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Proceedings from a conference on “Environmental impacts andenergy transition in the Nordic seafood sector”

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Report Summary
Icelandic Food and Biotech R&D

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Titill / Title	Proceedings from a conference on „Environmental impacts and energy transition in the Nordic seafood sector"		
Höfundur / Editor	Jónas R. Viðarsson		
Skýrsla / Report no.	24-23	Útgáfudagur / Date:	December 2023
Verknr. / Project no.	62777		
Styrktaraðilar /Funding:	AG-fisk (Nordic council of Ministers Working group for Fisheries and Aquaculture)		
Ágrip á íslensku:	Fiskur og annað sjávarfang gegnir mikilvægu hlutverki í að tryggja fæðuöryggi, atvinnu og efnahag í heiminum, og þá sér í lagi á Norðurlöndunum. Sjávarfang af Norrænum uppruna kemur auk þess almennt úr sjálfbært nýttum stofnum, er sérlega heilnæmt til neyslu og er í flestum tilvikum með mjög takmarkað kolefnisspor í samanburði við aðra próteingjafa. Það má því að vissu leyti halda því fram að Norrænt sjávarfang sé „sjálfbært ofurfæði". Neytendur eru hins vegar oft ekki vissir um hvort sjávarfang sé umhverfisvænn kostur. Norrænn sjávarútvegur stendur nú frammi fyrir því tækifæri að taka forystu í orkuskiptum, og þannig geta státað að því að bjóða upp á besta og umhverfisvænasta sjávarfang sem völ er á. Vinnuhópur um sjávarútveg og fiskeldi (AG-Fisk) sem starfar innan Norðurlandaráðs hefur bent á þessi tækifæri, og sem hluti af formennsku Íslands í ráðinu árið 2023 fjármagnaði AG-fisk verkefni sem ætlað var að stuðla að tengslamyndun innan Norræns sjávarútvegs til að auka vitund og miðla þekkingu um framfarir í fortíð, nútíð og framtíð hvað varðar sjálfbærni og orkuskipti í sjávarútvegi. Hápunktur verkefnisins var ráðstefna sem haldin var í Reykjavík 13. september 2023, en daginn áður var haldin vinnufundur þar sem tækifæri til aukins Norræns samstarfs voru rædd. Ráðstefnan samanstóð af 13 erindum og sóttu um 150 manns viðburðinn, sem fram fór í Hörpu. Í þessari skýrslu er að finna yfirlit yfir þær framsögur sem fluttar voru á ráðstefnunni. Upptökur frá ráðstefnunni eru einnig aðgengilegar á vefsíðu verkefnisins.		
Lykilorð á íslensku:	*Norrænn Sjávarútvegur, sjálfbærni, kolefnisspor, orkuskipti*		
Summary in English:	Seafood is generally a climate-efficient and nutritious type of food. Consumers, however, are often confused as to whether seafood is sustainable or not and what seafood to choose. The Nordic seafood sector has now the opportunity to take the lead in transitioning to low greenhouse gas emissions through energy efficiency measures and shifting to alternative fuels. The Working Group for Fisheries and Aquaculture (AG-Fisk) within the Nordic council has recognized this, and as part of Iceland's presidency of the council in 2023, initiated a networking project to raise awareness and share knowledge on past-, present- and future advances in reduction of environmental impacts in Nordic seafood value chains. The highlight of the project was a conference that was held in Reykjavík on 13 September 2023. The conference consisted of 13 presentations and was attended by close to 150 persons. This report contains the proceedings from the conference, representing an abstract of each presentation and the slides presented. Recordings form the conference are also available on the project's webpage.		
English keywords:	*Nordic seafood industry, sustainability, carbon footprint, energy transition*		

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1 Introduction

Environmental impacts, as well as mitigation- and adaptation to climate change, have become major considerations in today's food systems, where reduction of fossil fuel use and transition to alternative fuel sources are currently being focused on. There are few protein sources that have as modest environmental impact as Nordic Seafood. Yet, the public opinion does not reflect that. The Nordic sector has in recent years managed to significantly reduce fossil fuel use and CO2 emissions, but there is still room for improvements. The Nordic seafood sector has now the opportunity to take the lead in transitioning to low greenhouse gas emissions through energy efficiency measures and shifting to alternative fuels. The Working Group for Fisheries and Aquaculture (AG-Fisk) within the Nordic council has recognized this, and as part of Iceland's presidency of the council in 2023, initiated a networking project to raise awareness and share knowledge on past-, present- and future advances in reduction of environmental impacts in Nordic seafood value chains. The highlight of the project was a conference that was held in Reykjavík on 13 September 2023. This report contains the proceedings from the conference, including an abstract of each presentation and the slides presented. Recordings form the conference are also available on the project's webpage.

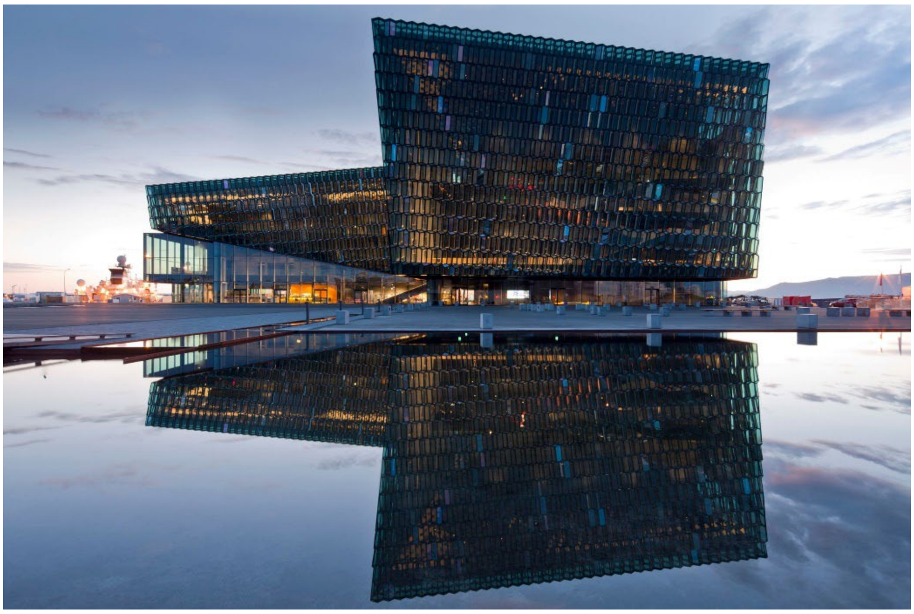
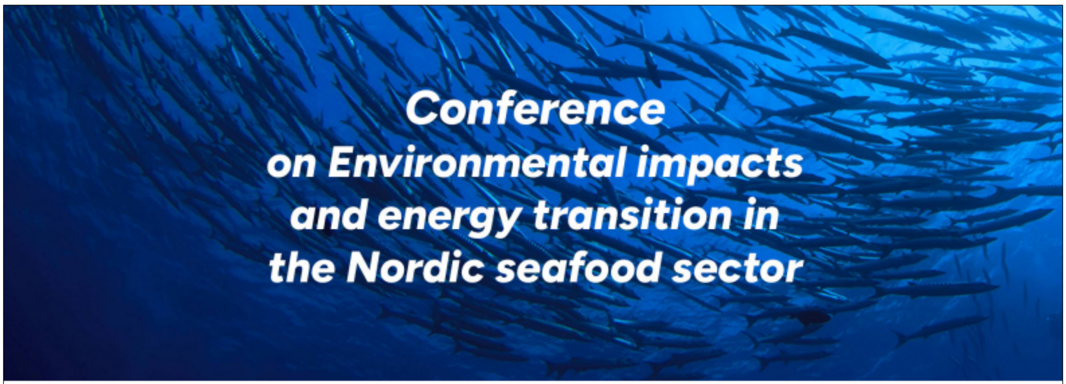


Figure 1: The conference was held at Harpa conference hall in Reykjavík

The conference consisted of 13 presentations and was attended by close to 150 persons, the agenda can be seen in Figure 2.



September 13th 2023
Harpa Conference Centre, Reykjavík, Iceland

09:00 – 09:10	Welcome, *Jónas R. Viðarsson (on behalf of AG Fisk)*
09:10 – 09:20	Opening, *Svandís Svavarsdóttir (Icelandic Minister of Food, Fisheries & Agriculture)*
09:20 – 09:40	Decarbonising fisheries to supply low-carbon and nutritious food for the future *Friederike Ziegler (Senior scientist at RISE Research Institutes of Sweden)*
09:40 – 10:00	The transition to green energy for the fishing fleet and its ports *Ditte Stiler (Nordic Energy Research /Nordis Energiforskning)*
10:00 – 10:15	What are the most influential factors affecting co2 emissions in fisheries, *Daði Már Kristófersson (University of Iceland)*
10:15 – 10:30	Benthic disturbance and fisheries, *Ole Ritzau Eigaard (DTU – Danish National Institute of Aquatic Resources)*
10:30 – 11:15	Coffee break (Solutions and ongoing initiatives to reduce environmental impact of fisheries presented in booths/stands during coffee- and lunch breaks) *
11:15 – 11:30	Fishing gear development to reduce environmental impact, *Georg Haney (Hampiðjan Group)*
11:30 – 11:45	Vessel design to reduce CO2 and other environmental impacts, *Kim Nørby Christensen (Knud E. Hansen)*
11:45 – 12:00	Engine development, *Kaj Portin (Wärtsilä Oyj Abp)*
12:00 – 12:15	The sustainability approach of Royal Greenland, *Lisbeth Due Schönemann-Paul (Royal Greenland)*
12:15 – 12:30	Initiatives to reduce environmental impacts at Brim, *Sveinn Margeirsson (Brim hf)*
12:30 – 12:45	The Nordic Marine Think Tank, *Carl-Christian M.R. Schmidt (NMTT)*
12:45 – 13:45	Lunch break (Solutions and ongoing initiatives to reduce environmental impact of fisheries presented in booths/stands during coffee- and lunch breaks) *
13:45 – 14:00	Policy and incentives for change, *Karl Gunnar Aarsæther (UiT The Arctic University of Norway)*
14:00 – 14:15	Policy and challenges for implementation, *Hildur Hauksdóttir (Fisheries Iceland – SFS)*
14:15 – 15:15	Panel discussions
15:15 – 15:30	Closing, *Benedikt Arnason (Permanent Secretary at the Icelandic Ministry of Food, Fisheries & Agriculture)*

Figure 2: The conference agenda

The organising committee for the conference consisted of the following persons:

- Jónas R. Viðarsson (chair) – Matís, Iceland
- Ólafur Ögmundarson – University of Iceland, Iceland
- Friederike Ziegler – RISE, Sweden
- Unn Laksá – Sjokovin, Faroe Iselands
- Karl Gunnar Aarsæther - University of Tromsø, Norway
- Lisbeth Due Schoenemann-Paul – Royal Greenland, Greenland

2 Opening: Svandís Svavarsdóttir (Icelandic Minister of Food, Fisheries & Agriculture)

Svandís Svavarsdóttir, the Icelandic Minister of Food, Fisheries & Agriculture, opened the conference. She acknowledged the focus of Iceland during its presidency in the Nordic Council of Ministers on maritime issues and green transition. She did as well emphasise the challenges the Nordic countries face by climate change. Iceland has set the goal of carbon neutrality by 2040, and with the fishing fleet representing 20% of the country's carbon emissions it is clear that the seafood industry will need to reduce its carbon footprint. There is a common international pressure in eliminating subsidies in global fisheries, and Svandís believes that Iceland should take a lead in such a worldwide initiative.

