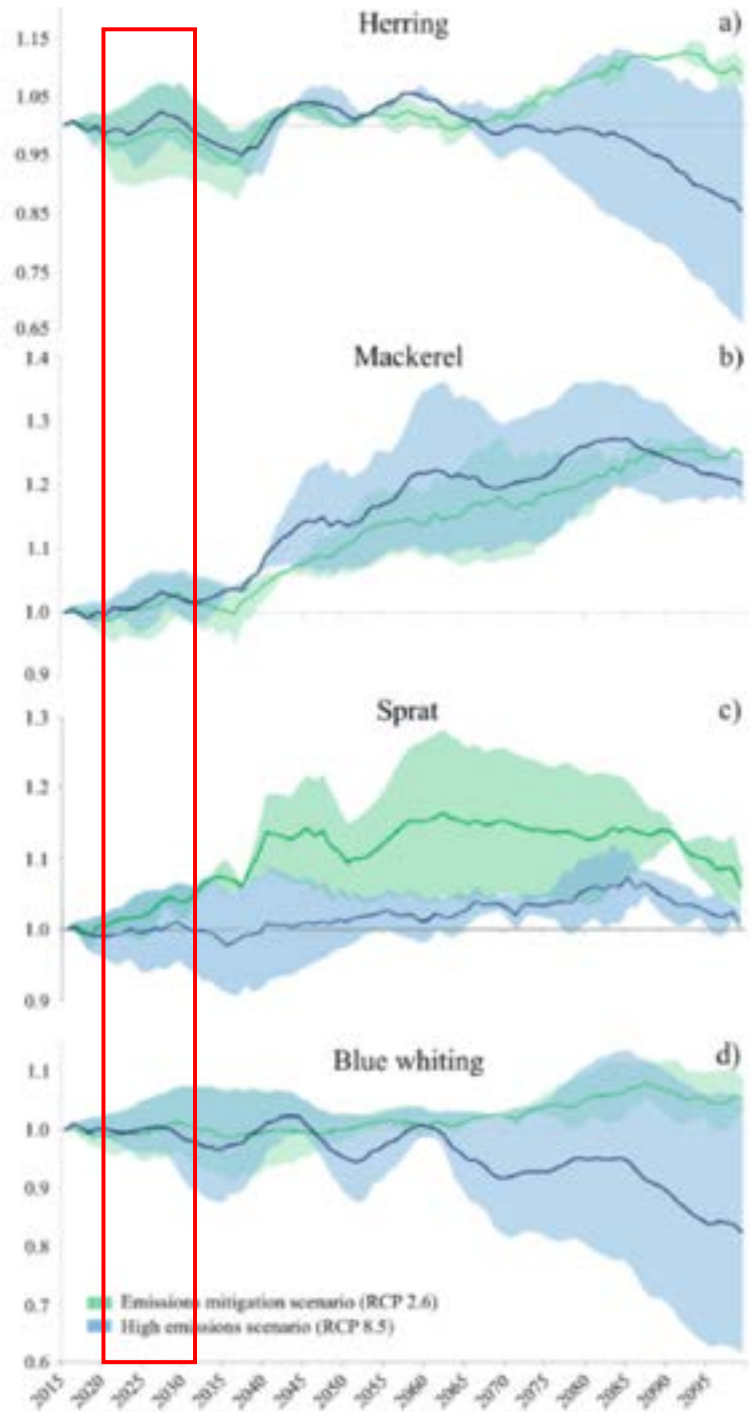
PhD-project: *The effect of climate change on fish population dynamics in the Northeast Atlantic*

Axelle Cordier

PhD student from the Center for Macroecology, Evolution and Climate (CMEC)

Supervisors: Katherine Richardson and Henrik Sparholt

KØBENHAVNS UNIVERSITET



Fernandes et al (2020)

Looking for new resources

MEESO research project: Can mesopelagic organisms, living at depths between 200 and 1000 m, be exploited in an ecologically and economically sustainable way?

Stickleback: Unused ressource in the Baltic Sea

Nordic Seals Project: what are the effects of the seal population on the ecosystem and economy

The industry´s role in climate change mitigation

The marine ingredients industry’ role in the circular economy is vital and should keep increasing

Certification programmes and multistakeholder initiatives are instrumental

Advocate for having the role of blue food in the global food production system recognised

Help the aquaculture sector to continue generating more sustainable food

Thank you

- questions?

International Council for the Exploration of the Sea

SERVICE AWARD

is hereby presented to

Carl-Christian Schmidt, Denmark

in recognition of his contribution to ICES as Chair of the Joint ICES/ NMTT Workshop exploring the establishment of a Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA) from 1 January 2021 to 31 December 2021.

William Karp
William Karp
ICES President

31 January 2022

ICES
CIEM

Ministry of Food, Agriculture and Fisheries of Denmark
Department

Danish responses to climate change

- Fisheries and aquaculture

Henry Damsgaard Lanng
Chief Advisor
Ministry of Food, Agriculture and Fisheries

Joint NMTT-ICES Workshop
launching the
Nordic Climate Change Forum for
Fisheries and Aquaculture
9.-10. december 2021

Ministry of Food, Agriculture
and Fisheries of Denmark
Department

Priorities for scientific research and state funded projects

➢ A brief overview with examples

The Danish Ministry of Food, Agriculture and Fisheries has a framework contract with the National Institute of Aquatic Resources (DTU Aqua)

- and for economy related issues with the Department of Food and Resource Economics (IFRO) at Copenhagen University

The services to the Ministry from DTU Aqua in relation to fisheries and aquaculture are targeted at the following focus areas:

1. Commercial fishing
2. Aquaculture
3. Recreational fishing
4. **Climate adaptation and environmental effects**

In 2019
the Ministry of the
Environment and Food,
together with DTU Aqua,
Copenhagen University
(and Aarhus University),

decided to prepare a roadmap of research efforts for the research-based government service to support core challenges regarding environment and food production in the period up to 2030

including especially climate change nationally and internationally.

Research priorities in the <u>field of fisheries </u>in Denmark in relation to the

reduction of climate impact:

- Fuel efficiency
- Life Cycle Assessment (LCA) for fish and fish products.
- Use of marine protein sources (blue biomass) as an alternative to meat.
- Strengthening and maintaining the ocean's ability to absorb and store CO_2
- Holistic climate adaptation solutions that take into account vulnerable landscapes, habitat types and landscape interests across efforts

Research priorities in the field of aquaculture in Denmark in relation to the

reduction of climate impact:

- Energy efficiency
- Life Cycle Assessment (LCA) for fish and fish products
- Climate-friendly breeding and purification technology for aquaculture
- Alternative raw materials for feed production and recycling of residual products
- Sustainable and innovative aquaculture production with a focus on animal welfare and environmentally and climate-friendly fish farming on land
- Genetic improvement of fish breeds with increased resource efficiency, health and less environmental impact
- Development of marine aquaculture with a low CO_2 footprint and reduced environmental impact.

Research priorities in Denmark in relation to

climate adaptation:

- Research into fish stock changes and fisheries.
  - changes in production for different populations (including invasive species) as well as their interaction
  - knowledge of future changes regarding different life stages of stocks
- Research into climate effects on biodiversity and the environmental status of ecosystems

Through the national and state funded

Green Development and Demonstration Programme (GUDP)

a green transition of the Danish food sector is promoted.

GUDP covers the value chain from primary production over food processing to retail.

Budget: +185 million DKK per year.

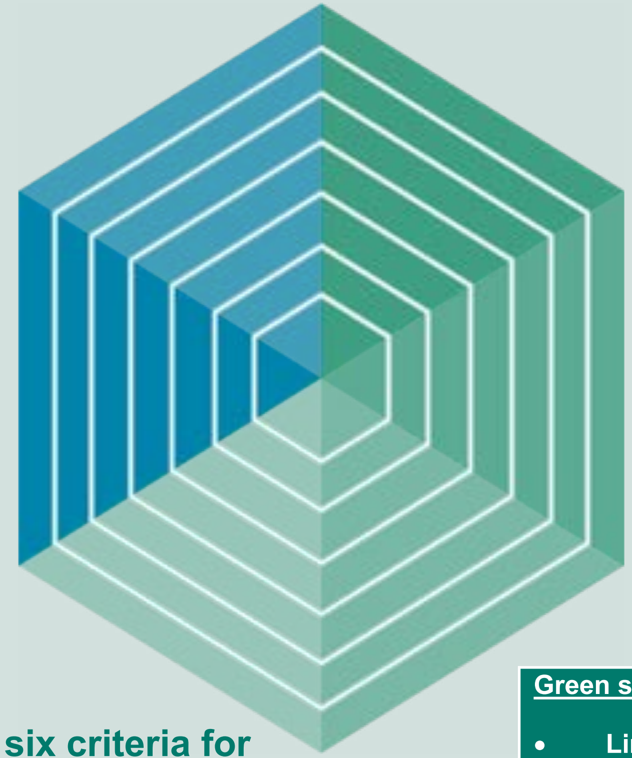
Since the start in 2010 GUDP has funded more than 500 projects with in total approximately 2,5 billion DKK.

GUDP's beneficiaries are farmers, fishermen, enterprises, organizations, researchers/universities.

GUDP is designed to motivate the applicants to cooperate in order to ensure growth and at the same time address crucial challenges facing society and the Danish food sector.

GUDP has defined the challenges and the applicants are encouraged to identify the required solutions.

GUDP's 'spiderweb' – Criteria for Green and Economic sustainability



GUDP's spiderweb shows six criteria for Green and Economic sustainability that are used to prioritize the applications.

Four are about green sustainability and two are about economic sustainability:

Green sustainability:

- Limited impact on the environment from nutrients (N and P), pesticides and greenhouse gasses
- Food safety and -quality, human health and nutrition
- Sustainable use of resources
- Sustainable animal production

Economic sustainability:

- Project proceeds
- Further financial impact

Examples of GUDP projects within fisheries with focus on reducing the impact on the climate.

1. **Steerable trawl doors that reduce sea bottom contact and improve fuel efficiency**

   - Development of a patented steerable trawl door that can be used in both pelagic and demersal fisheries.
   - Reduced fuel usage, reduced seabed impacts and decrease of greenhouse gas emissions.
   - The applicant estimates that the use of MLD steerable trawl will reduce CO_2 emissions by 10-12 percent per vessel. It gives in average a reduced emission of 334 tons CO_2/vessels.

Examples of GUDP projects within aquaculture with focus on reducing the impact on the climate.

2. **UV-based advanced oxidation technology to improve water quality in Recycled Aquaculture (UVOXiRAS)**

   - The overall aim of the project is to minimize purging time in tanks as well as minimize overall geosmin* occurrence in RAS, additionally the project evaluate on UV desinfection and effects on larval and juvenile fish physiology and welfare.

   - The applicant expects a reduced emission of CO2 as a result of the minimized purging time. Less water must be pumped around and heated. The applicant estimates that the reduction will be 116 kg CO2 / tons of fish.

*Geosmin are naturally occurring compounds that are commonly found in the fish production of RAS (Recirculating Aquaculture Systems). Both substances accumulate in the fat tissue of the fish which can lead to a muddy taste from the fish, which is not attractive for the buyers

Ministry of Food, Agriculture
and Fisheries of Denmark
Department

Thank you!

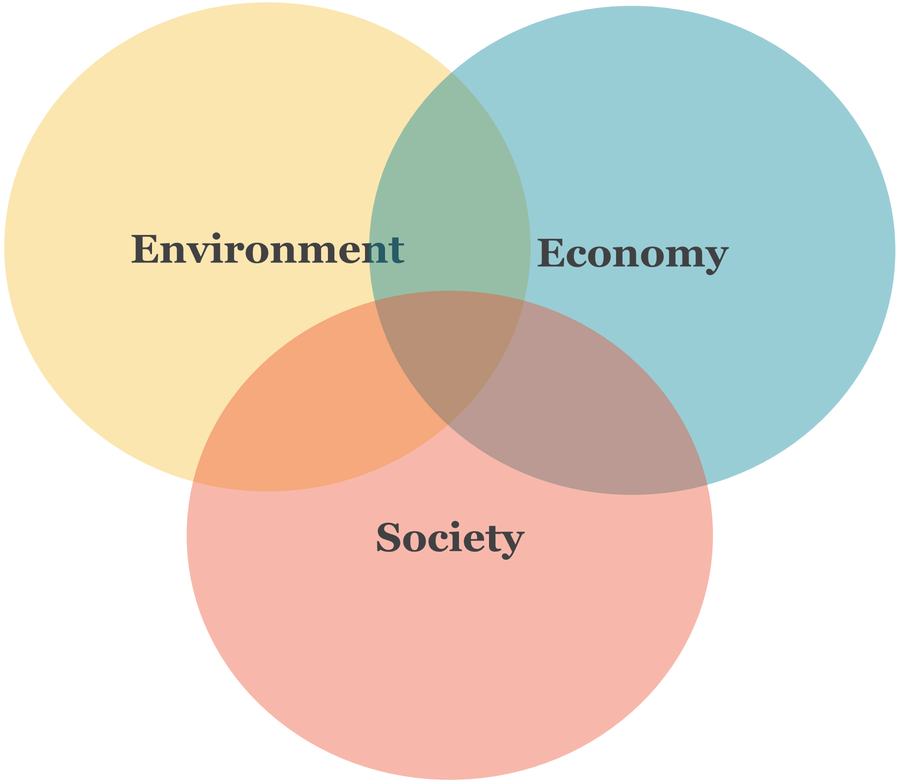
Climate Change Issues and Challenges,

Capture Fisheries for Human Consumption

Hildur Hauksdóttir, Fisheries Iceland

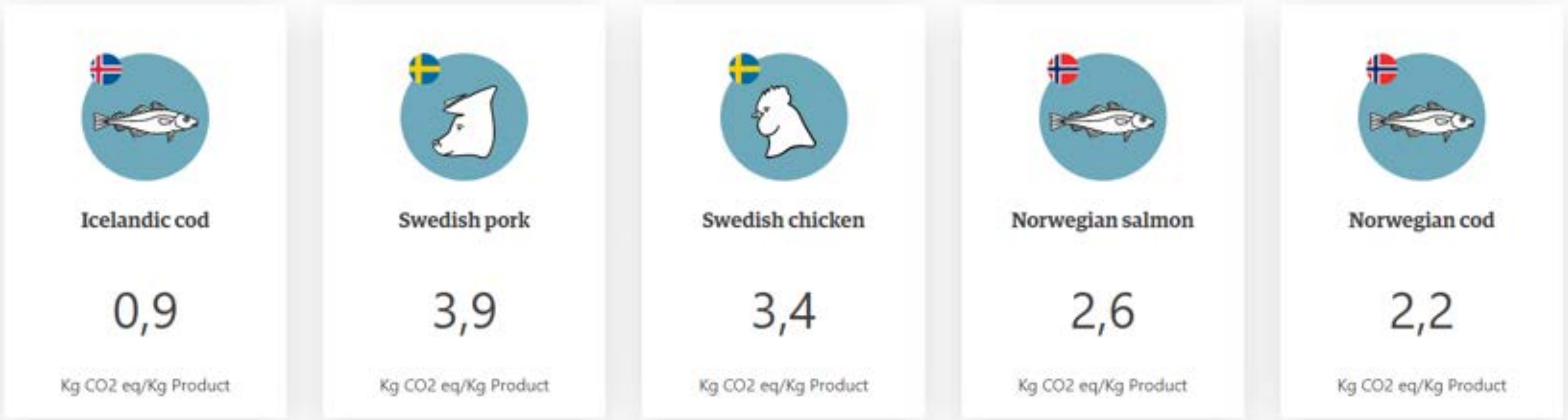
Sustainability – finding the right balance

Icelandic Act on Fisheries Management, Article 1: …*The objective of this Act is to promote the* <u>*conservation*</u> *and* <u>*efficient utilization*</u> *of fishing stocks, thereby ensuring* <u>*stable employment and settlement throughout Iceland…*</u>



Carbon footprint of Icelandic fish

The following is the carbon footprint of Icelandic cod in comparison to selected protein providers; the results do not include transportation.



Source: **Matís 2014, Life Cycle Assessment on fresh Icelandic cod loins**

Social licence to operate

Community

Investors

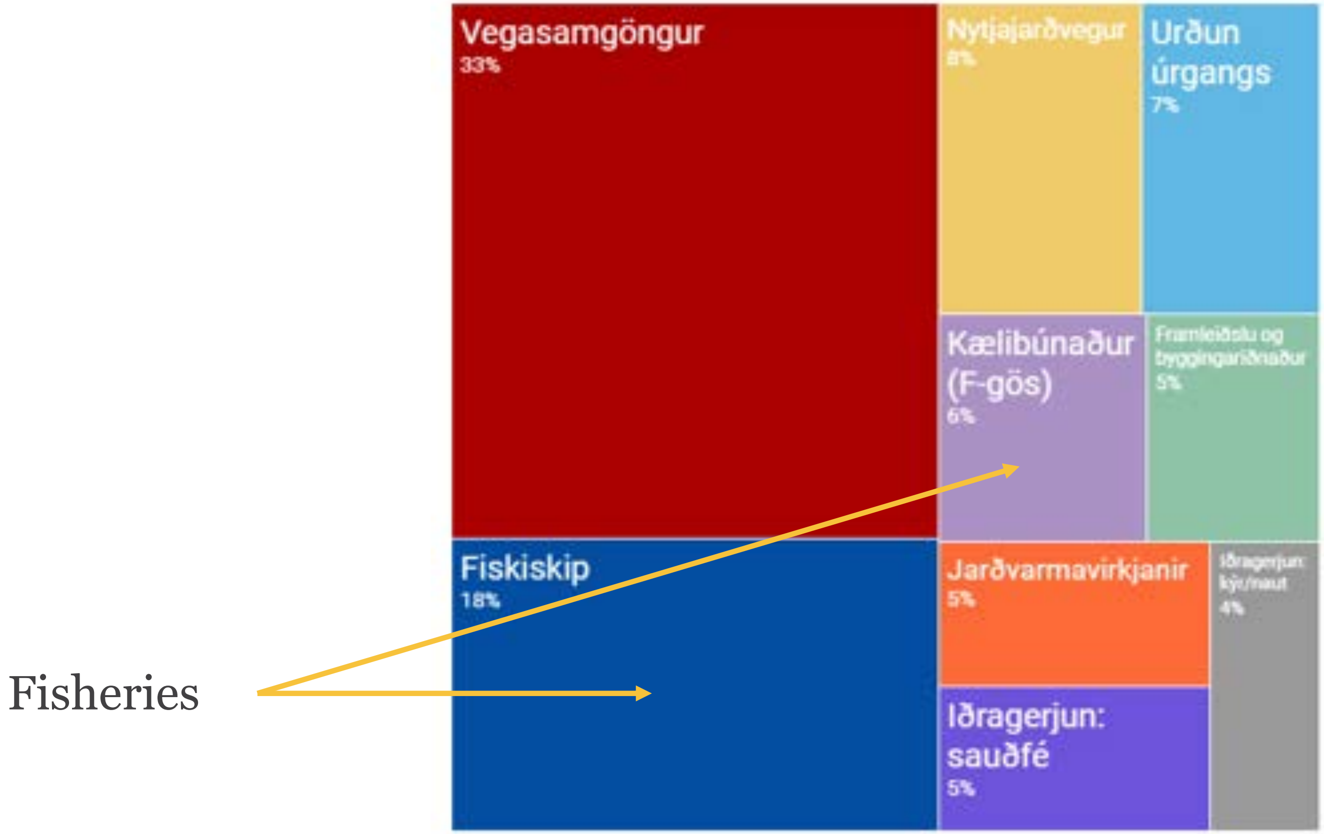
Employees

Buyers/ consumers

Government

Emission in Iceland

Non ETS emission by sector in Iceland (excluding LULUCF)



Source: Environmental agency Iceland

CSR policy –
How did we do it?

Voices of stakeholders

In order to explore what the fishing industry can do better and to increase understanding and trust, Fisheries Iceland (SFS) held four public meetings during late winter [of 2020] on issues relating to the industry. The meetings addressed transparency, environmental issues, social gains and innovation.




Workshop

CSR policy

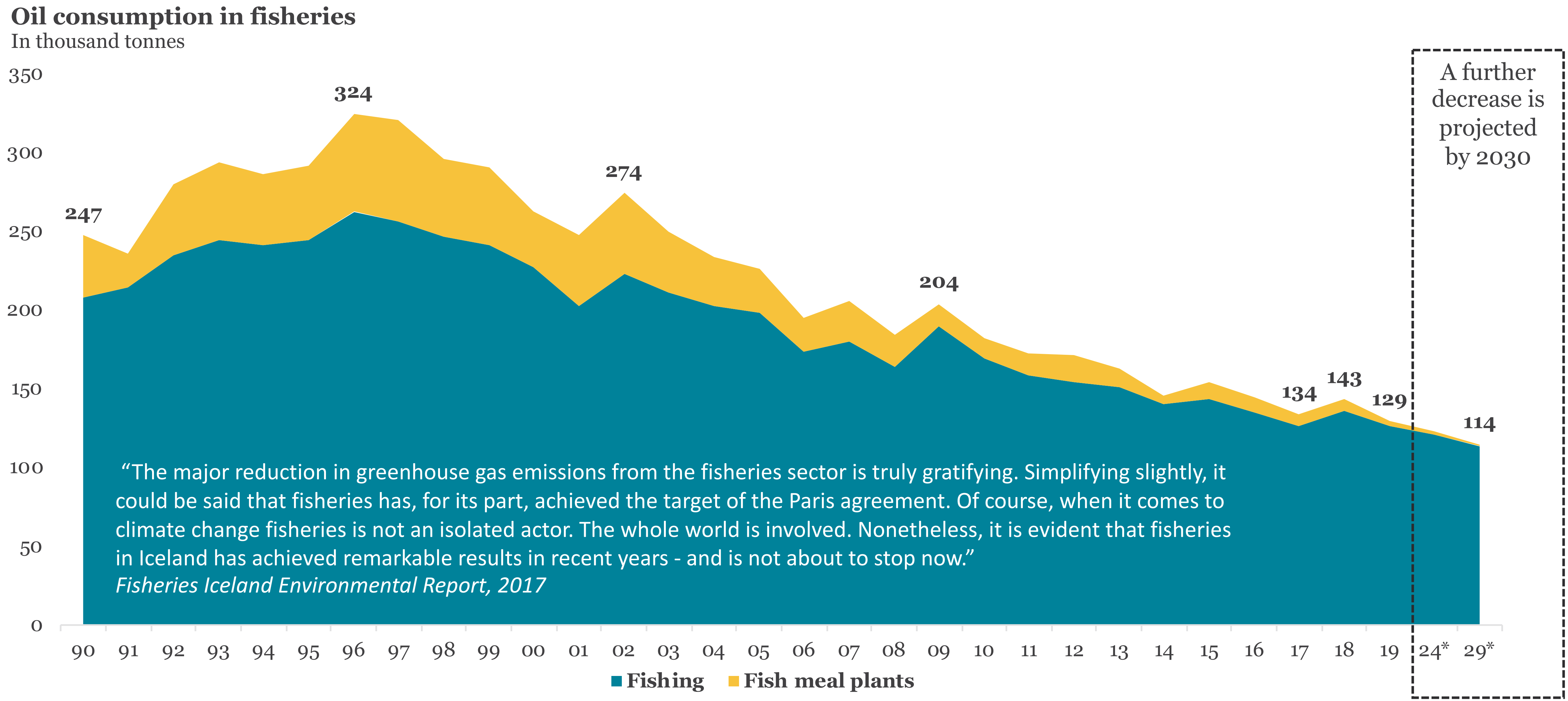
csr.sfs.is

“Icelandic fisheries companies take their responsibilities seriously as food manufacturers and as pillars of the economic prosperity for the Icelandic nation. Companies within Fisheries Iceland have established a social responsibility policy that is based on the UN Sustainable Development Goals.”

csr.sfs.is

How sustainable fishing has led to less oil consumption and added value

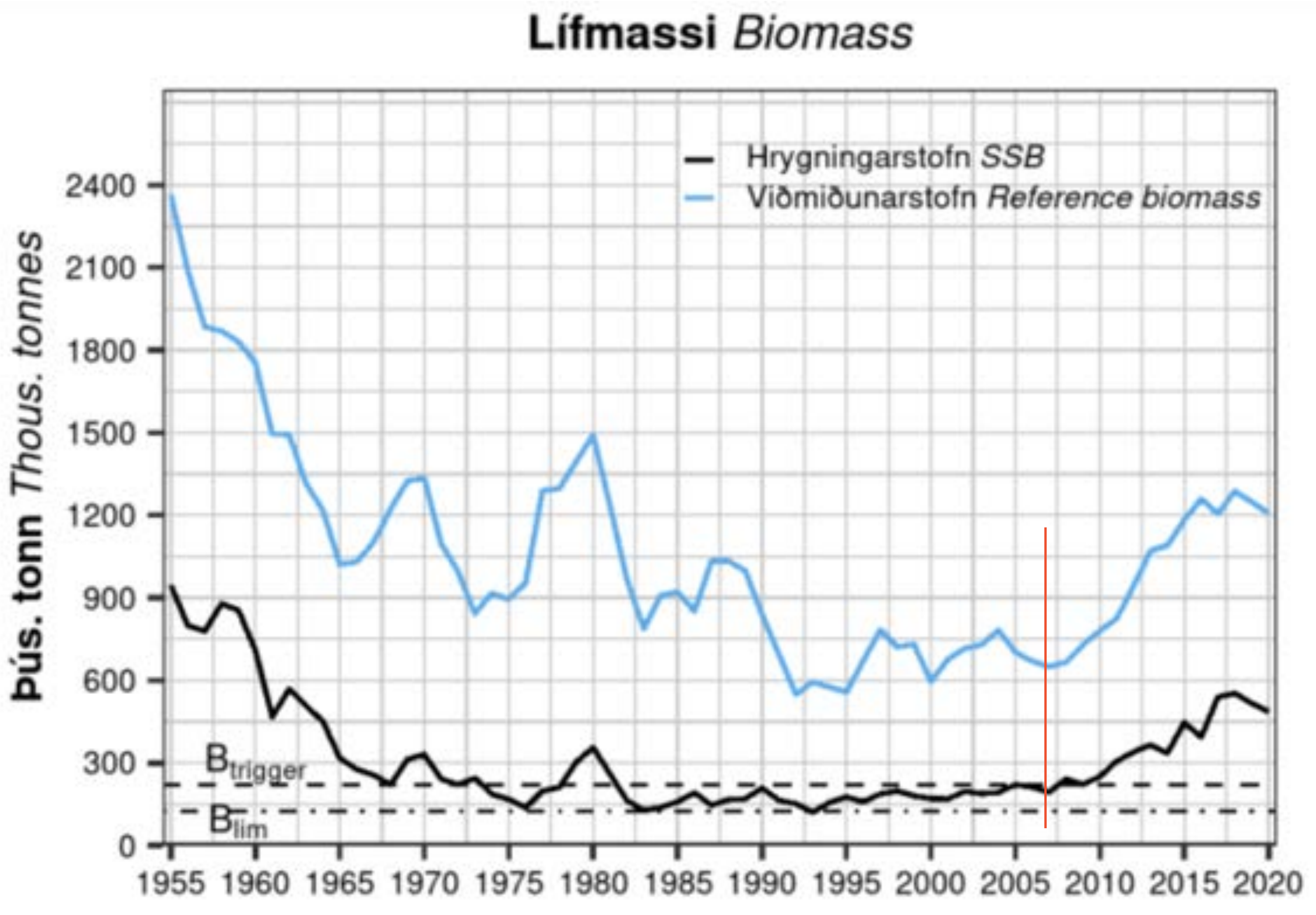
Sustainability – reaping the harvest



Source: National Energy Authority, Energy Forecast Committee 2016 end the Association of Icelandic Fishmeal Producers

The story of the cod

- Fisheries management and consolidation is the main reason for decreased oil consumption
- Larger fishing stocks = easier to catch the fish = less oil consumption



Then and now

1980 2.400 tonn

2016 3.200 tonn

CPUE - Catch per unit effort

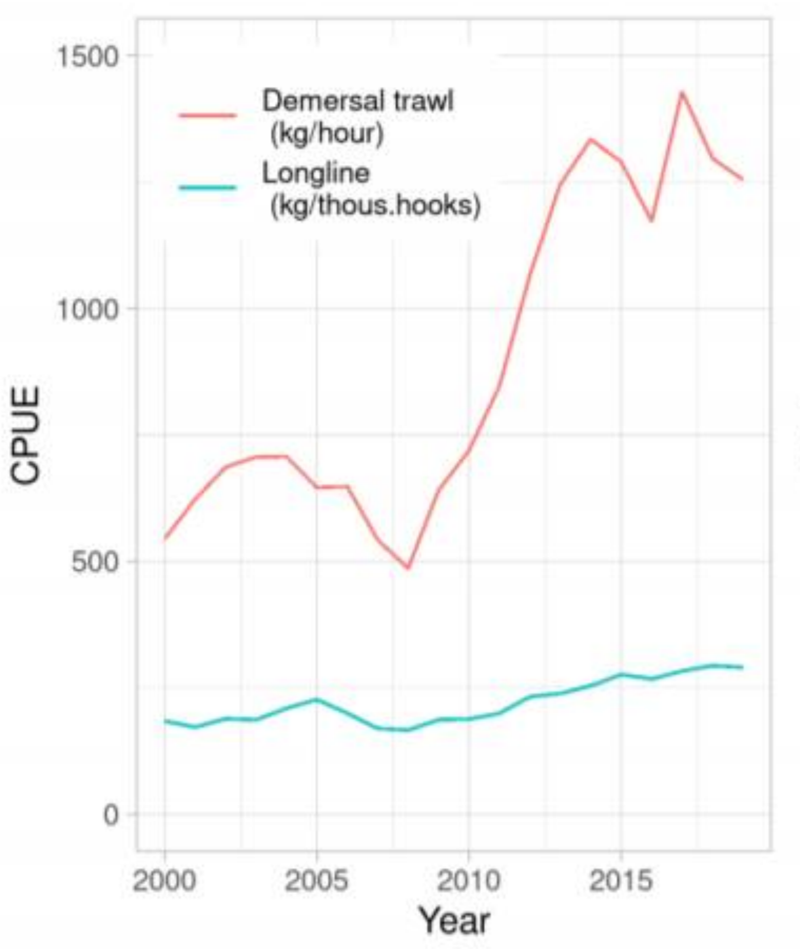


Figure 8. Cod. Non-standardised estimates of CPUE (left) from demersal trawl (kg/h) and longline (kg/1000 hooks).

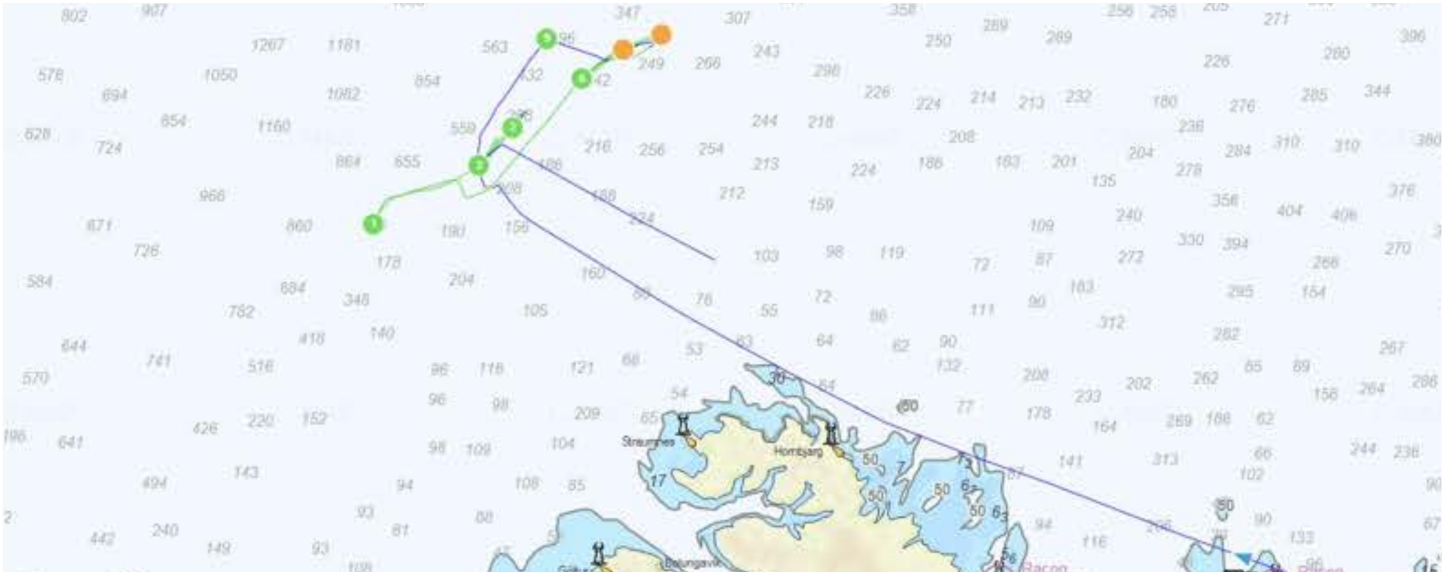
Source: Marine and freshwater research institute https://www.hafogvatn.is/static/extras/images/01-cod_tr1206998.pdf

Icefish trawler

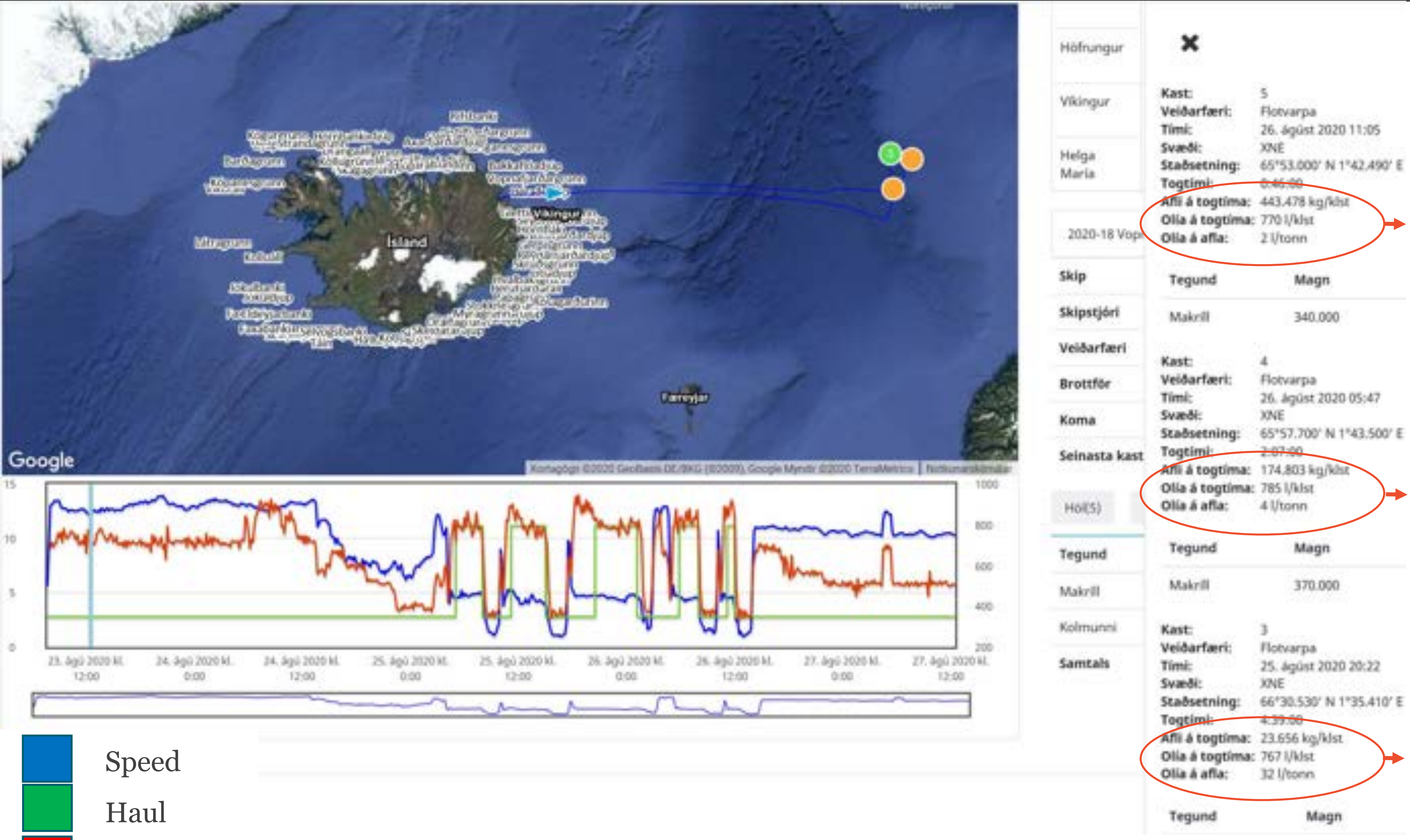
Speed

Haul

Fuel consumption



Pelagic vessel



Speed

Haul

Fuel consumption

Translation:

Catch per hour when towing:**443 tons/hour**
Fuel per hour when towing: **770 liters/hour**
Fuel per catch: **2 liters per ton**

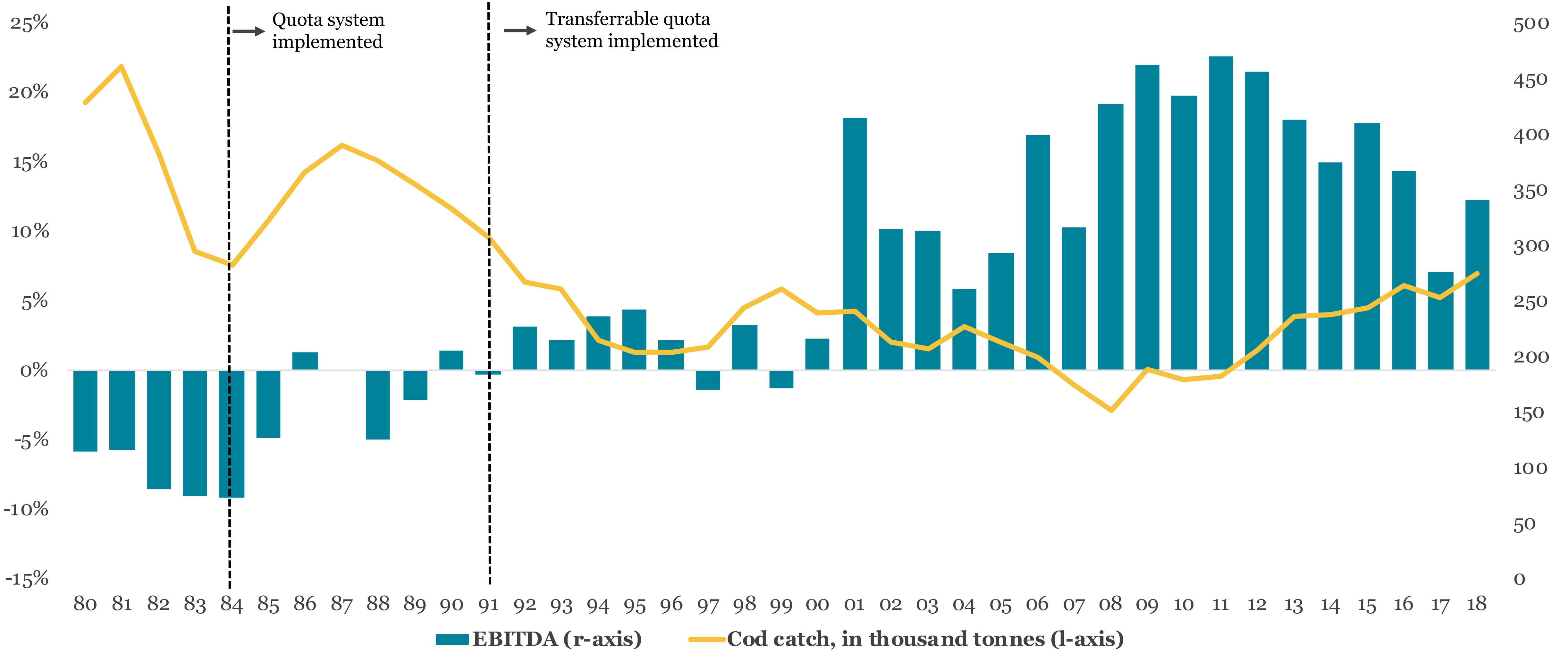
Catch per hour when towing:**174 tons/hour**
Fuel per hour when towing: **785 liters/hour**
Fuel per catch: **4 liters per ton**

Catch per hour when towing:**23 tons/hour**
Fuel per hour when towing: **767 liters/hour**
Fuel per catch: **32 liters per ton**

Final haul uses 16 X more fuel per catch compared to the first haul

Sustainability – not a quick fix

Cod catch and earnings in Icelandic seafood industry



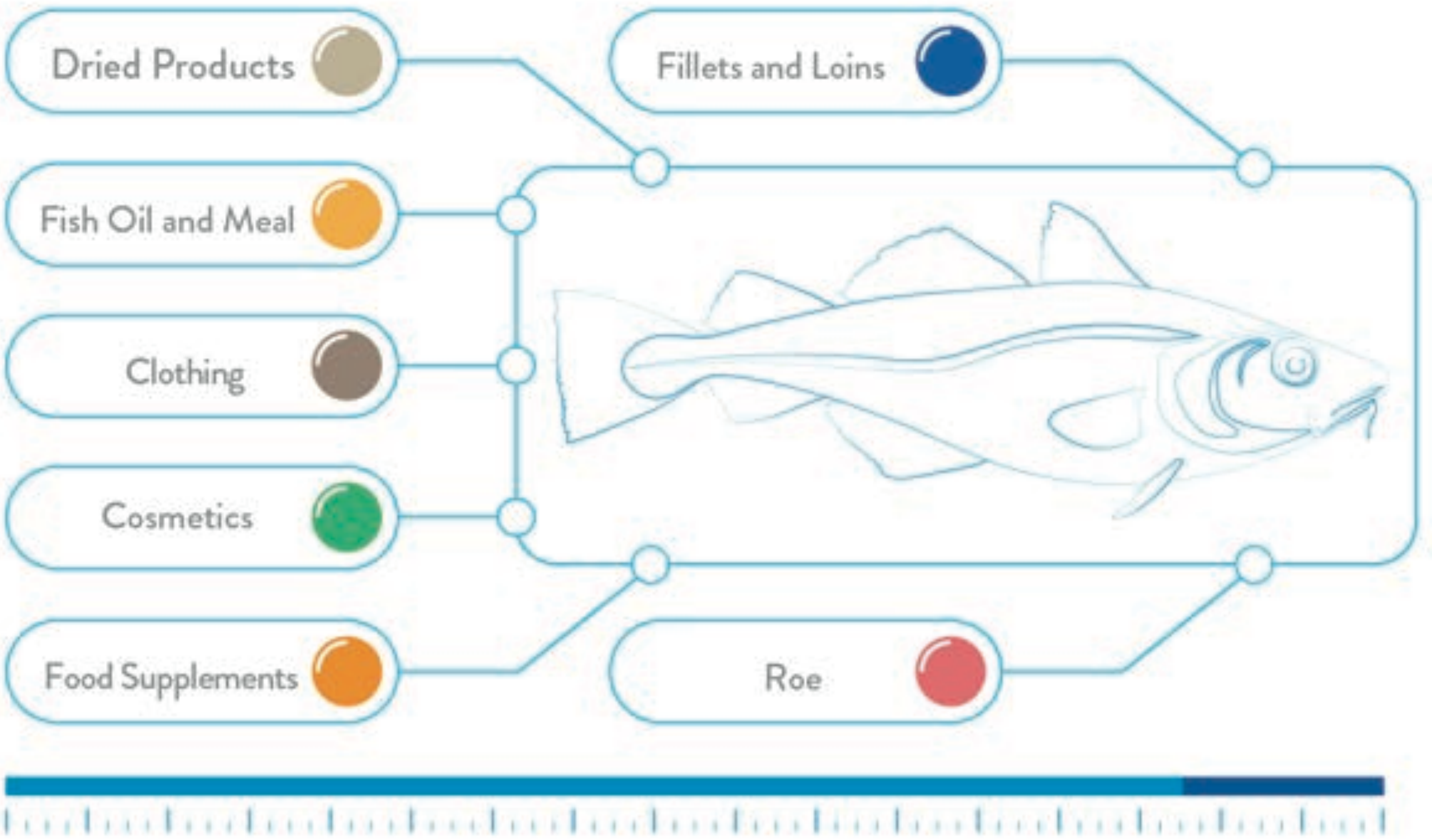
Source: Statistics Iceland

What happens when you put a cap on fishing

Incentive for innovation

Increased utilation of the fish

Value creation



Further emission reduction

What does a CO_2-neutral fishery look like?