Figure 3: Svandís Svavarsdóttir, the Icelandic Minister of Food, Fisheries & Agriculture

Svandís reviewed the actions taken within her time at the Ministry of Fisheries, many of which are specifically set to reduce energy use and facilitate energy transition in fisheries. She finally emphasised the importance of knowledge exchange and cooperation to reduce carbon emissions, and that Nordic cooperation should be at the forefront so that Nordic countries can continue to be seen as world leaders in sustainable fisheries.

3 Welcome and introduction: Jónas R. Viðarsson (Matís)

Jónas R. Viðarsson, as the moderator of the conference, thanked the Minister for her encouraging words, reviewed the motivation for the event and acknowledged AG-fisk for its part in the preparations and funding of the conference. He then presented some of the background for why the conference was initiated, highlighting that seafood is generally sustainable, climate-efficient and nutritious, but not necessarily perceived as such by consumers. He presented some facts and figures on sustainability, environmental impacts, and carbon footprint of seafood in comparison with other protein sources, concluding that fish is sustainable superfood. He emphasised that the Nordic seafood sector is in a fantastic position to take the lead in transitioning to alternative fuels and reducing even further the environmental footprint of its products.

Figure 4: Jónas R. Viðarsson, director of division of value creation at Matís and the moderator of the conference

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Environmental impacts and energy transition in the Nordic seafood sector

Miljøpåvirkning i Nordiske fiskeri

Conference 13.9.2023
Harpa
Reykjavík, Iceland

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Background

Iceland has the chairmanship in the Nordic council 2023

- As part of the chairmanship the Icelandic authorities have chosen some priority areas that they wanted to highlight this year.
- Among those priorities are **measures to reduce environmental impacts of seafood** and **energy transition in the seafood industry.**
- **How can the Nordic countries work together to be global leaders in these fields?**

- AG-Fisk is the Nordic council of ministers working group for fisheries and aquaculture, and among its tasks is to facilitate co-operation and networking in the Nordic seafood sectors.
- AG-fisk is therefore able to fund small networking projects that align with its tasks.
- We are grateful that AG fisk decided to fund this conference.

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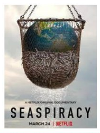
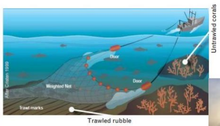
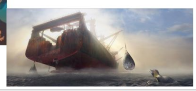
Background

- Seafood is generally a sustainable, climate-efficient and nutritious type of food. Consumers, however, are often confused as to whether seafood is really sustainable or not, and what seafood to choose.
- To many the image is this:







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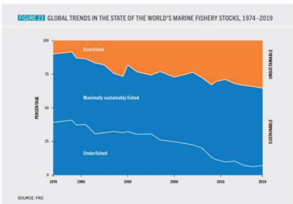
Background

The reality is however that most fish stocks are sustainably harvested.

- **65% of assessed stocks are sustainable**
- **82.5% of global catches are from sustainable sources**



Source: https://www.fao.org/3/cc0461en/cc0461en.pdf

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The reality is however than most fish stocks are sustainably harvested.

- 65% of assessed stocks are sustainable
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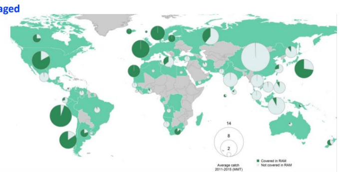
- **Nordic and European fisheries are managed according to best-available science**



% of utilised stocks with stock assessment (www.ramlegacy.org)

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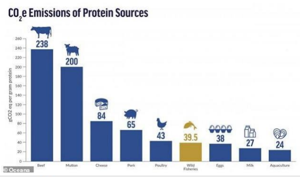

Source: Oceana https://oceana.org/blog/wild-seafood-has-lower-carbon-footprint-red-meat-cheese-and-chicken-according-latest-data/

Nordic Co-operation matis

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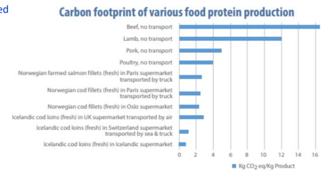
- Nordic and European fisheries are managed according to best-available science
- **Seafood has a modest CO2 footprint**
- **...and Nordic seafood is in the lead**



Source: https://matis.is/wp-content/uploads/2020/11/Icelandic-Cod.pdf

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Nordic Co-operation matis

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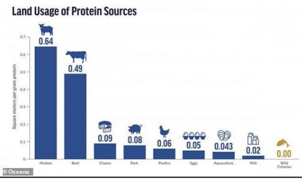
- **Seafood has a modest CO2 footprint**
- **.........and land use**



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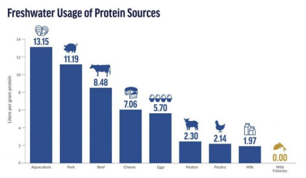
- **Seafood has a modest CO2 footprint**
- **.........and land use**
- **.........and water footprint**



Source: Oceana https://oceana.org/blog/wild-seafood-has-lower-carbon-footprint-red-meat-cheese-and-chicken-according-latest-data/

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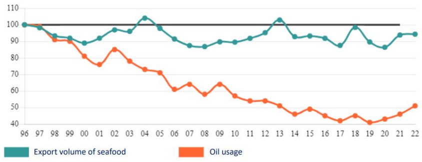
Background

Oil usage per kg production volume has been decreasing

- Figures for Iceland indicate 40% reduction



Source:
https://radarinn.is/Umhverfismal/Oliunotkun

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The opportunity

The Nordic seafood sector has the opportunity to take the lead in transitioning to low greenhouse gas emissions through energy efficiency measures and shifting to alternative fuels.

……….And take a global lead in these fields.

……….and use it to gain competitive advantage.

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What can we do?

Facilitate networking among stakeholders, raise awareness and share knowledge on past-, present- and future advances in reduction of environmental impacts in Nordic seafood value chains.

….and that is why we are here today

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Conference agenda

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14:15 – 15:15 Panel discussions (Hildur, Sveinn, Kaj, Karl & Friederike)
15:15 – 15:30 Closing, Benedikt Arnason (Permanent Secretary at the Icelandic Ministry of Food, Fisheries & Agriculture)

4 Decarbonising fisheries: Friederike Ziegler (RISE Research Institutes of Sweden)

Dr. Friederike Ziegler from RISE, the Research Institutes of Sweden, had a presentation titled "Decarbonising fisheries to supply low-carbon and nutritious food for the future". Dr. Ziegler is a leading expert in Life-Cycle Assessment of in food value chains and has a long experience in analysing environmental impacts of fisheries.

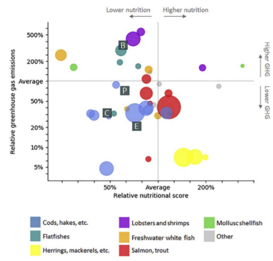
She showed that fish have in general a low carbon footprint compared to other protein sources, but there are major differences between types of fisheries and target species. She also showed that air transport of seafood makes fuel efficiency in other links of the value chain rather meaningless. Friederike discussed the many means to decarbonizing fisheries i.e., 1) energy efficiency, 2) alternative fuels, 3) improving utilization of catches. She finally highlighted new EU reports and initiatives for decarbonizing the fish sector.

Figure 5: Dr. Friederike Ziegler from RISE, the Research Institutes of Sweden

This talk

- Seafood = low-carbon, nutritious food?
- Why the focus on fuel use?
- Decarbonise- how?
- Nordics take the lead

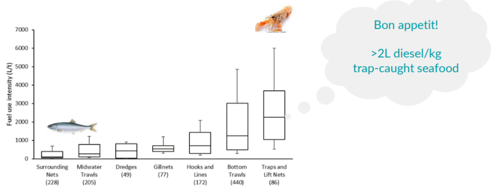
Climate in relation to nutrition quality



B=Beef
P=Pork
C= Chicken
E= Egg

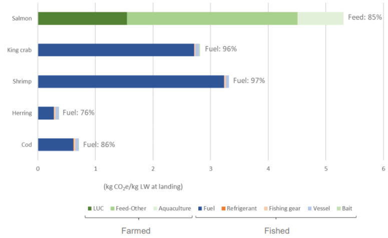
Hallström et al. 2019 Combined climate and nutritional performance of seafoods

Fishing method matters



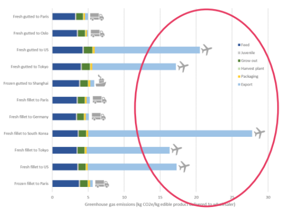
Data from the Fisheries Energy Use Database FEUD,
graph prepared by Rob Parker for report Ziegler & Hornborg 2023 Decarbonising the fishing sector

Fuel dominates fisheries GHGs



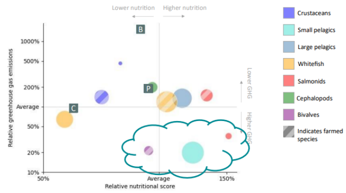
Ziegler et al. 2021 Greenhouse gas emissions of Norwegian seafoods

Transports generally don't, unless…



Johansen et al. 2022 Greenhouse gas emissions of Norwegian salmon products

Nutrition and climate



- Seafood is on average more nutritious than meat and less climate intensive than red meat
- Pelagic fish, wild salmon and farmed bivalves are best-performers

Bianchi et al. 2022 Assessing seafood nutritional diversity together with climate impacts informs more comprehensive dietary advice

Fuel price development

Two (or three) ways to decarbonise fisheries

1. Energy efficiency

Measures for increased energy efficiency

- Make fuel efficiency an **explicit** goal of fisheries management
- Create a baseline and collect and share data
- Implement current regulations (rebuild stocks, remove overcapacity, aim for MEY, use Article 17 to allocate fishing opportunities based on transparent and objective criteria e.g. GHG performance among gears, fleets, vessels)
- Allow more flexible choice of fishing gear, without causing tradeoffs

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2. Alternative fuels

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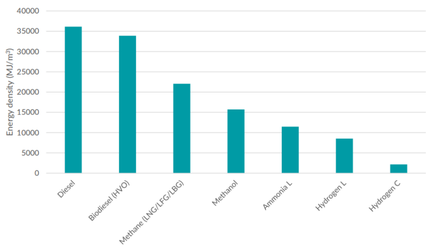
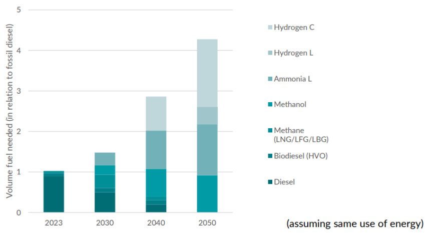
Energy density of fuels

L= Liquid
C= Compressed
LNG/LFG Liquid Natural/Fossil Gas
LBG Liquid Biogas
HVO Hydrotreated Vegetable Oil



RI.SE

Fuel volume development during the transition



(assuming same use of energy)

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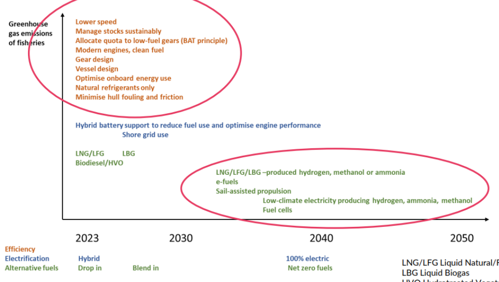
The road to decarbonised fisheries



Efficiency
Electrification
Alternative fuels

Hybrid
Drop in

Blend in

100% electric
Net zero fuels

LNG/LFG Liquid Natural/Fossil Gas
LBG Liquid Biogas
HVO Hydrotreated Vegetable Oil

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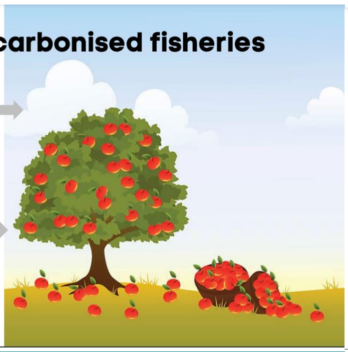
The road to decarbonised fisheries

"High-hanging fruits"

Sail-assisted propulsion
Low-climate electricity producing hydrogen, ammonia, methanol
Fuel cells

"Low-hanging fruits"

Lower speed
Manage stocks sustainably
Allocate quota to low-fuel gears (BAT principle)
Modern engines, clean fuel
Gear design
Vessel design
Optimise onboard energy use
Natural refrigerants only
Minimise hull fouling and friction



Measures for conversion to alternative fuels

- Tax exemption only for renewable fuels
- Introduce clever economic instruments- fee or tax for fossil (per energy content…), while basing compensatory measures on landing value or volume to keep the incentive to reduce fuel use intensity and shifting fuel
- Relax vessel restrictions (length, engine replacement) for vessels using alternative fuels
- Support infrastructure- in collaboration with the shipping sector!
- Compensate fishers for green investments
- Training needs for skippers and crews
- Ban the maritime use of fossil fuels by 2050!

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3. Utilization of catches

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Increase the denominator

- Maximise utilization
- Minimize losses through the supply chain

Photo of famous Iceland Ocean Cluster figure taken at whitefish processor in Grindavik

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The Nordics can lead

- Make fuel efficiency an **explicit** goal of fisheries management
- Collect and share data on fuel use in fisheries- establish a joint database?
- Compare and share data and experiences of technologies and regulations/taxes/funding mechanisms
- Make a timeline for the phasing out of fossil fuels from Nordic fisheries

RI. SE

It will have a cost, but it will be worth it!
(and it will cost anyway)

RI. SE

Thank you!

Friederike Ziegler

friederike.ziegler@ri.se
+46 704 205609

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5 The Transition to Green Energy for the Fishing Fleet and Its Ports: Ditte Stougaard Stiler (NER)

Ditte Stiler from Nordic Energy Research, the platform for cooperative energy research and policy development under the auspices of the Nordic Council of Ministers, presented some of the alternative fuels being developed for the Nordic fishing fleets and ports. Each of them have their pros and cons, which she explained. The fuels she presented were electricity, bioenergy, hydrogen, methanol, and Ammonia.

Figure 6: Ditte Stiler from Nordic Energy Research

Background

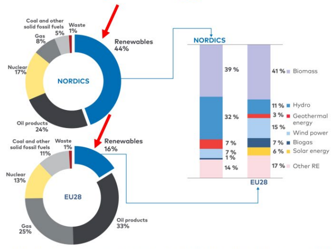
The Working Group for Fisheries (AG-Fisk) for the Nordic Council of Ministers has invited us

Net zero emissions fisheries and aquaculture sector by 2050 target by the EU

- Energy efficiency
- Cleaner energy sources
- Low-carbon power sources

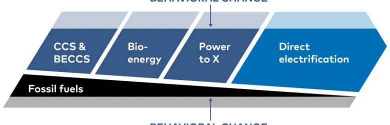
Norwegian Artificial Intelligence Research Consortium (2023)

Total Primary Energy in the Nordics



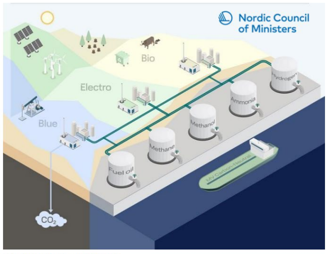
Nordic Clean Energy Scenarios –Solutions for Carbon Neutrality, Nordic Energy Research (2021)

The Transition of the Nordic Energy System



Nordic Clean Energy Scenarios –Solutions for Carbon Neutrality, Nordic Energy Research (2021)

Alternative Energy for Fishing Vessels



The Nordic Roadmap, DNV (2023)

Today:
Fuel oil

Alternatives:
- Electricity
- Bioenergy
- Hydrogen
- Methanol
- Ammonia

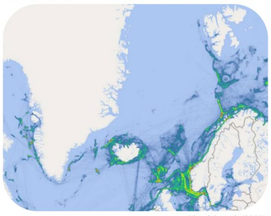
Nordic Fishing Traffic

Fishing Vessels:

- 83% domestic voyages
- 15% of total fuel consumption

Aquaculture vessels operate domestically as well

Fuel Consumption Density of Nordic Fishing Vessels



Rivedal et.al. (2022)

Fuel or Powertrain?

- Operational Profile
- Distance
- Engine Power
- Speed
- Weather Conditions

Electricity

Grønarók – Electric Catamaran Workboat (the Faroe Islands)

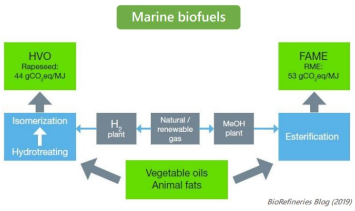
Baird Maritime (2022)

Fully Electric
- Coastal fishing

Hybrid-electric
- Provides greater flexibility

Bioenergy

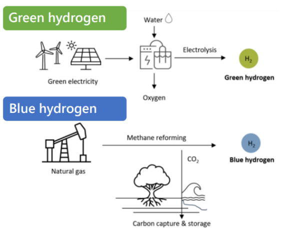
- Mature technology
- Small- and large vessels
- Blend in or 100% biofuel
- Feedstock availability



BioRefineries Blog (2019)

Hydrogen

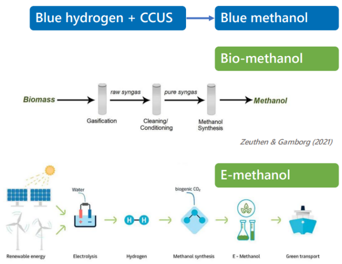
- Small-scale potentials
- Small fishing vessels
- Lack of technical maturity
- Lack of carbon-neutral supply chains



Winje E. et.al. (2022)

Methanol

- Large-scale potentials
- Medium and large fishing vessels
- Technical maturity
- Relies on a carbon source



Zeuthen & Gamborg (2021)

Dahl & Linnet (2021)

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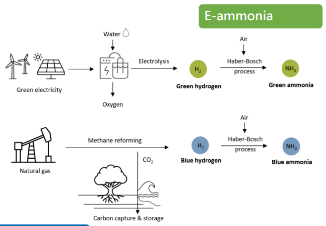
Ammonia

- Potentials similar to methanol
- Lack of technical maturity
- Higher safety risks



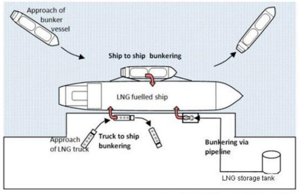
Winje E. et.al. (2022)

Bunkering Infrastructure in Ports

1. Pipeline-to-ship
2. Truck-to-ship
3. Ship-to-ship

Bunkering time:

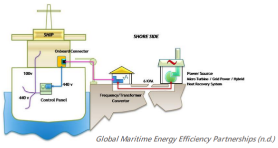
- Powertrain: Battery capacity and onboard connector
- Fuels: Flow rate and fuel carriage capacity



(Danish Maritime Authority (2012)

Electricity

- All major ports in the EU must by 2030 provide onshore power
- Needed power rating depends on:
  - Number and onboard battery capacity
  - Time laying in port
  - Charging system

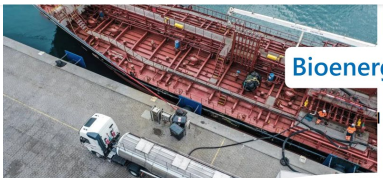


Global Maritime Energy Efficiency Partnerships (n.d.)

Fishing Vessel Segments:

- Small fishing vessels <1 000 GT: 3-phase 400V AC
- Larger ships require upgraded grid capacity and power converters

Bioenergy and Methanol

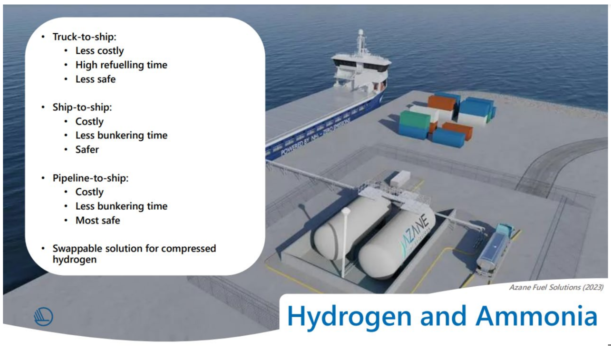


Valeur (2023)

- Technical maturity of biofuel bunkering
- Insufficient infrastructure and uncertainty related to scalability

- Some ports offer bunkering of methanol:
  - Ship-to-ship and truck-to-ship
- Insufficient infrastructure in the Nordics
- Technical maturity

Hydrogen and Ammonia

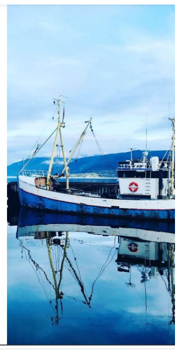


- Truck-to-ship:
  - Less costly
  - High refuelling time
  - Less safe
- Ship-to-ship:
  - Costly
  - Less bunkering time
  - Safer
- Pipeline-to-ship:
  - Costly
  - Less bunkering time
  - Most safe
- Swappable solution for compressed hydrogen

Azane Fuel Solutions (2023)

Where does this leave us?

- Upscaling of Renewable Energy Production and Infrastructure
- Business case and financial support
- Rules and regulation
  - Measures to push the development
  - Safety measures
- Who takes the lead? Ships or ports?