What does a CO2-neutral fishery look like?

For a CO2-neutral fishery to materialize there are two ways

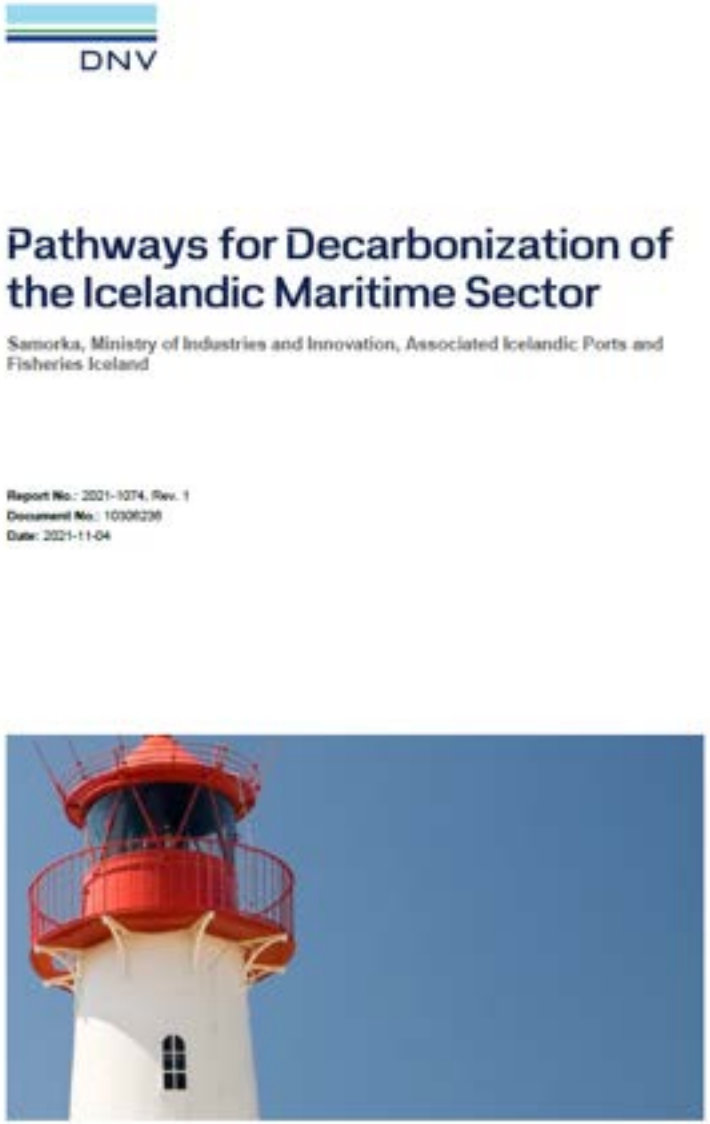
1. measuring our carbon footprint

2. reducing emissions even further

3. offsetting and binding carbon

Or:

Transition away from fossil fuel


DNV

Pathways for Decarbonization of the Icelandic Maritime Sector

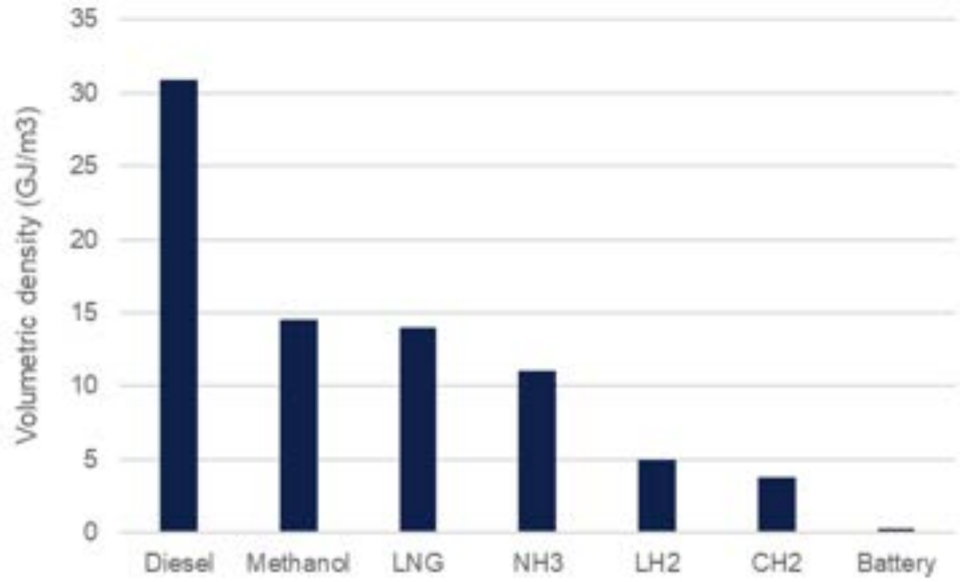
Samorka, Ministry of Industries and Innovation, Associated Icelandic Ports and Fisheries Iceland

Report No.: 2021-1074, Rev. 1
Document No.: 10306238
Date: 2021-11-04

Barriers

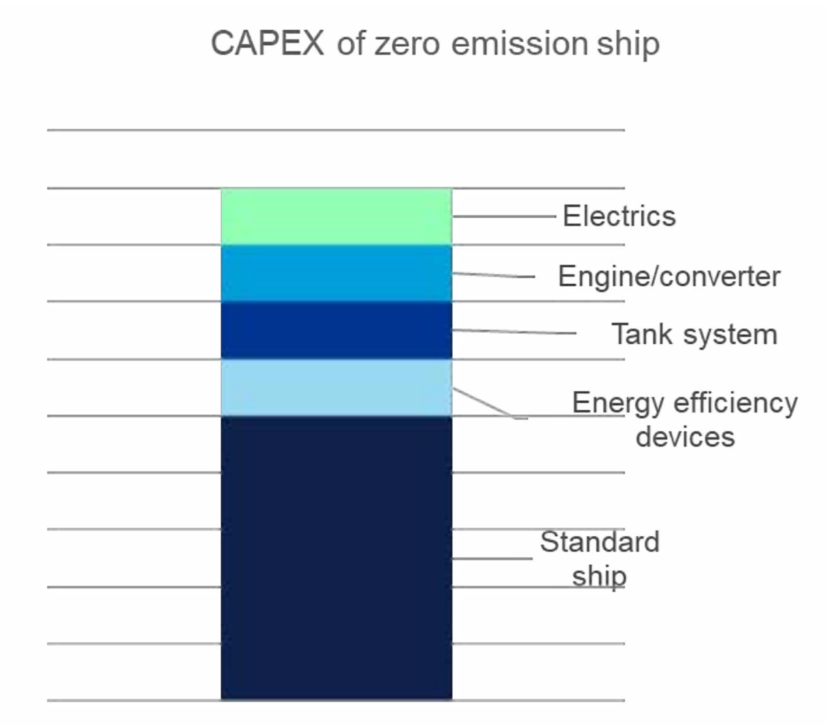
/ Energy storage
/ Energy density
/ Safety
/ Energy production and supply
/ Infrastructure
/ Technical maturity
/ Costs

Volumetric energy density of energy carrier including containment



Heimild: DNV, Pathways for Decarbonisation of the Icelandic Maritime Sector

Zero carbon emission ship



50 % - 100 % additional CAPEX?

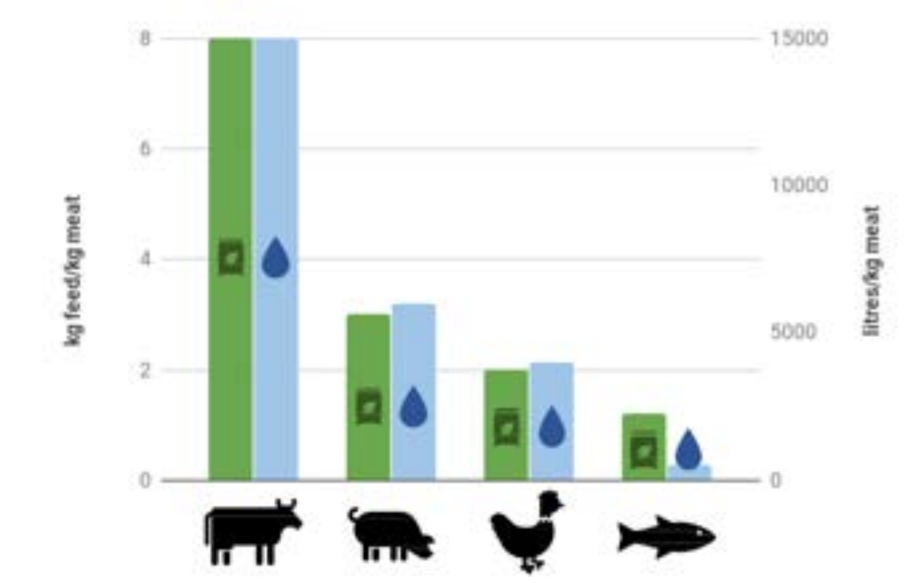
Source: DNV, Pathways for Decarbonisation of the Icelandic Maritime Sector

Moving forward

Nordic Climate Change Forum for Fisheries and Aquaculture

AquaCircle

- ”Technical challenges in reducing CO_2 emissions in Aquaculture”, Jesper Heldbo



Danish Recirculation Technology
- the future of Aquaculture now

Challenges – now and ahead.

1. Acculture is key to ensure a food secure future for all.
2. Too few domesticated species.
3. Feed development needed
4. LCA
5. Technical

REMEMBER

- Aquaculture products are the most efficient and responsible way to produce animal protein for human consumption!
- Why?
- Because the fish is weightless in the water – not spending energy in counteracting the gravity.
- Because the fish is poikilotherm – not spending energy to keep a certain fixed body-temperature.
- Saved energy used for growth – that's why

- CONCLUSION: To reduce the overall greenhouse gas contribution from food production: FARM MORE SEAFOOD

FAO: Aquaculture to double production towards 2050

AquaCircle

- Global consumption of fish has increased by 122 % since 1990 and aquaculture now accounts for more than 50%.
- Despite this, Seafood count for only 17% of the worlds food production in 2021.
- To feed the growing population 70% more protein will be needed in 2050.
- Due to climate change, it is not conceivable that this expansion can take place on land alone.
- Since most wild fish stocks have been fished to the sustainability limit or above, the expansion can only come from aquaculture

Salmon-Salmon-Salmon
SOS

AquaCircle

- Salmon & trout breeding is relatively easy, and they have become commodities as customer in developed countries have them in high demand.
- Farming “top-predators” will eventually reach natural boundaries as they have high requirements for content in the feed.
- Although, it is through working with these species that we in the western world have developed industrial aquaculture.
- We need to domesticate new species, also species at lower trophic level, avoiding dependencies on delivery of eggs/fry from the wild.

Feed development

AquaCircle

- As feed can account for 50 to 70% of opex, it is understandable that fish farners are putting pressure on producers to cheapen the feed.
- Development of new feed will, among other factors, be directed by new species, availability of ingredients, the digestibility and price of these, but also the carbon-footprint.
- It is well-known that the marine ingredients (catching forage fish and turning them into meal & oil and the actual feed manufacturing) creates the greater part of the carbon-footprint of todays fish-feed.
- Fish on lower trophic level has a limited need for marine ingredients.

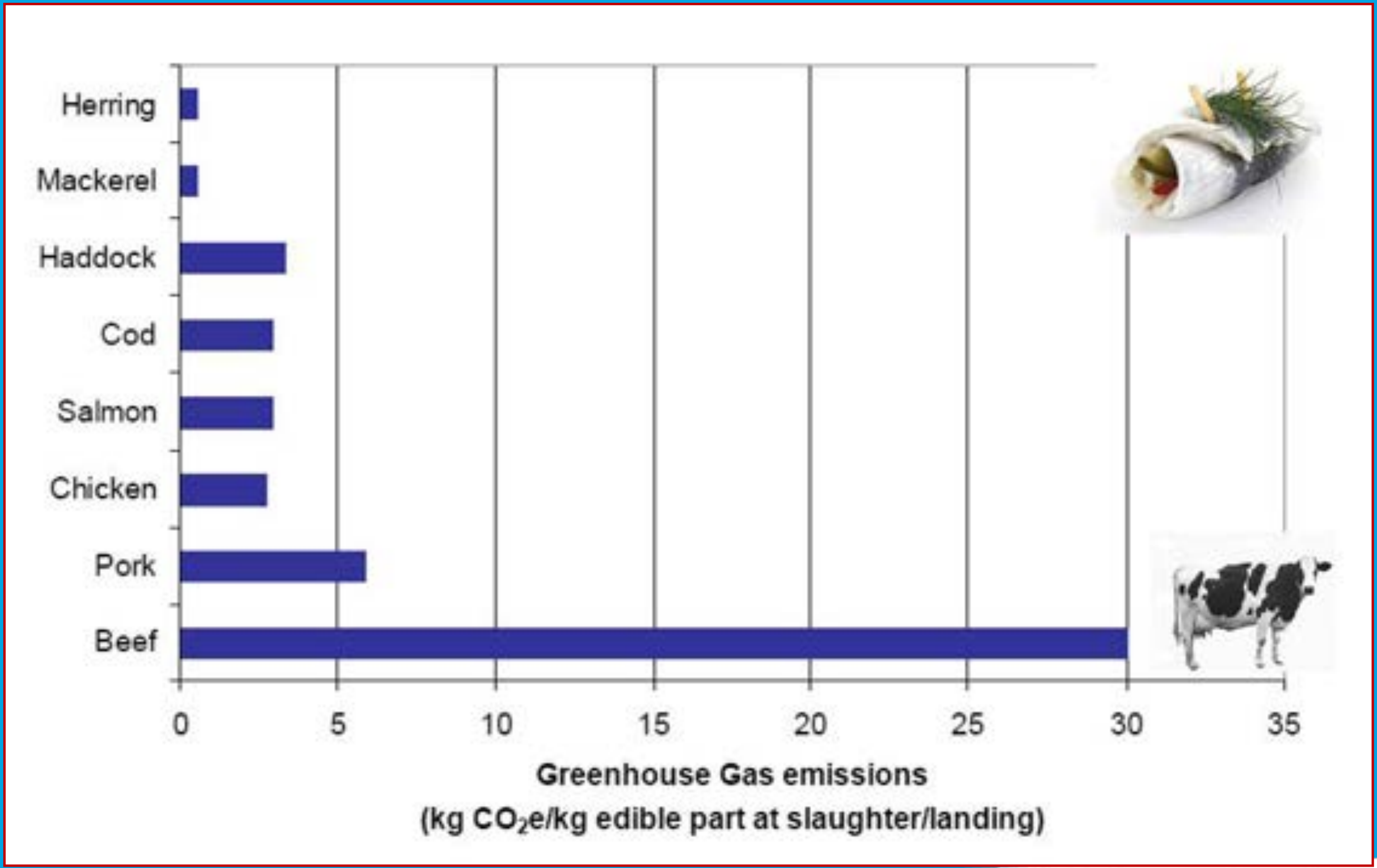
Life Cycle Analysis/Assessment [LCA]

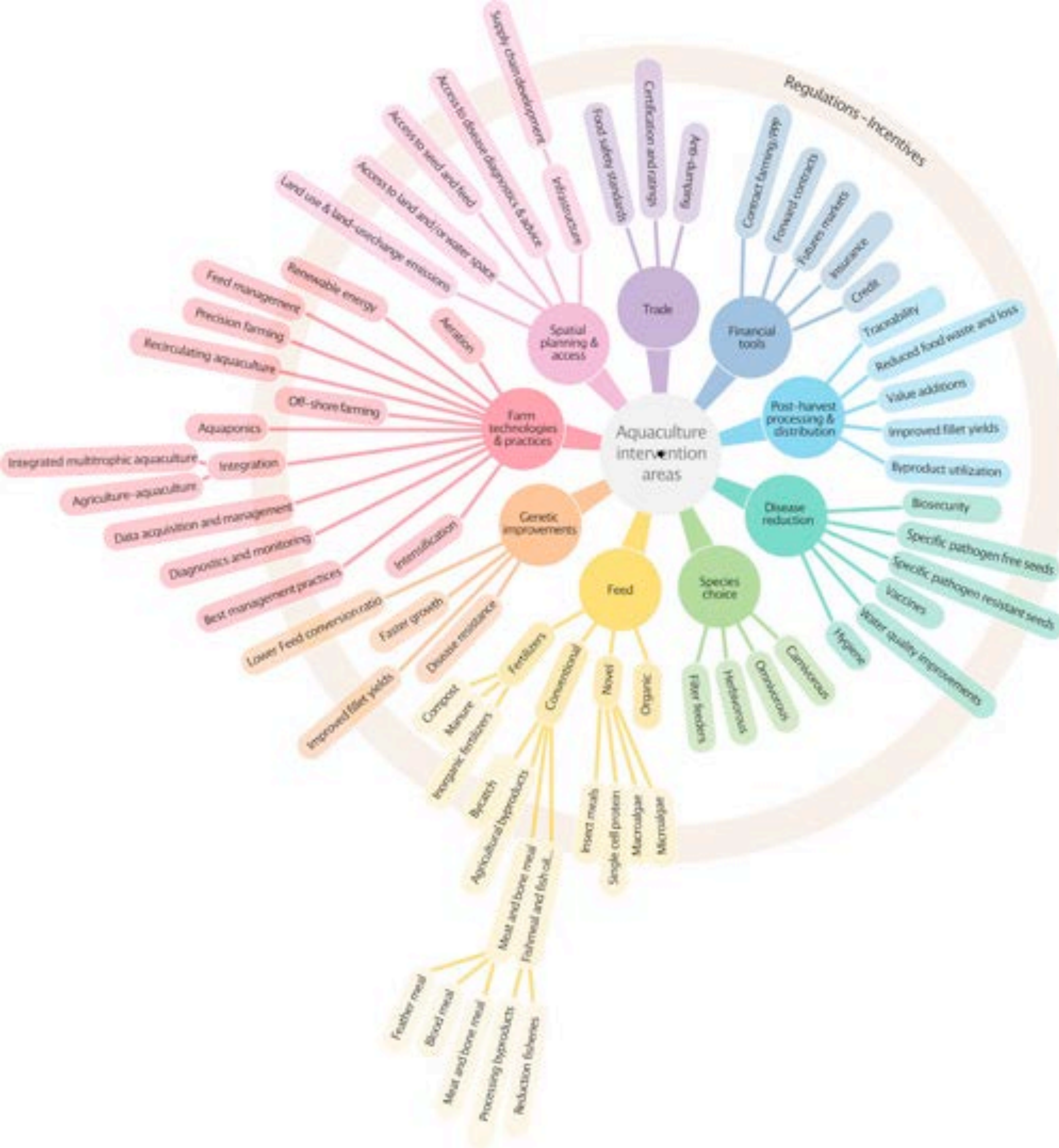
AquaCircle

- A rapidly expanding aquaculture sector demand sustainable feed with a low carbon-footprint – and documentation for these factors.
- In the hunt for both lower carbon footprint and cheaper raw materials, feed manufacturers are testing a wide range of new and local ingredients e.g. insects, algae, new cereals to be included in recipes. Time will show if these ingredients will impose the carbon-footprint negatively or positively.
- Several feed companies have now started to indicate LCA on their products.
- The aquaculture industry can therefore, in principle, take the manufacturers' LCA information and add the CO_2 equivalents that their own production produces

Greenhouse Gas Emissions

AquaCircle





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LCA of aquaculture systems

Danish Recirculation Technology
- the future of Aquaculture now

Red tape

AquaCircle

- Technical challenges are often generated in the surrounding society.
- There are confusingly many different ways to conduct, and present LCA.
- EU Commission are working on a standard for Product Environmental Footprint (PEF).
- In the future PEF shall allow customers to make a knowledge based decision when buying.
- This calls for the aquaculture sector to be engaged and work for standardized way to document LCA for marine and freshwater aquaculture to be added to the feed LCA – to give a full picture or PEF.

Artificial Intelligense Buzz-word or New tools

AquaCircle

- AI is rippling through the aquaculture industry, promising greater efficiencies and insights, as well as investor interest.

Saving energy in de-gassing

AquaCircle

- Degassers are used to strip CO_2. The efficiency of the degassing is pH, salinity and temperature dependant. Formulas to calculate percentage distribution of CO_2, bicarbonate and carbonate in water can be implemented in an algorithm. Data can be collected digitally from sensors at the facilities.
- Degassed CO_2 is removed by ventilators running in full power, regardless of the CO_2 concentration. Therefore, the ability to manage CO_2 removal can reduce energy and an algorithm can manage pumps and ventilators - finding the most economic point in energy consumption to possible degassing demand.
- An automated process control managed by the algorithm can result in at least a 10% reduction of energy used and consequently reduction of CO2-equivallents (depending on the energy-source – fossil or renewable

On-line surveillance 1

AquaCircle

- In Marine farming cameras has long been used for surveillance of feeding – in the start manual-based – a person following the feeding on monitors and stopping the feeding when it seems that the fish stops eating.
- Underwater cameras are quite expensive and demands regular removal of fouling organisms and other maintenance.
- In RAS (land-based in-door facilities) it is more convenient (and cheaper) to have cameras above the water surface. Build-in data-handling CPU's ensures that the amount for further processing does not become unmanageably large.
- Parallel to cameras hydrophones (sub-surface) collect sounds in the tanks.

On-line surveillance 2

AquaCircle

- Build-in AI in a production management system will receive data from cameras, hydrophone and standard sensors monitoring water-quality-parameters, combining data, also including historic data, and give Warnings/ alarms/ recommendations to the staff – when needed.
- Automatic stop feeding when video and sound indicates less interest for feeding among fish.
- Fish-dimensions – for calculating the biomass and compare with growth table, prognosis etc.
- Recording normal behaviour of the fish in the tank and alarming when anything deviates from normal behaviour.

Digital management

AquaCircle

- Using tools like this will give the farmer the following advantage:
- Saving 5-10% of feed (normally lost)
- Documenting fish welfare
- Documenting carbon footprint.
- A production of portion sized trout may save app. 7.5 kg CO_2-EQ per Kg fish produced – using this tool.

Danish Recirculation Technology
- the future of Aquaculture now

Further possibilities to reduce the carbon-footprint

AquaCircle

- Of course, the easy way out is to buy Carbon quotas.
- Stop flying fish around the globe.
- Establish production facilities at or near the market = RAS in vicinity of dense populated areas.

AquaPort – The future fish-farm

- Part of a green transition for a whole municipality. An integrated part of an industrial-energy-cluster with symbiosis an synergy effects.
- Zero-discharge and climate neutral production of fish.

BUSINESS MODEL IS BUILT ON THE FOLLOWING

AquaCircle

USE OF THE LATEST CLEANING TECHNOLOGY FOR RAS

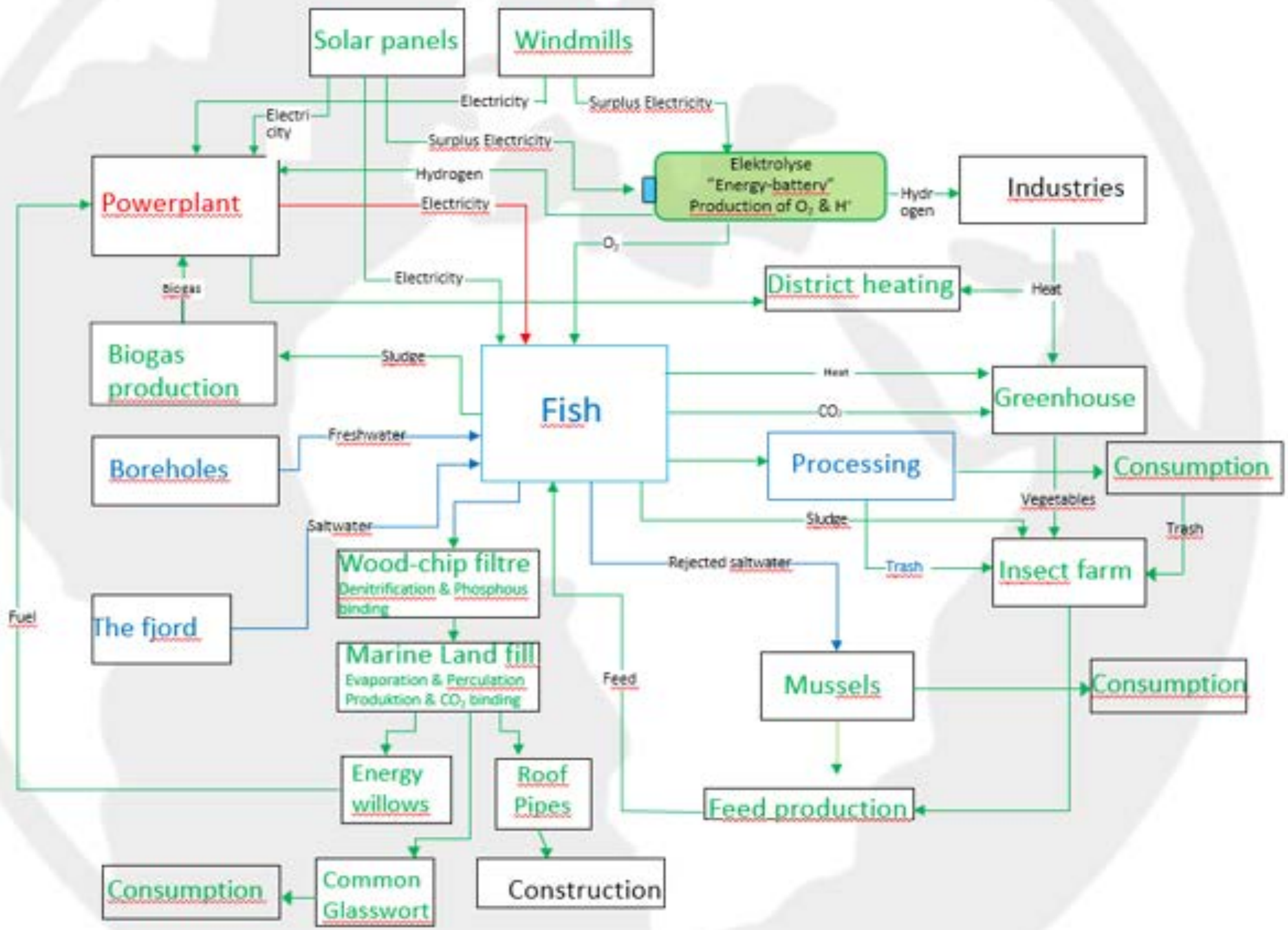
0 DISCHARGE TO RECIPIENT

CO_2 NEUTRAL PRODUCTION

RECYCLING OF COLLECTED NUTRIENT SALTS FOR BIOMASS PRODUCTION

90 hectare: Evaporation, Perculation & Carbon-capture

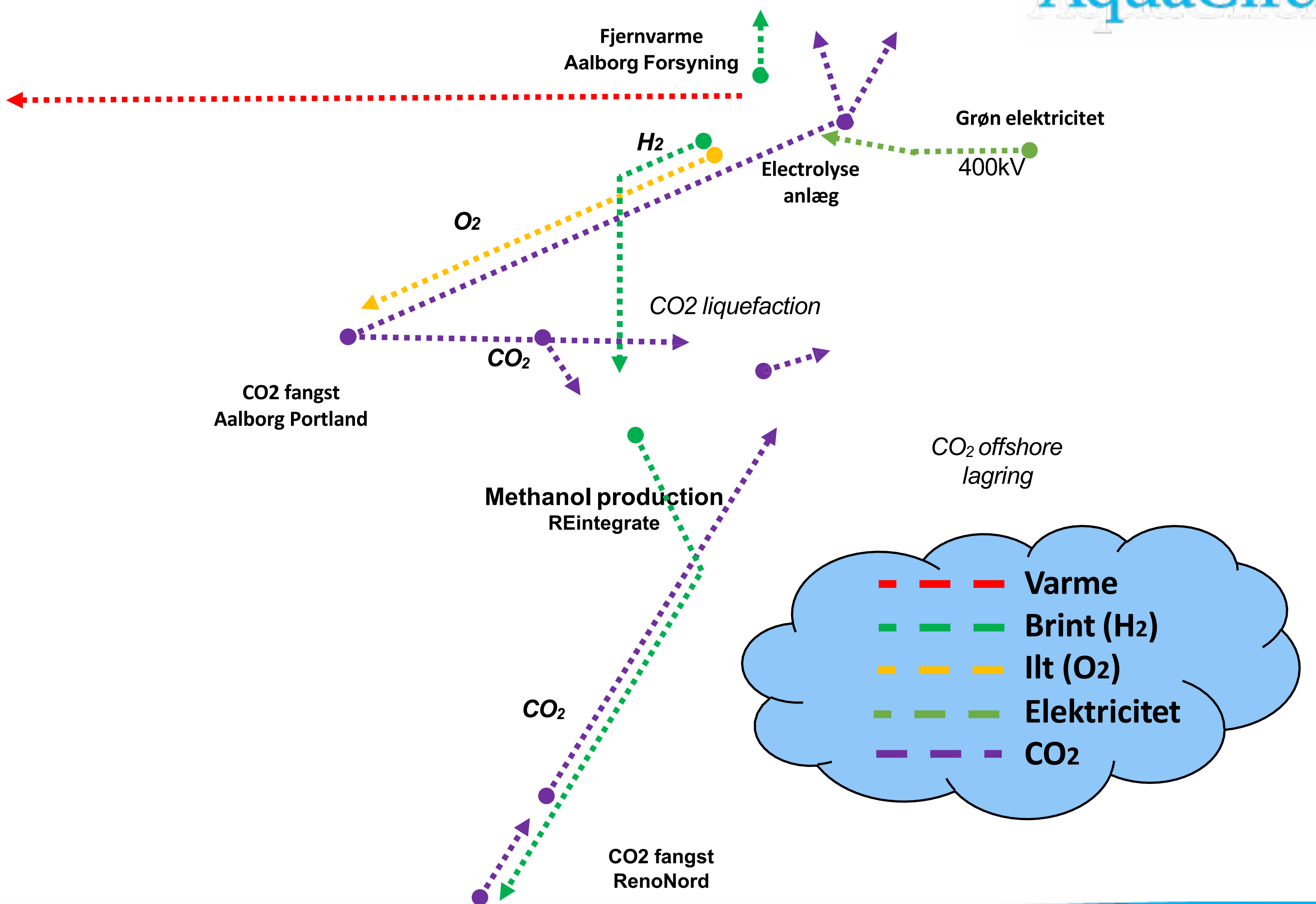
AquaCircle



Solar panels
Windmills
Electricity
Surplus Electricity
Electri city
Surplus Electricity
Hydrogen
Elektrolyse "Energy-battery" Production of O_2 & H^+
Hydr ogen
Industries
Powerplant
Electricity
O_2
Electricity
District heating
Heat
Biogas
Biogas production
Sludge
Fish
Heat
Greenhouse
CO_2
Boreholes
Freshwater
Processing
Consumption
Vegetables
Saltwater
Sludge
Trash
Wood-chip filtre
Denitrification & Phosphous binding
Rejected saltwater
Trash
Insect farm
Fuel
The fjord
Marine Land fill
Evaporation & Perculation
Produktion & CO_2 binding
Feed
Mussels
Consumption
Energy willows
Roof Pipes
Feed production
Consumption
Common Glasswort
Construction

AquaCircle

FISH-POWER TO X



- Thank you for the opportunity to speak
  - and for your time

10 December 2021

Climate change and the effects on fisheries management

Nordic Climate Change Forum for Fisheries and Aquaculture
Presentation by Dr. Jón Þrándur Stefánsson

Government of Iceland
Ministry of Industries and Innovation

The starting line

Is there a need to change fisheries management to meet or adjust to the climate challenges?

Agreement on the Platform for the Coalition Government of the Independence Party, the Left Green Movement and the Progressive Party

We want to create a consensus on the utilisation of resources. **We emphasise combating climate change by reducing emissions, energy conversion and green investment**. At the same time, it is our task to prepare Icelandic society for increased technological advances, while ensuring further improvement in living standards for all generations. Emphasis will be placed on balancing economic, social and environmental factors.

The new coalition government target

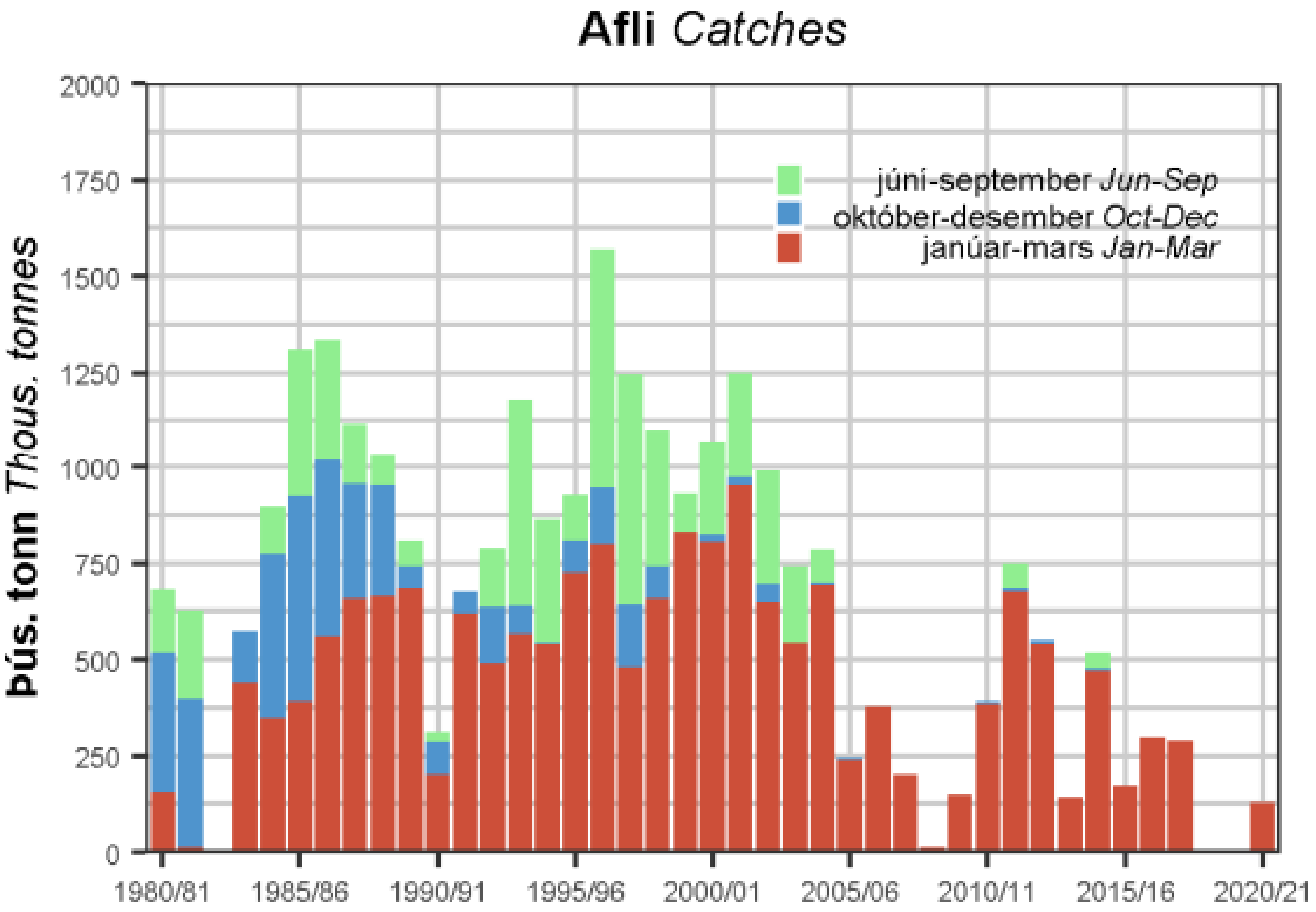
Independent target to reduce Icelandic greenhouse gas emissions by **55%** compared to 2005.

10 December 2021

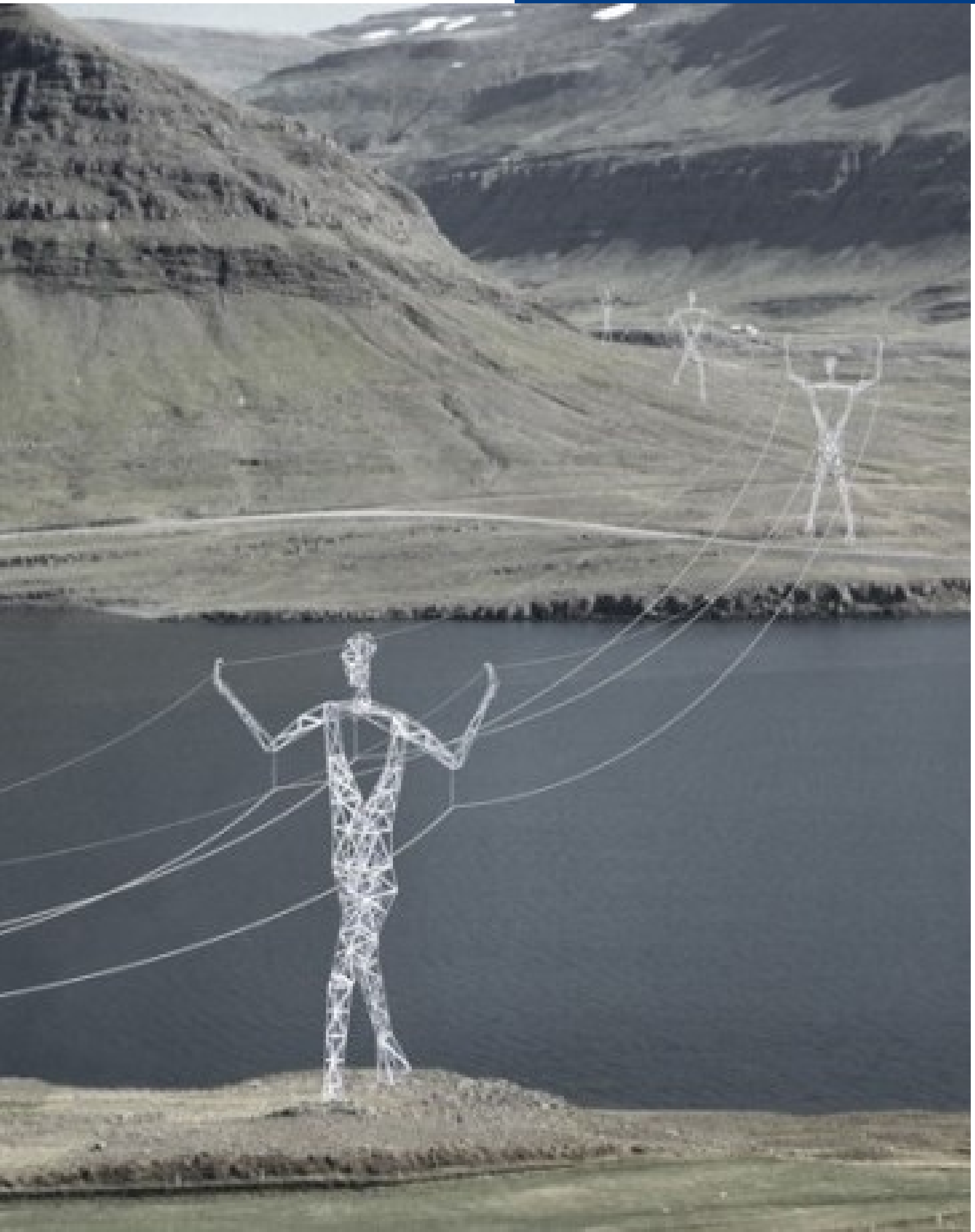
The capeline catch case story!

Government of Iceland
Ministry of Industries and Innovation

What will be the climate impact of the 904.200 tons capelin catch quotas for the 2021/22 season in Icelandic waters?