Thank You for Your Attention

Feel welcome to contact:

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+47 90 05 91 70
ditte.stiler@nordicenergy.org

Nordic Energy Research

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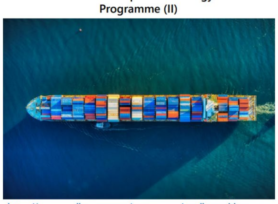
https://www.nordicenergy.org/

And check out our:
Nordic Maritime Transport and Energy Research Programme (II)



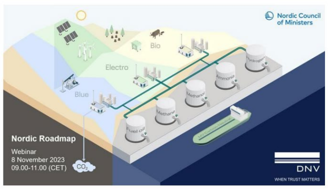
https://www.nordicenergy.org/programme/nordic-maritime-transport-and-energy-research-programme/

Nordic Roadmap Invitation

DNV
Nordic Council of Ministers

Date: October 3rd
Location: Nautholl, Nauthólsvegur 106, 101 Reykjavik, Iceland

Register here:
cdn.forms-content.sg-form.com/f8692786-368f-11ee-b2a8-9ae53f85e4b2



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6 Most influential factors affecting CO2 emissions in fisheries – Daði Már Kristófersson (UI)

Dr. Daði Már Kristófersson, professor of economics at the University of Iceland, attempted to answer the question of what are the most influential factors affecting CO2 emissions in fisheries? Dr. Kristófersson has analysed and published papers on that subject, focusing on linking fuel use in the Icelandic seafood industry with other developments in the fishing fleet, management of the resources, condition of the stocks etc. The presentation revealed what is most important in order to reduce CO2 emissions in fisheries. The core of his presentation was based on a paper published by him and two colleagues in ICES Journal of Marine Science in 2021 (Kristofersson, Gunnlaugsson & Hreiðarsson, 2021[1])

Figure 7: Dr. Daði Már Kristófersson, professor of economics at the University of Iceland

[1] Factors affecting greenhouse gas emissions in fisheries: evidence from Iceland's demersal fisheries https://doi.org/10.1093/icesjms/fsab109

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Most influential factors affecting CO_2 emissions in fisheries

Dadi Kristofersson
Professor of Economics
University of Iceland

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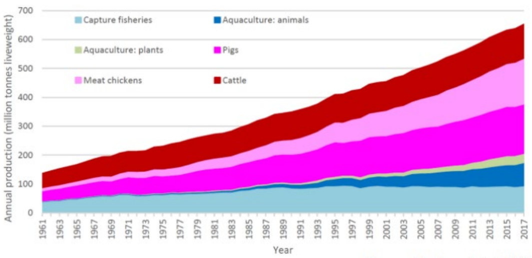
GHG emissions from animal production



Source: MacLeod et al 2020

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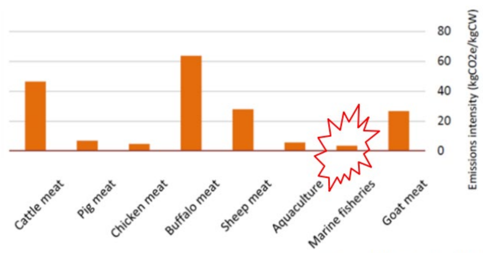
Carbon intensity



Source: MacLeod et al 2020

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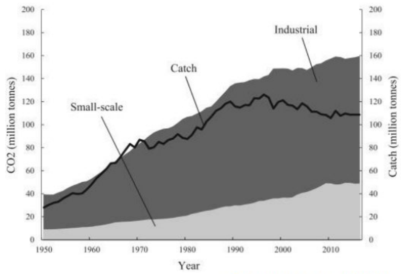
Development of catch and emissions



Source: Greer et al 2020

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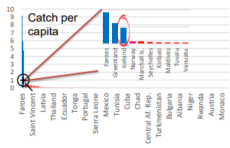
Icelandic fisheries

- Among top 20 fishing nations in the world by quantity
- Multi species fishery
- Quota regulated since 1984
- Mostly industrial and very consolidated
- TAC regulated by harvest rule
- Very profitable



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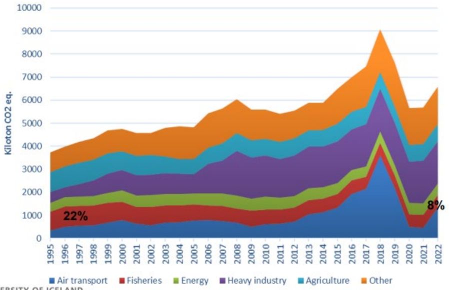
Iceland´s story



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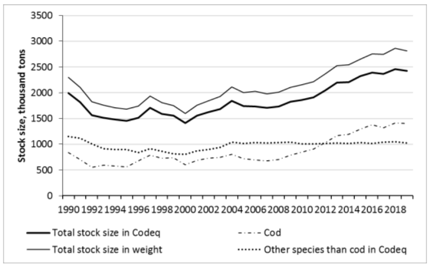
Stock size development



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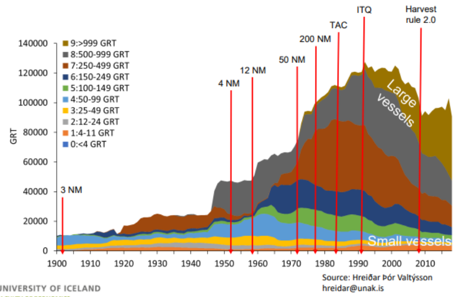
Icelandic fishing fleet- GRT



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Factors that might affect carbon intensity in fishing

- Management system
- Gear
- Vessel type
- Technology
- Carbon pricing
- Stock size

How much does each factor contribute?

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Study focus

- Focus on the Icelandic demersal fishing by fleet segment
- Study period 1997 to 2018
- Quantity aggregation based on cod equivalents
- Carbon intensity based on kg CO2 eq. per kg catch in cod equivalent

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Data

- Emission data from the Icelandic Environmental Agency
- Input, output and price data from Statistics Iceland
- Stock size data from Icelandic Marine Research Institute

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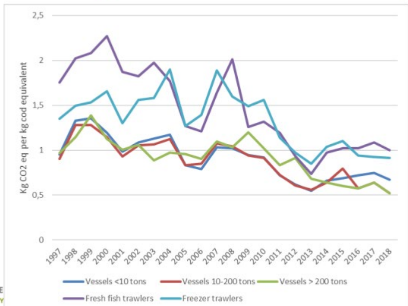
Development of carbon intensity



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Change over the period

	1997 to 2000	2015 to 2018	Change
Weighted average of all demersal fisheries	1.47	0.89	-39.5%
Boats <10 GRT	1.21	0.71	-41.4%
Boats 10 to 200 GRT	1.15	0.63	-45.1%
Boats >200 GRT	1.16	0.58	-49.5%
Fresh fish trawlers	2.03	1.03	-49.2%
Freezer trawlers	1.51	0.97	-35.7%

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Model

- We estimate the relationship between emissions and fishing using an implicit production function derived from:

$$\max_{y,x}\{p'y - w'x\}$$
$$\text{S.t.}$$
$$g(y, x, z, e, \bar{y}) \leq 0$$
$$z = z_0$$
$$y \leq \bar{y}$$

y is output (regulated by a quota $\bar{y}$), x is input, z are environmental factors and e are emissions and p and w are prices

Statistical results

Gear type	Stock size	Trend	Total quota	Fuel price	Fish price
Passive	-0,97	0,0009	0,96	-0,44	0,50
	(-3,45)	(0,07)	(-57,81)	(-8,03)	(-4,27)
Active	-0,95	-0,0216	0,87	-0,13	0,44
	(-2,20)	(-1,21)	(-20,56)	(-1,53)	(-2,44)

t-values in parenthesis

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on intensity and stock size

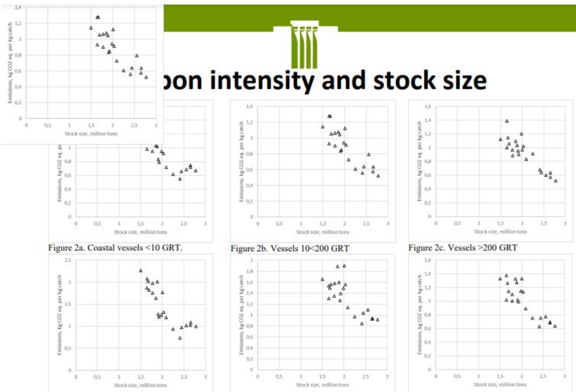

Figure 2a. Coastal vessels <10 GRT.
Figure 2b. Vessels 10<200 GRT
Figure 2c. Vessels >200 GRT
Figure 2d. Fresh fish trawlers
Figure 2e. Freezer trawlers
Figure 2f. Average for all fleet segments

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Conclusion

- There has been a dramatic reduction in carbon intensity in the demersal fishery in Iceland
- It is most clearly related to stock size and scale
- Carbon pricing has also affected emissions
- Technology has played a minor role (why?)
- Nations can reduce emissions, increase output and improve profitability by improving fisheries management

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7 Benthic disturbance and fisheries - Ole Ritzau Eigaard (DTU aqua)

Dr. Ole Ritzau Eigaard from DTU aqua is an expert on environmental impacts of fisheries, including benthic disturbance of bottom-trawling. In his presentation he addressed the debated issue of quantifying the environmental impacts caused by bottom-trawling on the seafloor. In 2021 Sale *et al.* published in *NATURE* a paper claiming that global bottom trawling is responsible for as much carbon release as air travel. The paper received great attention and has been debated heavily since then. In 2023 Hiddink *et al.* published also in *NATURE* a paper that refutes the assertion in the paper of Sale *et al.* The issue remains heavily debated, and it is clear that more research is needed. Dr Eigaard presented and compared the results of Sala et al and Hiddink et al., as well as other similar studies done on the subject in recent years.

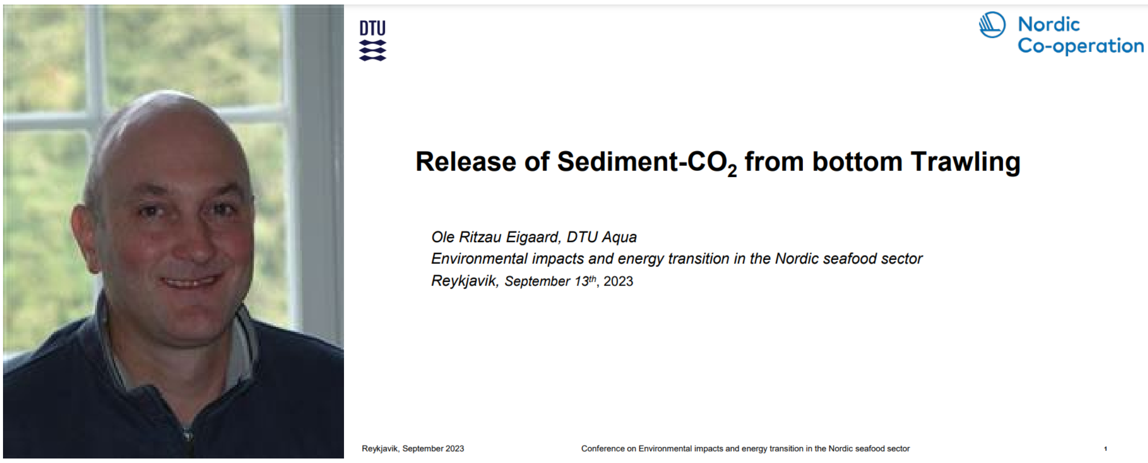
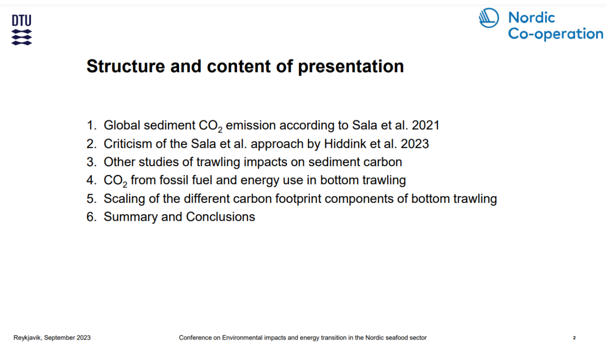
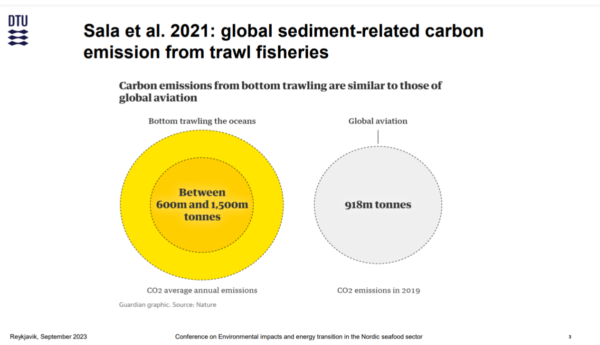
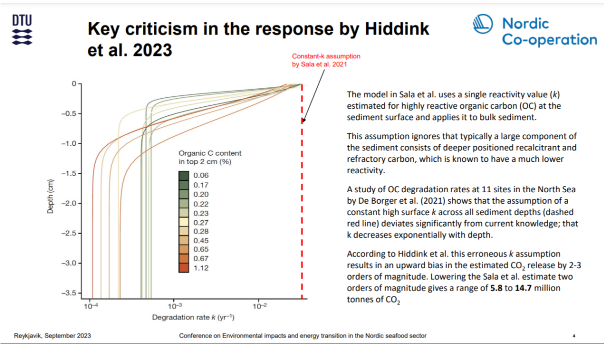
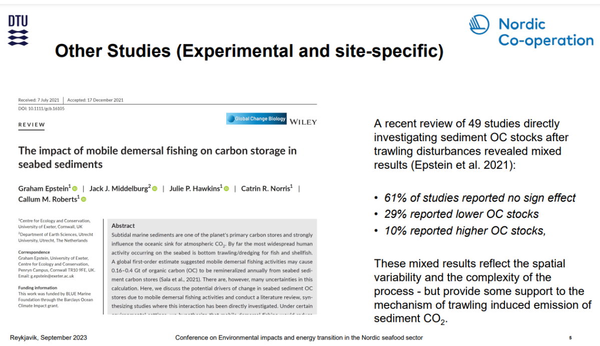


Figure 8: Dr. Ole Ritzau Eigaard from DTU aqua









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CO_2 from fuel and energy use in bottom trawling

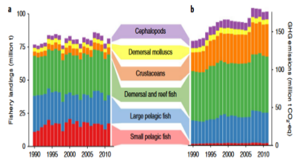

Fig. 2 | Global marine fishery landings and GHG emissions for 1990–2011 categorized by species groups. a, Global marine fishery landings. b, Global GHG emissions from marine fisheries.

- Global emission of **179 million t** CO_2-equivalents annually from all fishing (both passive and active gears)
- Estimate of **135 million t** from all fishing for demersal species.
- These estimates cover all non-sediment related emissions (fossil fuels generally contribute most)
- Difference in climate footprint between demersal (large) and pelagic (small) fish and shellfish capture when related to catch weights.

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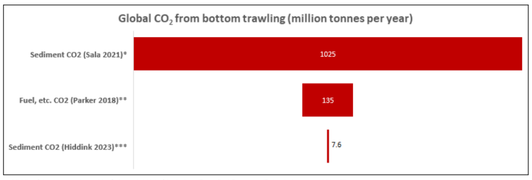
Scaling of the carbon footprint components



- Middle of the range estimated by Sala et al. 2021 of 0.58–1.47 (Pg yr^{-1}). 1 Petagram (Pg) = 1 gigaton = 1000 million tonnes

** The estimate from Parker et al. 2018 is in CO_2 equivalents and includes all demersal fisheries (passive and active) and all non-sediment related emissions

*** Middle of the range estimated by Sala et al. 2021 (0.58–1.47 Pg yr^{-1}) after downscaling by two orders of magnitude based on Hiddink et al. 2023

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Summary and Conclusions

- The mechanism of increased emission of sediment-CO_2 caused by bottom trawling has been timely flagged by Sala et al. 2021.
- However, their approach is based on poorly substantiated assumptions of carbon reactivity and uncertain maps of sedimentary carbon stocks, and according to Hiddink et al. (2023), the global CO_2 emission estimates are several orders of magnitude too high.
- Overall, the use of fossil fuels is likely a substantially bigger source of atmospheric CO_2 in bottom trawl fisheries than sediment-related emissions.
- In some marine areas sediment-CO_2 can likely be a substantial component of the total carbon footprint of bottom trawl fisheries (areas with high organic carbon content, high reactivity of the organic carbon, and low primary production in the water column).

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Thank you for listening

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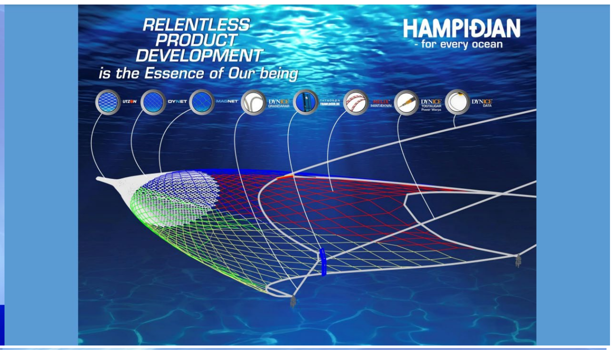
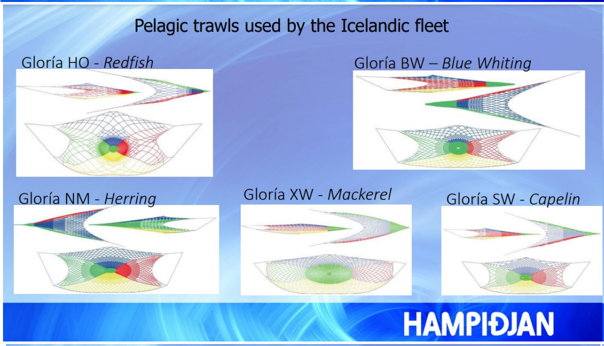
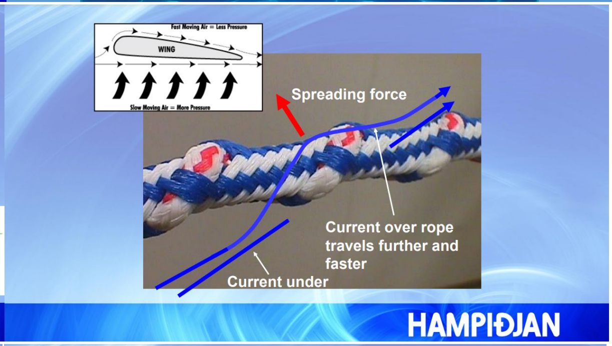
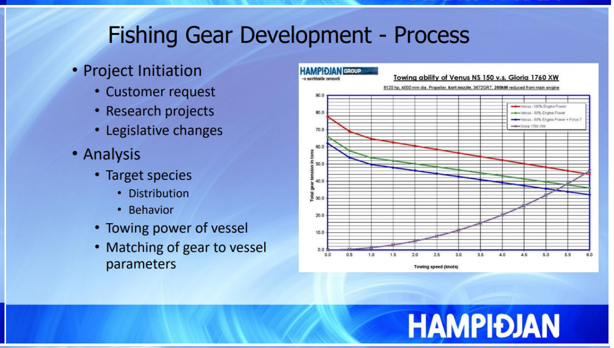
8 Environmental Impact of Fishing Gear – Georg Haney (Hampiðjan)

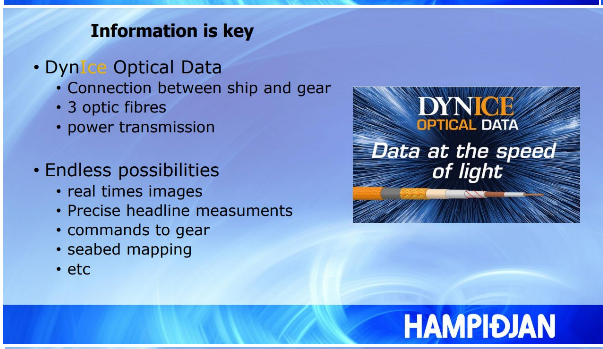
Georg Haney is the Environmental Manager of Hampiðjan Group, which is a world leader in developing and producing fishing gear. Georg presented what fishing gear developers and working on to reduce the environmental impact of their gear e.g., in relation to bottom contact, fuel consumption, selectivity and life cycle perspectives, such as recyclability, of the gear.

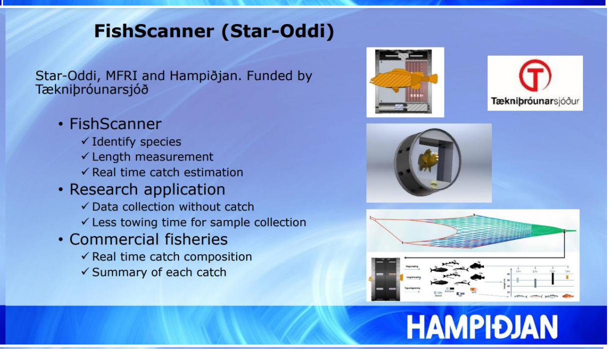












Product group	Ingredient	Brand	Name	Recycling	Landfill	Processing company
HMPE ropes	HighModulusPolyEthylene	DynIce, Prima	HMPE		(X)	(DSM Dyneema)
HMPE netting	HighModulusPolyEthylene	DynIce, Prima	HMPE		(X)	(DSM Dyneema)
Coverbraided ropes	Polyethylene 55% og Polyamid 45%	Pepa, Helix, Capto, Jaco, Torex	PE+PA	(X)		Nofir
Braided ropes	Polyamid	Nylex	PA	X		Polivektris
Nylon net	Polyamid	Utzon	PA	X		Polivektris
PE netting	Polyethylene	Magnet	PE	X		Plastix
Twisted ropes	Polyethylene	PE rope	PE	X		Plastix
	Polypropylene	PP rope	PP	X		Plastix
	Nylon	Utzon	PA	X		Polivektris
	Polypropylene 80% - Polyethylene 20%	Kraftur, Kraftex, Danline	PP+PE	X		Plastix
	Polyethylene 50% - Polyamid 50%	Codline	PE+PA		X	
	Polyethylene 50% - Polyester 50%	Gleipnir	PE+PES		X	
Floats	Acrylonitrile butadiene styrene	Castro,	ABS		X	
Rockhopper	Rubber	Eurorock	PI	X		Granuband
Chain, wire , hardware	Ferros Metals		Fe	X		Local