This will increase CO_2 emissions and likely reversing the reduction trend at least temporarily due to higher energy needs for the catch.



Limiting the access to electrical power

The National Power Company of Iceland, announced that it would immediately reduce the delivery of electricity to large users including to fish meal factories.

This decision is expected to have a major effect on fish meal factories, which will likely have to increase their use of oil of 54.400 tons of CO_2 equivalents.

This will drastically increase the carbon footprint of Icelandic fisheries, in addition to increasing cost to the fish meal factories.

Source: News | Iceland Monitor | Wed 8 Dec 2021 | 11.22 GMT

10 December 2021

Back to the climate issues

Government of Iceland
Ministry of Industries and Innovation

Fisheries management in Iceland

Climate challenges are not addressed as **direct variables** in fisheries management.

However, fisheries management can in some cases potentially address climate challenges **indirectly** through other means.

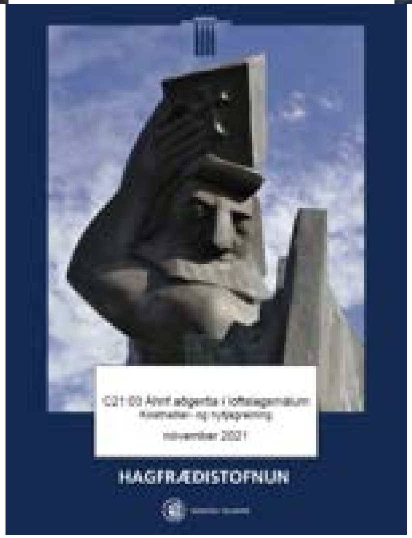
- Use of fishing gear
- Open fishing areas
- Types of vessels and requirements
- Allocation of TAC
- Resource rent/taxation

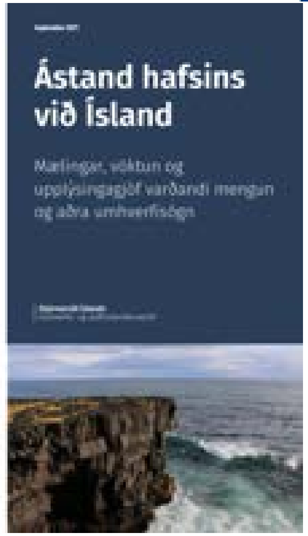
Considerations in fisheries management

An example of potential climate change challenges and migration patterns: Fisheries management and „new species“ disputes

- It is of vital importance that the coastal states, Iceland, Norway, the Faroe Islands, the EU, and the UK, reach an agreement on the management of mackerel fisheries, including the allocation of quotas, as soon as possible.
- The coastal states carry a joint responsibility for preventing overfishing from the stock and ensuring sustainable fisheries.
- All parties must all contribute to reaching an agreement.
- This dispute needs to be resolved at the negotiating table in a civilized manner based on objective factors and the principles of sustainable fisheries.

Recent reports published on the issue






Græn skref í sjávarútvegi

Skýrsla starfshóps fjármála- og efnahagsráðherra

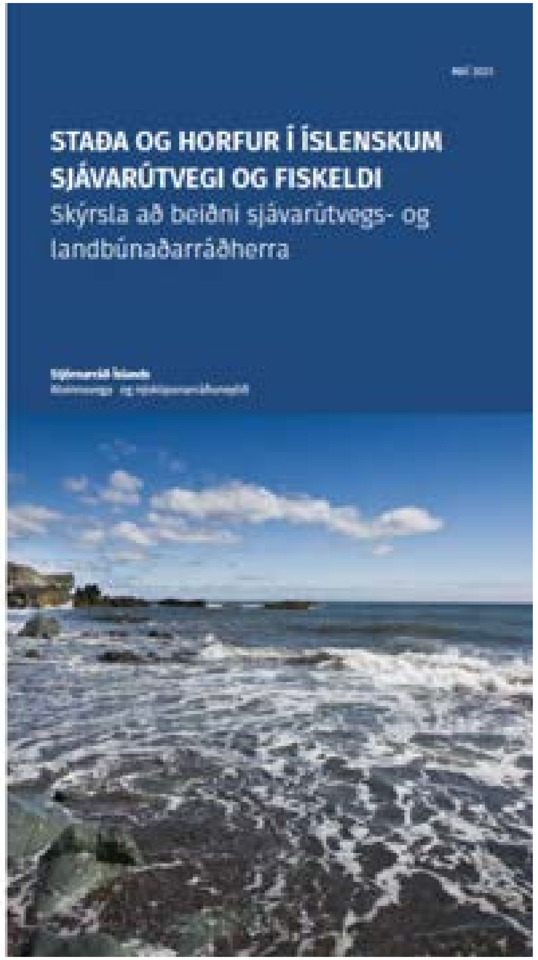
Green steps in the fishing industry

- Some measures to be considered in order to increase efficiency and reduce energy use
  - Changes in catch
  - Changes in fisheries management e.g. allocation of TAC to specific vessels
  - Changes in resource rent to promote more efficiency

„**Proposals** of the working group **for green steps in the fisheries sector will be followed up on**, to accelerate as much as possible energy conversion in the fisheries sector.

Agreement on the Platform for the Coalition Government of the Independence Party, the Left Green Movement and the Progressive Party

The state and the outlook for the Icelandic Seafood Sector



- New resources to be utilized
  - Opportunities in aquaculture
  - Opportunities considering the catch and utilization of mesopelagic fish species

The state of the ecosystem and the sea and the outlook for next decades

- Regulatory challenges
  - Changing migration patterns of joint fishing stocks
  - Changing distribution patterns of fishing stocks
  - Changing productivity in the sea
  - Changing temperatures and degree days
  - The effects of fishing gear

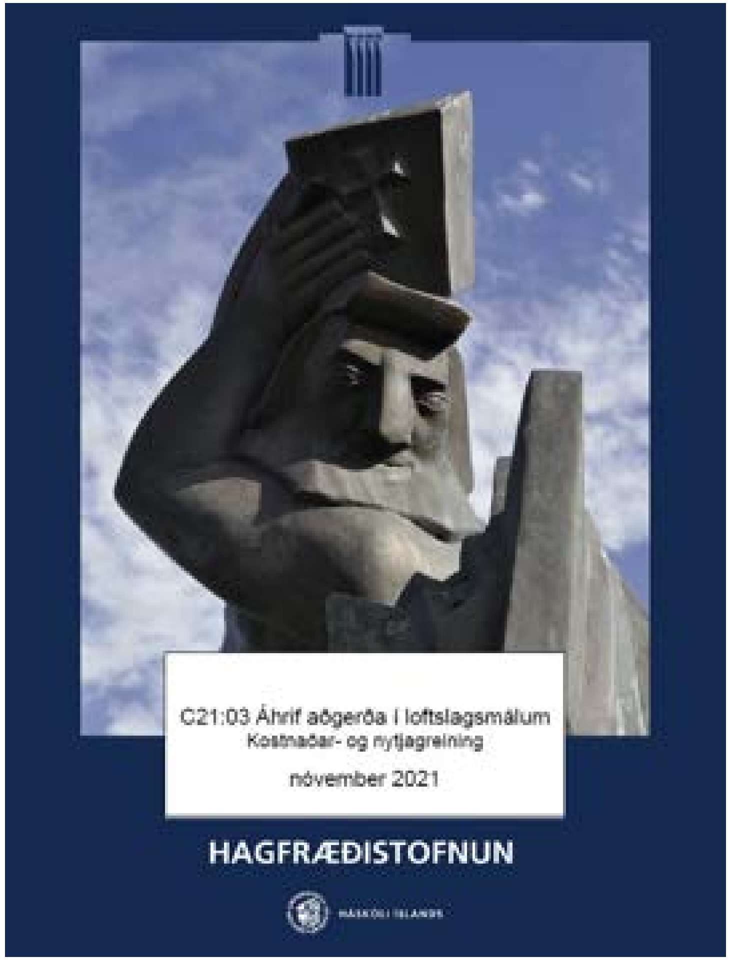
White Paper on Adaptation to Climate Change

- Fisheries management related issues
  - Ensure sufficient monitoring and assessment of the effects of climate change on stocks and distribution of exploitable marine stocks
  - MFRI funding and research
  - Risk assessment and assessment of the adaptation needs of the seafood and aquaculture industry

Fisheries management regulations in Iceland

The Fisheries management in Iceland is heavily regulated.

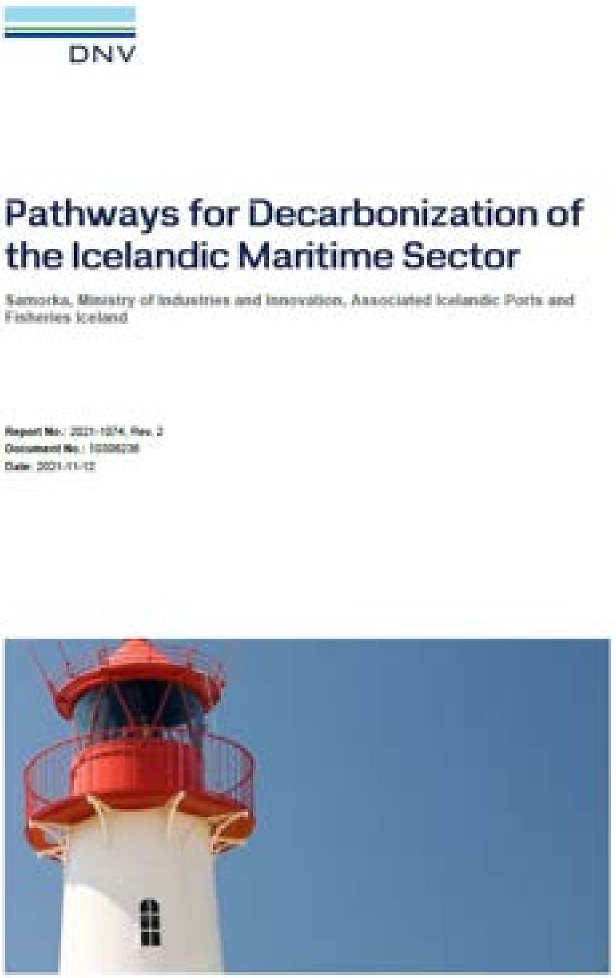
- We are in the early stages of forming new regulation to meet the climate challenges
- The recent reports will serve as guidelines in assisting on how to formulate the regulations



The Impact of Climate Actions Cost and benefit analysis

(work in progress)

- Work in progress on cost benefit analysis on various measure that are included in current action plan.
- No cost and benefit analysis directly related to fisheries management issues
  - Clear benefits to implement connections to the electrical grid for vessels in docking in harbour.
  - Clear benefits to convert fishmeal factories from using oil to electricity.



Pathways for Decarbonization of the Icelandic Maritime Sector

- Analysis of the current situation.
  - Current fleet, energy use, and CO_2 emissions
- Emission targets and drivers for the decarbonization
- Alternative marine fuels
- Scenarios towards 2050

Thank you for listening

ICES climate & fisheries

Mark Dickey-Collas

@DickeyCollas
@ICES_ASC

ICES CIEM

Science for sustainable seas

ICES science on climate going back to 1990s

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- 1992-2005 Cod and climate change activities
- 2010 onwards Climate Change Initiative with Pacific ICES
- 4 symposia on decadal variability of the North Atlantic (>40 years)
- 4 ICES/PICES/IOC/FAO symposia on effects of climate change on world's oceans.

Not so... tardy

https://doi.org/10.17895/ices.pub.5404 https://doi.org/10.17895/ices.pub.541

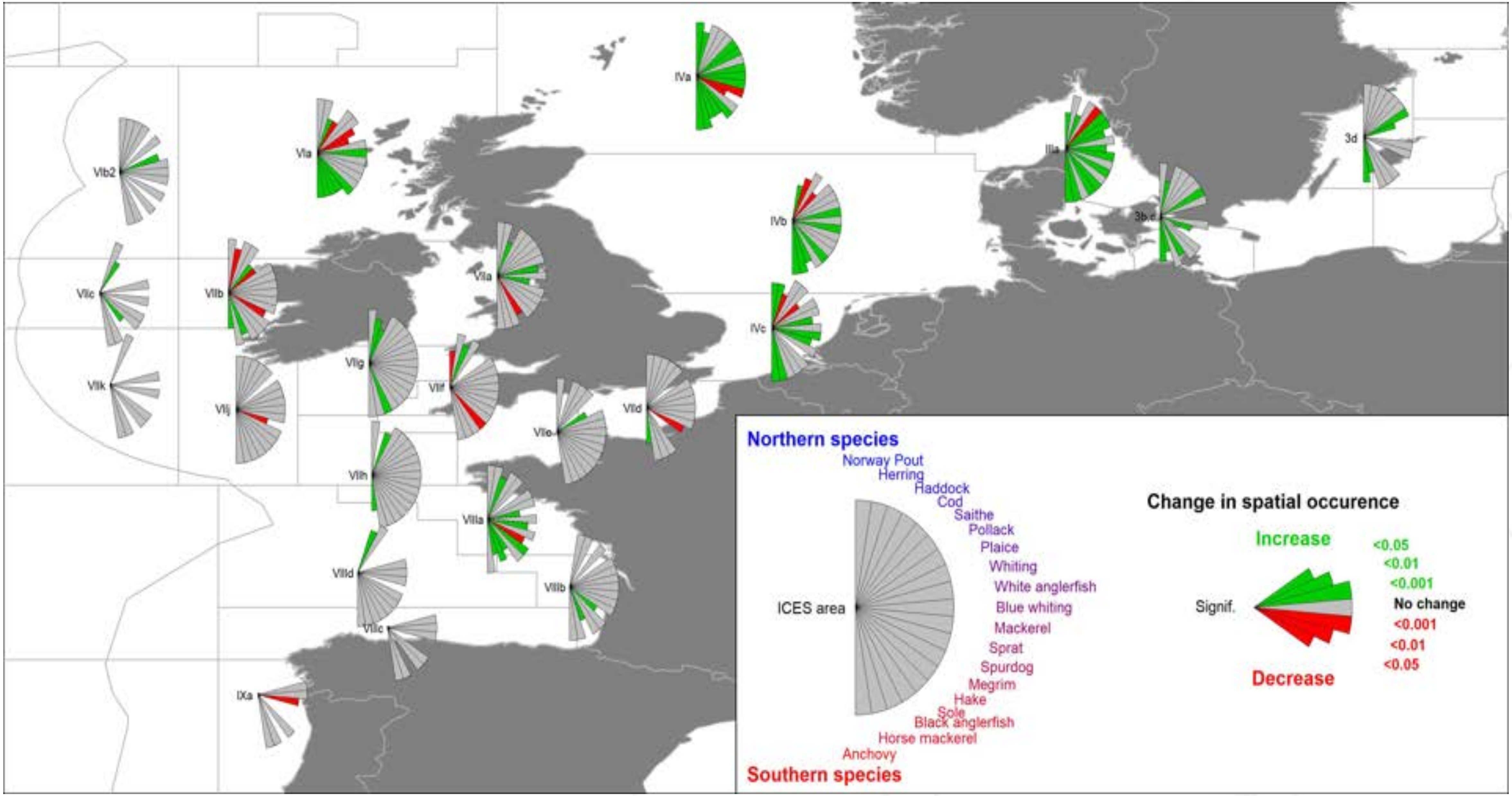
Workshop on Fish Distribution Shifts (WKFISHDISH) with Envr. Defense Fund (EDF) 2016

ICES CIEM

16 out 21 main commercially fished species changed their distributions across the northeast Atlantic since 1985, **hake & mackerel** shifting most.

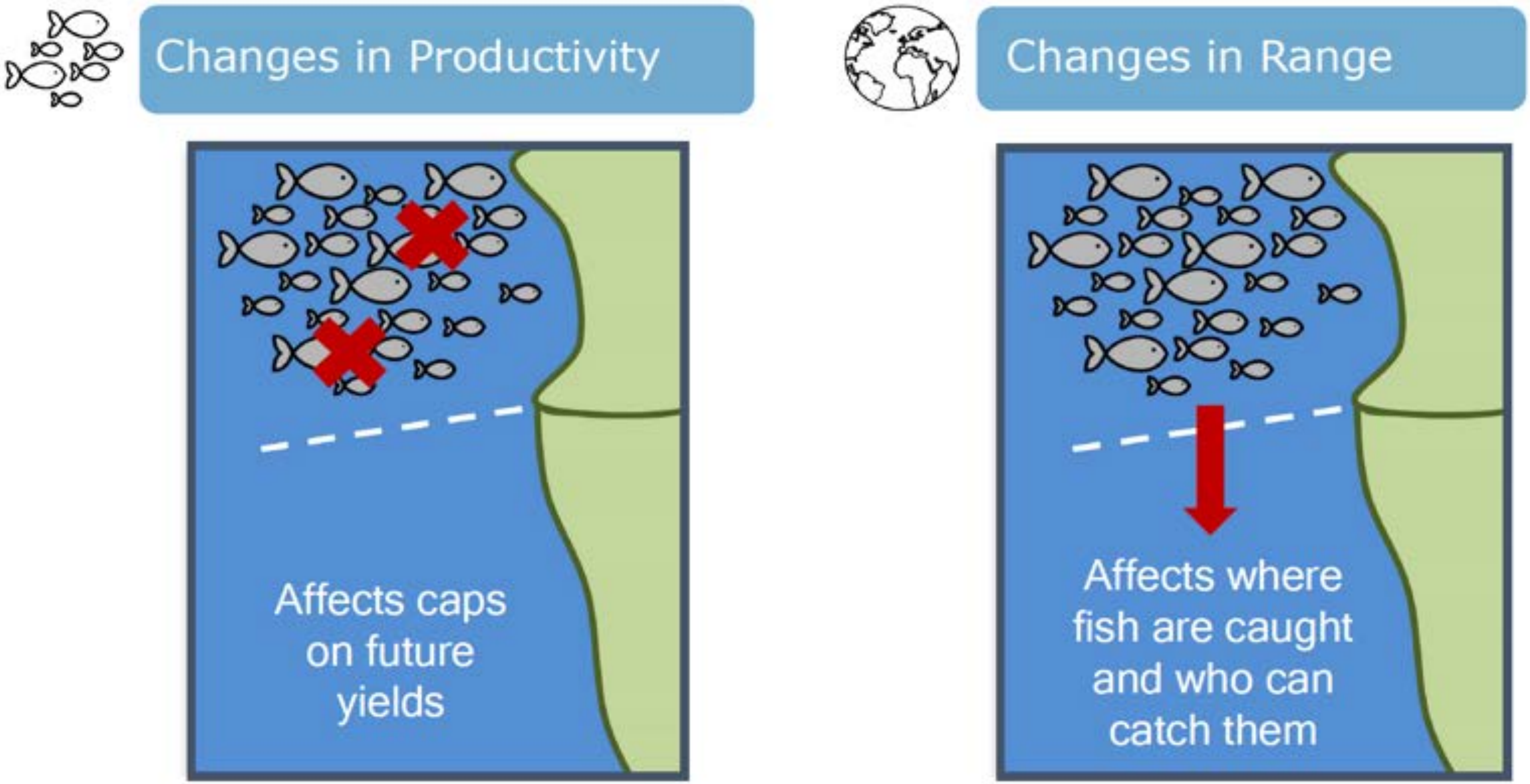
8 exhibited distribution changes that crossed **quota management** & **allocation** boundaries

Environmental conditions such as sea temperature, plus changes in **fishing effort** strong drivers



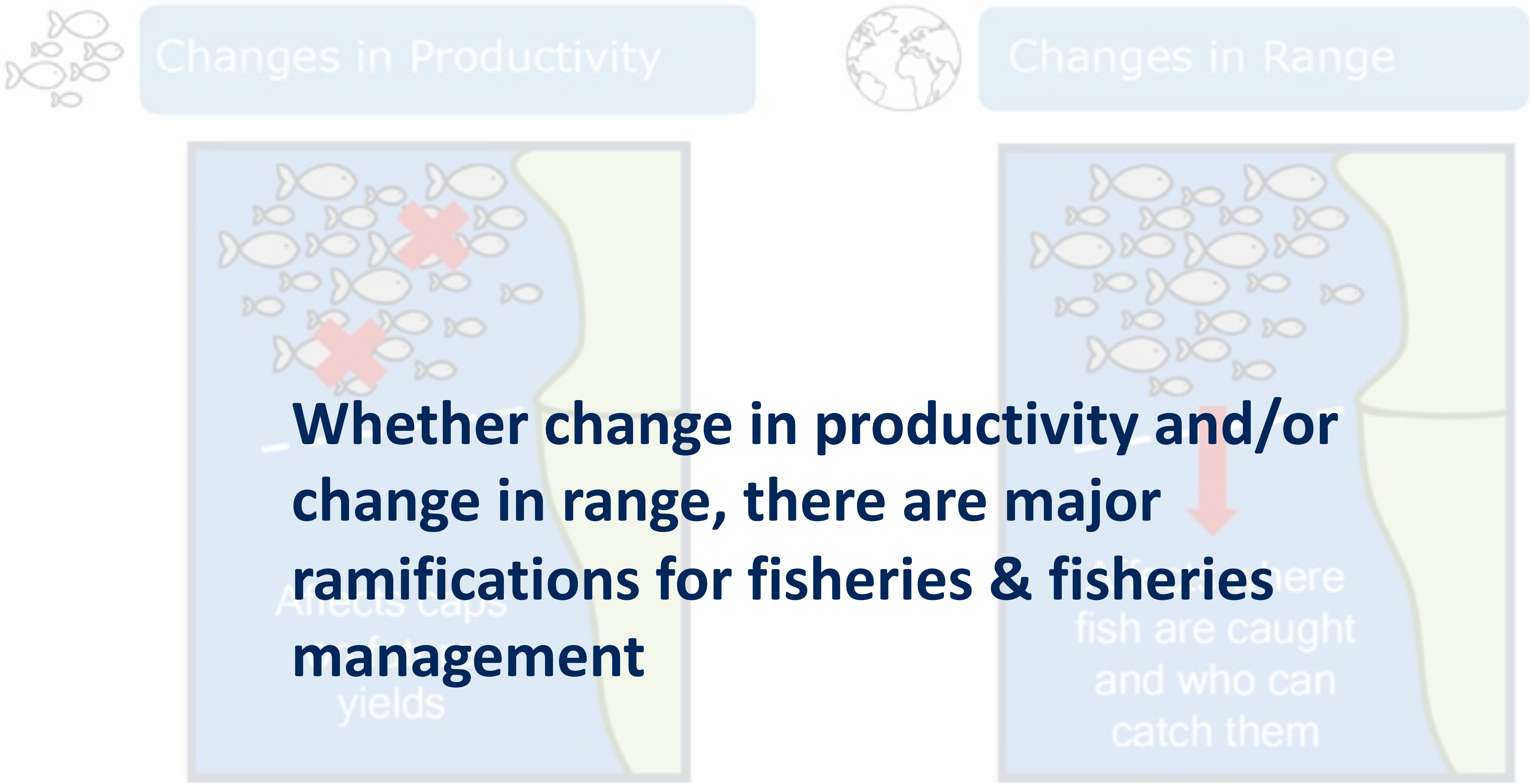
Baudron et al 2020 Ecography

FAO sustainable fisheries symposium 2019



Steve Gaines, University of California, Santa Barbara

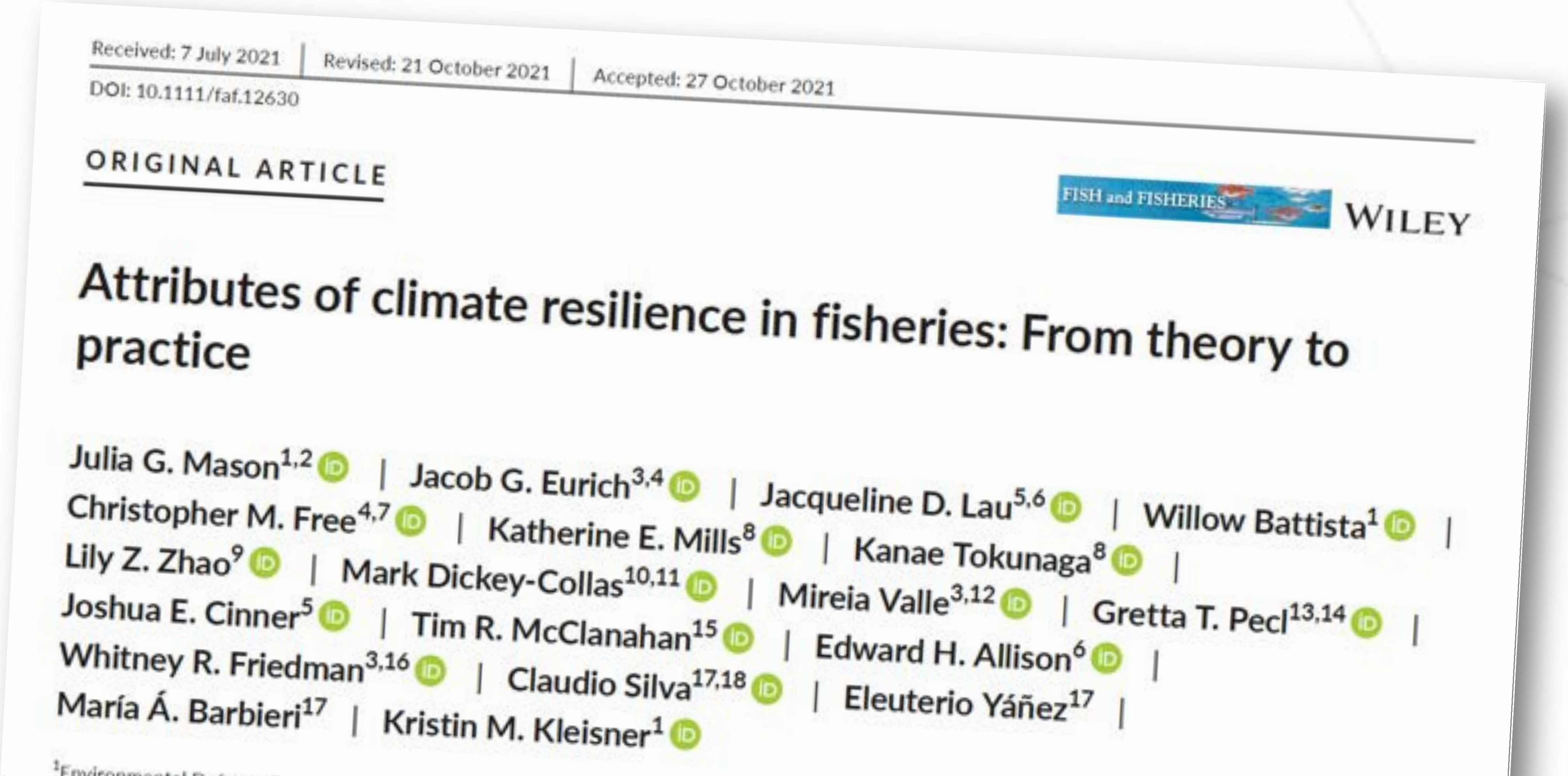
FAO sustainable fisheries symposium 2019



Whether change in productivity and/or change in range, there are major ramifications for fisheries & fisheries management

Steve Gaines, University of California, Santa Barbara

Consider beyond population dynamics of fish, let’s think about the fisheries system



Received: 7 July 2021 | Revised: 21 October 2021 | Accepted: 27 October 2021
DOI: 10.1111/faf.12630

ORIGINAL ARTICLE

FISH and FISHERIES
WILEY

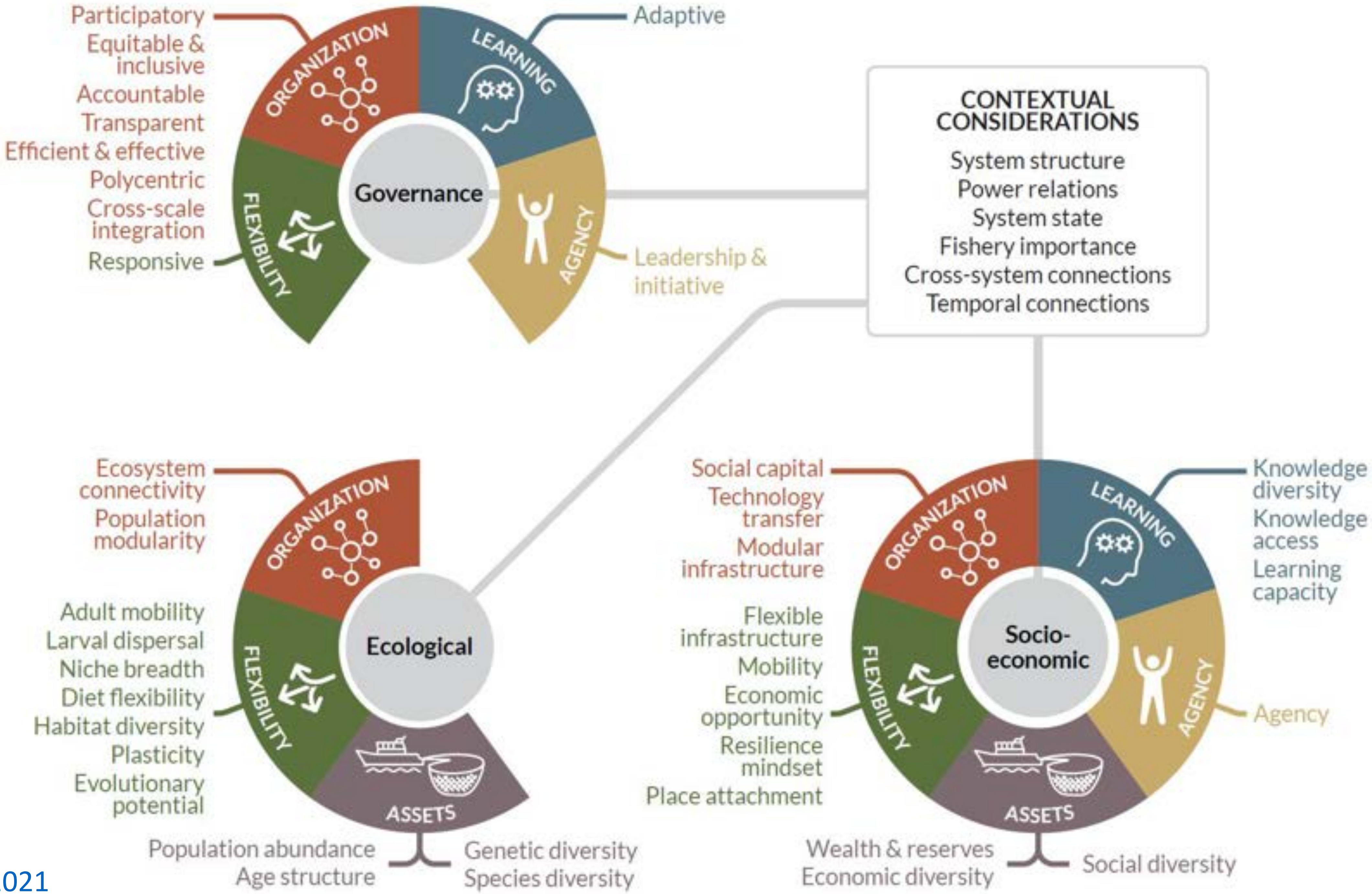
Attributes of climate resilience in fisheries: From theory to practice

Julia G. Mason[1,2] | Jacob G. Eurich[3,4] | Jacqueline D. Lau[5,6] | Willow Battista[1] | Christopher M. Free[4,7] | Katherine E. Mills[8] | Kanae Tokunaga[8] | Lily Z. Zhao[9] | Mark Dickey-Collas[10,11] | Mireia Valle[3,12] | Gretta T. Pecl[13,14] | Joshua E. Cinner[5] | Tim R. McClanahan[15] | Edward H. Allison[6] | Whitney R. Friedman[3,16] | Claudio Silva[17,18] | Eleuterio Yáñez[17] | María Á. Barbieri[17] | Kristin M. Kleisner[1]

Domains of the system that we need to consider

SNAPP Science for Nature and People PARTNERSHIP

Climate Resilient Fisheries Working Group



Mason et al 2021

Explores Northeast Atlantic mackerel system as a case study…

Mason et al 2021

Abundant populations and diverse **age structure** enable mackerel to withstand changes in temperature and fishing pressure. Ample **wealth and reserves** support fisher flexibility and agency (i.e. political influence), learning via scientific capacity, and multilevel governance organization. However, differing levels of **economic diversity** and fishery dependence among nations contribute to conflicting views on equitable quota allocation.

Adult mobility and **dietary flexibility** allow mackerel to exploit new environments in response to temperature change. Fishers throughout the region have high **mobility** to follow mackerel stocks, **agile supply chain infrastructure** to market them, and innovative **resilience mindsets** to embrace new species. However, the rigid governance system precludes **responsiveness** to environmental and political change.

Connectivity facilitates mackerel's northward expansion. Strong **social capital** helps fishers advocate for their goals, but entrenches national interests. Well-developed **participatory** and **polycentric** governance structures were highly **effective** for already-established parties but not **inclusive** to new entrants. Similarly, inadequate **integration across scales and sectors** hinders inclusion of other stakeholders such as mackerel retailers.

A robust scientific system provides high **access to knowledge** and **learning capacity**, which are key for evidence-based management and mackerel fishery development. However, lack of **adaptive governance mechanisms** for incorporating new actors and resolving disputes continues to erode resilience.

Fishers have strong **agency** and **leadership** to advocate for their interests at the subnational and national levels, but the rigid consensus-based structure at the international level stifles **leadership and initiative.**

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Mason et al 2021

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Mason et al 2021

H2020 projects

ICES CIEM

ClimeFish

https://climefish.eu/

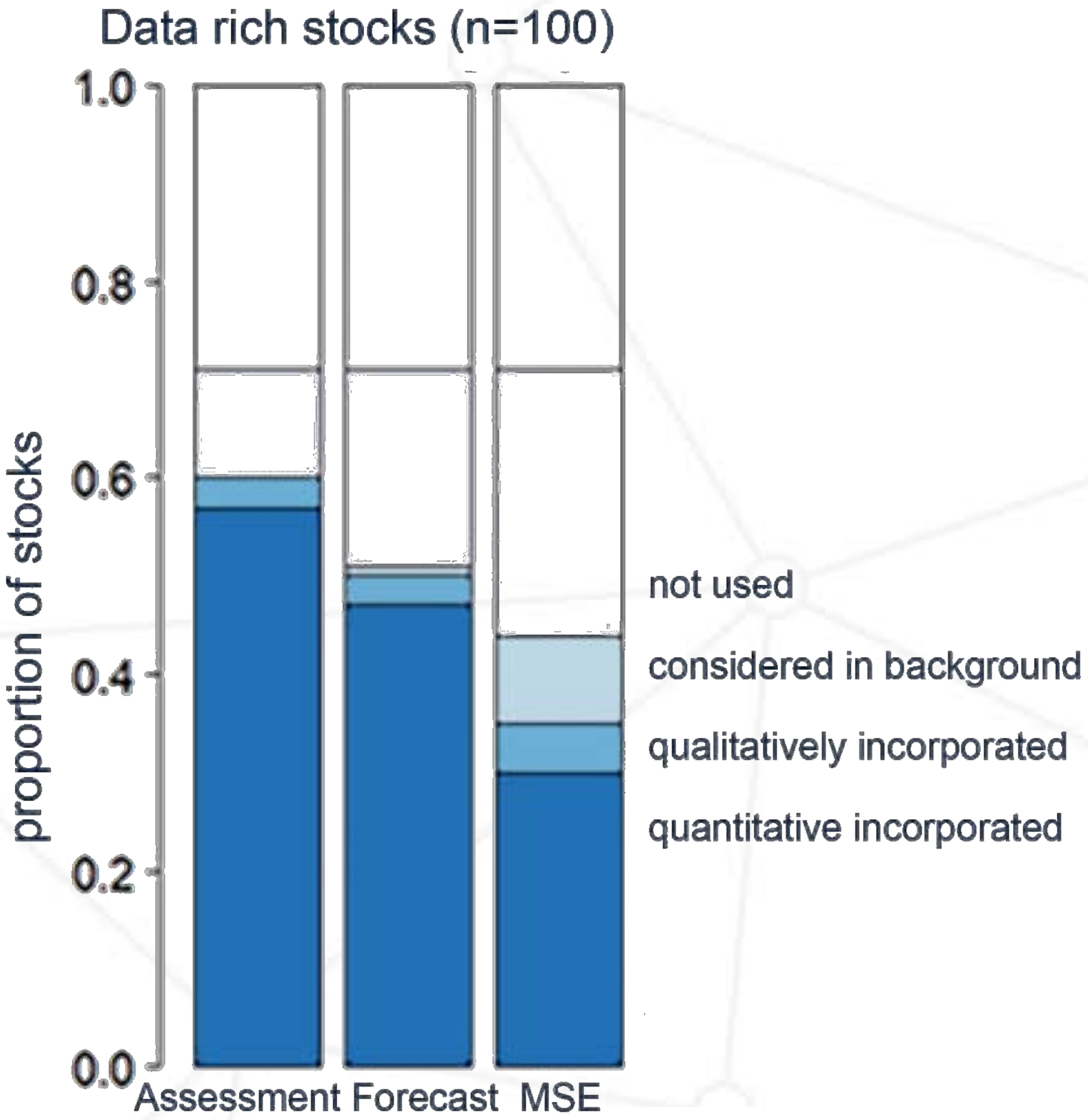
CERES

https://ceresproject.eu/

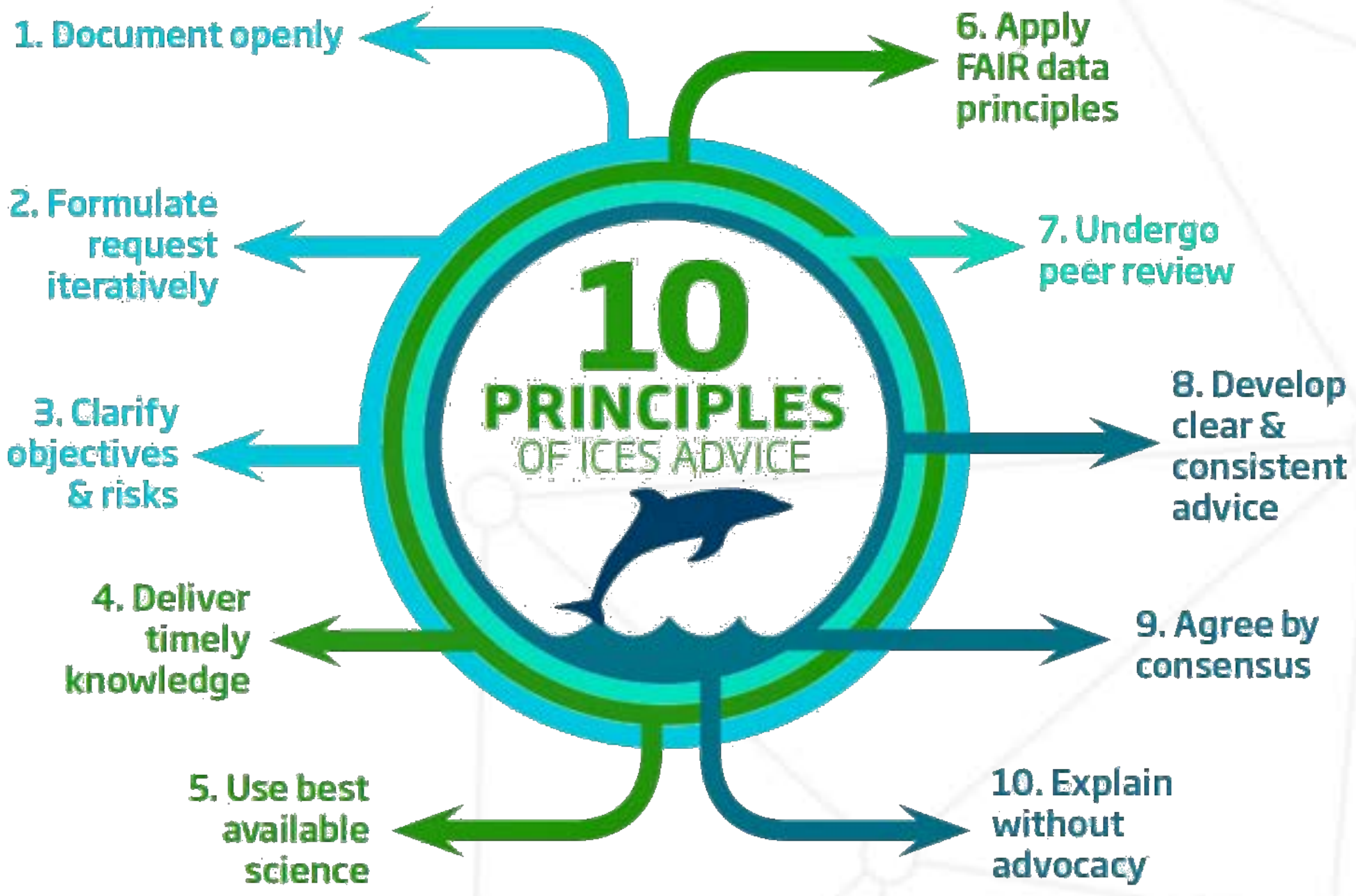
Science for sustainable seas

ICES realised – no framework to incorporate climate change into fisheries advice

Incorporating changing system into fish stock analysis

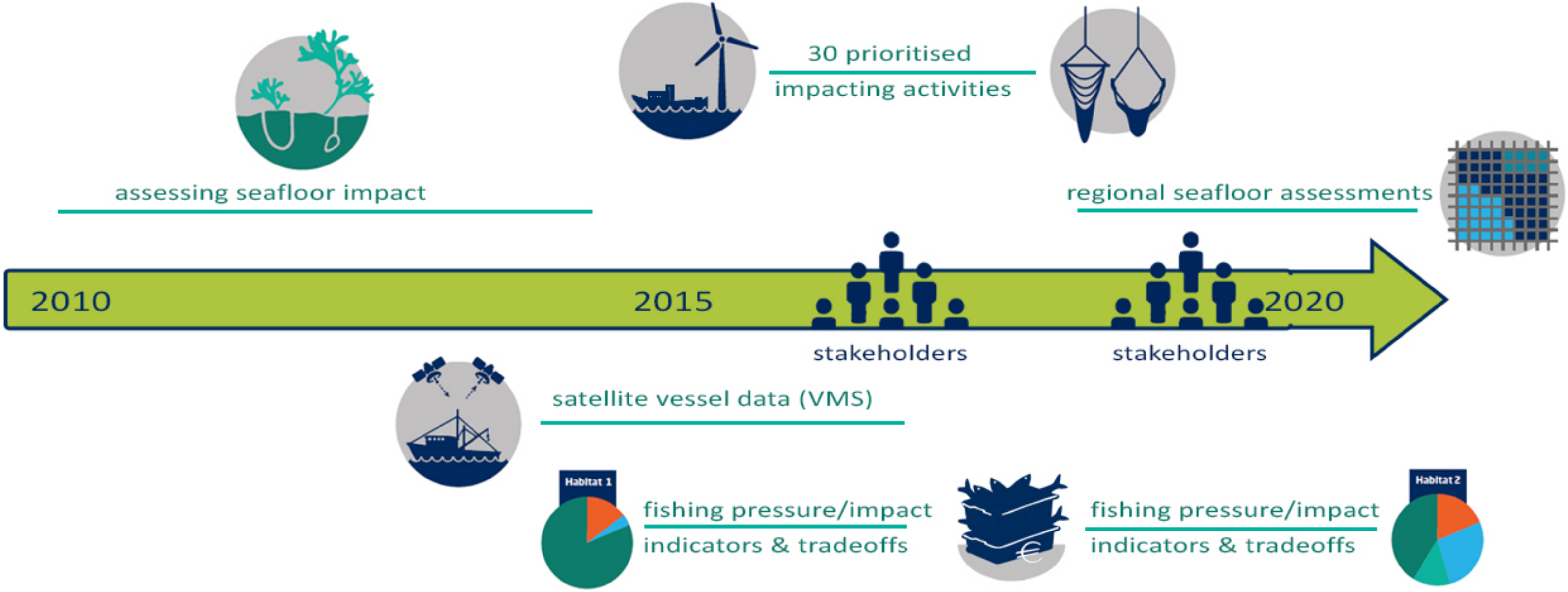


Advice governed by 10 advice principles



https://doi.org/10.17895/ices.advice.7648

Advice is can be iterative & developmental
e.g. regional seafloor assessments



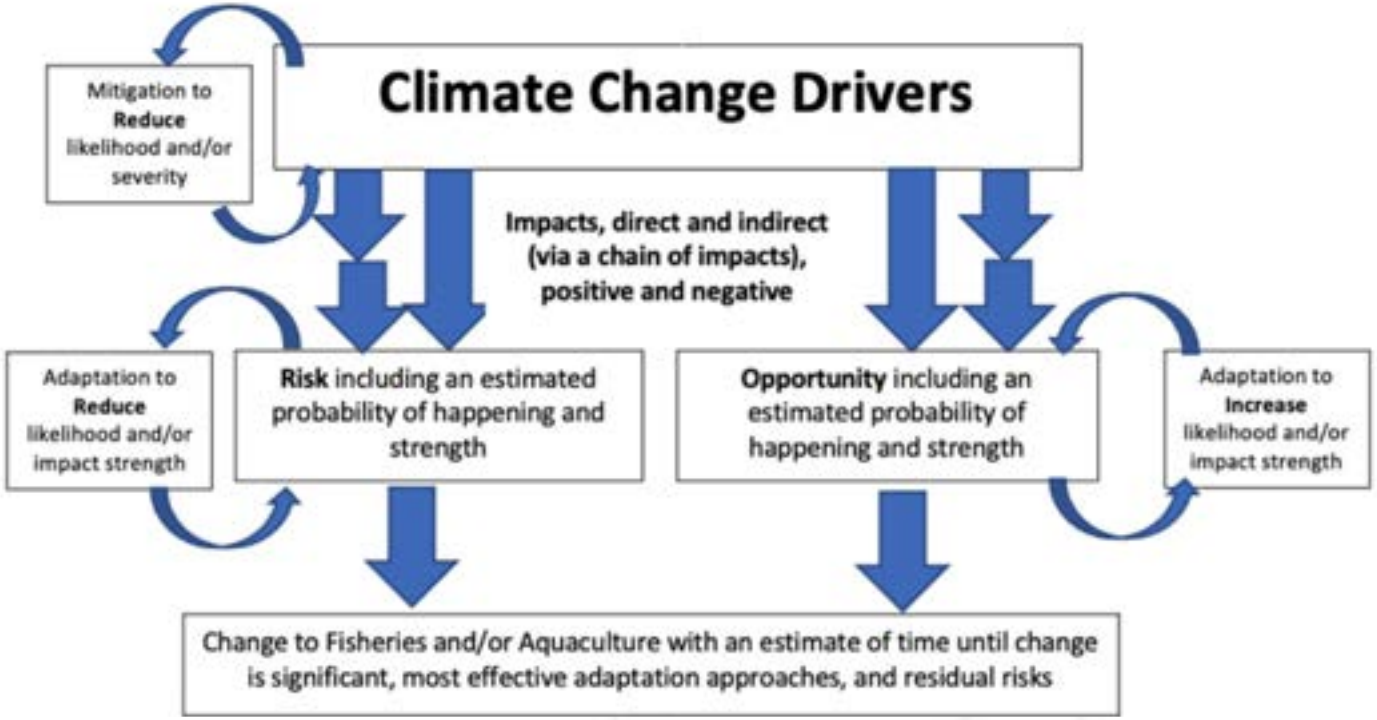
https://doi.org/10.17895/ices.advice.8191

Developing stakeholder engagement strategy in 2022

1. Opportunities for stakeholder involvement are inclusive & proportional to relevant issue.
2. Active stakeholder participation is consistent with impartiality, independence & integrity of ICES.
3. Roles, responsibilities & expectations of participation are transparent, & participants understand & respect their roles & that of others.
4. ICES communication strategy is aligned with the engagement strategy.
5. Stakeholders' participation is assessed, the engagement process is monitored, & constant organizational learning occurs.