15

HAMPIÐJAN

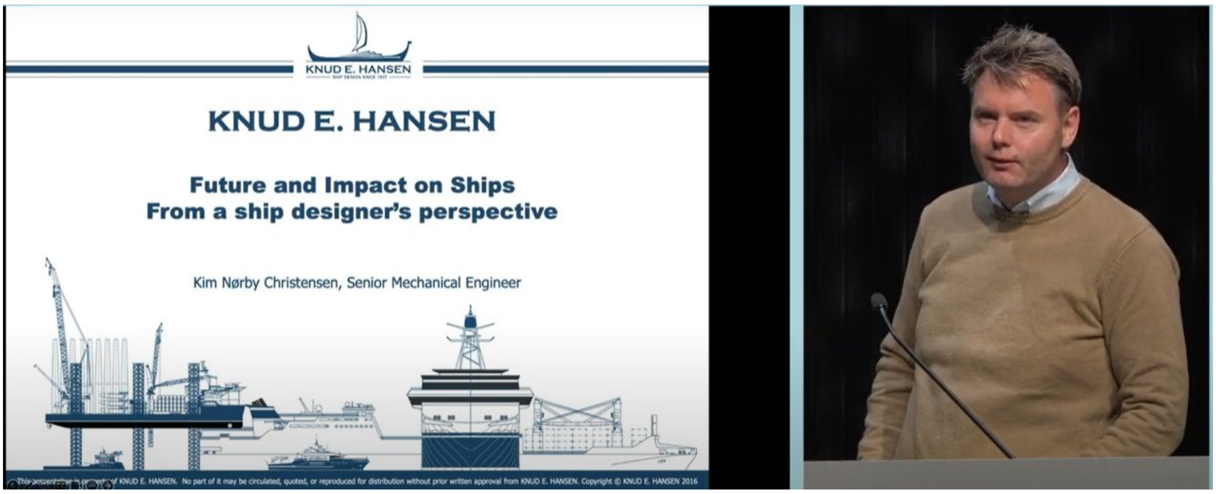

Recycling of PE in
Hampidjan Baltic
16
HAMPIÐJAN

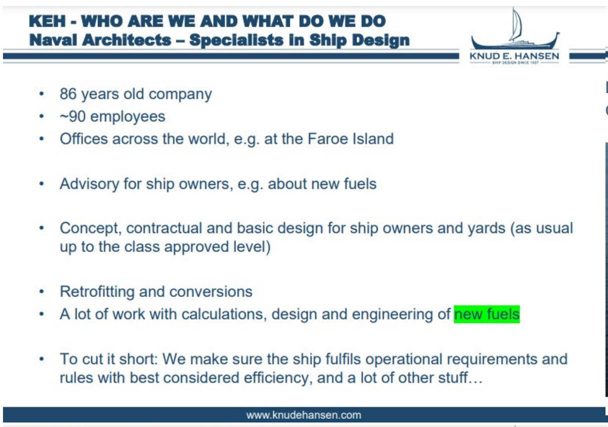

Fishing gear for recycling (2022)
Fishing gear „waste“
Rubber 73.957 kg
Steel 44.300 kg
Nylon 147.185 kg
PE 183.948 kg
Dyneema 1.391 kg
17
HAMPIÐJAN

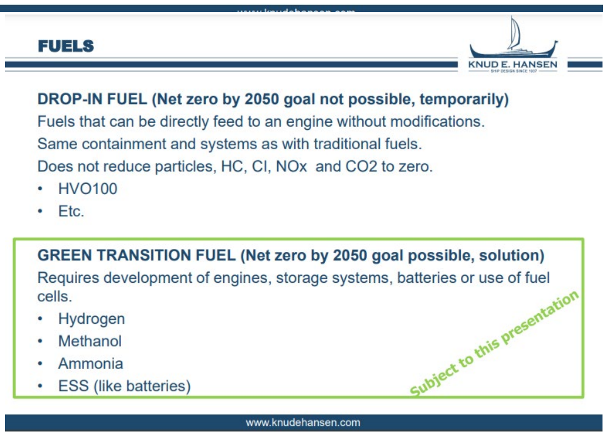

Thank You!
HAMPIÐJAN

9 Future and impact on ships: a designer's perspective: Kim N. Christensen (Knud E. Hansen)

Kim Nørby Christensen is a senior mechanical engineer at Knud E. Hansen, which is among the leading vessel design companies in Europe. Kim introduced the most recent trends in vessel design and how alternative fuels are becoming more important is ship building. The issue with transitioning to new fuel sources in ship building is that there are many potential fuel sources, each with their pros and cons, and no one knows which will come out on top. It is therefore difficult to take chances when investing in vessels that are meant to last for decades.







OUTSIDERS

- **Carbon capture technology** is not considered as a viable technology yet (too expensive, too heavy, too space consuming), especially for smaller ships.
  We see really no projects where this is considered
  (CARBFIX could however change the picture locally in Iceland)
- **Nuclear**, well with the new reactors the concept is tempting but we do not see any considering it
- **Lower speeds** can be a part of the future energy reduction, but not for fishing ships, and does not solve the 2050 goals as such

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WHAT FUEL TO SHORTLIST?

- Local fuel availability is the most important factor for deciding upon fuel
- We should not solve one problem by using energy to sail energy around the globe when locally produced energy is available (We need to look at the supply chain approach and not only the ship approach)
- Fishing ships not calling ports outside Iceland; hence fuel should be available at Iceland as to avoid CO2 footprint when importing

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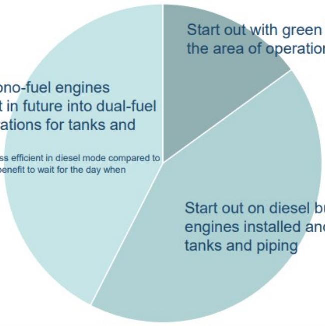
FUTURE IS IN EVERY DESIGN WE DO
3 Strategies



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THE PROJECT PROCESS

- Selecting and integrating the right commercially available equipment for the ship
- Using commercially available rules from classes. Available for all new fuels
- Have been dealing with LNG for the past decade, so new fuels are no new
- Have carried out projects "big scale" with methanol, ammonia, hydrogen and batteries for at the past 5 years
- Implementing a new fuel or any other piece of equipment, is a traditional development design/engineering process managed by the designer

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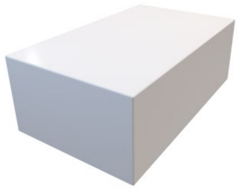
THE MAJOR CHALLENGE
Get Space for the Fuel Onboard

- For all projects, this is the challenge
- New fuel requires more space onboard and, in most cases, other locations

TRADITIONAL DIESEL TANKS

NEW GREEN FUEL TANK



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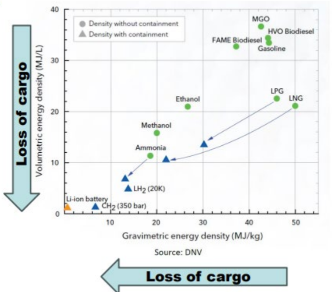
THE MAJOR CHALLENGE
Get Space for the Fuel Onboard

- One rough conclusion can be made:
  - The cargo carrying capacity of similar ship will decrease!



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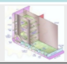
Containment
Outsiders Not Included

Fuel	State	Containment
Diesel	Atmospheric	
Hydrogen, gas	Small diameter cylinders with 300-500 bar	
Hydrogen, liquid	-253°C Vacuum insulated tank ~70% filling rate	
Ammonia	Ambient ~20°C 8,6 bar	
Methanol	Ambient temperature Atmospheric pressure N2 padded tank	Structural tanks with produceable cofferdams

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CAPEX / OPEX
Now We Tie It All Up

- CAPEX (i.e. building cost) for the ship will increase
  - Tank containment
  - Fuel supply system (diesel is still needed for backup)
  - Higher engine prices
  - Larger displacement/bigger ship to take same cargo (roughly speaking)
  - Waste heat recovery systems can be installed due to increased energy price
  - More efficient aux systems due to increased energy price
- OPEX (i.e. operation cost) for the ship will increase
  - More frequent bunkering due to lower endurance
  - Maintenance of new equipment
  - Increased electrical power consumption for handling of new aux systems
  - Fuel price means more expensive energy
  - CO2 tax shortens the return of investment (the "carrot" for making it more and more greener)
- Return of Investment for increased energy price
  - Waste heat recovery to be considered (e.g. ORC units)
  - Increased efficiency in aux systems

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KEEP AN EYE ON Fuel Cells

KNUD E. HANSEN

- We use engines for 98% of our projects today
- Solid oxide fuel cells (SOFC) is comming
- Not yet ready for marine use, yet
- Can use methanol or ammonia directly to produce electrical power
- High efficiency, especially in future

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Retrofitting = Asset Management Keep Value of Your Fleet

KNUD E. HANSEN

- If newbuilding is a struggle, retrofitting is totally exhausting, finding the space for fuel containment is the tricky part, especially because the ships are somehow small and filled with equipment
- Keep in mind, it is not only to find the space, we also need to consider:
  - Stability (moving fuel from bottom to upper part in heavy containment systems is not beneficial)
  - Cargo impact

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Turn Back Time When LNG Started

KNUD E. HANSEN

- LNG has been used for fueling ships for a decade (similar fuel as many of the new fuels)
- Introduced based on the SOx and NO x emission reduction requirements from IMO
- Slow start because LNG distribution in small scale was not available (and here LNG was already available in all major ports but not for fuel, only distribution was needed)
- Transition to new fuels; fuels needs to be available as well as distribution, then transition of the fleet will follow

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Container Ships Trend

KNUD E. HANSEN

- Jonas told me that he would like KEH to briefly touch upon container ships as these are carrying the cargo from Iceland to Europe
- KEH is involved in conversion projects with container ships (among others) to methanol
- When APMM decided to go for methanol some years ago it moved the market in that direction
- Methanol and container ships are really a kind of ideal combination due to the nature of the methanol storage

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SYSTEMS THAT WE IMPLEMENT AND DESIGN

KNUD E. HANSEN

- Container ships calling Iceland is relatively small ships powered by 4-stroke engines; while the big containerships are using 2-stroke
- 2-stroke runs on almost everything..
- …but for 4-stroke, the market is emerging, and a limited number of engines/power units are available right now
- Containerships, by nature goes to Europa; hence most likely fueling in Europe and not in Iceland
- Iceland does not need to produce fuel for containerships if endurance is based on a round trip; if fueling in Iceland container ships will compete with local market
- We see projects with very limited capacity due to space of new fuels, but for e.g. container ships the trend is not an each-port-refueling strategy

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10 Future fuels for marine – the path to decarbonization: Kaj Portin (Wärtsilä)

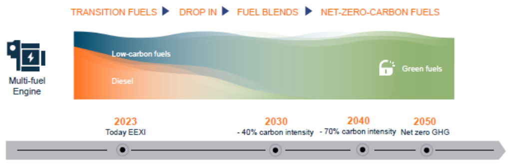
Kaj Portin is the General Manager of Sustainable Fuels & Decarbonization at Wärtsilä Finland Oy. Wärtisilä is among the world leaders in designing and manufacturing ship engines and has put major efforts into providing alternatives for alternative types of fuel. Kaj gave an overview of the development taking place at Wärtisilä, providing a time schedule for how the company is expecting to provide and install engines that run on renewable fuels. The current issues the company is challenged with is lack of infrastructure and availability of alternative fuels, lower energy capacity in these fuels resulting in more space being needed for storage, safety issues with fuels such as ammonia and hydrogen, as well as the fact that some of these fuels need storage tanks that have to be “difficult” in shape. The fact is that most companies that are having new ships designed are planning to own them for a very long time, and taking a gamble on what alternative fuels will come out on top is risky. Most are therefor going for hybrid solutions, with engines that can run on conventional fuel and renewable fuel; or can with simple retrofitting run on one. Kaj presented how Wärtisilä has been working on innovative solutions for energy exchange and what their future plans are.