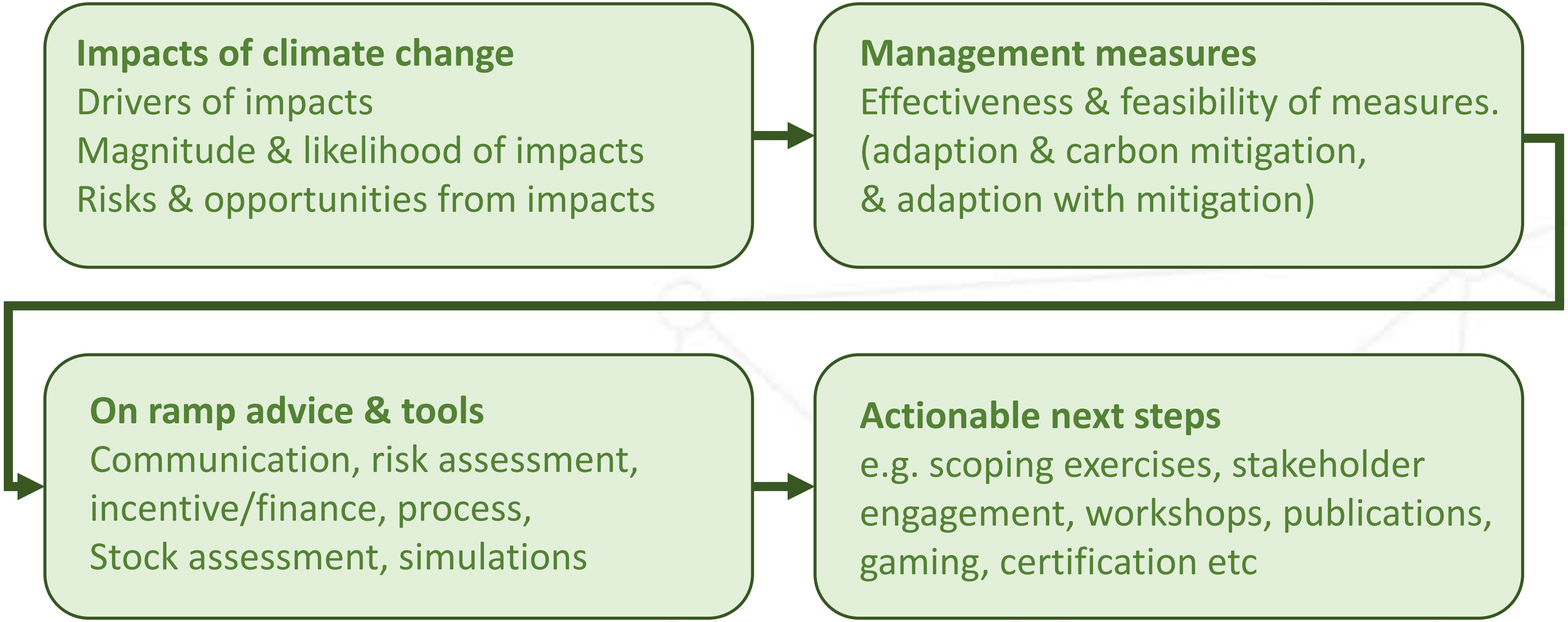
Climate-informed advice: WKCLIMAD 2021
Workshop on pathways to climate-aware advice

Constructing actionable strategies & approaches that are appropriate for advice to managers of fisheries and aquaculture.



WKCLIMAD

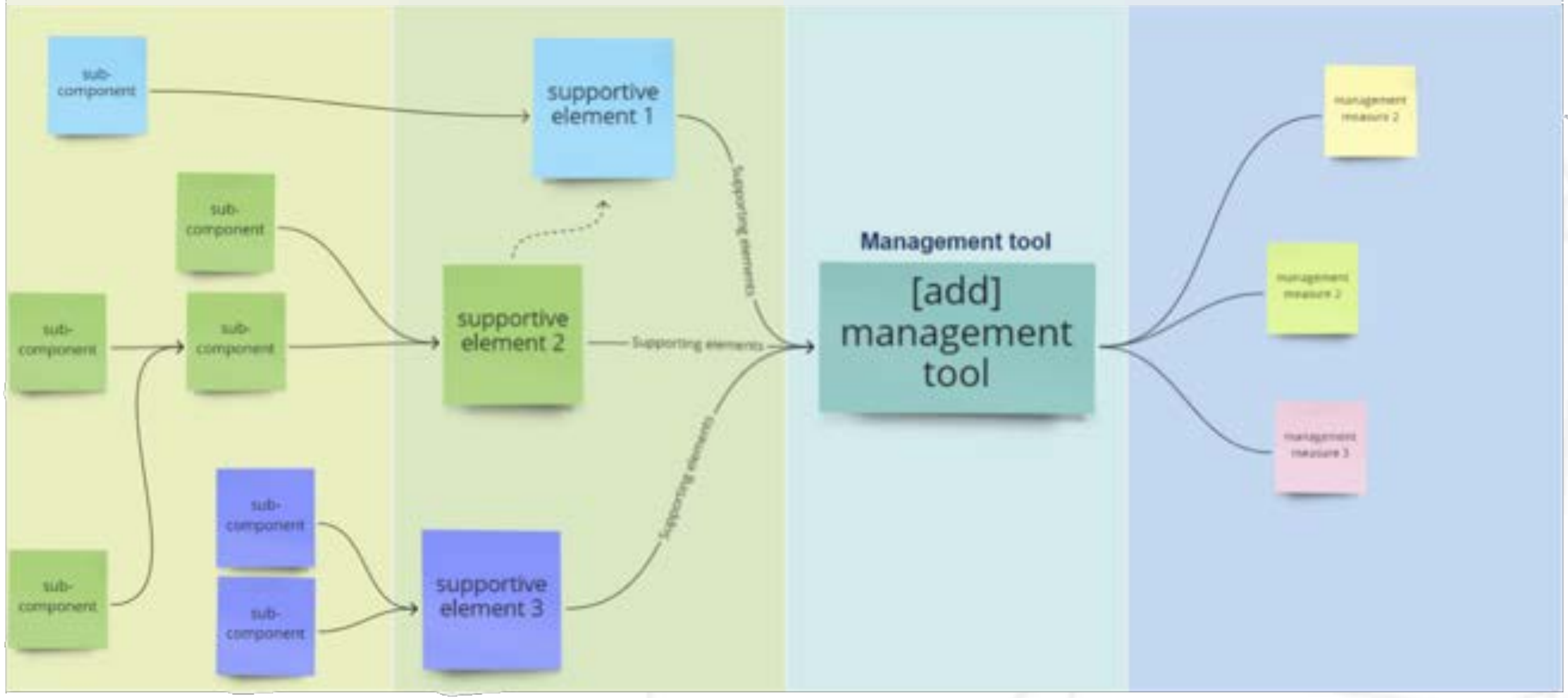
ICES CIEM



and for aquaculture too

Setting up the framework - information & tools

Data needs, steps & models	Support: maps, process, communication, online, databases	Climate-informed tool (advice, tool, policy)	Adaptive measure being address



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Extra reading…

Finally, we are more integrated than we think…

ICES Special Request Advice
Barents Sea, Greater North Sea and Norwegian Sea Ecoregions

Published 31 October 2016

3.4.2 Norway request for a technical review of the MAREANO programme

Advice summary

ICES concludes that overall the programme produces and delivers data products, maps, and dissemination materials that are in accordance with sound scientific standards and which meet the needs of the assumed objectives of the programme.

ICES advises that, following the fort
are defined and published.

ICES concludes that the external co
target groups by making reports, p
scientific community. ICES further
that the future quality and availab
outputs are of greatest use to other

While the external communication i
the internal communication and dat
of internal data users, and ensuring

ICES advises that the considerable e
of data collection standards would

ICES Special Request Advice
Barents Sea ecoregion
Published 5 July 2019

Norway request on identification of ecological special/valued areas in the Barents Sea

Advice summary

1. ICES advises a data-driven, expert-informed conceptual framework for mapping ecological and biological value and the subsequent identification of special/valued areas in the Barents Sea. The framework, which uses the EBSA criteria, is fully described in the report of the Workshop on ecological valuing of areas of the Barents Sea (see WKBAR; ICES, 2019).

2. ICES advises that a database of framework derived layers and maps (including associated metadata and confidence levels), conforming to international best practice, be established and maintained.

3. For the framework outputs to be used in decision-making, ICES advises that scientifically robust and transparent methods are applied; with expert decisions fully recorded and documented.

Short overview of the Swedish fisheries and climate change challenges

Mats Svensson

Director, Department of Marine management, SWAM

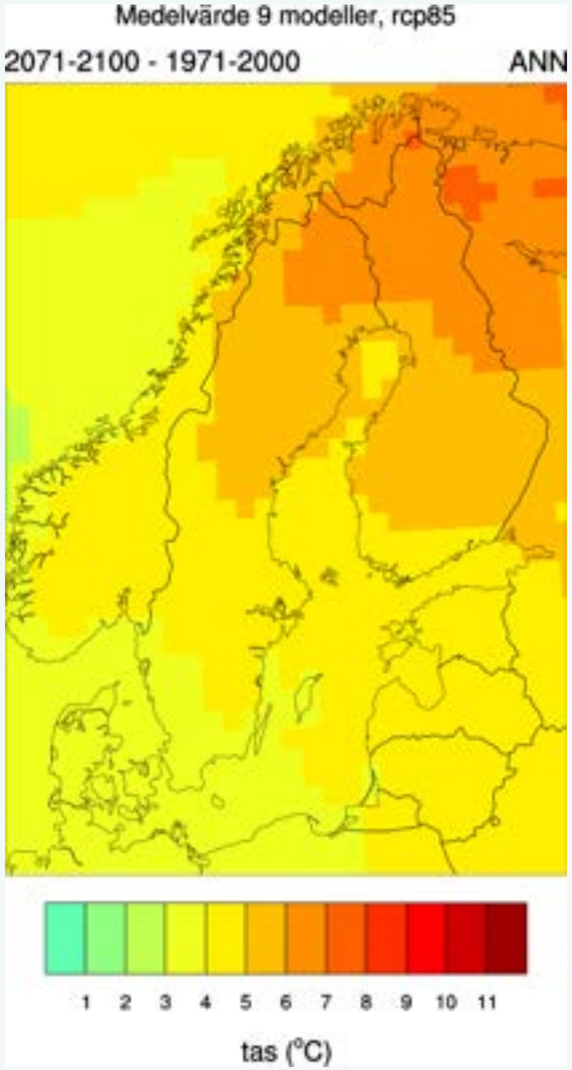
NMTT Workshop 9-10 December 2021

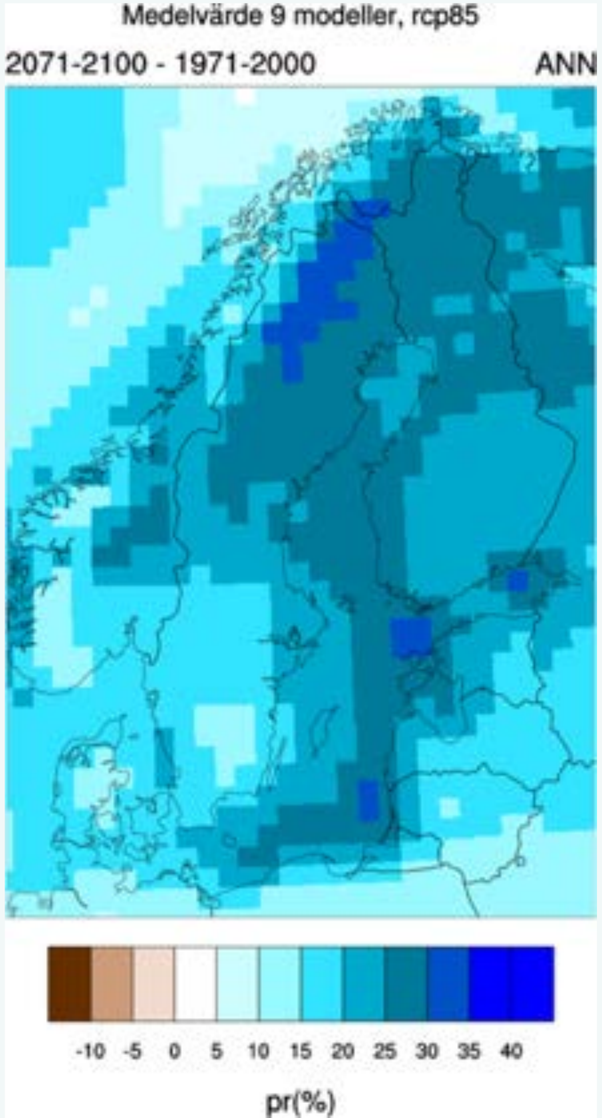
Havs
och Vatten
myndigheten

Climate change in Sweden – scenario 8.5

6 degrees higher air temperature (more/less in northern/southern Sweden)

3-4 degrees varmer in the Baltic sea (salinity 2 ‰ lower, less sea ice)

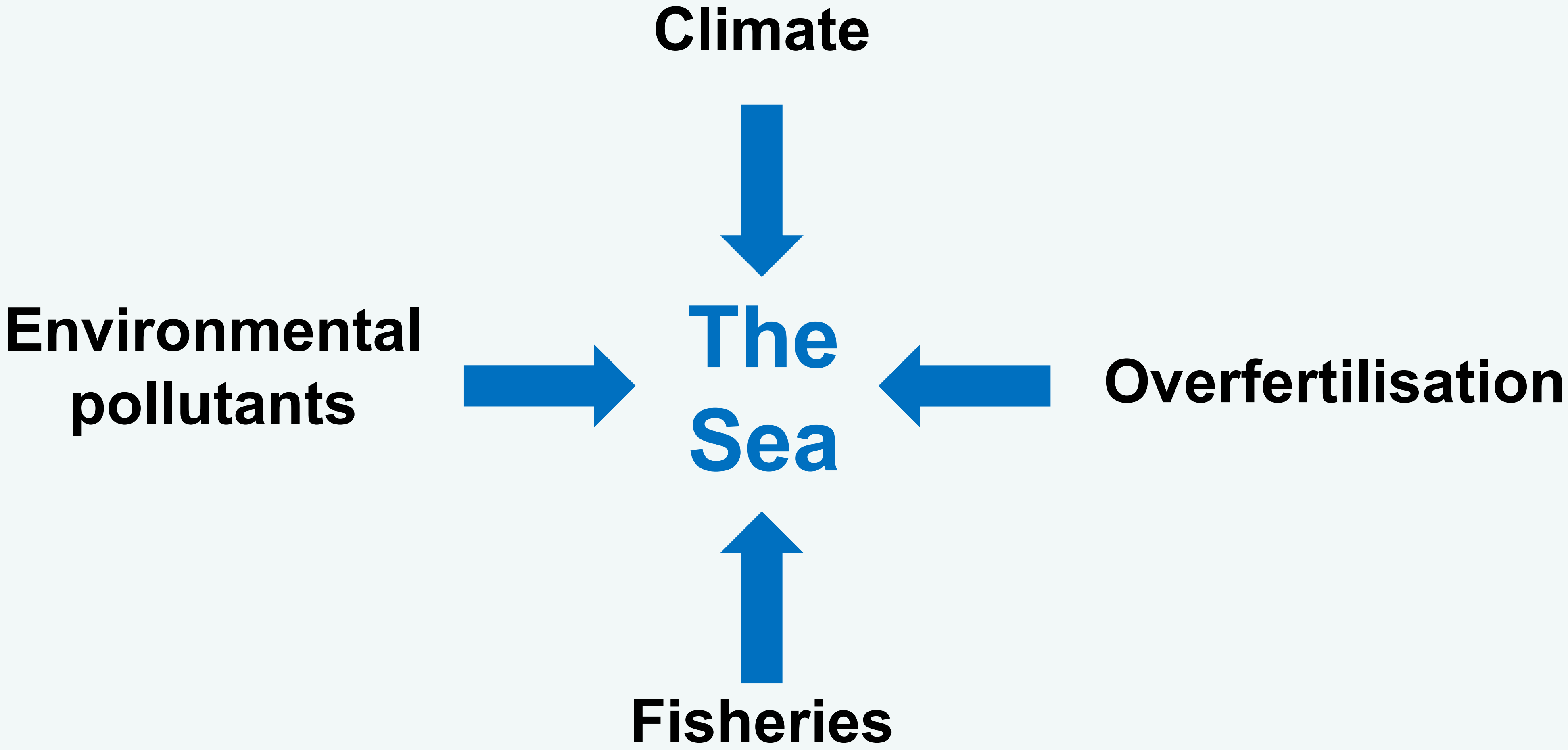




Förändring av årsmedianvärdet mellan perioderna 1970-1999 och 2070-2099 för ytvattentemperatur (°C) enligt RCP8,5. Positiva siffror innebär en temperaturökning.

Pressures in the marine environment

Havs och Vatten myndigheten



Havs och Vatten myndigheten

Marine planning

- Swedish marine plans for West coast, Baltic Sea and Bothnian sea
- Still not decided by swedish government
- Include scenarios for the climate future and climate refuges (report 2017: 37) – include Ringed seal, Zostera, Blue mussel, Herring, Cod, Saduria, Fucus
- New marine plan work will start in 2022
  - Ecosystembased management approach
  - Will include more marine protected areas
  - More areas for wind energy parks

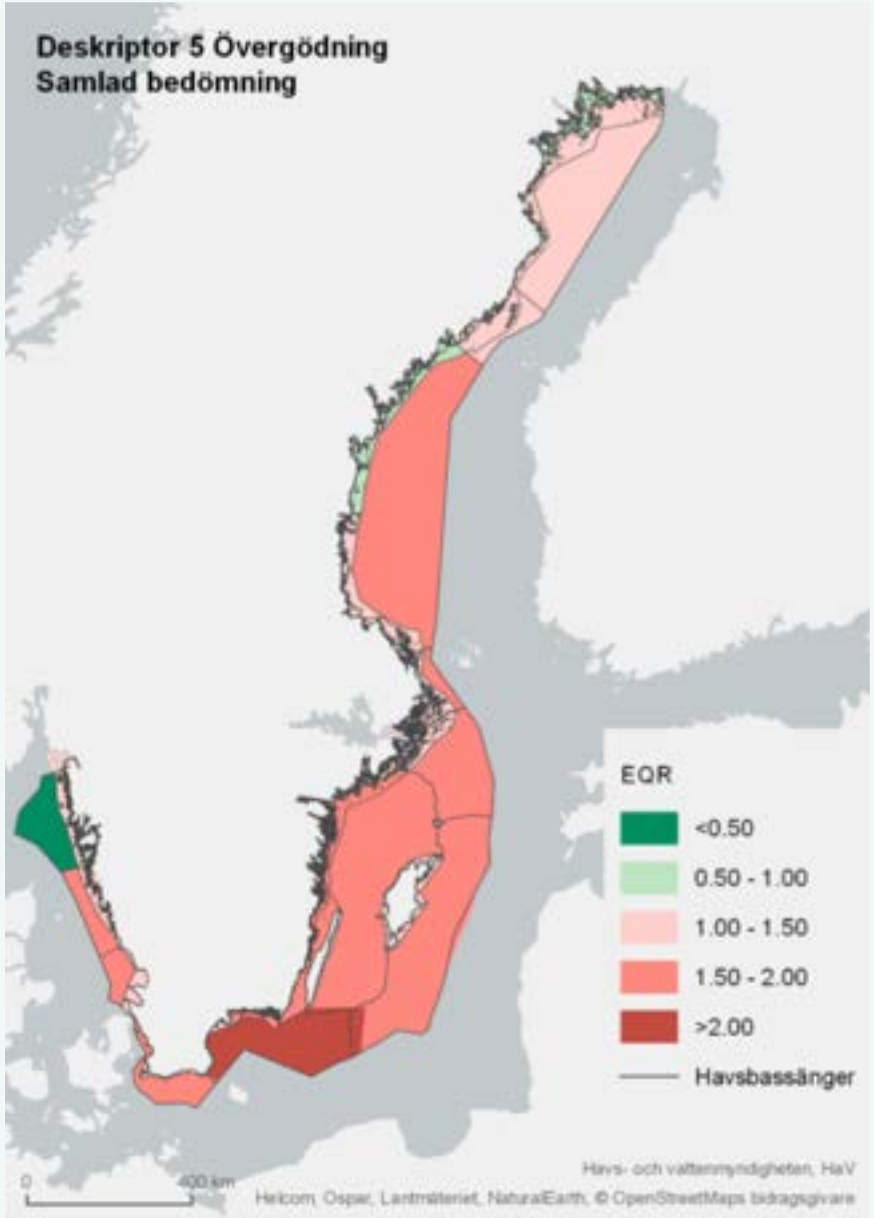
National fish management

Havs och Vatten myndigheten

- 2400 km coastline, five interior lakes and 1000 waterways up to first definitive migration barrier
- 100 fish species
- 1.6 million fishers (professional and recreational)
- Swedish fisheries:
  - The North sea and the Swedish west coast, including Kattegatt and Skagerack
  - The Baltic sea, including the Öresund strait
  - Interior waters: Lake Vänern, Vättern, Hjälmaren and Mälaren

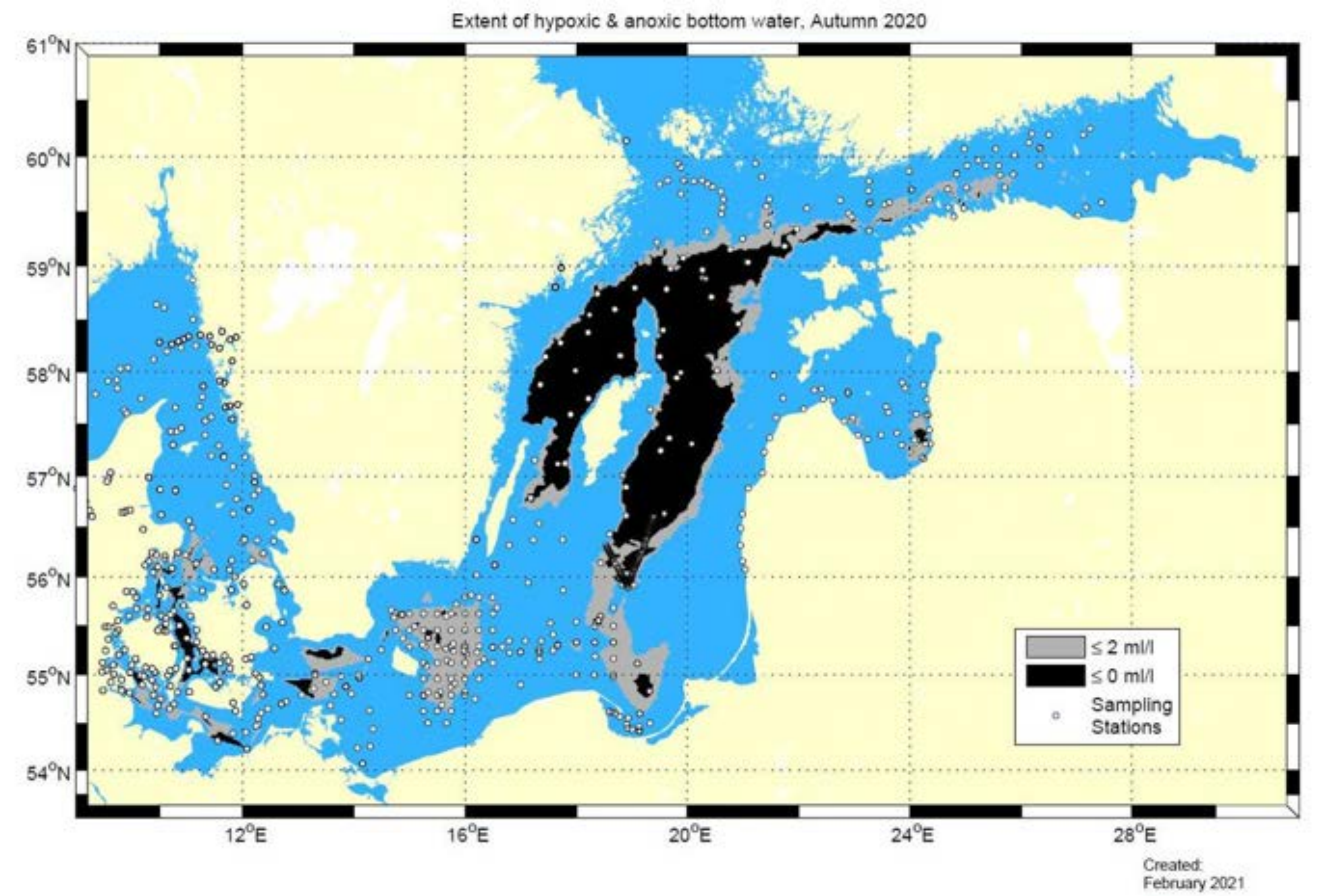
Havs
och Vatten
myndigheten

MFSD Descriptor 5 – overfertilisation in marine waters



Hypoxic and anoxic bottom water in the Baltic sea

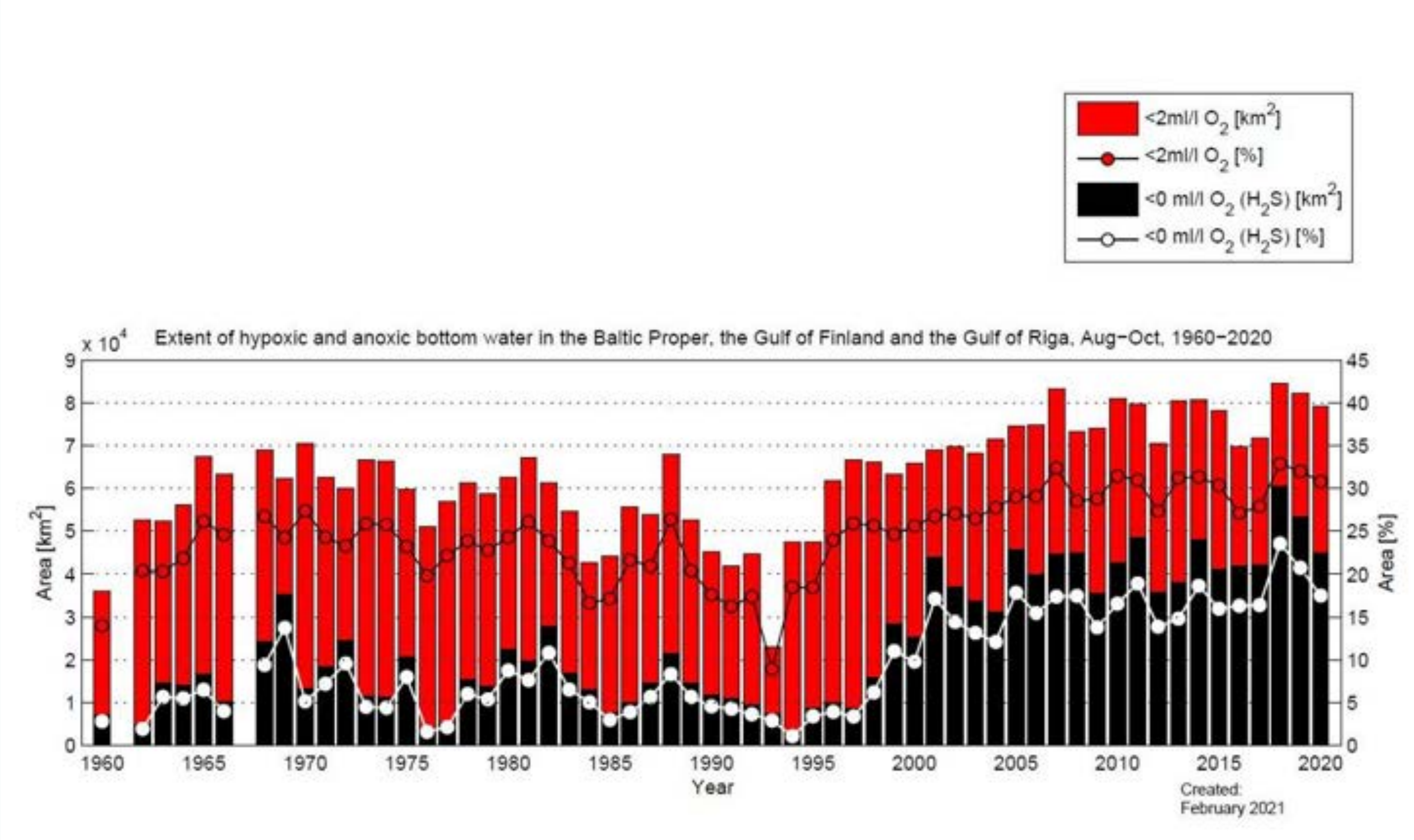
Havs och Vatten myndigheten



Source: SMHI 2021

Development of hypoxic and anoxic bottom water in the Baltic sea 1960-2020

Havs och Vatten myndigheten



Havs och Vatten myndigheten

Major swedish fisheries in North sea and West coast

- Cod
- Herring
- Sprat
- Shrimp
- Nephrops
- Mackerell

- Only adaptation measures.
- However, major changes taking place in the Cod and Herring populations throughout the North sea – climate effects or normal dynamics or both?
- Expect more southern species to migrate in; anchovy, tuna etc
- Coastal fisheries very reduced already
- Expect more overfertilisation measures
- River restorations

Havs och Vatten myndigheten

Major fisheries in the Baltic sea including Öresund

- » Cod
- » Herring
- » Sprat
- » Flounder/Plaice
- » Salmon

- » **Only adaptive measures:** overfertilisation, fishing pressures, environmental pollutants, better knowledge
- » Major shifts in the Baltic sea already in plankton communities
- » Cod fisheries stopped since 2019
- » Herring in Western and Eastern Baltic decreasing
- » Sprat
- » Salmon – national/regional/local management of rivers – expect more complicated dynamics
- » Gear development. Politics want more fisheries for consumption

Havs
och Vatten
myndigheten

Institute of Food and Resource Economics

9 December 2021

How does the fisheries and aquaculture value chains impact the climate?

Identifying pathways to mitigating the impacts of our activities: An Economic Perspective

Max Nielsen, Associate Professor
Department of Food and Resource Economics



Content

1. Role of economics in climate change
2. GHG emissions and regulation
3. GHG emissions fisheries and aquaculture
4. Mitigation fisheries and aquaculture
5. Conclusions.

1. Role of economics in climate change

- Mitigation vs. adaptation → my focus mitigation
- Economists consider GHG emissions as an externality

  "An activity on one entity that affects the welfare of another entity in a way that is outside the market mechanism"
  - An unpaid negative effect on others
- Solution: Make prices right – let the polluter pay
  - Give incentives for reducing GHGs
- How much and how fast shall we react to reduce climate change?
  - View 1: The Stern 2006 Review *"The Economics of Climate Change"* – called for immediate action to fight climate change
  - View 2: Nordhaus – Stern use unrealistic low discount rates → less need for immediate action
  - Economists agree on action needed – not on speed.

1. Role of economics in climate change

- The COP26 Agreement strives at avoiding > 1.5 degree C by
  - Asking countries to introduce ambitions 2030 goals on GHG reductions to reach net zero emissions 2050

- Nordic countries ambitions on carbon neutrality

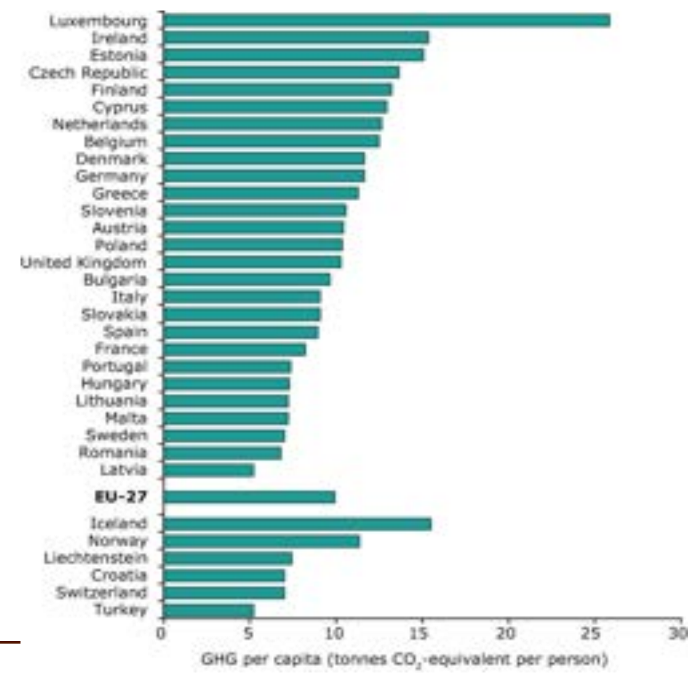
- Political discussions
  - Not on how much and that it must be fast
  - But on how and exactly how fast.

- Mitigation is a huge task with large costs
  - The core role of economics is to identify how to act cheapest, cost-effectively.

2. GHG emissions and regulation

- Global GHG emissions 2017 ~ 37 Billion tons CO_2e
  - CO_2 76%, Methane 16%
  - Largest GHG emitting sectors, electricity/heating, transport, agriculture, manufacturing, construction, e.g. shipping 3%, aviation 2.5%
  - Nordic countries ~200 Million tons CO_2e and EU28 3.5 Billion tons
- Nordic per capita CO_2e emissions
- European Trading System of CO_2 quotas
  - Regulate ~ 45% of emissions
  - Include EU countries, Norway and Iceland
  - Agriculture, cars and houses not covered
- Some countries have emission taxes.

GHG emissions as tons CO_2e per person



3. GHG emissions fisheries and aquaculture

Global fisheries

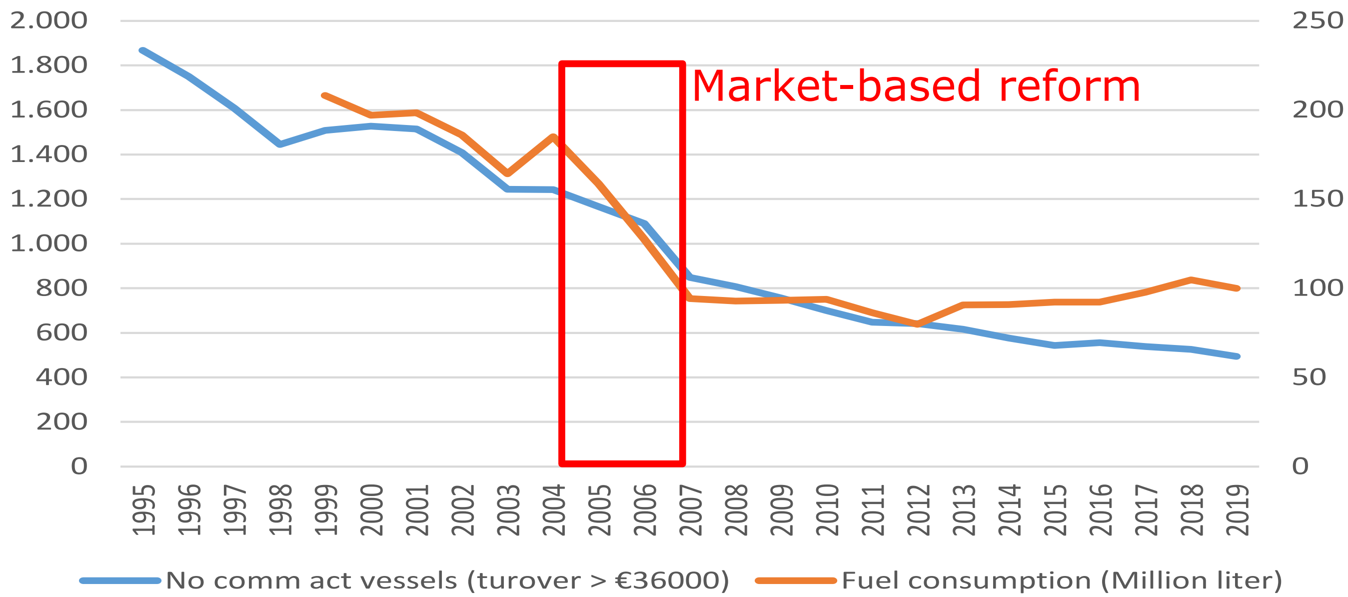
- GHG emissions comes from
  - Fuel use
  - Swirling of CO_2 by bottom trawling to surface waters and maybe to the atmosphere
- Fuel use induce 178-207 Million tons ~ 0.5% globally

Fuel use in Danish fisheries – an example

- Commercial active fleet use 100 Million liter fuel in 2019 ~264,000 tons CO_2 and 0.8% of Danish emissions.
- Development over time
  - Reliable data not available 1990-1998

3. GHG emissions fisheries and aquaculture

- Emissions commercial active Danish vessels 1999-2019 – two phases



- Phase 1: Total fuel use reduced 62% 1999-2012 with fleet size due to market-based reform/technological development – not by purpose
- Phase 2: Fuel use increase 2012-2018 30% totally, 60% on average – partly due to increasing vessel size
- 48% of the 2030 70% reduction target fulfilled, although not accounting for fisheries.

3. GHG emissions fisheries and aquaculture

- Indicators for fuel consumption in Danish fisheries 2019

2019 Vessel group3.2	Fuel cons. (Mil liter)	Fuel use liter per			EBIT (% assets)
		kg. fish caught	€ sold fish	€ invested (assets)	
1. Net (<24 m)	3	0.403	16	3.5	-0.2
2. Seiners (12-15/18-24 m)	1	0.333	17	3.1	-0.1
3. Trawl (<24 m)	17	0.312	32	4.9	1.1
4. Trawl consumption (24-40)	25	0.546	47	8.1	2.1
5. Trawl reduction (>40 m)	13	0.82	36	6.7	4.2
6. Seiners/trawl (>40 m)	27	0.93	23	3.0	5.5
7. Other	13	0.195	33	5.1	0.6
Total	100	0.158	31	4.7	3.2

Updated calculations from Nielsen, M. and L Ståhl (2012), Aspects of green transition in Danish fisheries (in Danish). Retrieve at: https://static-curis.ku.dk/portal/files/44835493/FOI_udredning_2012_20.pdf.

- Results
  - Seiners/trawl >40 m cannot be separated statistically
  - Over 80% of fuel used by trawlers and seiners/trawl >40 m

3. GHG emissions fisheries and aquaculture

- Results
  - Fuel use per kilo fish smaller for large than small vessels
  - Small vessels <24 m: Fuel use per € sold/invested around half for net/seiner fishing than trawlers
  - For large vessels >24 m: Fuel use per € sold/invested around half for seiners/trawlers >40 m than for pure trawlers
  - Fuel efficient vessels: Net/seiners fishing <24 m and seiners/trawlers >40 m
  - For small vessels, trawlers have better economy than netters/seiners
  - Seiners/trawlers >40 m fuel efficient and with good economy – but separation not possible

- Results accounts for other Nordic fisheries
  - Market-based management ICE, DEN, GR shrimp, SW/FIN/FAR pelagic
  - MBFM in NOR – more transferability between vessel groups can reduce fleet/CO_2
  - Options of reducing fleet/CO_2 in demersal fisheries such as at FAR and in GR Greenland halibut fishing.

3. GHG emissions fisheries and aquaculture

Swirling of CO_2 by bottom trawling globally

- 2021 *Nature* study by Eric Sala et al *Protecting the global ocean for biodiversity, food and climate*
- Marine sediments the largest carbon pool on the planet
- Disturbance by bottom trawling affect bottom fauna, reduce the carbon buffering capacity and potentially add to atmospheric CO_2
- Emissions may potentially reach same level as global aviation ~ five times CO_2 emissions from fuel use in fisheries
- If correct, pressure to stop bottom trawling prevail. But
  - It is obvious that the effect exist
  - It is one study, representativeness to be controlled
  - Not known how much adds to atmospheric CO_2
  - Not known whether the effect depends on sea floor/water depth
- Our knowledge limited → but fishery reforms reduce activity and fuel use in many countries – also swirling.

3. GHG emissions fisheries and aquaculture

Aquaculture

- Aquaculture the fastest growing animal food producing sector worldwide ➡ CO_2 emissions increasing
- Nordic Aquaculture
  - Marine salmon farming Norway/Faroe Islands
  - Pond/cage farming of trout Denmark/Finland
  - Recirculation increasingly used

3. GHG emissions fisheries and aquaculture

Aquaculture

- Literature review of LCA studies identify CO_2 emissions of one kilo of fish to 1.8-7.0 kilo for salmon and 0.7-13.6 kg. for trout (Nielsen and Nielsen 2020)
- CO_2 emissions of farmed salmon and trout the same as of wild caught cod, less than for beef and pork meat
- Feed induce the largest CO_2 emissions, both fish- and plant based ingredients - share of plant-based ingredients rising
- CO_2 emissions from recirculated aquaculture highest ➡ CO_2 can be reduced using more green energy.

4. Mitigation fisheries and aquaculture

- CO_2 reduction in fisheries and aquaculture likely – or inevitable
- Targets/regulations not decided yet – may be taxes, tradable permit or in other incentives
- Important that measures are cost-effective – cheapest

Potential measures

- Increase incentive for net/seiners instead of trawling
  - Economy negatively affected
  - Done in the Danish coastal arrangement for vessels <17 m
- Increase fuel efficiency of fishing gears e.g. by developing trawl with less water resistance and bottom contact.

4. Mitigation fisheries and aquaculture

Potential measures

- Increase fuel efficiency of vessels
  - Shipping in Europe expected in ETS → Action necessary → Fishery can learn
  - Studies finds that shipping can reduce CO_2 50% by investing/operational changes *without extra costs ~ fuel savings* by cold ironing, solar cells, optimization of the hull/propulsion/light, less ballast water, slow sailing (Eide et al 2011; Schwartz et al 2020).
- Develop clean propulsion of vessels
  - Electricity-driven vessels – mainly small vessels with short trips?
  - Hybrid driven vessels
  - Methanol/hydrogen/bioethanol driven vessels
  - Technically possible but also expensive
  - To be broadly used, they must be cheaper or incentivized
  - Many initiatives logically start outside fishing.

5. Conclusions

Fisheries

- Market-based management reforms efficiently reduced CO_2 from fisheries – but not by purpose
- More may be needed such as increasing fuel efficiency and considering the net/trawl balance –important to do it as cheap as possible
- Many initiatives such as on low carbon propulsion logically start in shipping – fisheries can apply their technologies developed.

Aquaculture

- Feed necessary and feed conversion ratio can be reduced, but CO_2 reductions depend on fishing for reduction/farming of soy
- Recirculation – CO_2 reductions depend on availability of cheap green energy.

UiT The Arctic University of Norway

Impact of climate change on seafood production, and adaptation measures

Professor Michaela Aschan

UiT the Arctic University of Norway, Tromsø, Norway

Joint NMTT-ICES Workshop:
Nordic Climate Change Forum for Fisheries and Aquaculture

Konventum, Eldinore, Denmark, 9-10 December, 2021

- Are you an seafood producer who is worried about how climate change may influence your production?

- Are you involved in making or updating of fisheries or aquaculture production plans in your region or country?

- Or are you a scientist keen to fill the knowledge gaps?

Then this presentation is for you!

Outline

Aquaculture – CC impact and adaptation

Fisheries – CC impact and adaptation

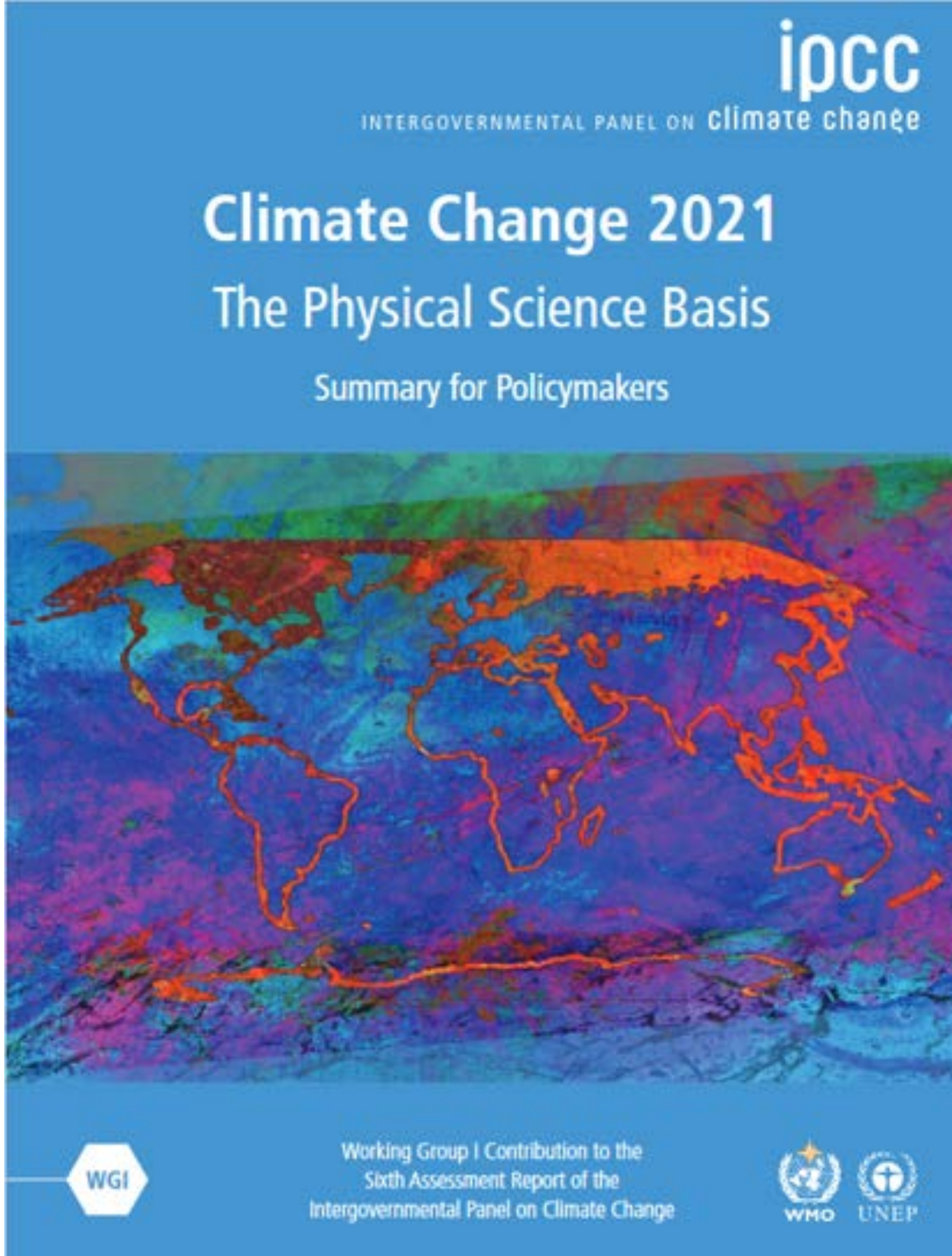
Climate Adaptation Plans for fisheries and aquaculture

EU actions towards climate adaptation

IPCC AR6-WGI

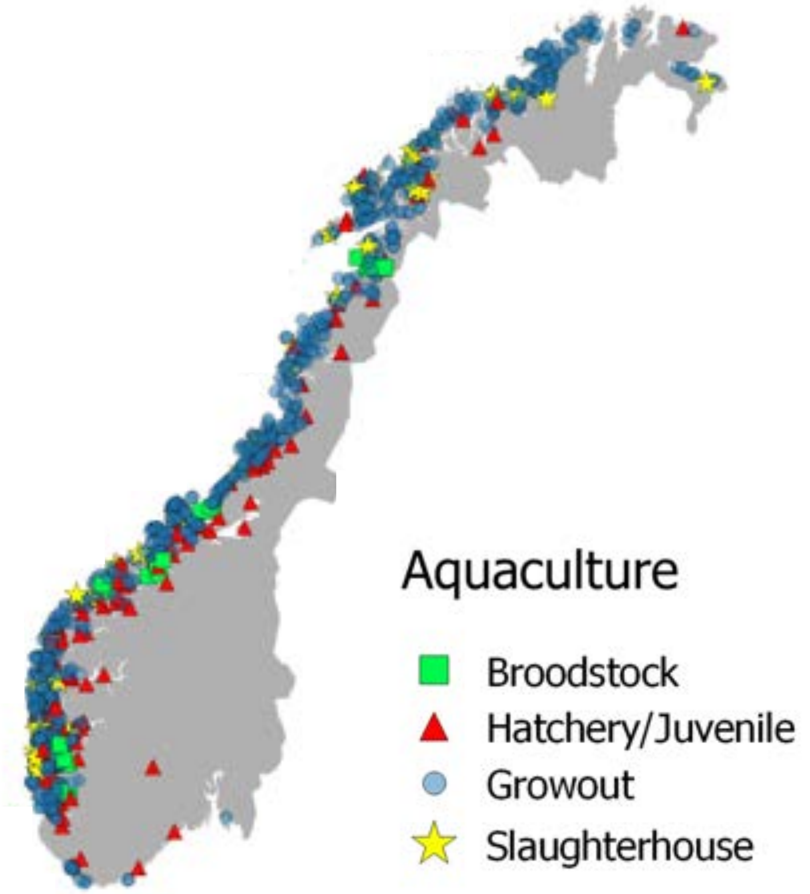
Physical science underpinning past, present and future climate change:

- Closing in on the 1.5°C global temperature change.
- More extreme events!
- Science is robust.



Aquaculture and climate change stressors

Salmon aquaculture in Norway



- Temperature
- Heatwaves
- Storms
- Deoxygenation
- Ocean acidification
- Precipitation and runoff
- Sea level rise and extreme water levels

Falconer L, Telfer TC, Garrett A, Hermansen Ø, Mikkelsen E, Hjøllo SS, McAdam BJ, Ytteborg E. Insight into real-world complexities is required to enable effective response from the aquaculture sector to climate change - **PLOS Climate**

ClimeFish Institute of Aquaculture UNIVERSITY of STIRLING Nofima seafish

Impacts on Aquaculture

Growth/size variabilty and mortality

- Growth rates and yields
- Increased size variability
- Changes to growing season
- Increased mortality

Escapees, predation and HABs

- Increased Escapees / Detachment
- Increased predation
- HABs and jellyfish blooms
- Occurrence of pathogens

Suboptimal conditions

- Increased fouling
- Anoxic conditions
- Accessibility and human safety issues
- Infrastructure deterioration

Suitability of sites

- Change site productivity
- Conflicts of space and farm allocation
- Harvesting closures

Changes in productivity

- Changes in production capacity
- Changes in feed conversion rates
- Increased production costs

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

Adaptation impacts and measures

Salmon aquaculture in Norway

- Identified 45 potential impacts linked to climate stressors

- Identified over 100 potential adaptation measures

Salmonbusiness.com

East Sussex Highways

Falconer et al. PLOS Climate

ClimeFish Institute of Aquaculture UNIVERSITY of STIRLING Nofima seafish

Potential measures

- Many factors to consider when deciding on adaptation strategies.

- Need to be aware of the risk of maladaptation:

  - Adaptation responses that have negative impacts larger than the effect they were intended to alleviate

  - Adaptation responses that increase emissions of greenhouse gases

Falconer et al. PLOS Climate

Aquaculture – Impact and adaptation measures

Risks and opportunities	Adaptation measures
Growth rates and yields	Higher model resolution
More extreme events	Diversify species and technology
Pathogens, algal, and jellyfish blooms	Better monitoring

AquaVitae

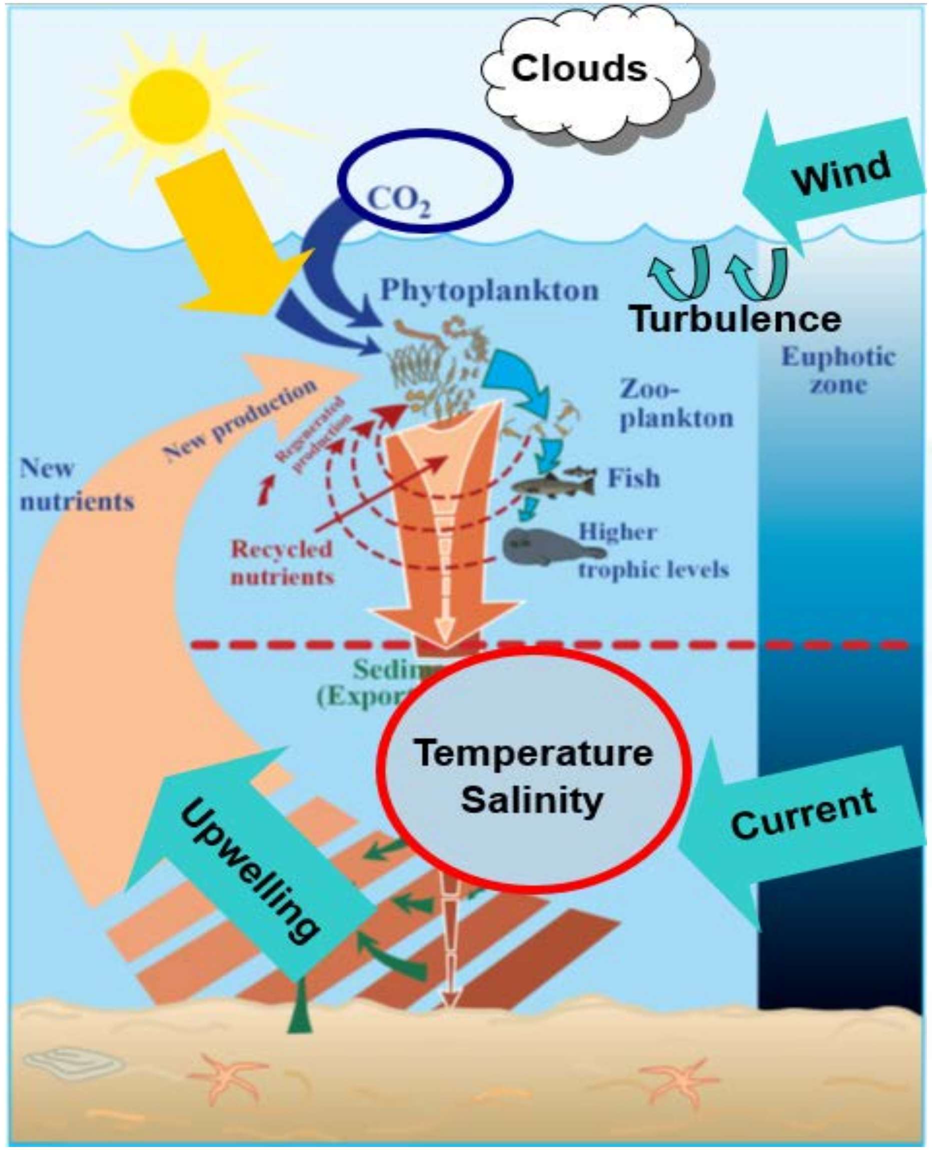
ClimeFish

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

Fisheries and climate change stressor

- **Temperature** increase
- Ocean acidification
- Storms
- Oxygen depletion
- Change in ocean circulation

- Combined effects



Impacts on Marine Fisheries

Species composition

- Northwards shift of species – Marine
- Increased stocks i.e. Mackerel, Whiting and Hake,
- Decreased stocks i.e. Herring, Cod, endemic species
- Emerging species: e.g. Seabass in WoS, invasive

Species phenology and growth

- Alterations year-class
- Food availability
- Growth rates

Distribution and fisheries dynamics

- Catch composition
- Spatial distribution
- Deployment of gear and catch efficiency

Quota allocation, licenses and TAC

- Increased complexity in negotiations
- Overfishing of shared stocks
- Choke Species

Production dynamics

- Longer distance to fishing grounds
- Reduced safety
- Damaged infrastructure
- Reduced fishing days / Increased costs

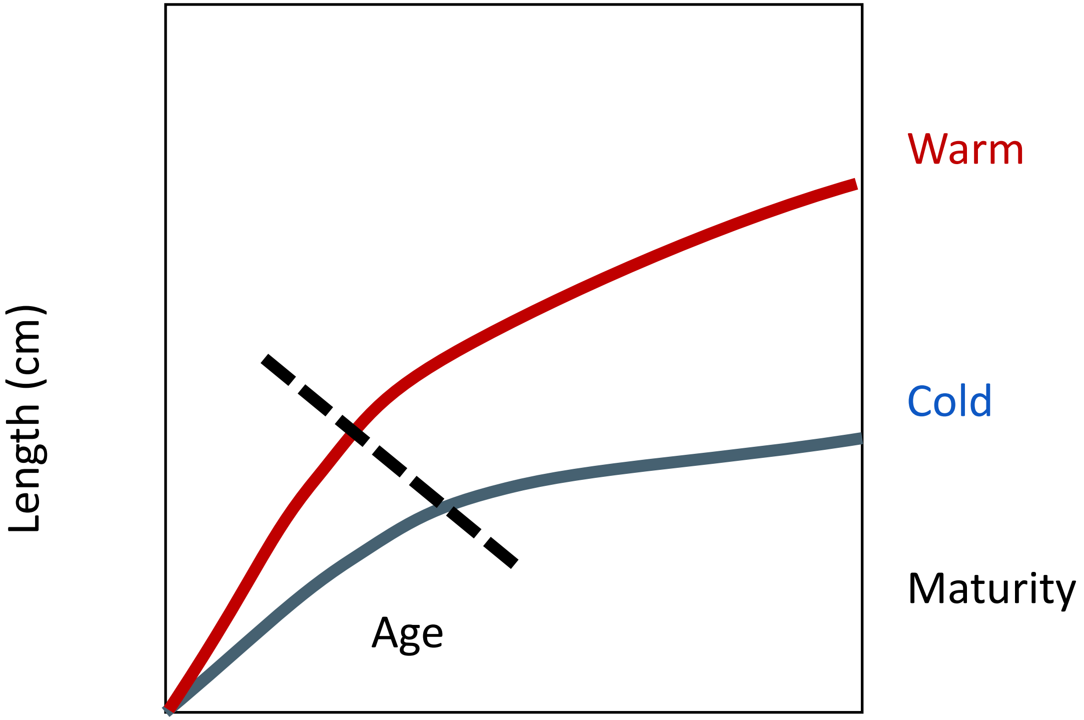
ClimeFish

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

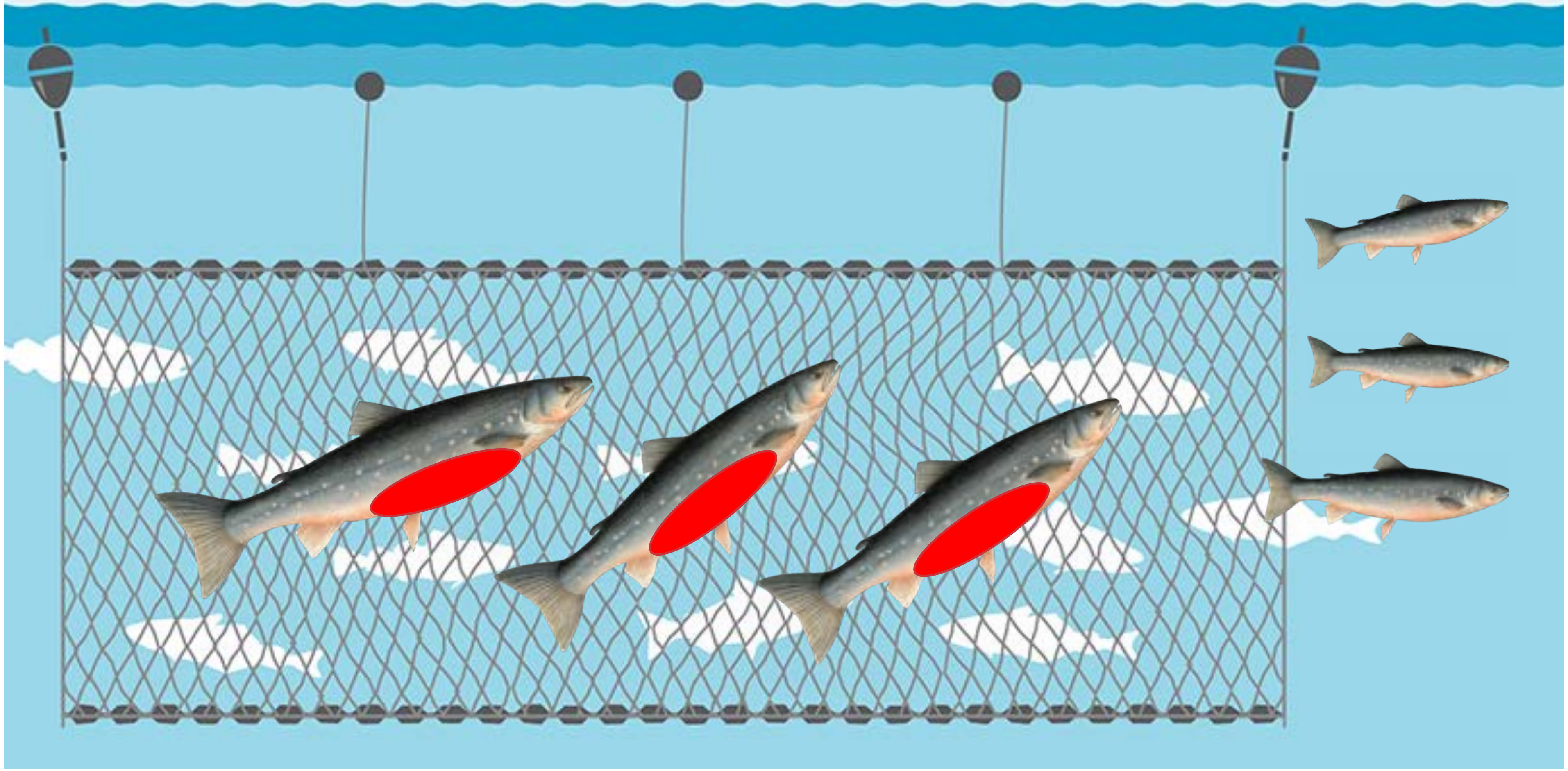
Fish grow faster and mature earlier due to warming

Cod

Salmon

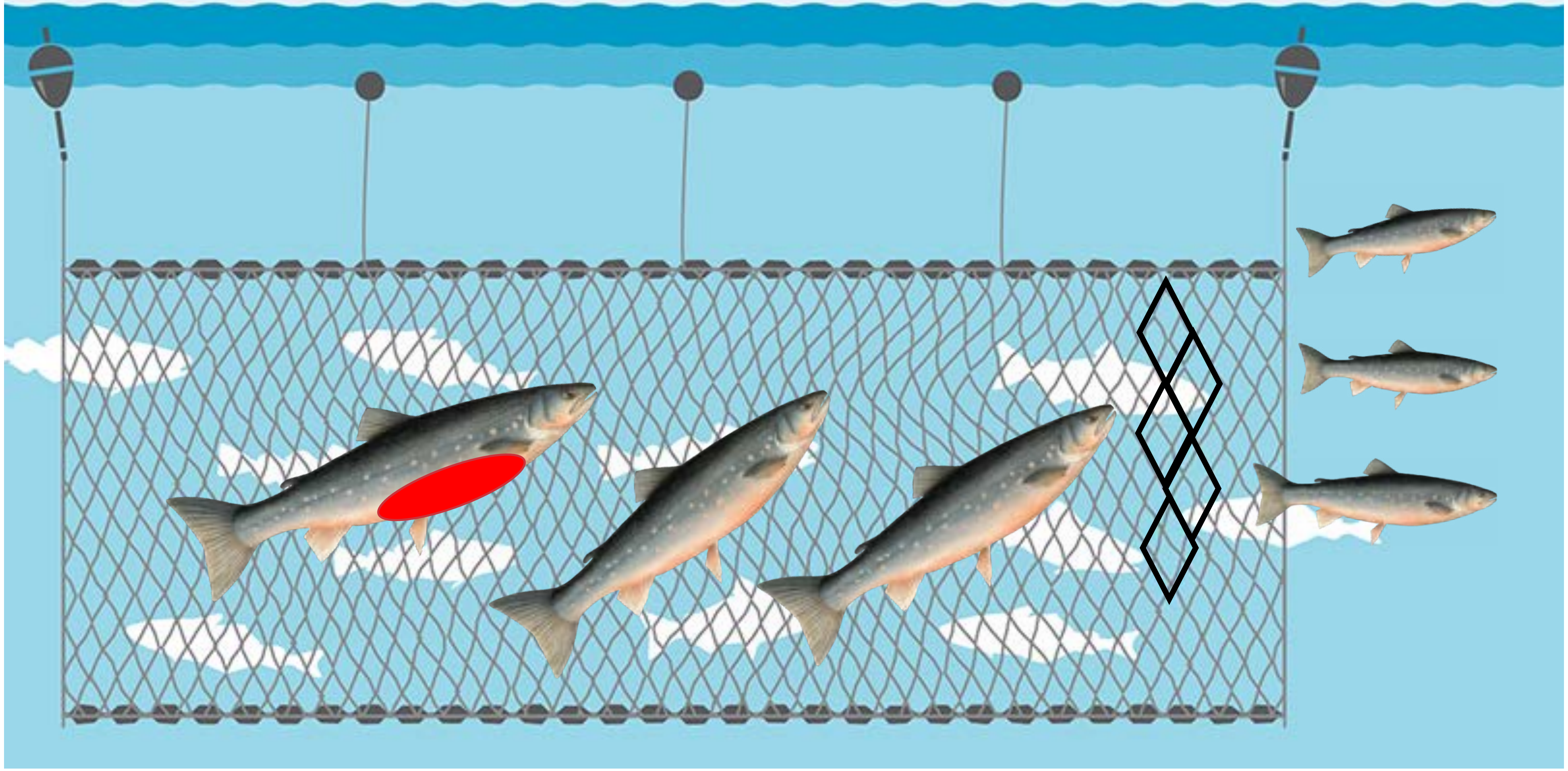


Before temperature increase: Mature fish is caught while immature ones escape



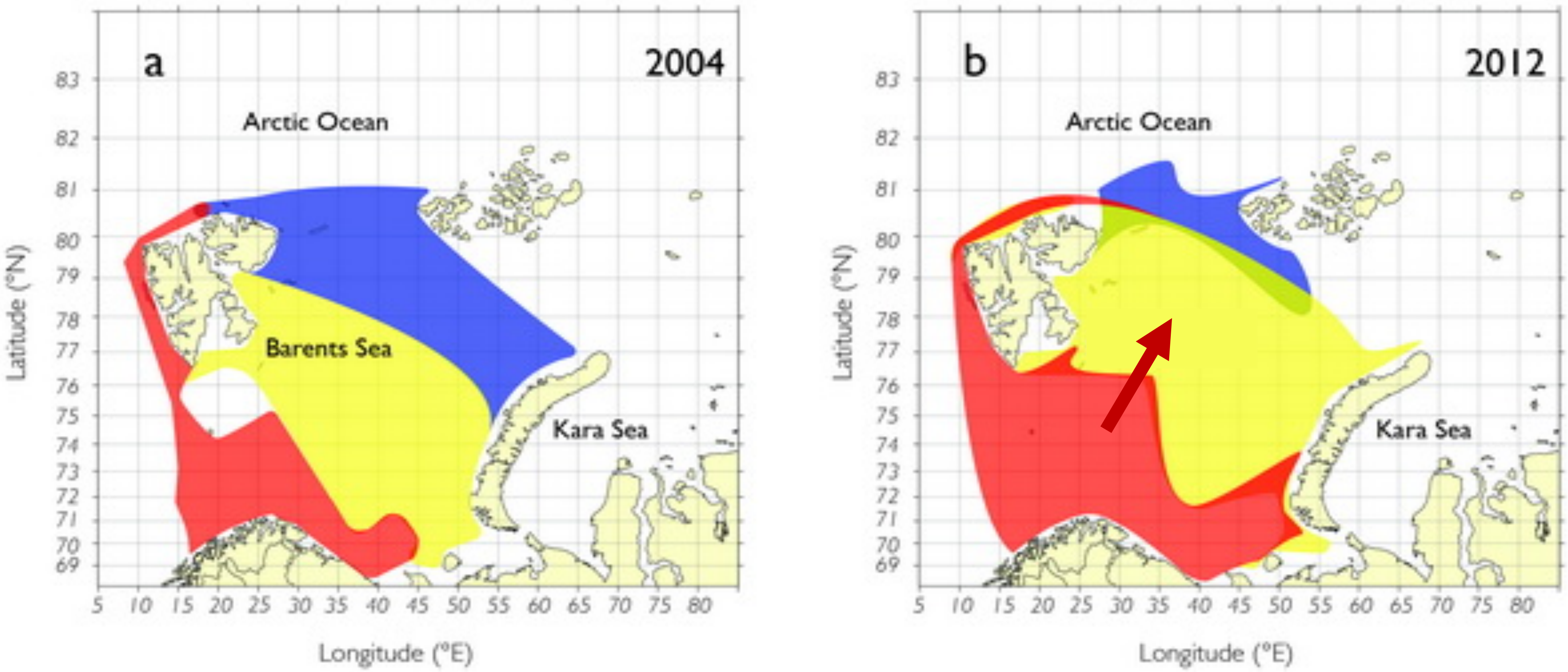
Smalås 2020 UiT

When warming: Immature fish becomes larger and gets caught – regulation of gear needed



Smalås 2020 UiT

Climate change is pushing fish polewards



Arctic and boreal fish communities in the Barents Sea

75 fish stocks show change in distribution over 30 years in the NE-Atlantic

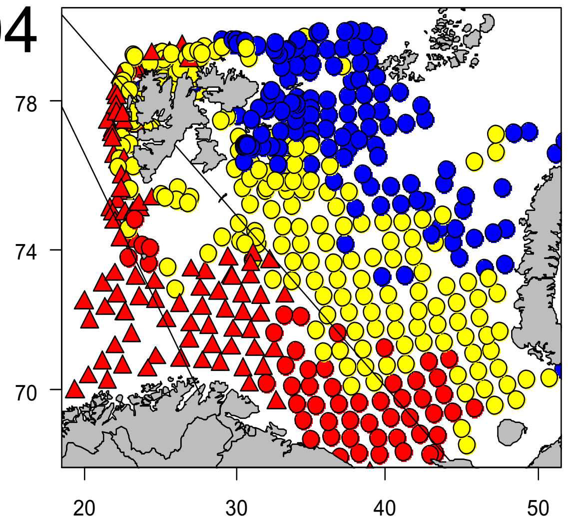
Fossheim et al. 2015 Nature Climate Change

Baurdon et al. 2020 Ecography

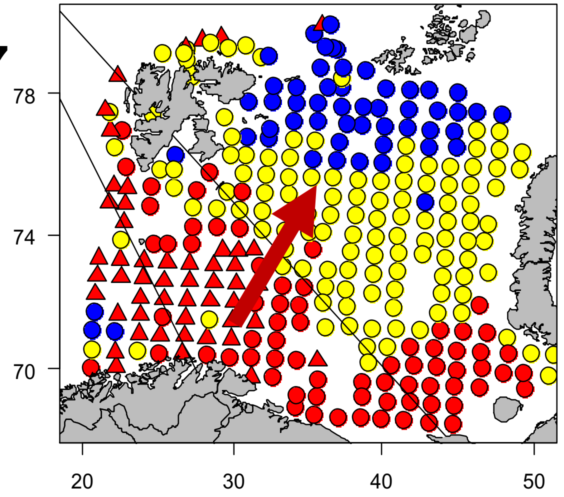
Changes in ecosystem structure → more sensitive to stressors