Figure 9: Kaj Portin, the General Manager of Sustainable Fuels & Decarbonization at Wärtsilä

Certainty in transition

WÄRTSILÄ

Infrastructure and availability of green fuels need time to mature - current Wärtsilä multi-fuel Wärtsilä multi-fuel technology offer a viable upgrade path



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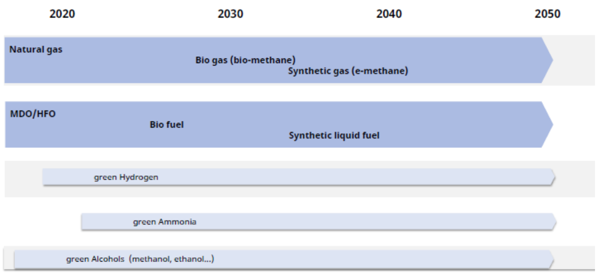
Fuel Roadmap – Focus on Renewable Fuels

WÄRTSILÄ



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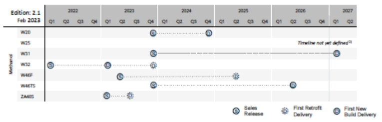
Marine Power Product Development - Methanol

WÄRTSILÄ

Current Status	Current Plan	Ambition
Technology Development Developing combustion technologies, fuel systems, automation systems and safety features to operate on future fuels	**Product Development** Applying technologies to specific product types	**Industrialised Solution** Decarbonise the marine industry with portfolio of engines running on future fuel applications
Product Development W32 Methanol engine now available to market and scheduled for delivery in 2023	**Roadmap of Development**[1)] Indicated product timelines remain subject to change	**At Which Time** Methanol is available with supporting infrastructure to meet customer demand and these fuels are economically viable



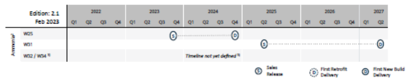
1) *Disclaimer: Subject to sufficient technology progression and quality, while ensuring maximum safety in these developments, the following indications in development have been made. It should be noted that both engine model and timeline remain subject to change based on market demand and other influencing factors.*
2) *The W25 Methanol timeline is not yet defined. Tentative plans indicate a sales release may occur not earlier than 2027*

5 © WÄRTSILÄ

Marine Power Product Development - Ammonia

WÄRTSILÄ

Current Status	Current Plan	Ambition
Technology Development Developing combustion technologies, fuel systems, automation systems and safety features to operate on future fuels	**Product Development** Applying technologies to specific product types	**Industrialised Solution** Decarbonise the marine industry with portfolio of engines running on future fuel applications
Product Development Current indications predict first Ammonia engine available for delivery as early as 2024	**Roadmap of Development**[1)] Indicated product timelines remain subject to change	**At Which Time** Ammonia is available with supporting infrastructure to meet customer demand and these fuels are economically viable



1) *Disclaimer: Subject to sufficient technology progression and quality, while ensuring maximum safety in these developments, the following indications in development have been made. It should be noted that both engine model and timeline remain subject to change based on market demand and other influencing factors.*
2) *40-60% blend based on fuel volume*
3) *Retrofit package is under planning. Sales release and first delivery dates are dependent on results from on-going technology tests. Tentative plans indicate a sales release not earlier than 2024.*

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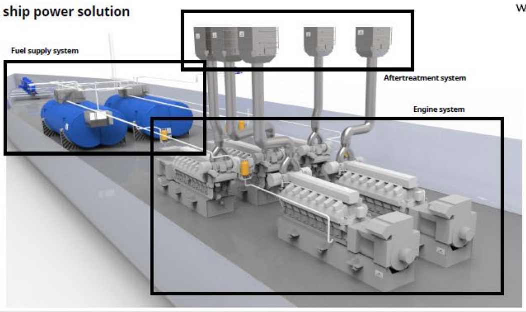
The ship power solution

WÄRTSILÄ



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Hydrogen

WÄRTSILÄ

Wärtsilä & US partners succeed with world's first-of-its-kind power plant fuel tests using blended hydrogen

Wärtsilä Corporation, News 8 November 2022 at 13:00 UTC+2

The testing of hydrogen blended fuel carried out by the technology group Wärtsilä in collaboration with WEC Energy Group, EPRI and Burns & McDonnell has been concluded. The tests were made at WEC Energy Group's 55 MW A.J. Mihm power plant in Michigan, USA using an unmodified 18 MW Wärtsilä 50SG engine. The hydrogen and hydrogen blending skid was provided by Certarus Ltd. The tests were completed in October 2022.

8 © WÄRTSILÄ

Hydrogen

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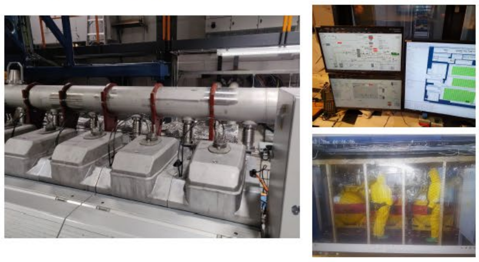
9 © WÄRTSILÄ

Ammonia engine testing - 30 June 2021

WÄRTSILÄ



10 © WÄRTSILÄ

Demo 2000 – Ammonia demonstration project at Stord

WÄRTSILÄ

2020 - 2023

Partners

SUSTAINABLE ENERGY | NORWEGIAN CATAPULT CENTRE

Forskningsrådet

REPSOL

Knutsen OAS Shipping

equinor

WÄRTSILÄ

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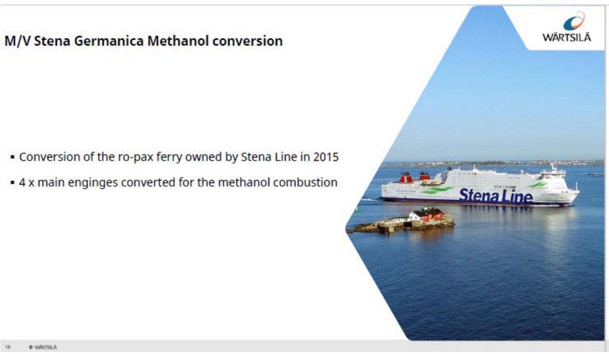
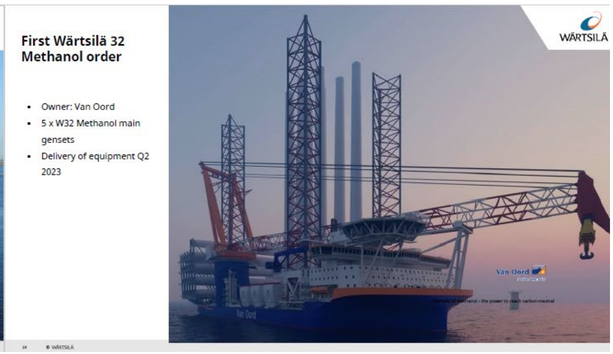
Ammonia safety

WÄRTSILÄ

- Master's Thesis by Laura Sariola in 2020 on engine, fuel system and engine room setup
- System approved by TUKES (Finnish authority) in June 2021
- Cooperation with Marine classification societies for Ammonia rules
- Verification of the robustness and functionality of the safety systems
- Personal Protection Equipment definition.

12 © WÄRTSILÄ


WÄRTSILÄ
M/V Stena Germanica Methanol conversion
▪ Conversion of the ro-pax ferry owned by Stena Line in 2015
▪ 4 x main enginges converted for the methanol combustion
Stena Line
13
© WÄRTSILÄ


WÄRTSILÄ
First Wärtsilä 32 Methanol order
▪ Owner: Van Oord
▪ 5 x W32 Methanol main gensets
▪ Delivery of equipment Q2 2023
Van Oord
14
© WÄRTSILÄ


WÄRTSILÄ
W32 Methanol available in March 2023 ExW
▪ Based on proven and reliable W32 engine concept
▪ Experience from earlier W32GD engine design, and Sulzer ZA40 methanol
▪ Back up fuel operation possible (LFO + LBF, HFO)
▪ Fuel switch (Methanol ⇔ Liquid) can be made without loss of power
▪ Auxiliary engine (AE), Diesel electric engine (DE) and Variable speed Main Engine
▪ Variable speed Main Engine October 2023 Exw
15
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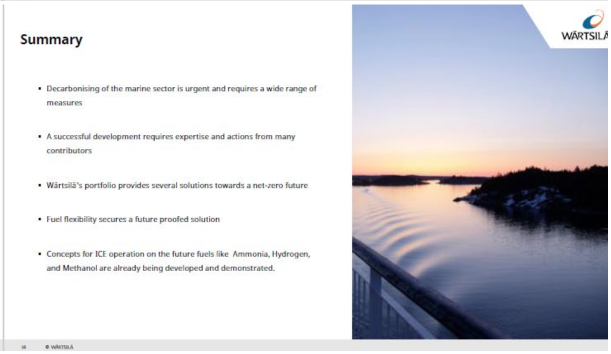
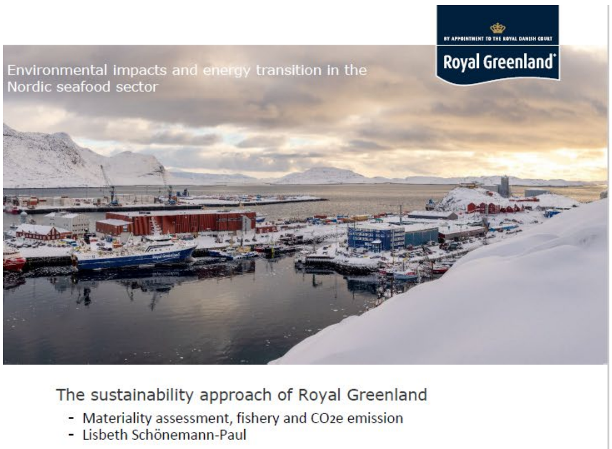

WÄRTSILÄ
Summary
▪ Decarbonising of the marine sector is urgent and requires a wide range of measures
▪ A successful development requires expertise and actions from many contributors
▪ Wärtsilä's portfolio provides several solutions towards a net-zero future
▪ Fuel flexibility secures a future proofed solution
▪ Concepts for ICE operation on the future fuels like Ammonia, Hydrogen, and Methanol are already being developed and demonstrated.
16
© WÄRTSILÄ

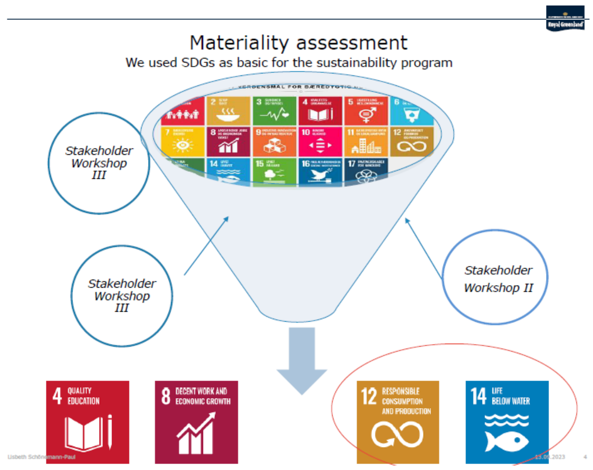
11 The sustainability approach of Royal Greenland: Lisbeth Schönemann-Paul (Royal Greenland)

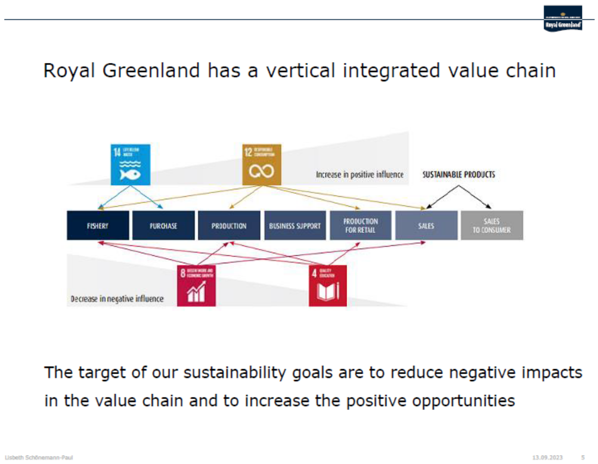
Lisbeth Due Schönemann-Paul is a Senior Corporate Sustainability Advisor at Royal Greenland and she presented in her talk the sustainability approach of Royal Greenland. Royal Greenland is a vertically integrated company operating in harsh and difficult areas, where infrastructure for energy exchange is lacking. Royal Greenland places utmost importance on sustainability in its operations, by fishing from sustainably managed stocks, reducing energy consumption and CO2 emissions, maximising utilisation, using more environmentally friendly packaging materials, reducing water consumption etc. Royal Greenland is also looking carefully at upstream and downstream activities (scope 2 and 3), which account for majority of the products carbon footprint when considering the entire value chain.