Community structure

2004

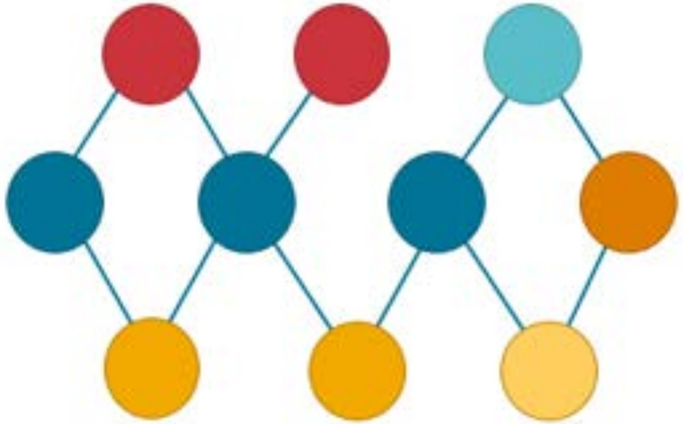


2017



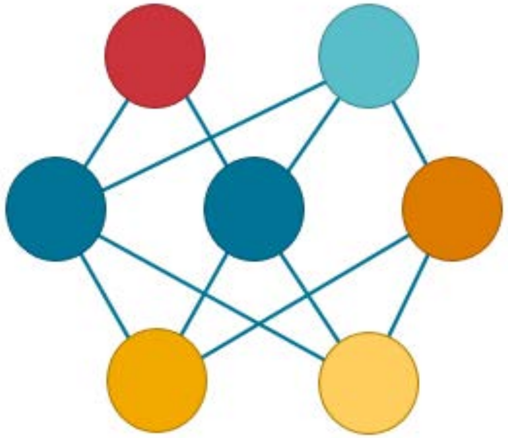
Functional diversity

Number of species with similar function



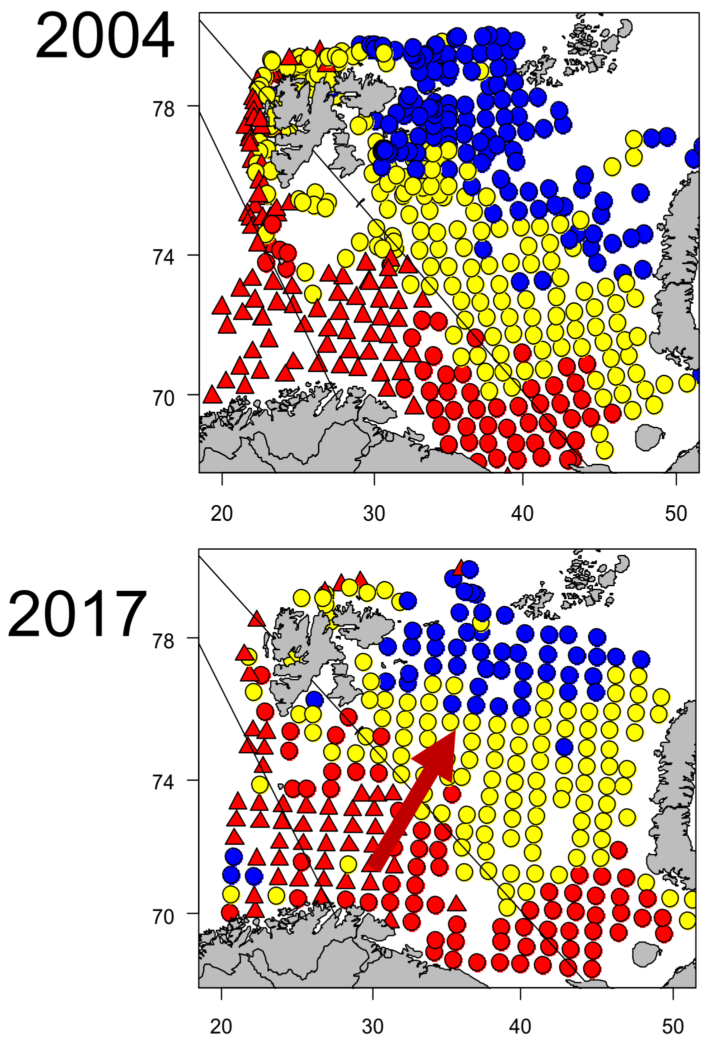
Food web connectivity

How connected the species are

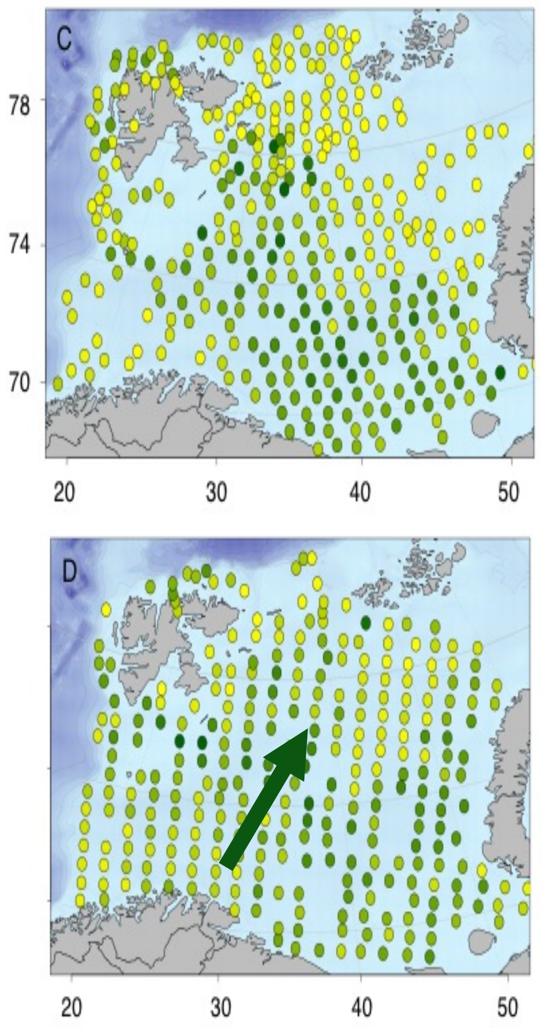


Changes in ecosystem structure → more sensitive to stressors

Community structure



Functional diversity

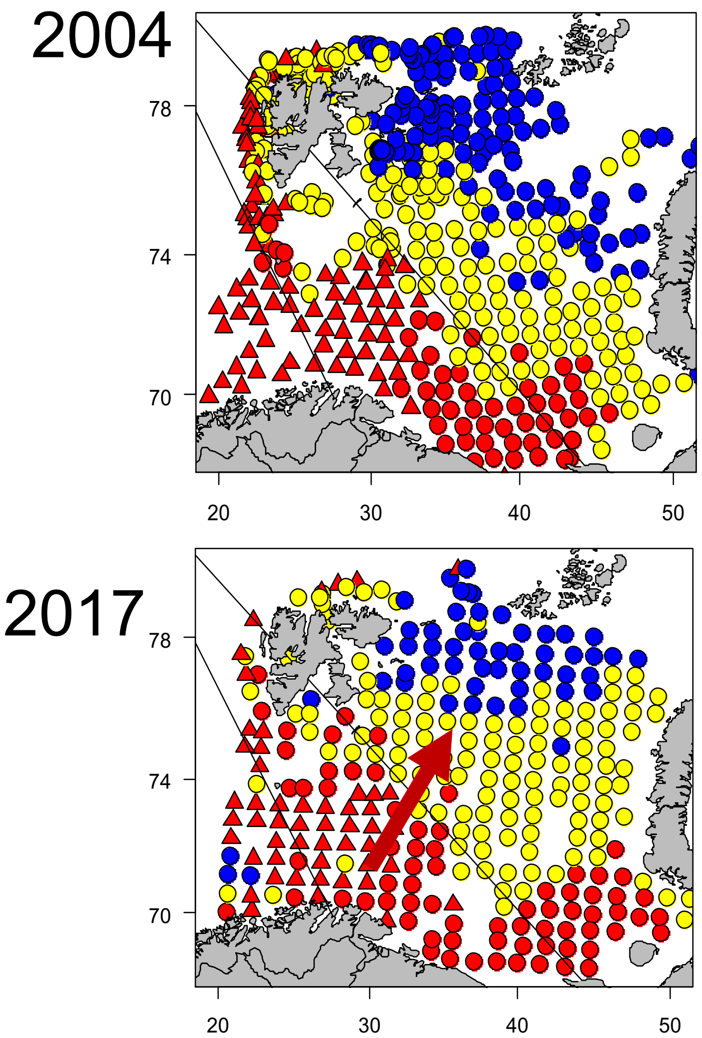


Frainer et al 2021 PRSB

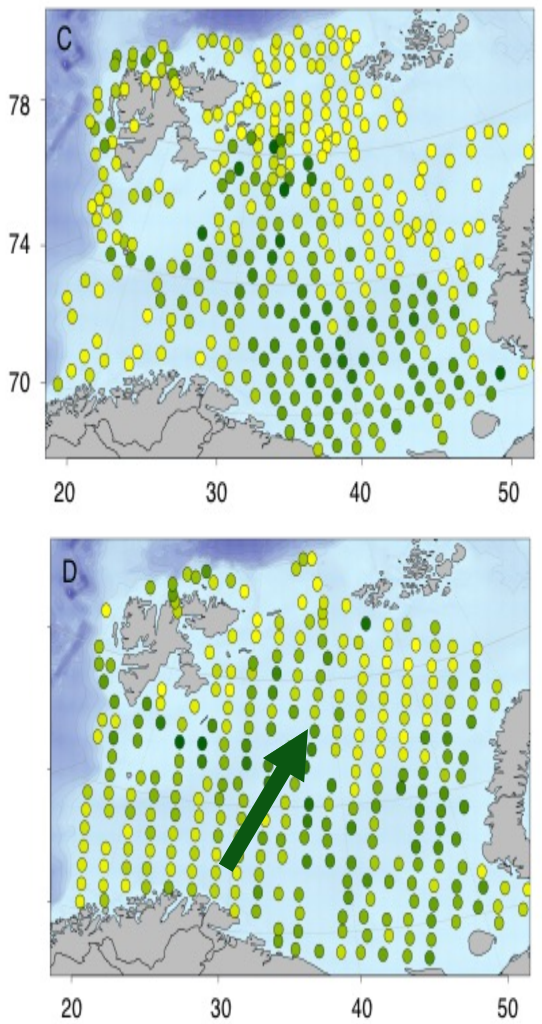
Food web connectivity

Changes in ecosystem structure → more sensitive to stressors

Community structure

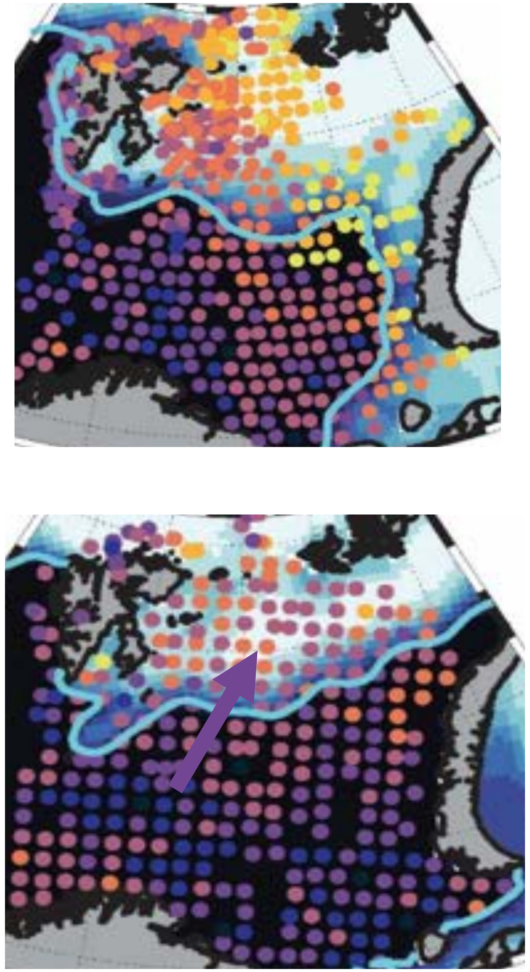


Functional diversity



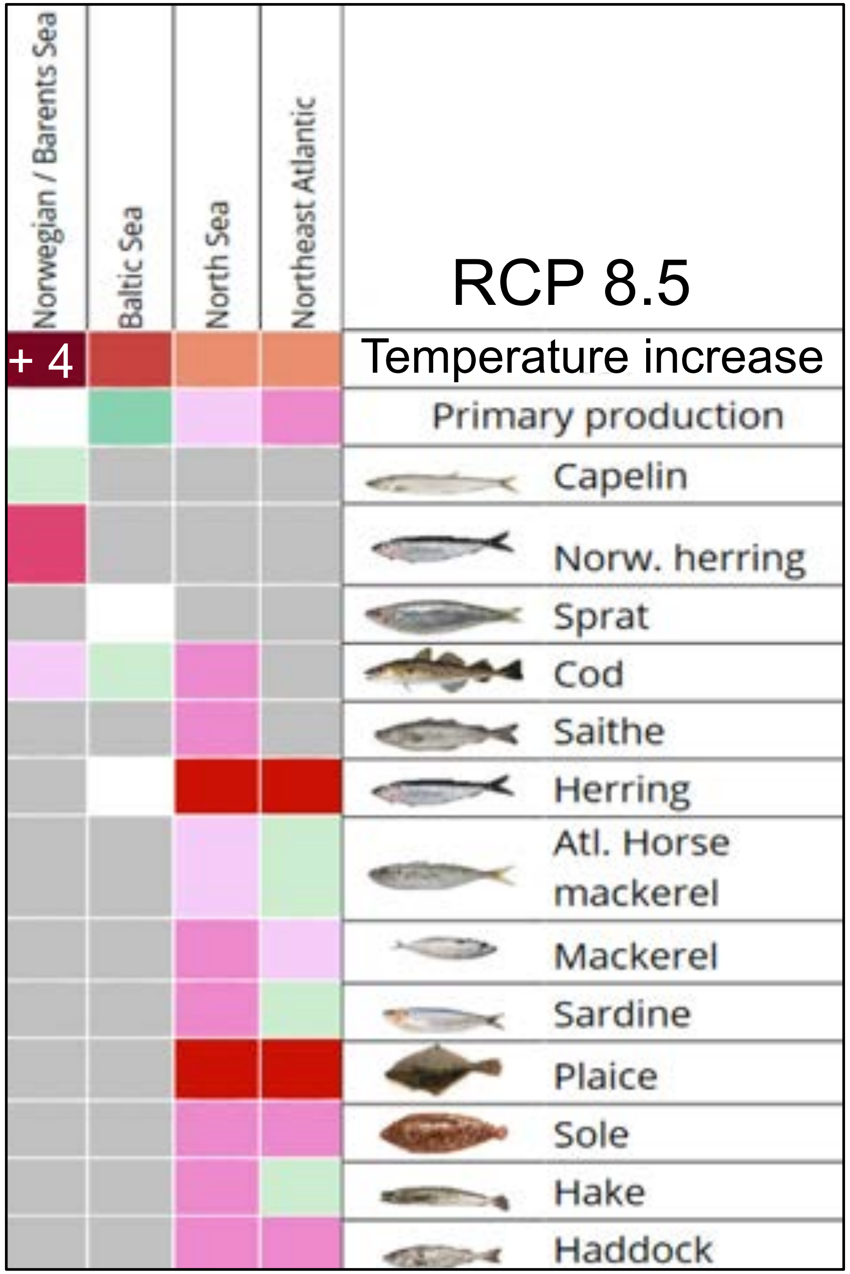
Frainer et al 2021 PRSB

Food web connectivity



Ingvaldsen et al 2021 *NREE*

Fish production response to temperature by 2050



Increase

Decrease

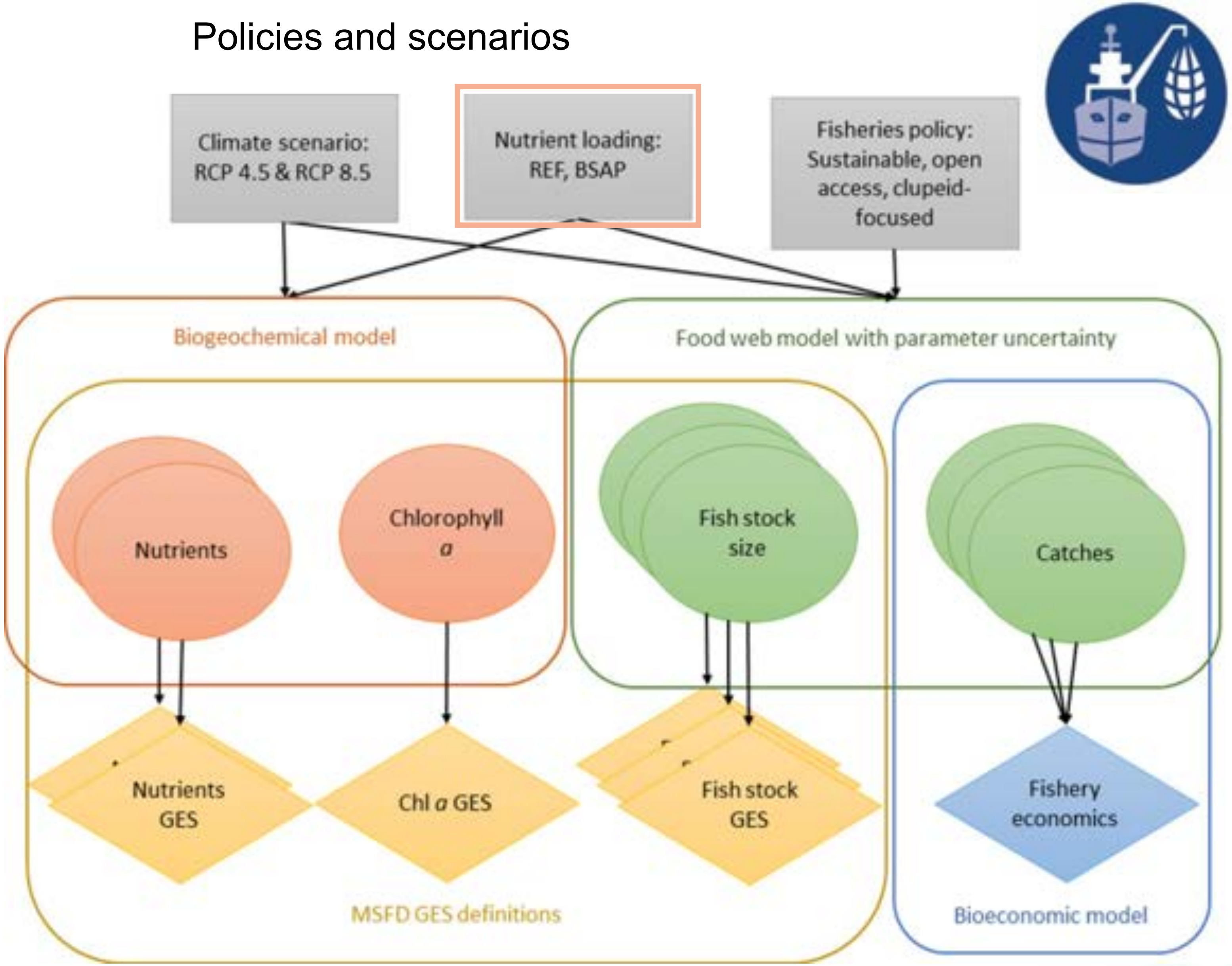
No information

[Peck et al. 2020: CC and European Fisheries and Aquaculture]

Baltic Sea Bayesian network- based decision support model

Models on environmental status, simulated with policies and scenarios

Provide probability of attaining policy objectives



Uusitalo et al. 2022 Science of The Total Environment

See also:
[SW Scotland Decision Support Tool]

Fisheries – Impact and adaptation measures

Risks and opportunitets

- Northwards shift of species
- Emerging species
- Mackerel and Whiting increase
  Herring decrease

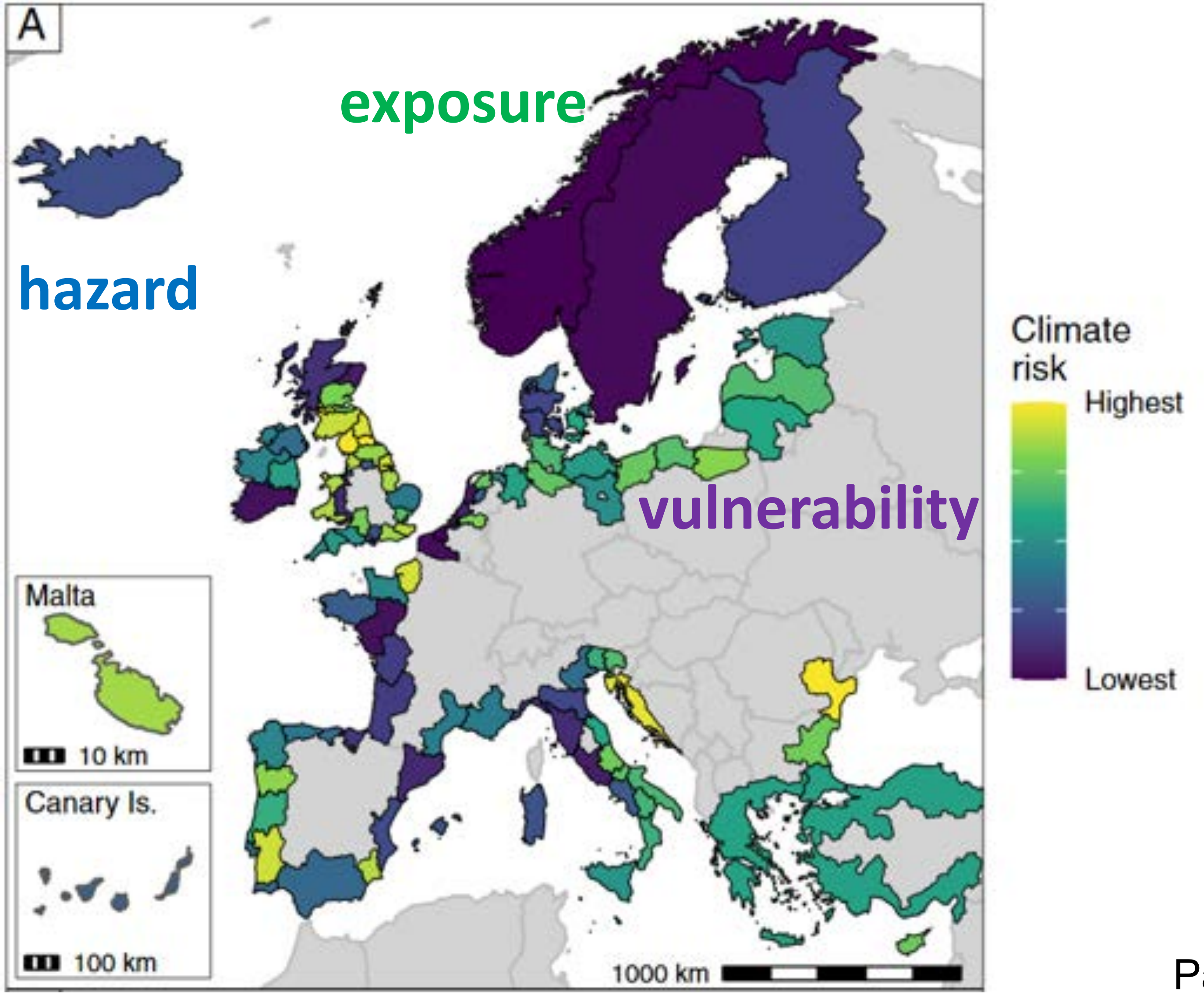
Adaptation measures

- Robust vessels and gear development
- Increased marketing effort for new emerging species
- Sharing agreements to prevent overfishing

ClimeFish

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

Climate risk to European fisheries and coastal communities



Diversity of challenges call for tailored climate adaptation

Payne et al. 2020 PNAS

Be prepared!

Develop a climate adaptation plan (CAP) for your business, municipality or country.

ClimeFish

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

Standard for developing CAPs available now

Good practice recommendations for making Climate Adaptation Plans for fisheries and aquaculture

- European voluntary standard (CWA 17518:2020)
- Journal paper Pham, T. et al. 2021. Guidelines for co-creating climate adaptation plans for fisheries and aquaculture. Climatic Change

Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment (EN ISO 14091:2021)

- Guides general risk assessment

European Committee for Standardization

Guidelines for creating Climate Adaptation Plans (CAPs)

European Committee for Standardization

CEN Workshop Agreement CWA 17518:2020

Good practice recommendations for making Climate Adaptation Plans for fisheries and aquaculture

Assess risks and opportunities 1

1. Evaluate current status
2. Forecasts
3. Risk assessment

Identify adaptation measures 2

4. Vulnerability assessment
5. Adaptation needs
6. Adaptation measures

Operationalize CAPs 3

7. Implementation plan

Outcomes

Main risks and opportunities

Main vulnerabilities

Adaptation measures and trade-offs

Implementation plan for adaptation measures

Published 24th February 2021

Regions - Baltic Sea

National Adaptation Strategies and Plans

Climate ADAPT

Shares information

Climate Change Impacts and Adaptation — Seafish UK

European Commission

BLUE FARMING IN THE EUROPEAN GREEN DEAL

A NEW STRATEGIC VISION FOR SUSTAINABLE AQUACULTURE PRODUCTION AND CONSUMPTION IN THE EUROPEAN UNION

Published 27th of August 2021

Strategic guidelines for a more sustainable and competitive EU aquaculture 2021-2030

Published 12th of May 2021

Take home messages

- Warming in the Arctic higher than the global average
- Knowledge gaps still very present, and uncertainty in models
- Expected aquaculture production growth hampered by CC
- Change in spatial fish distribution, biomass, and catches → Agreement on quota allocations nessessary and suggested
- Strategies and guidelines to support climate adaptation available

Thank You !

Find more information here:

- https://**climefish**.eu/project-results/
- https://**ceres**project.eu/-results-and-solutions/
- https://www.futuremares.eu/
- https://aquavitaeproject.eu/ & https://www.astral-project.eu/
- https://www.ices.dk
- https://eap.info/

Contact: Michaela.Aschan@uit.no

ClimeFish

AquaVitae

This project has received funding from the European Union´s Horizon 2020 research and innovation action under grant agreement no. 677039

JOINT ICES/ NMTT WORKSHOP LAUNCHING THE NORDIC CLIMATE CHANGE FORUM FOR FISHERIES AND AQUACULTURE (WKNCCFFA)

VOLUME 4 | ISSUE 7

ICES SCIENTIFIC REPORTS

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JOINT ICES/ NMTT WORKSHOP LAUNCHING THE NORDIC CLIMATE CHANGE FORUM FOR FISHERIES AND AQUACULTURE (WKNCCFFA)

Recommended format for purpose of citation:

ICES. 2022. Joint ICES/ NMTT Workshop launching the Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA).
ICES Scientific Reports. 4:7. 16 pp. http://doi.org/10.17895/ices.pub.10036

Editors

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Authors

Carl-Christian Schmidt • Mark Dickey-Collas

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

The Nordic Marine Think Tank (NMTT) and International Council for the Exploration of the Sea (ICES) Workshop launching the Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA) reviewed and considered recent research and other initiatives relevant to challenges posed by climate change for fisheries and aquaculture in the Nordic region. It also aimed to synthesize expertise, practical experiences and lessons learned of stakeholders in meeting challenges of climate change and to develop a collaborative platform to facilitate exchange among stakeholders, science, civil society and policy makers. The scoping workshop met these objectives. Scientists set the context and scene for the impact and measures for climate change. Participants considered the challenges facing industry and policy makers. The workshop concluded that future seafood availability will mostly be from aquaculture, that there is a need to establish a common protocol and standards for measuring CO2 emissions. More research on value chain is needed, including establishing open-source platforms for data sharing and on enabling consumer acceptance of new species. Policy frameworks are important and dedicated climate change policies in the fisheries and aquacultures sector needs to be established through dialogue across stakeholders. Climate change considerations need to be part and parcel of fisheries management considerations and quota allocations and a review of present-day governance structure for fisheries management is needed. Gear and vessel innovations are needed to reduce CO2 emissions of fishing activities and industry and policy makers should start by focussing on the low hanging fruits.

ii Expert group information

Expert group name	Joint NMTT-ICES Workshop launching the Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA)
Expert group cycle	workshop
Chairs	Carl-Christian Schmidt
	Arni M. Mathiesen
Meeting venue and dates	9–10 December 2021, Elsinore, Denmark (56 participants)

1 Introduction

The Nordic Marine Think Tank (NMTT) and International Council for the Exploration of the Sea (ICES) hosted the Workshop launching the Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA) on 9–10 December 2021. The workshop took place in Helsingør, Denmark, and was attended by 50 participants representing all Nordic countries: Denmark, Sweden, Norway, Finland, Faroe Islands, Iceland and Greenland. In addition, some colleagues attended via online connection. The program for the event is available in Annex 3. Presentations given by the speakers at the conference can be found on www.nmtt.org/forum.

The workshop was moderated by Arni M. Mathiesen, former Minister, Iceland, and the Round Table by Carl-Christian Schmidt, Chair of the NMTT and Mark Dickey-Collas, Chair of the ICES Advisory Committee (who were also the formal chairs).

In his opening remarks, the Danish Minister of Fisheries, Rasmus Prehn, underscored the importance of working on climate change challenges in fisheries and aquaculture. These sectors are directly affected by the changing climate. Changing climate are changing distribution and appearance of fish stocks in our oceans. Most important is to better understand how we adapt the industry to these changes. Also, we need to reduce the sectors own emission that affect the climate.

2 Setting the Scene

In the first keynote address, professor Michaela Aschan provided an overview of the latest Intergovernmental Panel on Climate Change (IPCC) report (ER6 Climate Change 2021). Over the past years, the climate change scientists have observed more extreme weather events based on a robust science. She underscored that a temperature increases of 1.5 per cent would affect both fisheries and aquaculture in several ways. For the aquaculture sector such temperature increase will affect growth rates of the farmed fish, increase the number of jelly fish blooms, and change the water quality. Aquaculture needs better monitoring, and this implies investment by the fish farmers in more technical equipment. For the fisheries sector the temperature increase combined with increasing CO_2 uptake have made oceans more acid while also changed the ocean circulation. Both these observations influence larvae developments and changes the nutritional availability and quality with direct consequence for the harvesting potential. Consequently, the spatial distribution of the fish will change, and this has implications for quota allocations, which choke species that will be relevant and also complicates the shared stocks negotiations.

Against increasing ocean temperatures fish grow faster and mature earlier which means that fisheries regulations need to change, e.g., increasing mesh sizes. Also, increasing temperatures drive ecosystem changes in terms of the functional diversity and food web connectivity of the ocean biomass. Such changes call for an ecosystem approach to fisheries management.

Professor Aschen underlined the need to develop climate adaptation plans (CAP) and in this regard referred to the Climefish project (www.climefish.eu) financed by the European Union as well as the standard CWA 17518: 2020 entitled “Good practice recommendations for making Climate Adaptation Plans for fisheries and aquaculture”.

The second keynote was given by Sara Hornborg and dealt with life cycle assessments (LCA). LCA is a method to measure the climate footprint of products through the value chain. She highlighted, however, that the methodological assumptions differ across studies of LCA which makes it difficult to compare results of LCAs. Combined with lack of appropriate data for the LCAs leads to assumptions that are central to the understanding of the results.

With respect to the LCA in the capture fisheries, Sara Hornborg detailed the various factors influencing the LCA results. These include stock size, management system, fish stock abundance, fleet structure and local management actions as well as the fishing gear used. In aquaculture, it is the feed structure that influences the LCA outcome.

Finally, Sara Hornborg underlined that the uncertainties in GHG emissions estimates are mainly due to data problems, system boundaries and certain knowledge gaps. Nevertheless, in conclusion it was clear that the fuel used in fishing and feed used in aquaculture are two key areas to further explore as these are the principal emitters of GHG.

The third keynote speech was given by Max Nielsen and provided an economic perspective to climate change in fisheries and aquaculture. He highlighted that GHG emissions is an externality which is not paid for and that it is therefore important to get prices right. It is also important to take action now with a view to reduce costs of future action i.e., action now is cheaper.

Max Nielsen then underscored that market-based reforms of the fisheries management systems across the Nordics have reduced the CO2 emissions but that once consolidation of fleets towards larger vessels start those CO2 emissions tend to increase. Nevertheless, the net result of the reforms is a lowering of CO2 emissions. Looking at fuel use across fleet segments larger vessels are more fuel efficient per kilo caught fish and this is also influenced by how the quota system functions. Recent research has revealed that bottom trawling may release CO2 stored in the sea floor which could render bottom trawling an unsustainable practice.

In aquaculture, it is the feed element in production that is the largest CO2 emitter and use of feed based on fish and agriculture protein should be limited. In this respect it would be beneficial if aquaculture would be part of the European Emissions Trading System for CO2 (see https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en for additional information).

3 Industry Challenges

The Workshop then turned to looking at the fisheries and aquaculture industry's challenges in addressing climate change.

The first speaker, Hildur Hauksdóttir from Fisheries Iceland, recalled the importance of fisheries in the Icelandic economy. About half of Iceland's export is seafood and 20 per cent of all CO2 emissions is from the fisheries sector. The Iceland objective is to reduce the emissions by 50 per cent by 2030 and with a view to becoming fossil fuel free by 2040/50.

Hildur Hauksdóttir mentioned that Fisheries Iceland had organised four public meetings to discuss corporate social responsibility (CSR) of the Icelandic fisheries sector. These meetings had been well attended by stakeholders and been used to identify an agenda for the CSR actions that would make the sector more sustainable and reduce its climate change impact. The main themes of these meetings had been transparency, environment, innovation, and the sector's contribution to society.

In concluding her remarks, she underlined the importance of efficient fisheries management which lower the fuel consumption of the fleet and the importance of better utilisation of the raw material once landed with a view to reduce waste.

Anne Mette Bœk, president of IFFO and director of EFFOP and Marine Ingredients Denmark talked about the marine ingredients industry's work on climate change. Mostly, fishmeal and oil are sourced from small pelagic fish with fishing fleets with very low CO2 emissions. She highlighted that in today's market costumers of fishmeal and oil are asking for traceability and also information about CO2 emissions.

The marine ingredients industry is affected by water temperatures, pH changes in sea water, sea level rise as well as El Nino and La Nina phenomena. Changes in these factors have led to changes in the species composition of landings in the Danish factories and has also meant lower yields of fish oil. The industry is therefore looking for new sources of raw material, for example mesopelagic fish and trials are underway to determine their catchability, yields, and use as input to marine ingredients.

She finished her presentation by underscoring the need for certification and multistakeholder initiatives both seen as instrumental to the future of the marine ingredient industry complex. The importance of "blue food" in the global food system is important for health and the marine ingredients industry help the aquaculture sector to become more innovative and more flexible in their use of marine ingredients.

To provide a more detailed look at the future of aquafeed, Vidar Gundersen, Global Sustainability Director of BioMar, started by presenting BioMar a Danish global leader of aquaculture feeds. 1600 persons work for the company producing annually 1,5 million tons of aquaculture feeds of which about 60 per cent is for salmon aquaculture. Salmon aquaculture is also a driver of innovation. He highlighted that since about 2012 the focus of BioMar has been on climate change impacts and how the company can help responding noting that 80 per cent of the environmental footprint in aquaculture is due to the feed used.

One outcome of working on lowering the environmental footprint has been, over time, a reduction in the use of fish in feed compounds which, today, is limited to just 20 per cent. Soy meal has been the biggest replacement of fishmeal. In doing this, the Omega 3 content in feeds has been reduced considerably but has lately been restored somewhat by using marine based microalgae.

As for future developments, Vidar Gundersen highlighted BioMar's work on single cell raw materials from industrial waste streams and by-products from existing industry. More use of by-products and trimmings, single cell raw material and the use of lower trophic levels fish are important avenues for the aquaculture feed manufacturers. Meanwhile most of the diet in aquaculture will still be plant based. Concurrently, BioMar seeks to reduce the GHG footprint of the feed compounds by one third by 2030, by 50 per cent by 2050 through circular and restorative approaches while enabling 100 000 people by 2030 to be part of capacity building on climate actions.

Jesper Heldbo of Aquacircle then talked about the technical challenges in reducing CO2 emissions in aquaculture.

For fish farmers innovation and the inclusion of artificial intelligence (IA) is seen as central to further expansion. AI is the means to ensure a better use of raw material, lower feed use and surveillance of the stock of fish in aquaculture production systems. In this regard degassing, i.e., removal of CO2, in aquaculture using AI is central to ensure proper process management. Overall, AI will create efficiencies in future aquaculture production systems. Further possibilities to reduce the sector's overall climate footprint lies in the placement of recirculating systems closer to the consumers, stopping flying the fish all over the world and in the introduction and trading of carbon quotas across food production systems.

He concluded by presenting a model aquaculture production system, AquaPort, where fish farms are an integrated part of an industrial-energy cluster which can result in zero discharge and carbon neutral fish production. He highlighted that often "red tape" is a problem in moving towards integrated approaches and that thinking outside the box is needed in both industry and in the regulatory area.

Alex Olsen, former Sustainability Director with Espersen A/S provided an overview of the climate change challenges faced by the processing industry. He underscored that while the processing industry could still do better it was a case of self-interest in that reducing energy use was part of an ongoing call for increasing profitability. Key areas for further reduction include energy, CO2 emission, water use and food waste.

As an example, Alex Olsen referred to the carbon footprint of cod fillets which includes 47,8 per cent for fishing/harvesting, 29,1 per cent for transport, 19,6 per cent is the processing of fillets and the rest of 3,5 per cent is sea transport. Most major fisheries processor source raw material from all over the world and hence transport is important. As far as possible, transport should be done by sea as the carbon footprint is low.

In concluding his presentation, he underscored the need for further cooperation across the value chain to ensure good behaviour of fishing companies. He also highlighted that certain fishing practices e.g., bottom trawling may have particular negative effects that needs to be addressed. Finally, he underlined the need for further international cooperation on innovation to reduce the environmental effects of fishing gear, getting stakeholders together and ensure transparency.

4 Policy Challenges and Responses

The second day of the workshop focussed on Policy Challenges and Responses thus turning to the political and administration of the fisheries and aquaculture sectors. Several countries provided an overview of policy initiatives taken or planned in dealing with climate change in fisheries and aquaculture. The purpose of this discussion was to cross-fertilise and ensure that countries were up to date with activities elsewhere. The workshop finished with a Roundtable, comprising of industry representatives, who provided their personal insights into what a possible future agenda to address climate change might look like.

The second day of the workshop was opened by Angus Garret, Head of Horizon Scanning and Long-Term Issues at Seafish. He provided an overview of the UK seafood industry's adaptation to changing climate conditions. He underlined that there are opportunities for smart food solutions in that fish and seafood have a very low climate footprint compared to other foods. Seafish has focussed on the adaptation side of climate change seeking solutions and ways that industry participants may respond to the climate challenge. Now in its sixth year the climate change work of Seafish is a continuing conversation among fisheries stakeholders, scientists and industry to build up a knowledge system, which is both practical and based on local knowledge.

He recalled the major publications on climate change in both fisheries and in aquaculture produced by Seafish (see https://www.seafish.org/insight-and-research/current-and-future-trends/climate-change-impacts-and-adaptation/ for further details). He recalled that the key drivers of climate change relevant to the industry are severity of storms and waves, temperature change of the sea and air, rainfall, sea level rise and ocean acidification. Such challenges have implications for fisheries management regimes due to dynamics of fish stocks and the appearance of new fish stocks, operational safety of fishing operations, aquaculture installations, but also ports and land-based infrastructure used in fisheries and aquaculture sector. Despite uncertainties and knowledge gaps it is important to prioritise areas for action.

In conclusion, Angus Garret underscored the need to enhance fisheries science, to allow for a more flexible fisheries management approach, building resilience into fisheries operations at sea and in ports and in doing so consider and engage the whole industry, and with stakeholders. In moving forwards, it is important to have a flexible approach to be able to respond to new science.

Mark Dickey-Collas of ICES and Chair of ACFM gave an overview of the work of ICES related to climate change. He highlighted that ICES works on climate change goes back several decades and has involved work with several international organisations. Since 1985, 16 out of 21 fish stocks have changed their distribution across the North Atlantic. Such changes are observed in distribution of stocks and in stock productivity with implications for fisheries management and negotiations as to who can catch the fish.

The existing governance system for fisheries is rigid, lacks flexibility and hence have difficulties in adapting to the changing climate conditions. For example, ICES have no framework for incorporating climate change in its advice on fisheries management. We therefore need to consider a new framework that is more resilient to climate changes. This involves a closer look at the way we build and use our organisations, our learning system, how we incorporate flexibility, and a review of agencies and assets.

Jon Stefansson of the Iceland Ministry of Industries and Innovation talked about Climate Change and the Effects on Fisheries Management. He highlighted that, in Iceland, climate challenges are not directly addressed in the fisheries management but that the fisheries management settings indirectly deal with climate through the use of fishing gear, open/closed fishing areas, types of vessels allowed to fish and the requirements for these vessels, through the allocation of TAC and via the resource rent taxation. The recently elected coalition government in Iceland has called for an acceleration of the energy conversion of the fleet based on proposals from the working group on green steps in the fisheries sector.

He referred to the ongoing mackerel dispute and called for a speedy negotiation with all parties involved to find a decent solution and thus avoid that the mackerel stock become overfished. The coastal states fishing the mackerel carry a joint responsibility for ensuring that the stock remains sustainable managed.

In conclusion, he referred to the recent White Paper on Adaptation to Climate Change. The fisheries management related issues in the White Paper calls for sufficient monitoring and assessment of the effects of climate change on fish stocks and their distribution, for more funding and research, and for assessment of the adaptation needs of the seafood and aquaculture industry.

Andreas Stokseth of the Norwegian Ministry of Trade, Industry and Fisheries told participants that Norway will hold the presidency of Nordic Council of Ministers in 2022 and is fully committed to the vision of the Nordics as the most sustainable and integrated region of the world. This vision also applies to the Nordic seas. Ocean climate and sustainability issues has a firm and central place in the programme during the Norwegian presidency. Norway is keen to bring the big issues of the international ocean agenda into the context of Nordic cooperation.

Norway has a climate goal of reducing the CO_2 emissions by 55 per cent by 2030 as compared to the level in 1990 including for the seafood industry. The seafood industry increasingly must document sustainability and carbon footprint for authorities, traders and consumers. The Norwegian government is therefore committed to contribute to innovation and supports new ways to organize production and new technology in the seafood industry. Considerable funding will be allocated to three areas of marine research that can have high positive effects on reducing greenhouse gas emissions in the future i.e., research into alternative and more sustainably produced ingredients for aquaculture fish feed, R&D in green shipping and technology, and research into cooling and frozen fish technology as an alternative to the fresh fish/air freight strategy which has been a major culprit in driving the size of the carbon footprint of the salmon industry.

Henry Damsgaard Lanng of the Danish Ministry for Food, Agriculture and Fisheries gave an overview of the Danish responses to climate change. The Danish approach has been increasing research activities on fisheries and aquaculture climate change challenges through the Danish Technical University (DTU). In capture fisheries priorities include vessel fuel efficiency, life cycle analysis for fish products, the use of marine protein as an alternative to meat, strengthening the ocean's ability to store and absorb CO_2 and holistic climate change solutions accounting for wider landscape issues. For aquaculture, priorities include energy efficiency, LCA, alternative feed sources, and genetic improvements of fish breeds to improve resource efficiency.

He also highlighted the Green Development and Demonstration Program (GUDP) established in 2010 and which since then has funded projects to the tune of 185 million DKr per year in both fisheries and agriculture. Fisheries projects, inter alia, have included improved trawl doors that reduce impacts on the sea floor while improving fuel efficiency and technologies to improve water quality in recirculating aquaculture.

Mats Svensson of the Swedish Agency for Marine and Water Management gave the workshop a short overview of the Swedish climate change challenges. He highlighted that the pressure on the marine environment comes from environmental pollutants, climate change, over-fertilization but also from fisheries activities itself. A new Marine Plan will be implemented in 2022 and deal with ecosystem-based management approach, more protected areas, and more areas for marine wind energy parks.

He highlighted the problems faced in the Baltic Sea with water quality as bottom water has become increasingly hypoxic and anoxic. Consequently, the plankton communities have undergone major shifts and has influenced fishing possibilities. As for North Sea and West coast fisheries he observed that major change to cod and herring stocks are underway. Coastal fisheries in Sweden have already been reduced considerably.

5 Round Table

With a view to garner the industry representatives experience of the workshop and point to relevant future agenda for the Forum a Round Table took place. Participating at the Round Table were Unn Laksá of Sjokovin, Faroe Islands, Jennie Montell of Espersen a/s, and Brian Thomsen of Danish Aquaculture Organisation. The Round Table was moderated by Mark Dickey-Collas, ICES, and Carl-Christian Schmidt, NMTT.

The key points that emerged from the Round Table discussion and the ensuing discussion with all participants were as follows:

- Future seafood availability will mostly be from aquaculture.
- There is a need to establish a common protocol and standards for measuring CO2 emissions.
- To fill our knowledge gaps on climate change impacts in the fisheries value chain more research is needed, including economic research.
- Regulations for aquaculture and fisheries, needs to be simplified and transparent to augment social acceptance of these activities and their environmental impacts.
- Work is needed on improving consumer acceptance of new species.
- To reduce food waste the whole value chain should focus on how to use all the fish.
- The fish processors need to team up with land-based vegetable producers to reduce overall CO2 emissions.
- Improve collaboration across the value chain and establish open-source data platforms through which data sharing can take place.
- Policy frameworks are important and dedicated climate change policies in the fisheries and aquacultures sector needs to be established through dialogue across stakeholders. This will improve acceptance and willingness to invest in CO2 reducing technologies.
- Climate change considerations need to be part and parcel of fisheries management considerations and quota allocations.
- A review of present-day governance structure for fisheries management is needed to ensure that climate change considerations are accounted for. Legal texts should be sufficiently flexible to consider climate change impacts focusing on processes rather than prescribed outcomes. One outcome would be adaptive management.
- Gear and vessel innovations are needed to reduce CO2 emissions of fishing activities and industry and policy makers should start by focussing on the low hanging fruits. The fishing industry will learn from the maritime transport sector as this sector moves to be carbon neutral.

Annex 1: List of participants

Name	Institute/ organisation	Email
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Annex 2: WKNCCFFA resolution

Joint ICES/ NMTT Workshop exploring the establishment of a Nordic Climate Change Forum for Fisheries and Aquaculture (WKNCCFFA), chaired by Carl-Christian Schmidt, Denmark; and Arni M. Mathiesen, Iceland, will meet in Elsinore, Denmark, 9–10 December 2021 to:

a) Review and consider recent research and other initiatives relevant to challenges posed by climate change for fisheries and aquaculture in the Nordic region (Science Plan codes: 1.1; 2.1; 3.6; 7.3);

b) Synthesize expertise, practical experiences and lessons learned of stakeholders in meeting challenges of climate change (Science Plan codes: 4.1; 5.2; 7.3; 7.7);

c) Develop a collaborative platform to facilitate exchange among the Nordic fisheries and aquaculture stakeholders, science, civil society and policy makers (Science Plan codes: 2.1; 3.6; 7.3; 7.5).

WKNCCFFA will report by 15 March 2022 (via HAPISG) for the attention of SCICOM and ACOM.

Supporting information

Priority	Rising sea temperatures, changing salinity, acidification, pH and oxygenation are some of the effects that increasingly will be felt by the fisheries and aquaculture sectors. Some changes have already taken place. However, little has been done in terms of supporting the preparedness of the fisheries and aquaculture sectors to reduce their own climate impacts while adapting to the anticipated changing conditions. The Workshop, organized jointly by the Nordic Marine Think Tank (NMTT), ICES and with support from the Nordic Council of Ministers, will bring together fisheries and aquaculture stakeholders and scientists from the Nordic countries to advance collaboration on addressing challenges imposed by climate change. Consequently, the workshop is considered to have a very high priority in establishing a climate change forum for fisheries and aquaculture stakeholders which will act as a knowledge exchange platform with mutual benefits for industry, science and fisheries policy makers.
Scientific justification	Term of Reference a) The IPCC report (2019) notes that " ***A.5. Since about 1950 many marine species across various groups have undergone shifts in geographical range and seasonal activities in response to ocean warming, sea ice change and biogeochemical changes, such as oxygen loss, to their habitats (high confidence). This has resulted in shifts in species composition, abundance and biomass production of ecosystems from the equator to the poles."*** **It is important to synthesize the science on a regional scale and reflect on it with science, industry, NGOs and policy makers to identify relevant knowledge for decision making,** specifically considering social and economic impacts and the future role of seafood production in the overall food producing sector. Term of Reference b) Industry is already challenged by climate change affecting the marine environment and the dynamics of the resources. In addition the sector needs to adapt to increasing regulations on emissions while reducing the environmental impact of their activities. Besides the scientific knowledge, sharing the lessons learned and knowledge within the sector will help to facilitate adaptation.

	Term of Reference c) **The fisheries and aquaculture sectors urgently need to identify pathways to adjust to a changing climate (adaptation) while concurrently take up measures and techniques in both fisheries and aquaculture that will reduce the sectors' impacts on the climate (mitigation).** To facilitate the exchange among stakeholders, industry, civil society science and policy makers need a safe and trusted forum for discussion. The proposed Nordic Climate Change Forum for Fisheries and Aquaculture aims to provide this.
Resource requirements	The resource required in the framework of this workshop is marginal and is mainl organisational support for establishing a workshop programme and assistance for broadening participation from stakeholders.
Participants	The Workshop will be attended by 100-120 participants from across the Nordic countries. Participation will be broad and include industry, scientific community, fisheries policy makers and managers, and NGOs working in the field of fisheries and aquaculture.
Secretariat facilities	Standard EG support.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	SICCME, SIHD, EPDSG, HAPISG, EOSG, FRSG, DSTSG, ASG, WGREIA, WGS2D, WGGRAFY, WGOOFE.
Linkages to other organizations	The work of this Workshop is aligned with other international fora considering climate change in fisheries and aquaculture such as the FAO, IUCN, OECD, UN.

Annex 3: WKNCCFFA programme

Funded by the Nordic Council of Ministers

Joint NMTT-ICES Workshop

launching the

Nordic Climate Change Forum for Fisheries and Aquaculture

Konventum, Elsinore, Denmark

9-10 December, 2021

AGENDA

As adjusted during the event

9 December 2021, Chair: Árni M. Mathiesen, former Minister, Iceland

08:00 Registration and coffee

09:00 Welcome and Introductions by NMTT and ICES

09:15 Opening of the Workshop by Rasmus Prehn, Minister for Food, Agriculture, and Fisheries, Denmark.

PART I: SETTING THE SCENE

The role of the keynote introductory presentations is to bring participants up to date with the latest available knowledge on climate change and its impacts on the fisheries and aquaculture sectors. It will also be an opportunity to lay out the challenges posed by adaptation policies and strategies.

09:40 Keynote 1: Impact of climate change on seafood production and adaptation measures. Professor Michaela Aschan, Norwegian College of Fishery Science, UiT the Arctic University of Norway.

10:10 Keynote 2: Fisheries and Climate Change: Insights from Life Cycle Assessments. Sara Hornborg, RISE- Research Institutes of Sweden

10:40 BREAK

11:10 Keynote 3: How does the fisheries and aquaculture value chains impact the climate? Identifying pathways to mitigating the impacts of our activities: An Economic Perspective. Max Nielsen, Department of Food and Resource Economics, Copenhagen University.

11:40 Discussion

12:00 Lunch

PART II: INDUSTRY CHALLENGES

Using a value chain approach Part II of the Workshop will highlight the fisheries and aquaculture industry challenges of addressing climate change. The session will provide examples of responses and provide an opportunity for participants to better understand how to implement actions to reduce CO_2 and other GHG while adapting industry to a new resource situation.

13:30 Capture Fisheries for Human Consumption. Climate Change Issues and Challenges. Hildur Hauksdottir, Fisheries Iceland

14:10 The Marine Ingredients Industry and Climate Change. Anne Mette Bæk, president IFFO, director EFFOP and MID.

14:40 Break

15:10 The Future of Aquafeeds, Vidar Gundersen. Global Sustainability Director BioMar Group.

15:40 Technical challenges in reducing CO_2 emissions in Aquaculture. Jesper Heldbo, Aquacircle.

16:10 Processing Industry. Climate Change Issues and Challenges. Alex Olsen, former Espersen A/S.

16:40 Discussion

17:00 End of Day 1

18:30 Welcome drink followed by dinner.

10 December 2021 Chair: Árni M. Mathiesen, former Minister, Iceland

PART III: POLICY CHALLENGES AND RESPONSES

This Part III of the Workshop will present Nordic policy responses to climate change and provide an opportunity for participants to discuss with policy makers and industry stakeholders about what additional responses are needed to address the climate challenge. Also, the Workshop will debate how our governance structure and institutional cooperation needs to be reorganised to face up more efficiently to the climate challenge.

09:00 Angus Garrett: Understanding and adapting to a changing climate for UK seafood.

09:30 Managing fisheries and aquaculture under climate change: Perspectives from the frontline:

a.) Jon Stefansson, Iceland: recent initiatives and preparatory steps on fisheries management.
b.) Andreas Stokseth, Norway will update participants on recent initiatives regarding climate change in fisheries and aquaculture.
c.) Henry Damsgaard Lanng, Denmark will provide an overview of recent initiatives.
d.) Mats Svensson, Sweden: Short overview of the fisheries and climate change challenges.

10:30 Break

10:50 Mark Dickey-Collas: ICES climate and fisheries

11:10 Roundtable moderated by NMTT and ICES

The Roundtable will address the "HOW" to move forward with respect to further the understanding and need to address climate change by the fishing industry. What are the pathways to ensure that all industry participants take appropriate action to reduce their CC impact and adapt to the changing climate? What questions and issues should be brought up in future events of the Forum?

11:45 Summing-up, Conclusions and Next Steps

12:00 Lunch and Departures

Seafood and Climate Change

Insights from Life Cycle Assessments

Sara Hornborg, researcher at RISE –Research Institutes of Sweden
Nordic Climate Change Forum for Fisheries and Aquaculture, Dec 9 – 10 2021, Helsingør

Today's talk

- Greenhouse gas emissions (GHG) of seafoods
  - Variability
  - Drivers
  - Reduction potentials
- Opportunities and challenges for industry and policy

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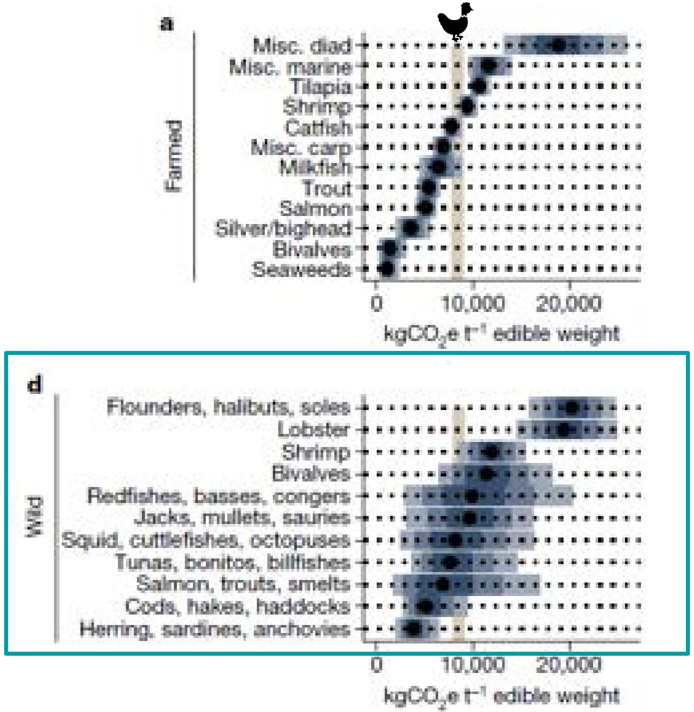
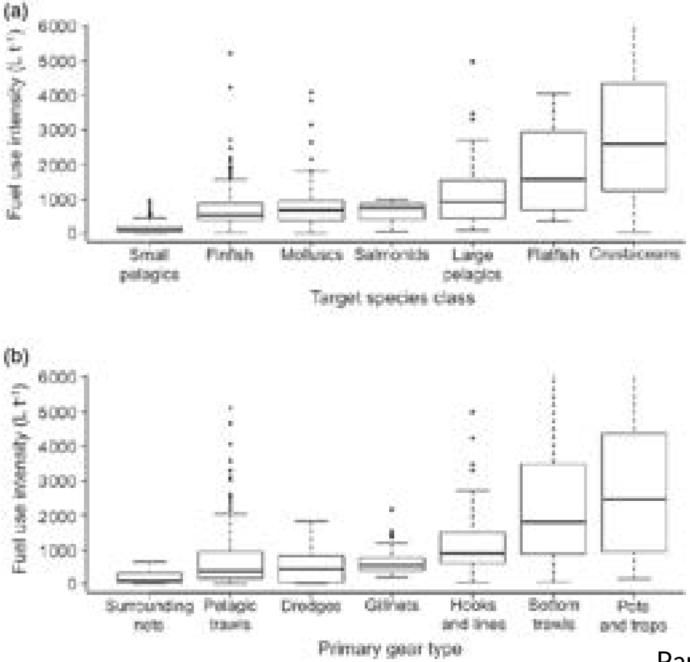
Seafood – carbon footprint overview



Gephart et al. (2021) Environmental performance of blue foods. Nature 597; 360-366

Capture fisheries: drivers and variability

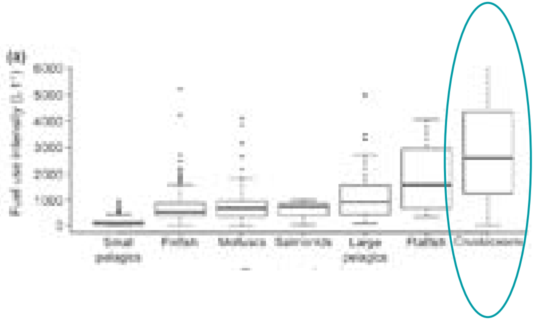


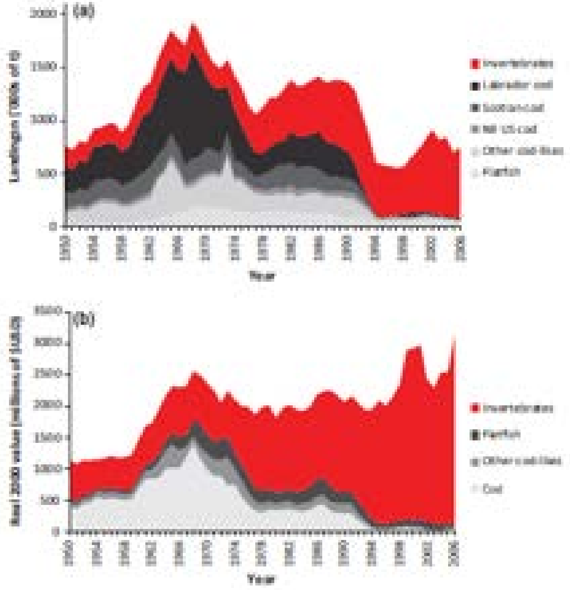
Parker & Tyedmers (2014) Fuel consumption of global fishing fleets: current understanding and knowledge gaps. Fish and Fisheries 16, 684-696

Example: Norwegian fisheries

Ziegler et al. (2021) Greenhouse gas emissions of Norwegian seafoods. From comprehensive to simplified assessment. J Ind Ecol 1-12

Ecosystem changes
"Simplifying the Sea"





Low edible yield

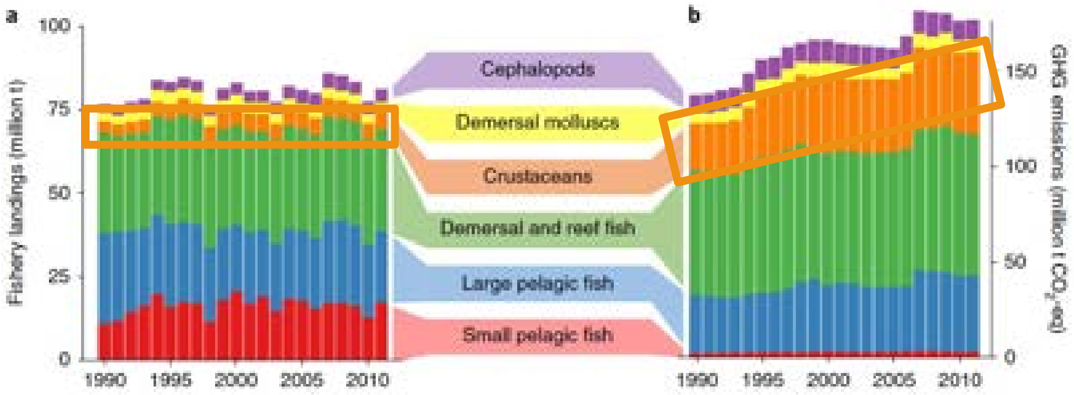
Higher risks

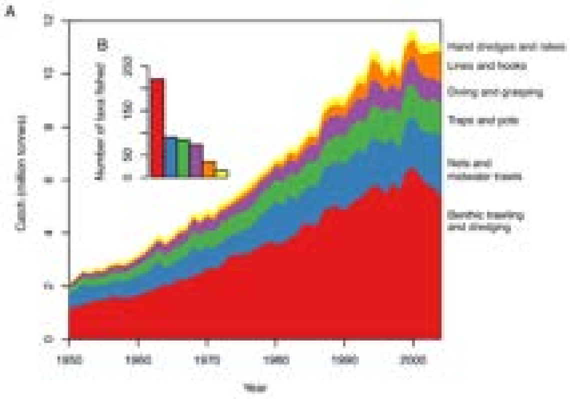
Climate change

Howarth et al. (2014) The unintended consequences of simplifying the sea: making the case for complexity. Fish and Fisheries 15, 690-711.

Capture fisheries - trends

Global GHG development





Parker et al. (2018) *Nature climate change* 8; 333-337
Anderson et al. (2011) *PloS ONE* 6, e14735

Stock status

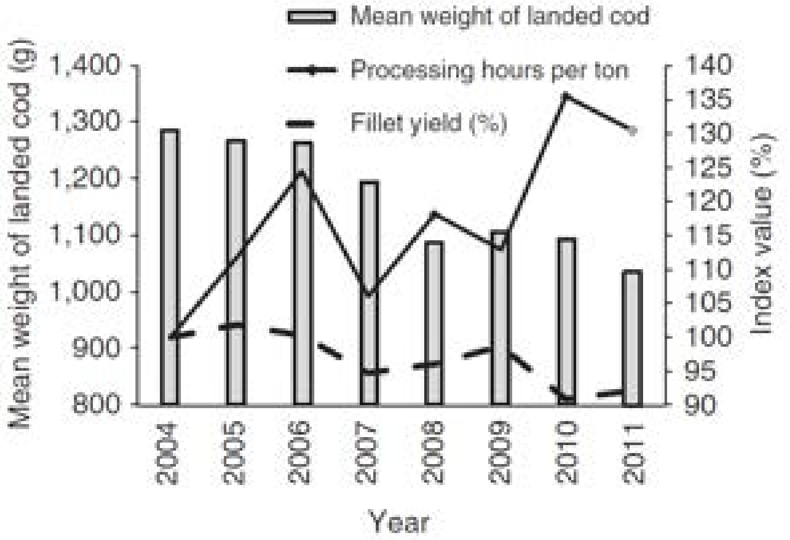
Detail no. 1

- **Iceland** (1997-2018): CO_2 emissions from *ITQ regulated fishing* fleet fell per unit catch (~40%) – overall catches and abundance by far the most important factors[1]
- **Norway** (2003-2012): increasing energy efficiency correlated with catch per days at sea, *fish stock biomass*, quota, and fuel price (little evidence of reductions from technological improvements)[2]
- **Australia**: many fisheries have decreased in fuel consumption, particularly in response to *increases in biomass and decreases in overcapacity*[3]
- **Theoretical:** l/kg rises hyperbolically with fishing effort— relatively flat at low levels of effort but rises steeply as effort increases and biomass and catch decline

[1]Kristofersson et al. (2021) *ICES Journal of Marine Science* 78, 2385-2394.
[2]Jafarzadeh et al. (2016) *Journal of Cleaner Production* 112, 3616-3630.
[3]Parker et al. (2015) *Journal of Cleaner Production*, 87, 78-86.
[4]Hornborg & Smith (2020) *ICES J Mar Sci* 77, 1666-1671.

Size matters

Detail no. 2



Svedäng & Hornborg (2014) Selective fishing induces density-dependent growth. Nature communications 5, 1-6.

Local management actions/fleets

Detail no. 3

- Lobster fishing in NW Atlantic: fishing in the US requires 3 times as much bait than in Canada (3 kg herring/kilo lobster) – but the same fuel use[1]
- Different fleets fishing on the same stock (*Pandalus borealis*) exhibit different fuel use per kg, affected by fleet structure and fishing pattern[2]
- Rock lobster Australia: possibly 80% reduction of emissions from fishing at MEY instead of MSY, but 23% increase from introduction of MPA[3]

[1]Driscoll et al. (2015) *Fish Res* 172, 385-400
[2]Ziegler et al. (2016) *ICES J Mar Sci 73*, 1806-1814
[3]Farmery et el. (2013) *J Clean Prod* 64, 368-376

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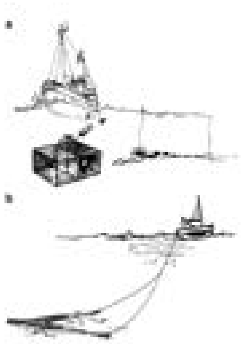
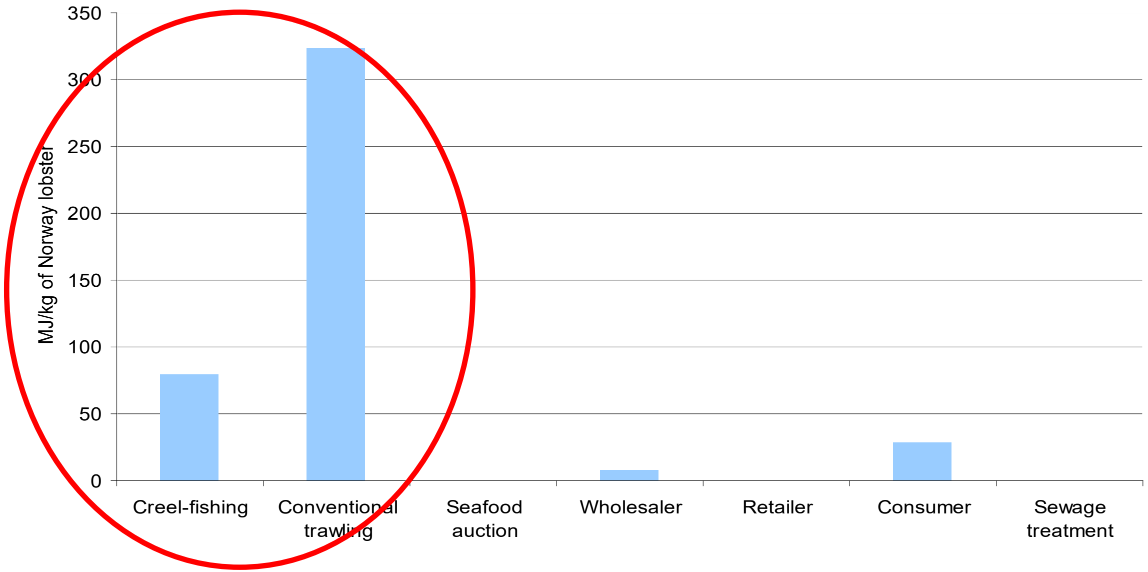
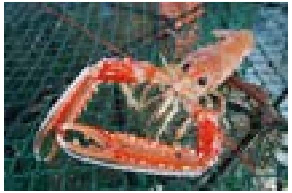
SE

The role of fishery management

a Swedish case study





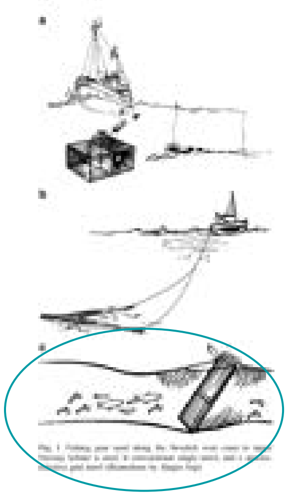


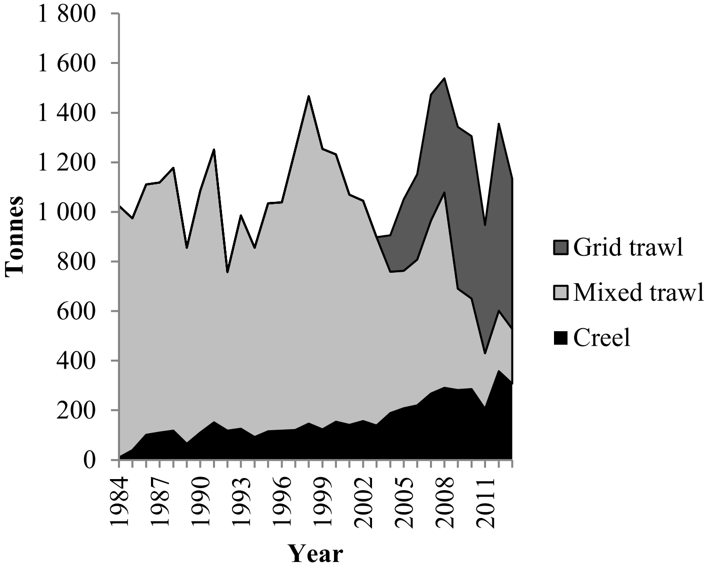
Nephrops norvegicus

Ziegler & Valentinsson (2008) *International Journal of Life Cycle Assessment 13*, 487-497

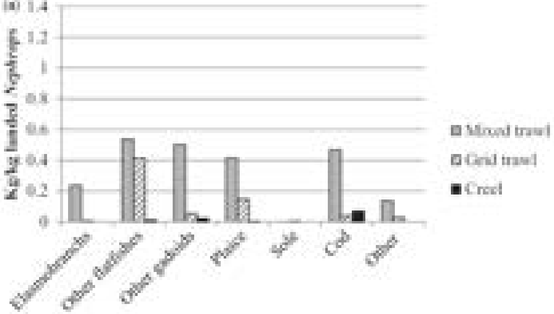
The role of fishery management

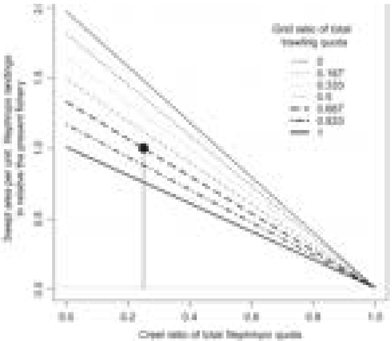
quick fixes rather than best available technology





Quick fix:
Making a fuel-intense practice less effective

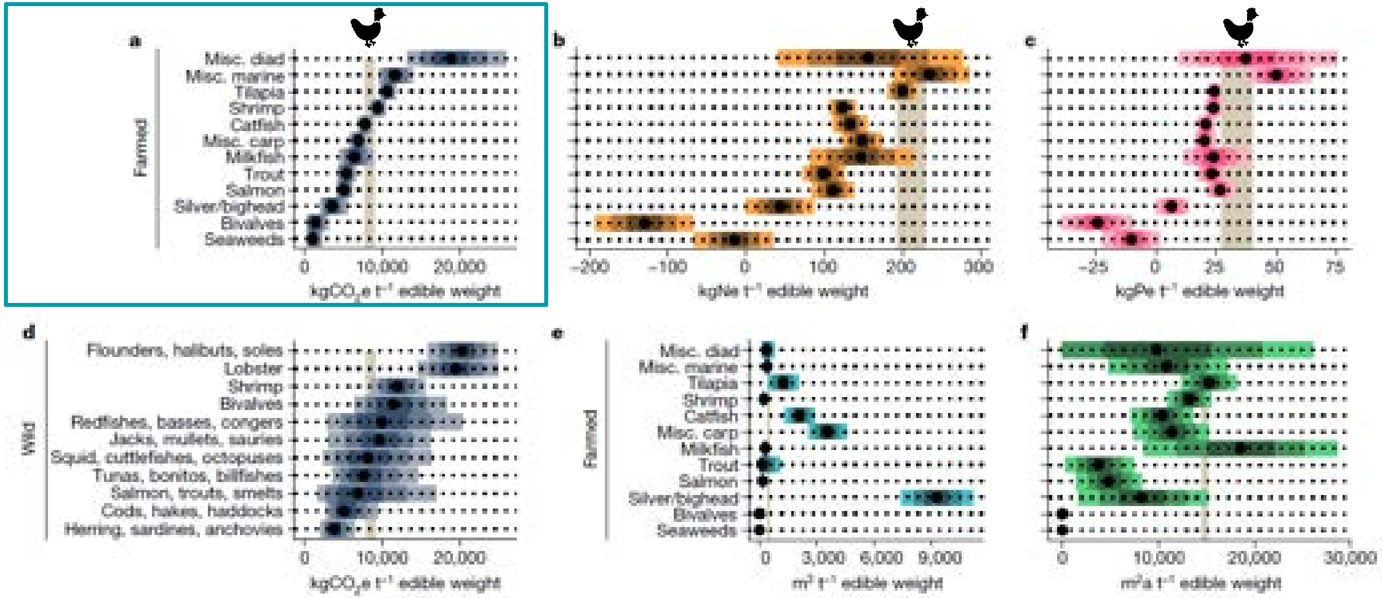




Hornborg et al. (2016)
ICES J Mar Sci 74, 134-145

Seafood – an overview again

Eutrophication



Freshwater use **Land use**

Gephart et al. (2021) Environmental performance of blue foods. Nature 597; 360-366

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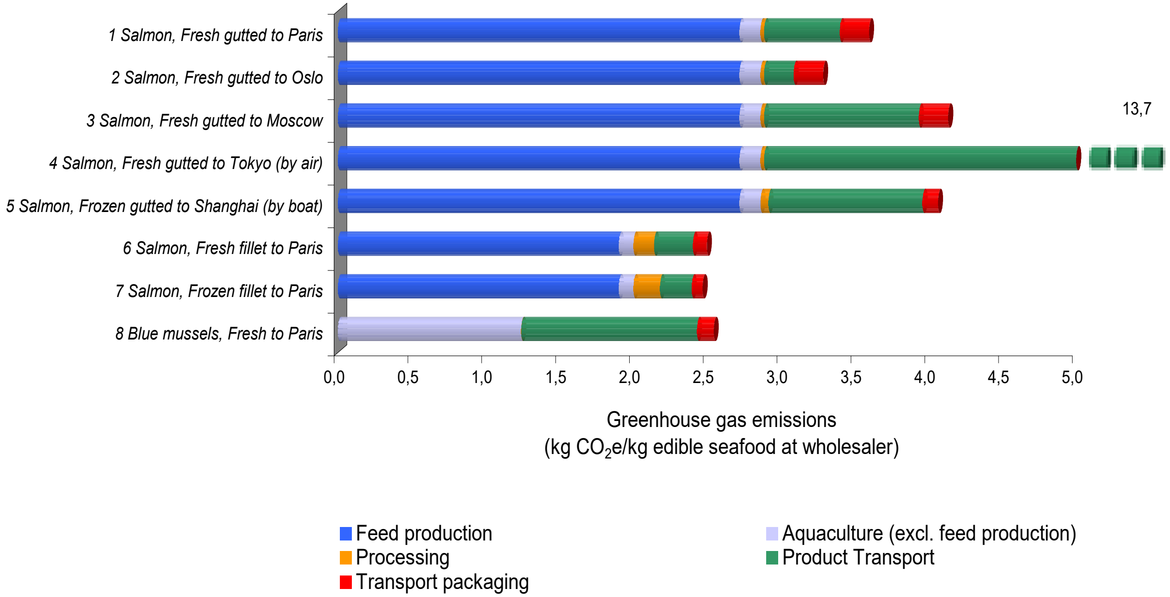
Farmed seafood
Norwegian examples



Important for GHGs:

- Transport mode
- Utilization

Ziegler et al. (2013) The carbon footprint of Norwegian seafood products on the global seafood market. J Ind Ecol 17, 103-116.

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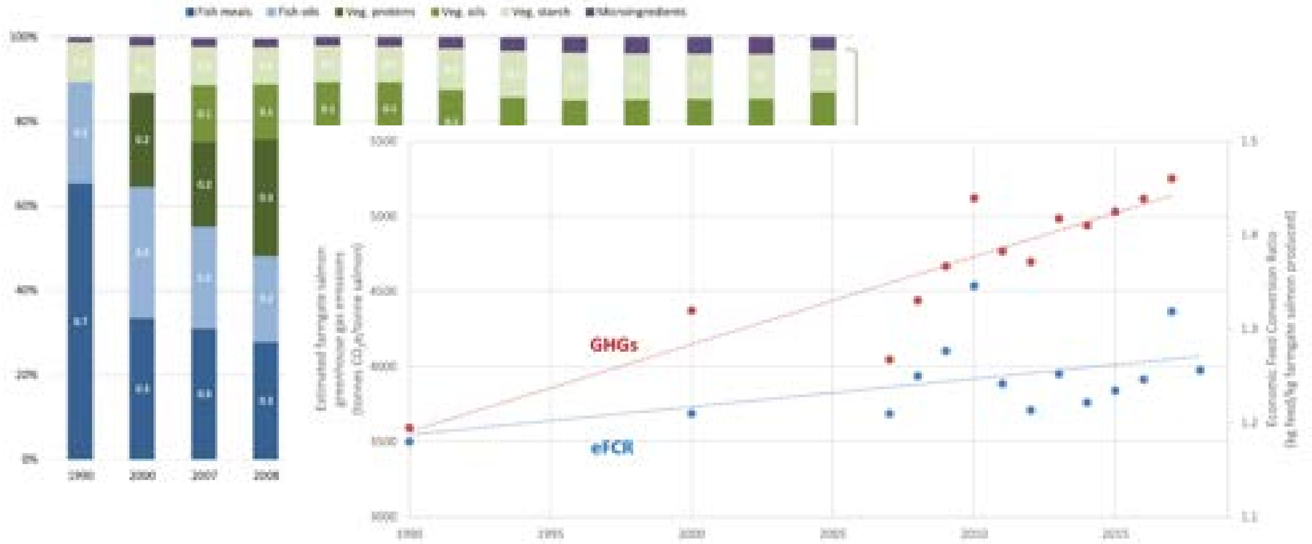
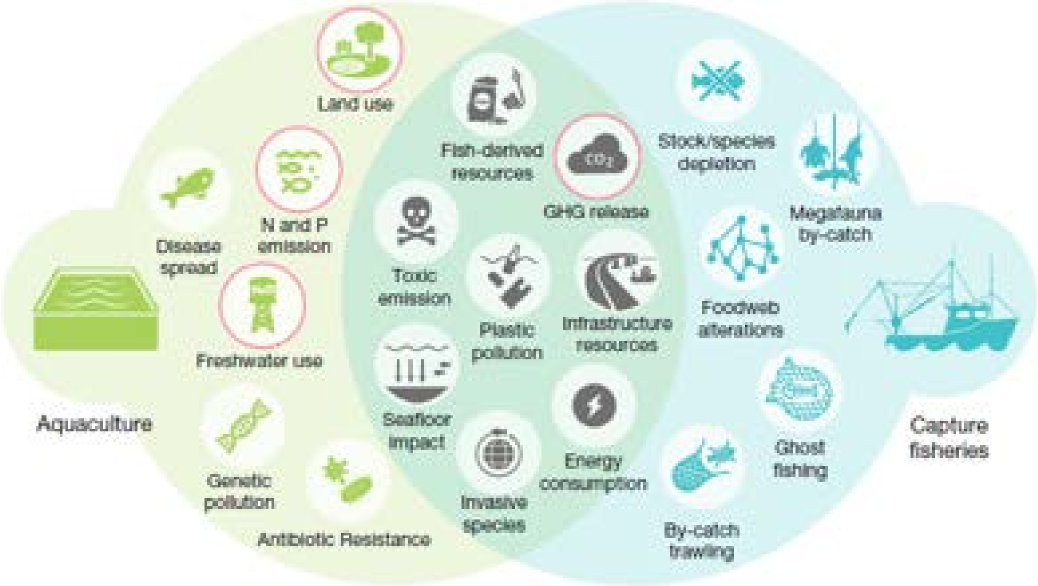
Feed: composition and amount

Norwegian salmon farming



Ziegler et al. (2021) Greenhouse gas emissions of Norwegian seafoods. From comprehensive to simplified assessment. J Ind Ecol 1-12

Common and unique pressures



Gephart et al. (2021) Environmental performance of blue foods. Nature 597; 360-366

Uncertainties in GHG estimates

-a brief note on knowledge gaps-

- Current estimates are highly influenced by underpinning data (e.g. age, representative) and methodological choices of the LCA (e.g. system boundaries, allocation of burdens)
- Knowledge gaps:
  - Demersal trawling effect on carbon sequestration
  - Use of climate forcing coolants
  - Biogenic emissions from aquaculture
  - Small-scale fisheries (in particular inland fisheries)

To summarize

What matters for seafood?

Take home messages

Capture fisheries

- *Fuel inputs* during fishing most often dominates total carbon footprint
- Influenced by target species (e.g., shoaling or not, gear used, stock status)
  - strongly linked to fishery management

Aquaculture

- *Feed inputs* most often dominates total carbon footprint
- Influenced by farmed species (e.g., feed conversion efficiency, feed composition)
  - requires both innovations in feed and grow-out

Overview provided in Ziegler et al. (2016) Expanding the concept of sustainable seafood using Life Cycle Assessment. *Fish and Fisheries* 17, 1073-1093.

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Oportunities and challenges

Capture fisheries policy-makers and managers

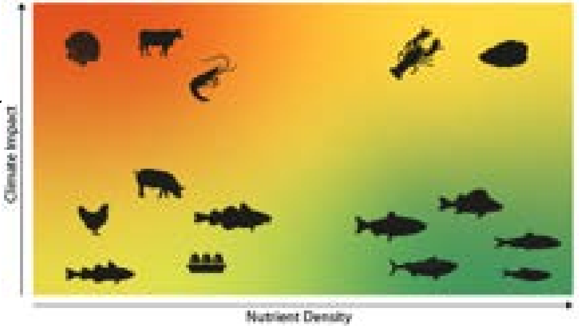
- **Short-term mitigation and adaptation**
  - from policy to action: quota allocation to certain gears [*in line with article 17 of CFP*]
  - mitigate unintended consequences of using different tools (effort restrictions – spatial measures – selectivity)
  - increasing fuel costs and changing ocean will affect fishing patterns, calls for pro-active management!
- **Long-term transformation** – change in path
  - target reference points: allow for higher fish abundance, including a size composition with more large fish *[=in line with MSFD descriptors*]
  - management allowing for improved carbon sequestration and biodiversity restoration

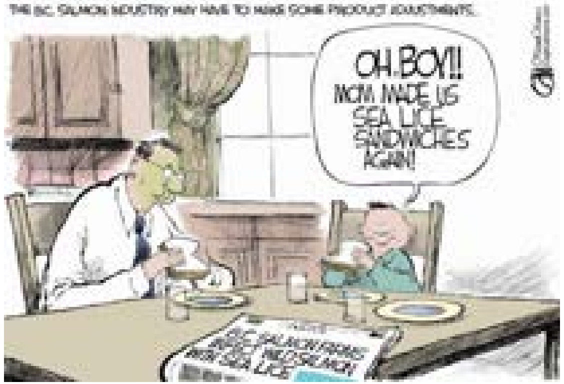
Challenge & potential

Opportunities and challenges

Seafood industry

- Easier path to cut emissions in capture fisheries!?
  - ***Opportunities:*** other energy sources, cut fuel use (gears, fishing pattern, technology)
  - ***Challenges:*** how&what, investment costs, room for improvement
- Aquaculture:
  - ***Opportunities***: efficient feed converters
  - ***Challenges***: finding low-impact feed ingredients, feeding efficiencies (eFCR), suitable production location (coastal, offshore or on land)
- Seafood value chains
  - ***Opportunities:*** dietary advice, waste less (= less pressure per kg)
  - ***Challenges:*** product/process development to utilize new species and side streams while attracting consumers





Thank you for your attention!

Sara Hornborg

Sara.Hornborg@ri.se
+46 10 516 66 96

Want to know more about our seafood work at RISE?

https://www.ri.se/en/what-we-do/expertises/seafood

The Future of Aquafeeds

Nordic Climate Change Forum for Fisheries & Aquaculture

Vidar Gundersen | Global Sustainability Director

BioMar Group | December 9-10, 2021

BioMar Global Production Facilities

Turnover
EUR ~1.6bn

EBIT
EUR ~86m

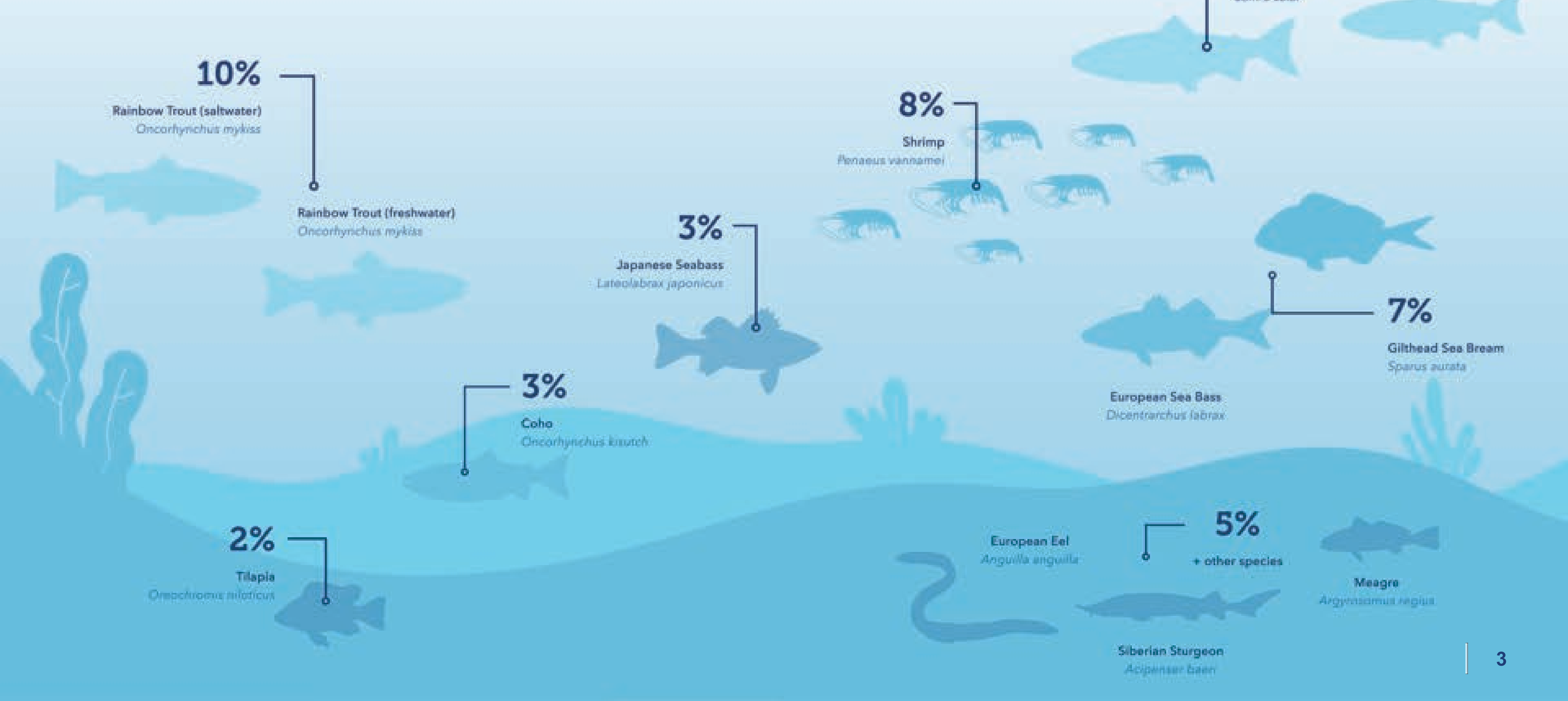
Tonnage
~1.34m tons

Employees
~1,600

Feed for +45
different species of fish + shrimp

Sale to more than
90 countries

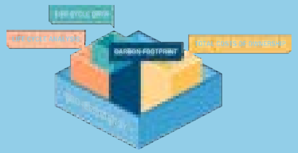
Top Species where BioMar supplied the most feed in 2020



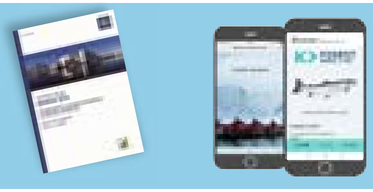
Sustainability Approach, Design & Solutions

BioSustain™ | BLUE IMPACT™ SOLUTIONS

	Corporate Sustainability		Product / Service Sustainability	
Differentiation *Added Value*	Strategic program for continuous improvement	Pioneer brands	BLUE IMPACT	Sustainability leader
	Sustainability Committee; BioMar Omega Technology	Company initiatives	Premium products; ASC; Best Aquaculture Practices Certified	Advanced sustainability differentiator
Must have *Risk Management*		Voluntary Global standards	Extended product standards; GLOBALG.A.P.	Industry Standard follower
		Company activities	Product Requirements	Legal compliant player

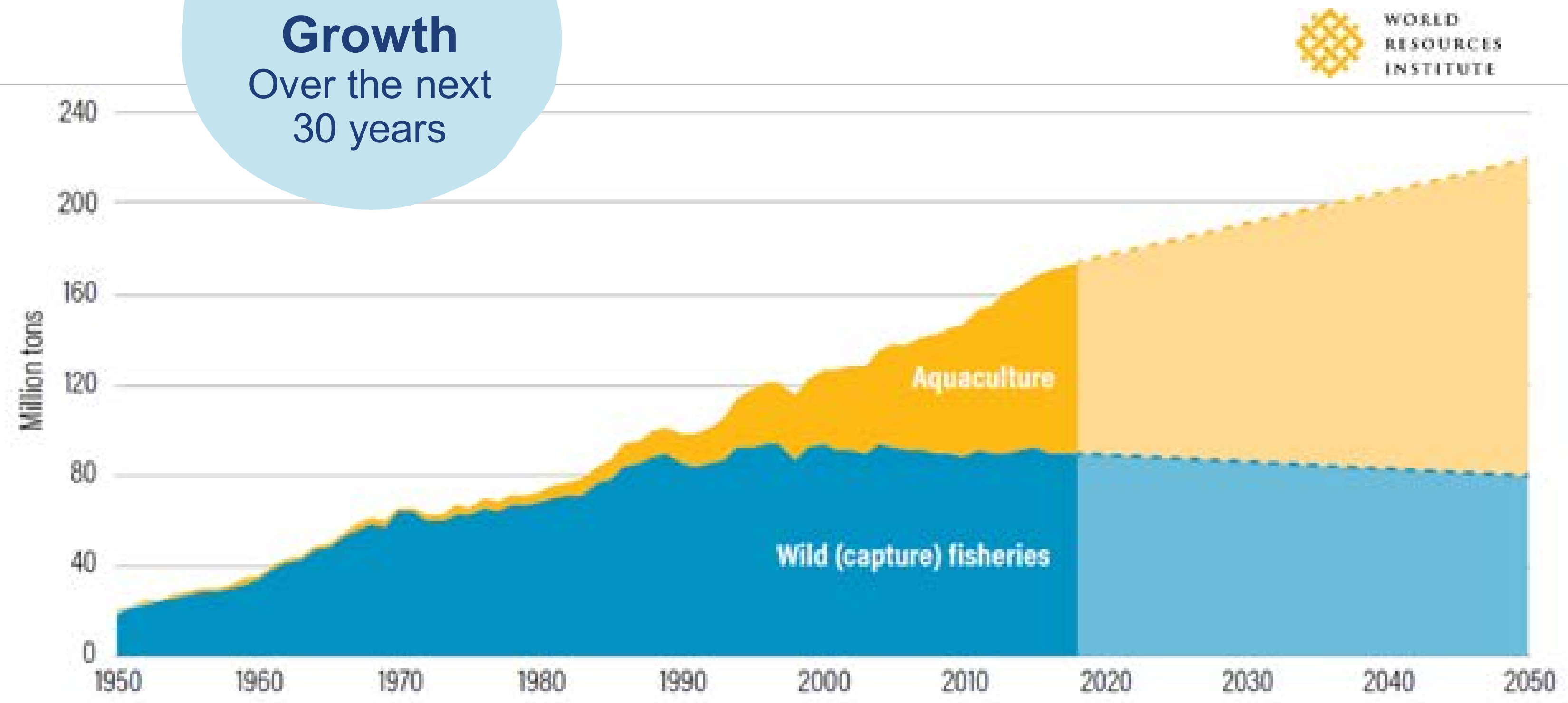


MFA
Sankey chart



Mission for Sustainable Aquaculture

2x
Growth
Over the next
30 years



Source: Historical data, 1950–2016: FAO (2017b) and FAO (2018). Projections to 2050: Calculated at WRI; assumes 10 percent reduction in wild fish catch from 2010 levels by 2050, linear growth of aquaculture production of 2 Mt per year between 2010 and 2050.

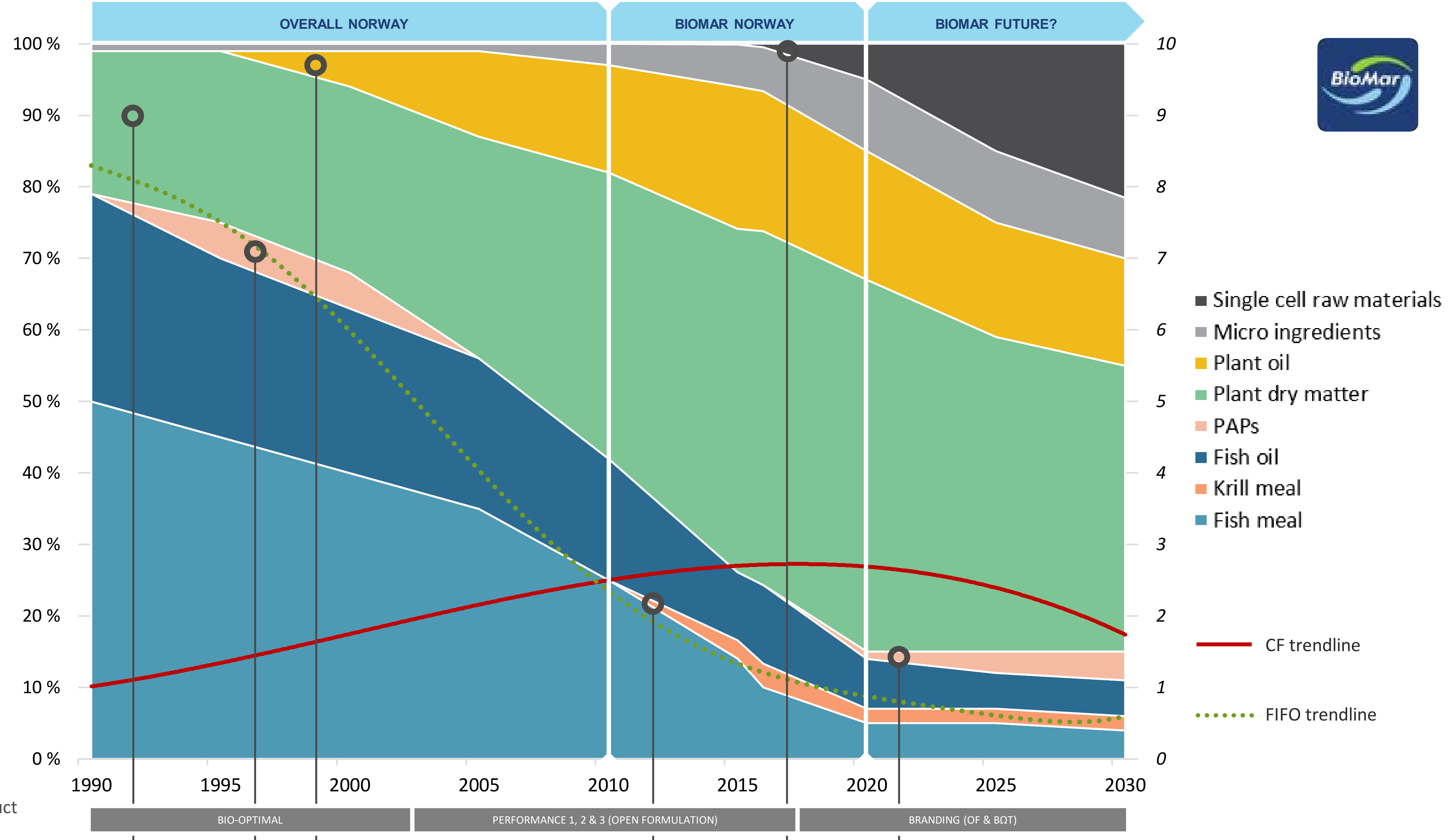
Double aquaculture production by 2050
without taking one more fish from the ocean or using any more agriculture land for crops.

Aquaculture feed is responsible for up to **80% of the environmental impact** of producing seafood.

Reference: World Resources Report: Creating a Sustainable Food Future, World Resources Institute, December 2018

Salmon Feed Evolution

Raw material inclusion levels



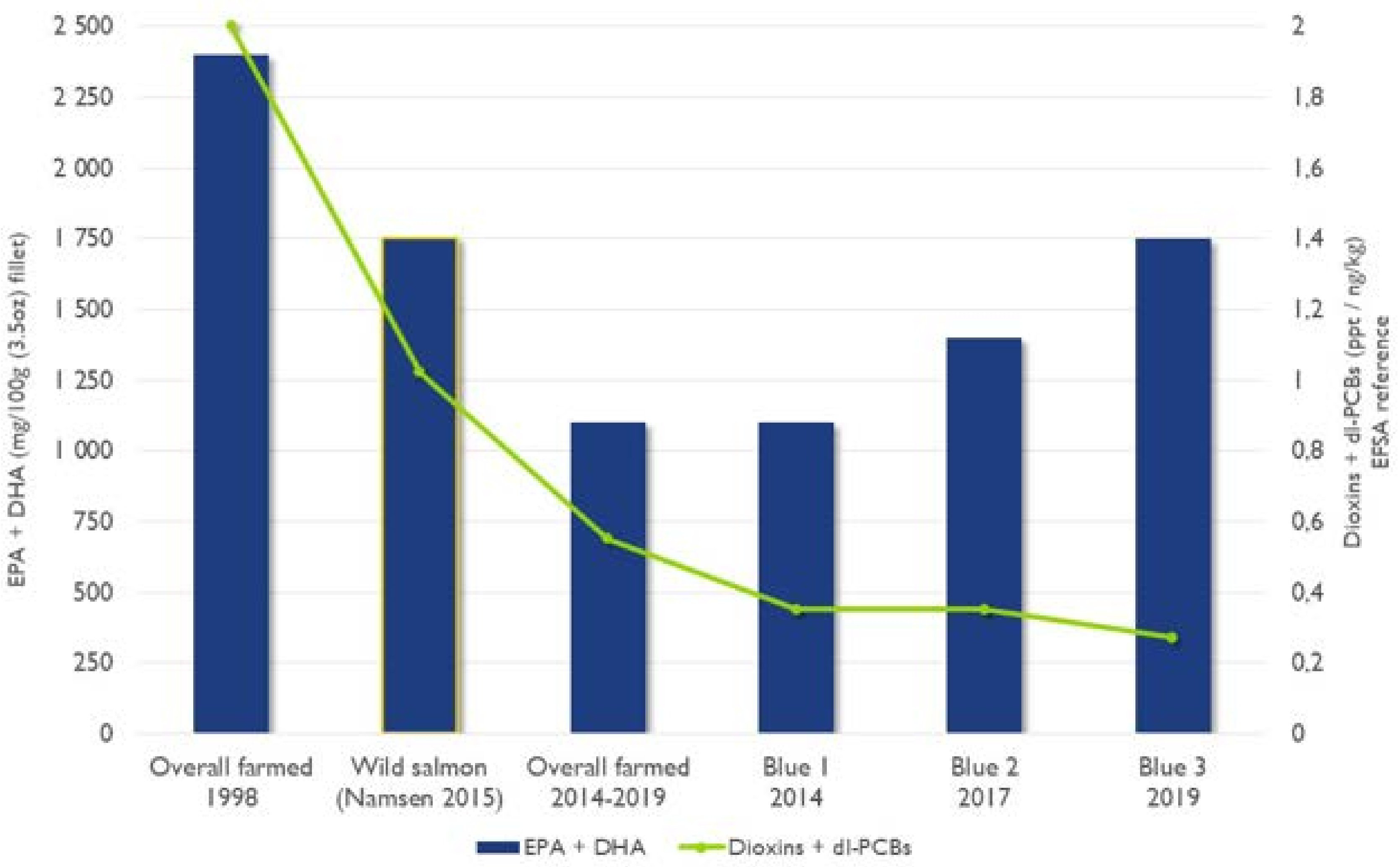
Concepts & product development

Key ingredient highlights

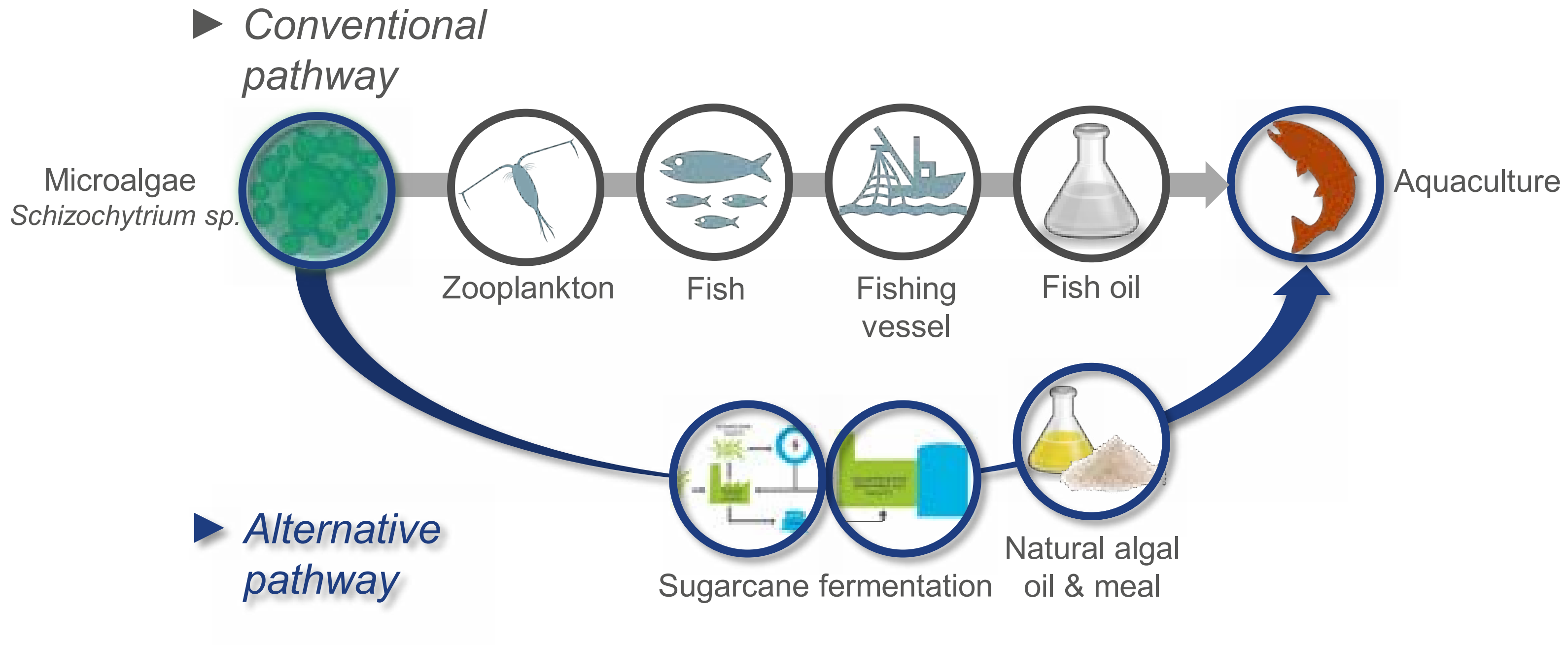
PLANT PROTEINS	BLOOD MEAL	PLANT OILS	KRILL MEAL	SINGLE CELL RMs	INSECT MEAL
Plant proteins (soy) is used at larger extent	Blood meal is used, but is phased out due to fear of Mad Cow decease	Plant oil (soy/ rapeseed) makes its entry, strongly driven by El Niño	Krill meal is put into use	Nutrients produced by single cell organisms is put into use and higher inclusion is expected	Insect meal is expected to be used

Restoring marine omega-3s,

responsibly and sustainably…



Restoring marine omega-3s with novel ingredients



The future of aquafeeds

More **by-product** ingredients and **trimmings**

More ingredients from **single cell** technologies

More ingredients from **lower trophic levels**

The majority of the diet will still be **vegetable**

Climate Action

1/3 by 2030

Reduce BioMar total feed GHG footprint by 1/3 by 2030

Circular & Restorative

50% by 2030

BioMar feeds are 50% circular and restorative by 2030

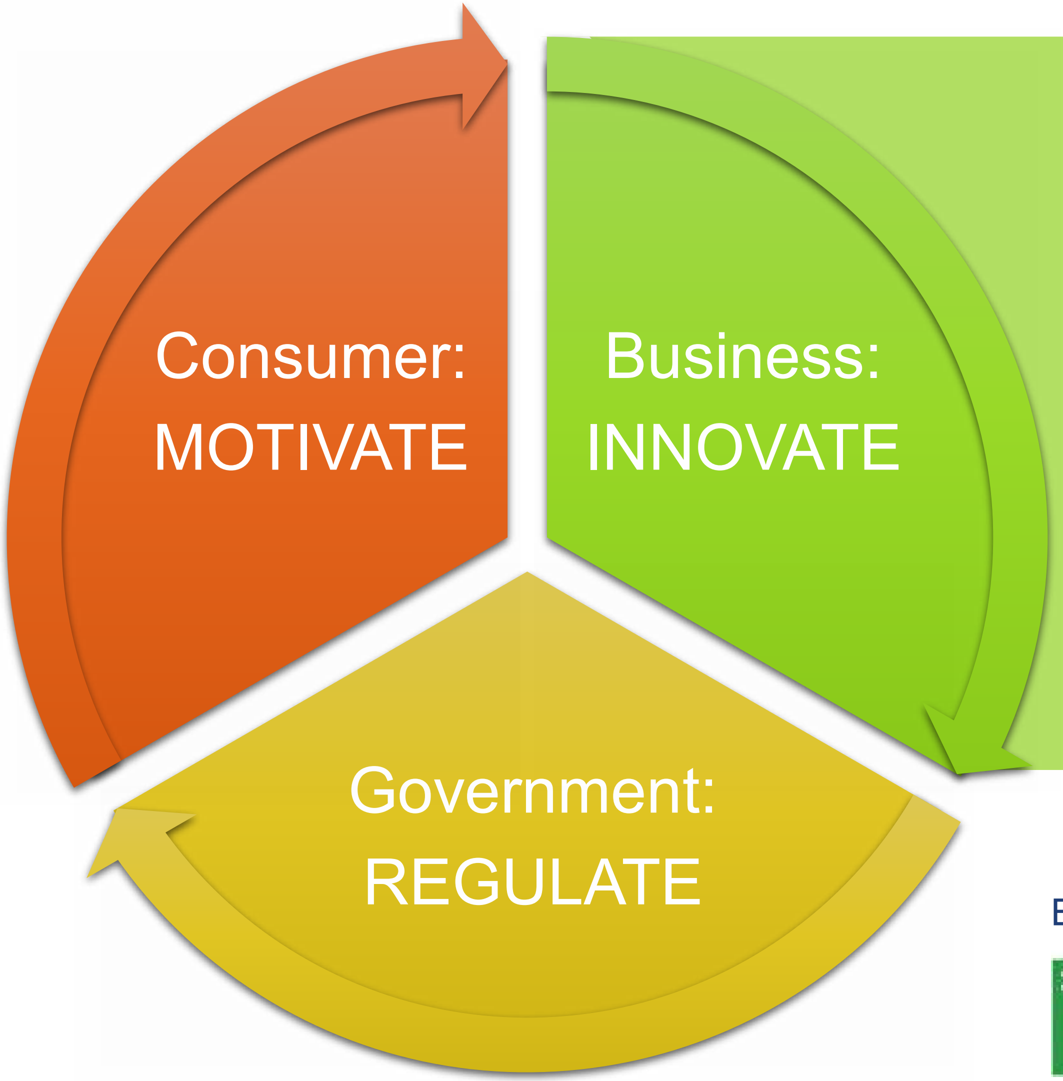
Enable People

100,000 by 2030

100,000 people directly engaged in capacity building initiatives annually by 2030

Powered by Partnership
Driven by Innovation

Ensuring Sustainable Development



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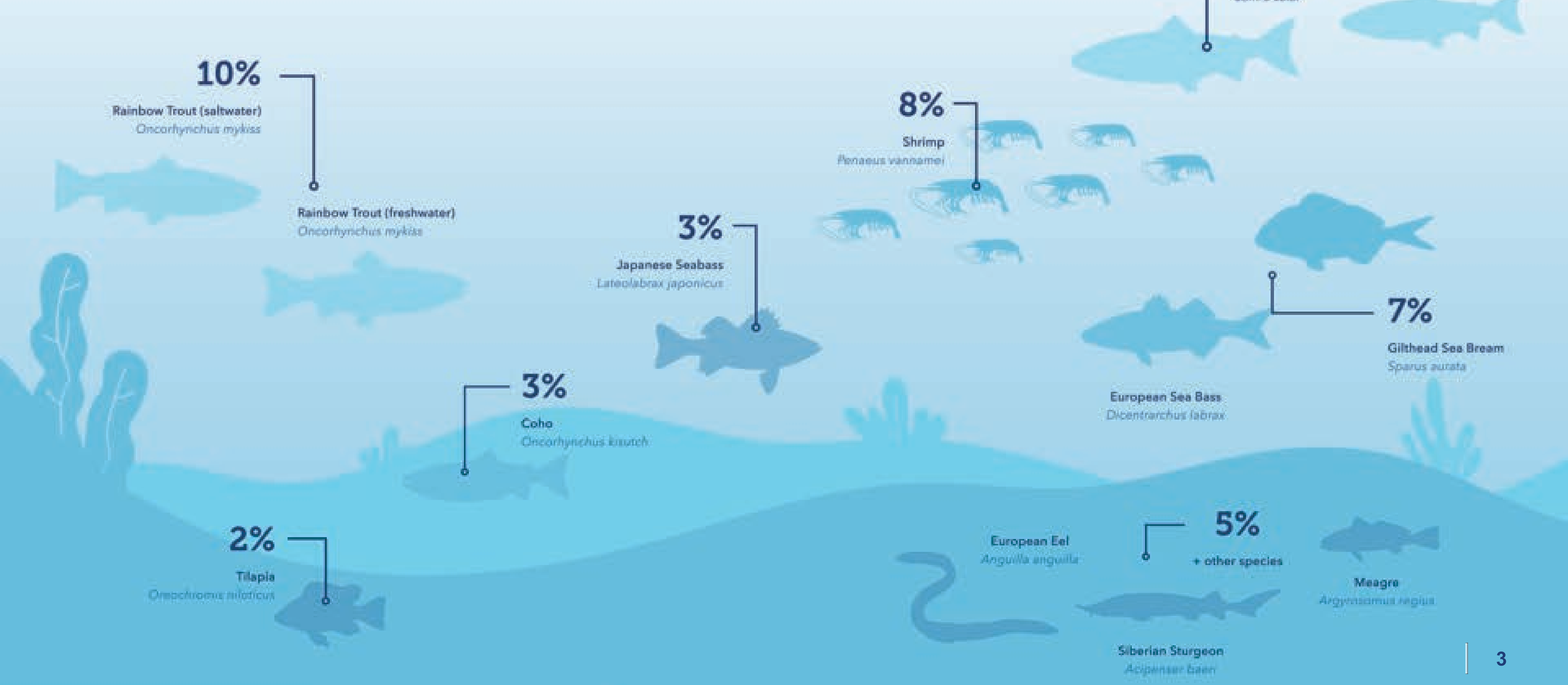

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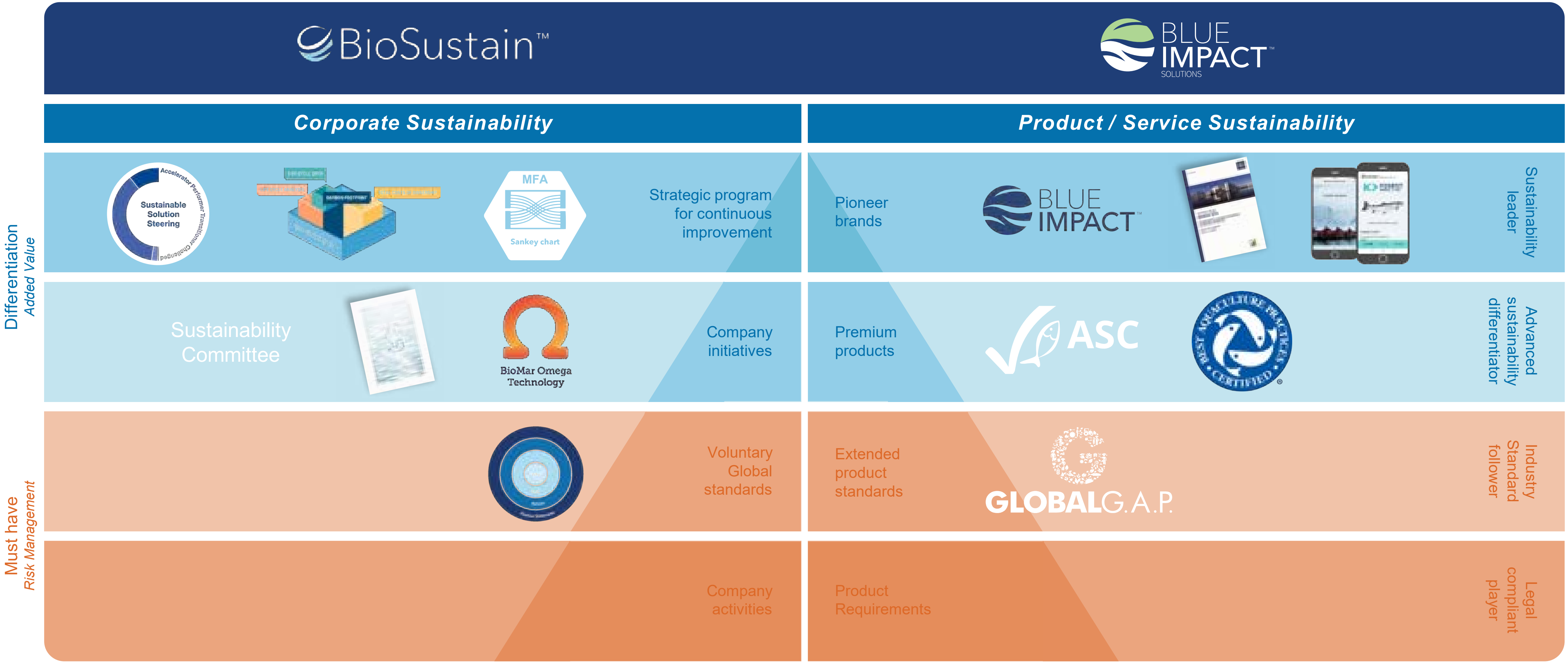

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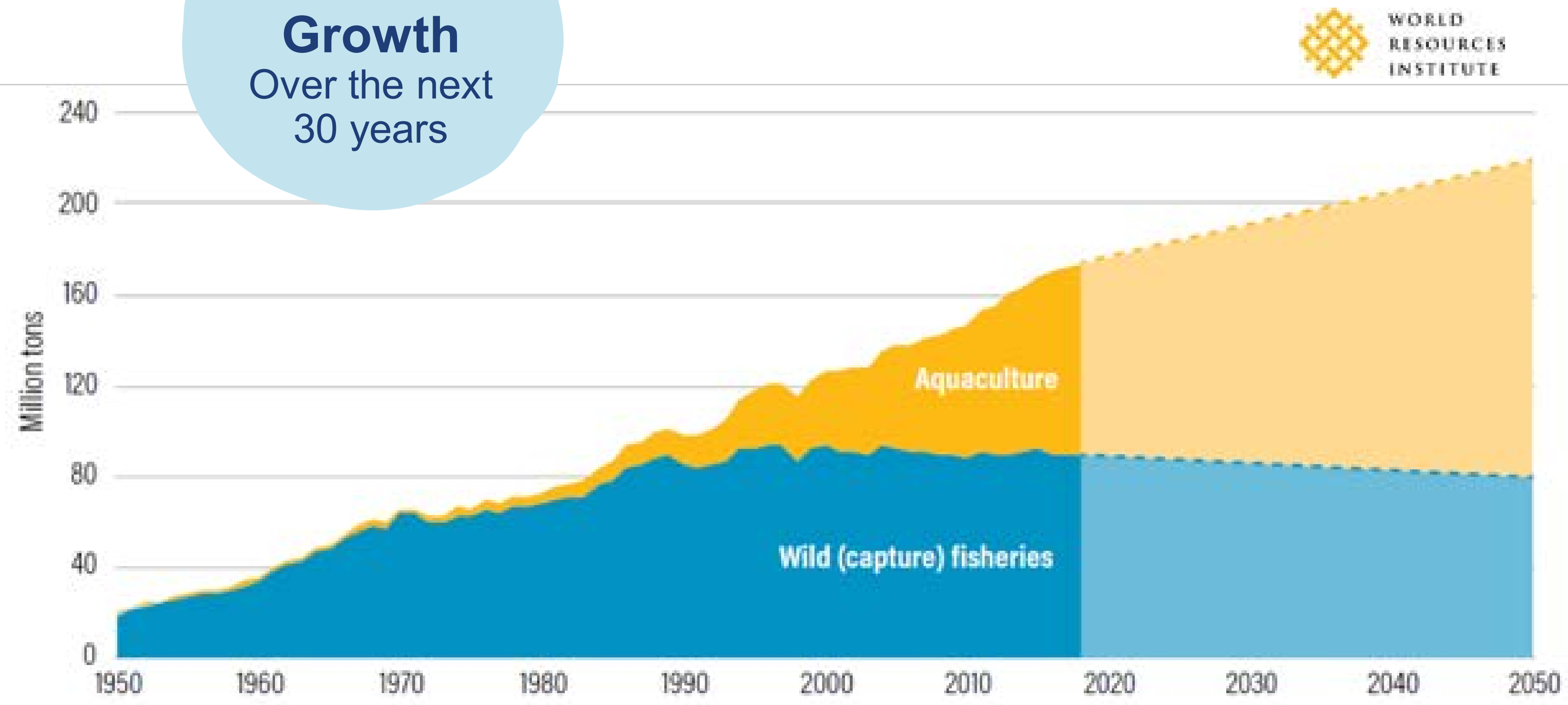

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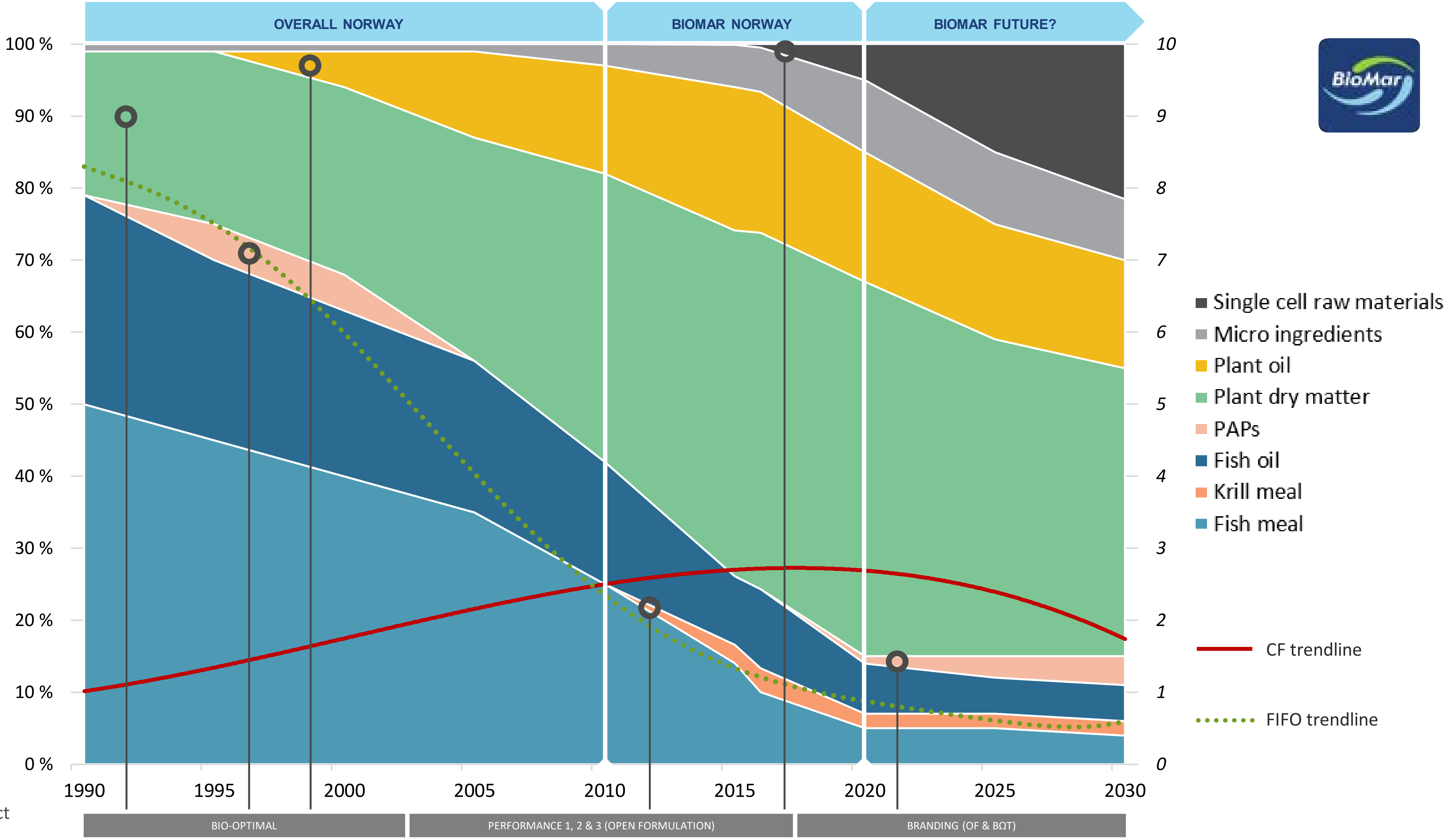

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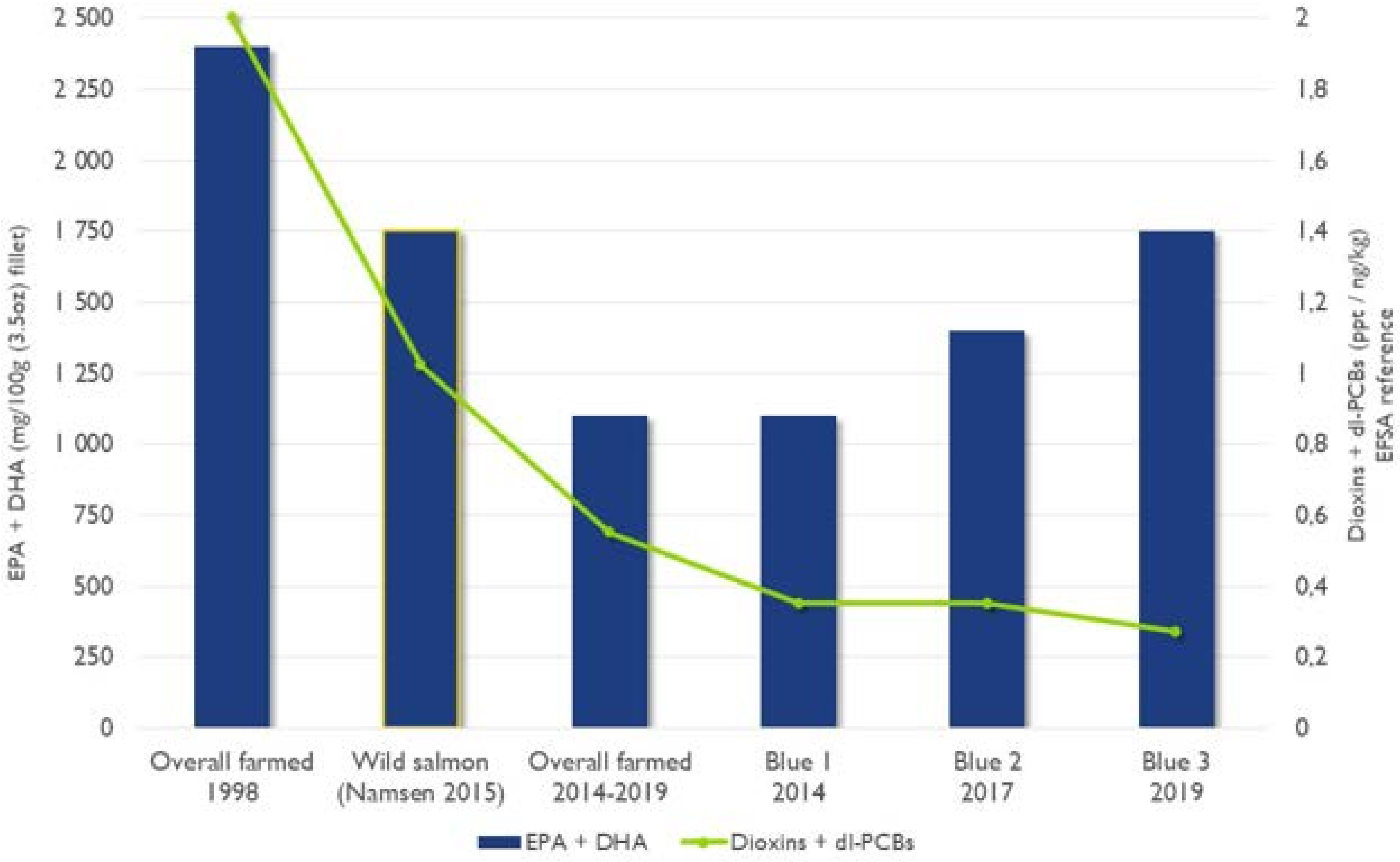

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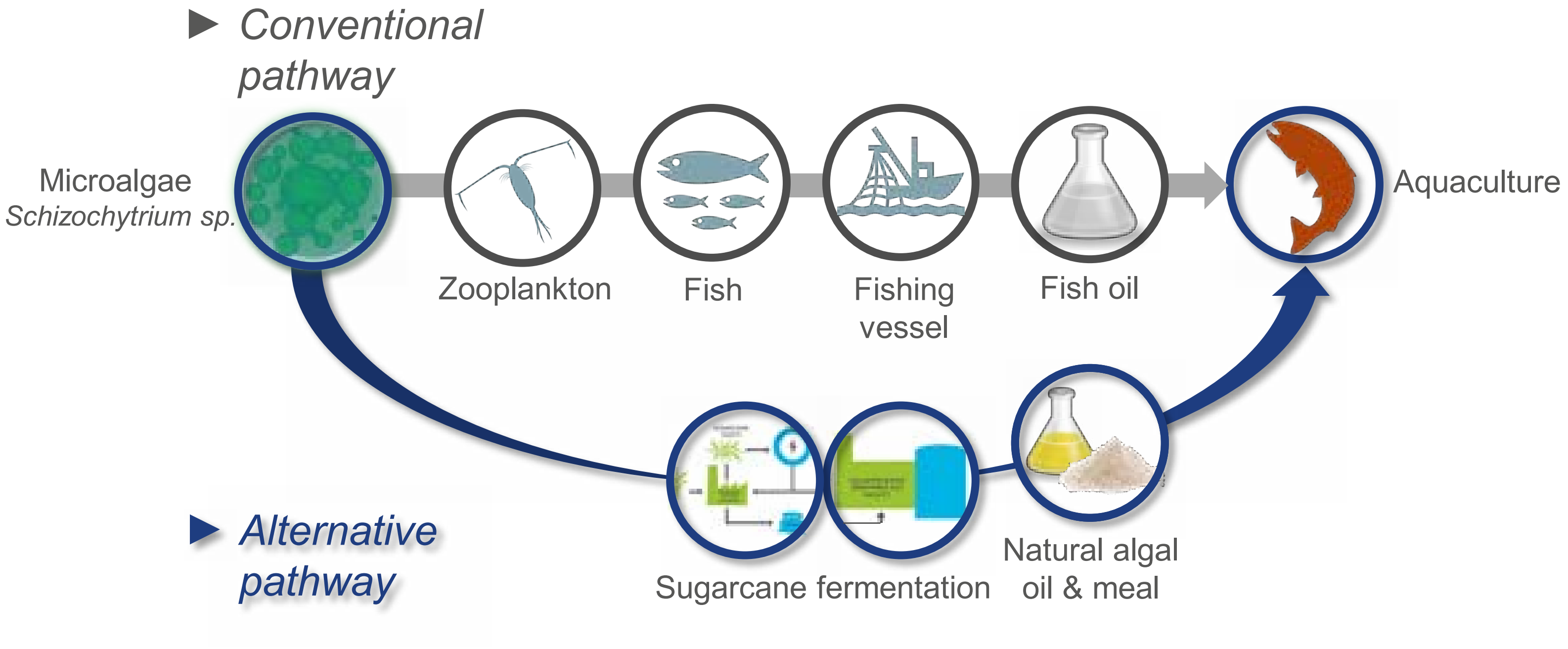

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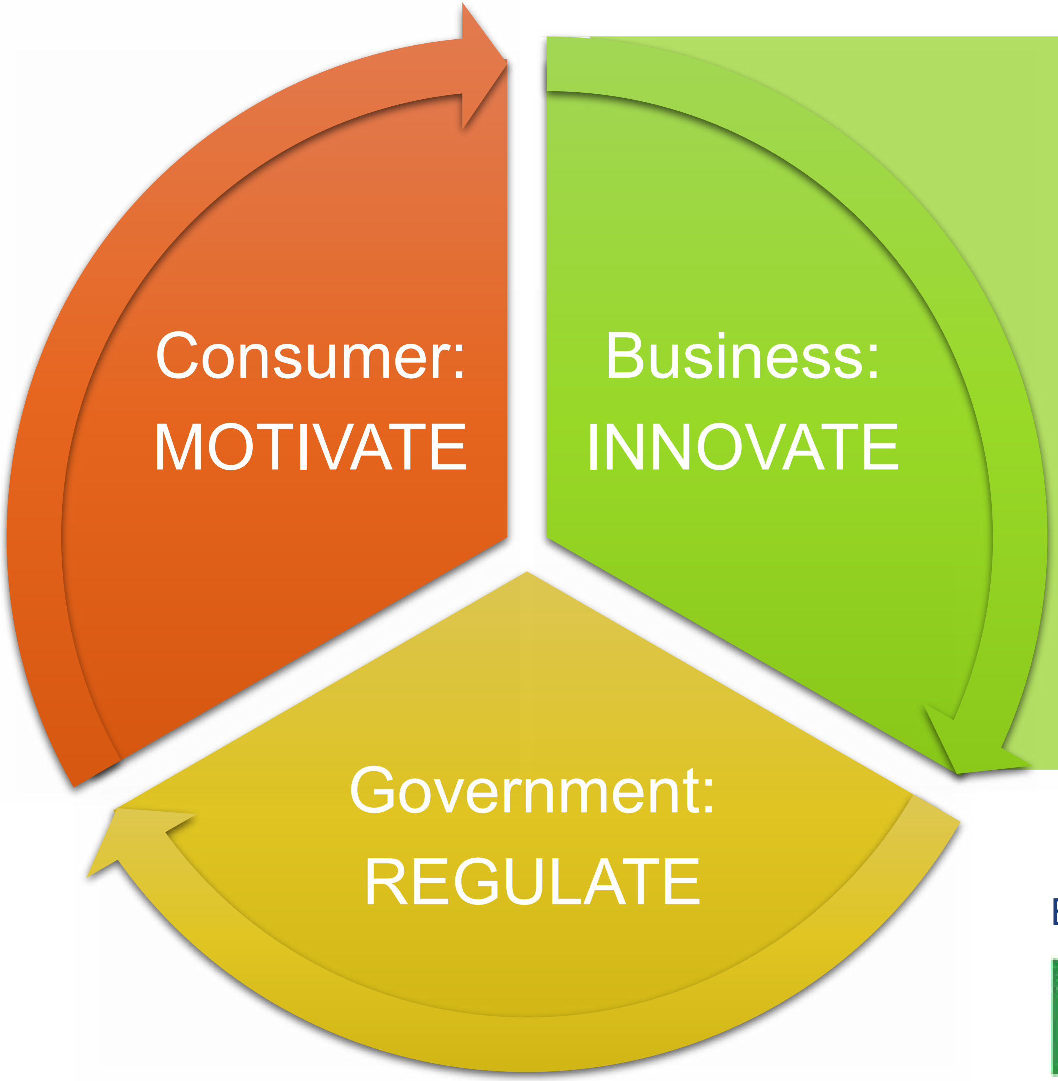

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