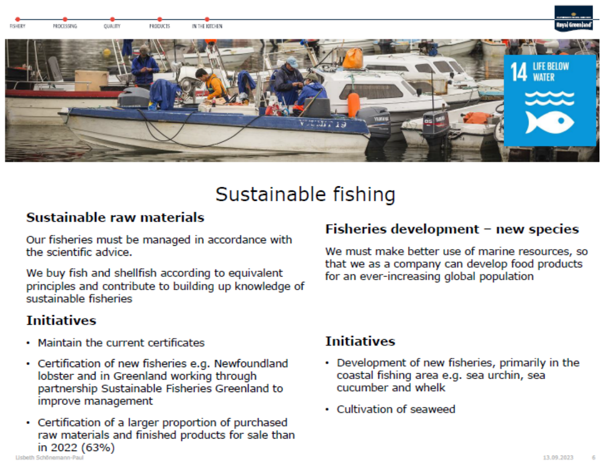
Figure 10: Lisbeth Due Schönemann-Paul is a Senior Corporate Sustainability Advisor at Royal Greenland

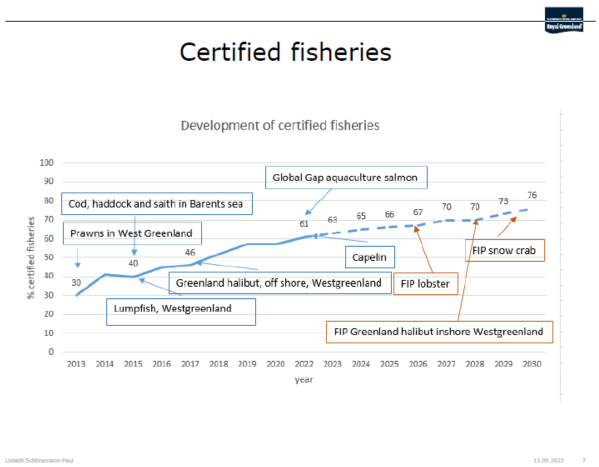


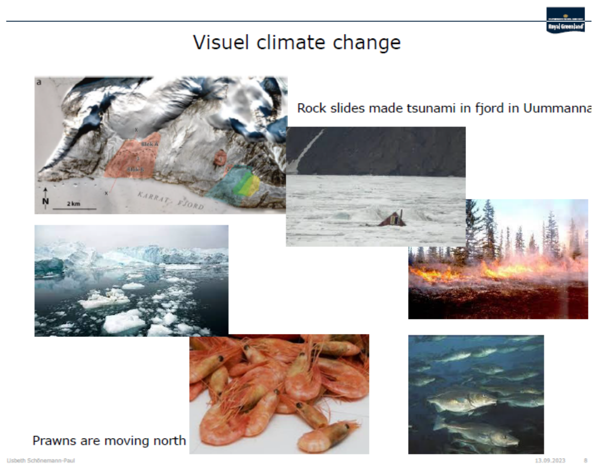

Royal Greenland
A large seafood company in the North Atlantic
Independent company owned by the Greenlandic Government
Present in 37 settlements in Greenland of 65
More than 2.200 employees around the globe, here of almost 1.400 in Greenland
Operates own off shore and coastal fishing fleet and production units in Greenland, Atlantic Canada and Germany
Local presence in major world markets
Mission
We sustainably maximize the value of marine resources to which we have privileged access, for the benefit of our owners and our local communities
GRØNLAND


Materiality assessment
We used SDGs as basis for the sustainability program
Stakeholder Workshop III
Stakeholder Workshop III
Stakeholder Workshop II
4 QUALITY EDUCATION
8 DECENT WORK AND ECONOMIC GROWTH
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
14 LIFE BELOW WATER

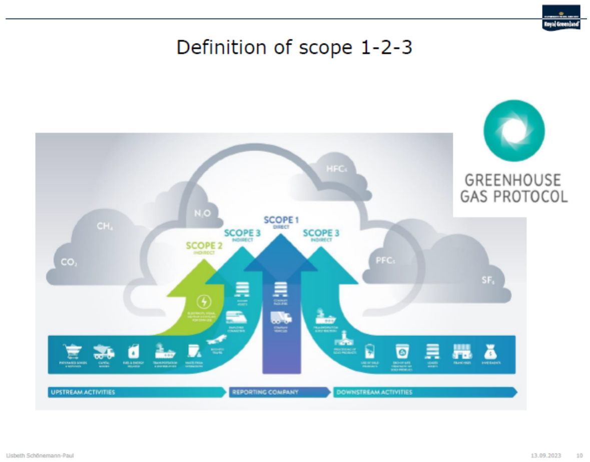

Royal Greenland has a vertical integrated value chain
Increase in positive influence
SUSTAINABLE PRODUCTS
FISHERY
PURCHASE
PRODUCTION
BUSINESS SUPPORT
PRODUCTION FOR RETAIL
SALES
SALES TO CONSUMER
Decrease in negative influence
The target of our sustainability goals are to reduce negative impacts in the value chain and to increase the positive opportunities

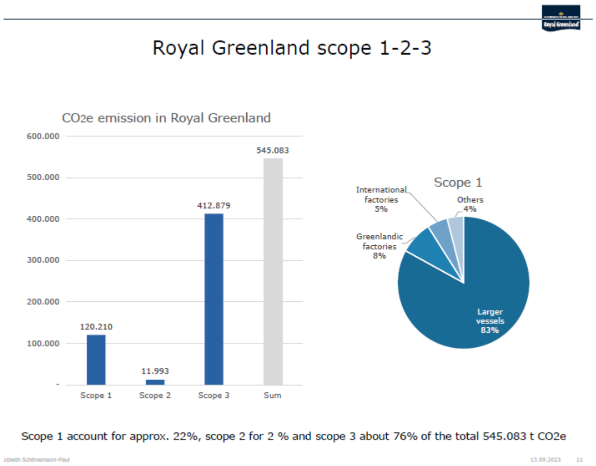

14 LIFE BELOW WATER
Sustainable fishing
Sustainable raw materials
Our fisheries must be managed in accordance with the scientific advice.
We buy fish and shellfish according to equivalent principles and contribute to building up knowledge of sustainable fisheries
Initiatives
Maintain the current certificates
Certification of new fisheries e.g. Newfoundland lobster and in Greenland working through partnership Sustainable Fisheries Greenland to improve management
Certification of a larger proportion of purchased raw materials and finished products for sale than in 2022 (63%)
Fisheries development – new species
We must make better use of marine resources, so that we as a company can develop food products for an ever-increasing global population
Initiatives
Development of new fisheries, primarily in the coastal fishing area e.g. sea urchin, sea cucumber and whelk
Cultivation of seaweed

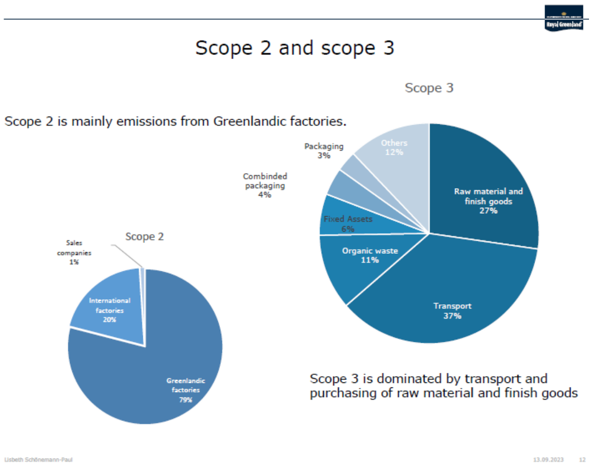

Certified fisheries
Development of certified fisheries
% certified fisheries
year
Global Gap aquaculture salmon
Cod, haddock and saith in Barents sea
Prawns in West Greenland
Capelin
FIP snow crab
Greenland halibut, off shore, Westgreenland
FIP lobster
Lumpfish, Westgreenland
FIP Greenland halibut inshore Westgreenland
30 40 46 61 63 65 66 67 70 70 73 76
2013 2014 2015 2016 2017 2018 2019 2020 2022 2023 2024 2025 2026 2027 2028 2029 2030

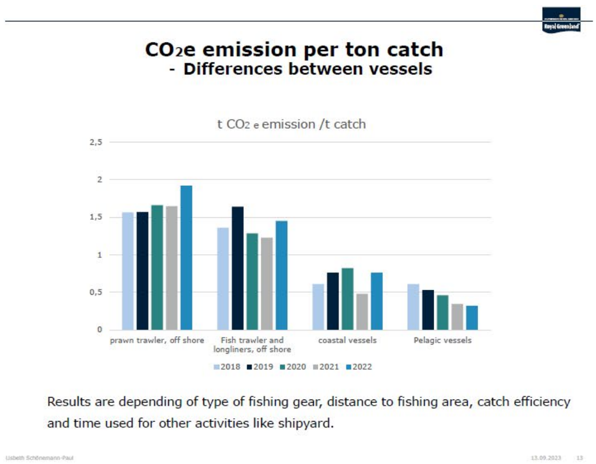

Visuel climate change
Rock slides made tsunami in fjord in Uummanna
Prawns are moving north


12 RESPONSIBLE CONSUMPTION
Responsible footprint
Five sub areas
• Energy consumption
• CO2e emission
• Maximum utilisation of resources
• Cardboard, paper and plastic
• Water consumption
We will minimise our environmental footprint through responsible consumption and circular handling of non-renewable resources
We will maximise the degree of utilisation by creating new food products from the fish and shellfish that we produce.
Initiatives (extracts)
• Determine action plans to reduce energy consumption at factories and facilities
• Engage in a partnership for a model to calculate the carbon footprint for seafood-based product chains
• Development of production methods for maximum utilisation of resources
• Substitution of laminates with mono-materials
• Production of fresh water from seawater approved for food production at certain locations


Definition of scope 1-2-3
GREENHOUSE GAS PROTOCOL
SCOPE 1
SCOPE 2
SCOPE 3
SCOPE 3
UPSTREAM ACTIVITIES
REPORTING COMPANY
DOWNSTREAM ACTIVITIES


Royal Greenland scope 1-2-3
CO2e emission in Royal Greenland
600.000
500.000
400.000
300.000
200.000
100.000
120.210
11.993
412.879
545.083
Scope 1
Scope 2
Scope 3
Sum
Scope 1
International factories 5%
Others 4%
Greenlandic factories 8%
Larger vessels 83%
Scope 1 account for approx. 22%, scope 2 for 2 % and scope 3 about 76% of the total 545.083 t CO2e


Scope 2 and scope 3
Scope 2 is mainly emissions from Greenlandic factories.
Scope 2
Sales companies 1%
International factories 20%
Greenlandic factories 79%
Scope 3
Packaging 3%
Others 12%
Combinded packaging 4%
Fixed Assets 6%
Organic waste 11%
Raw material and finish goods 27%
Transport 37%
Scope 3 is dominated by transport and purchasing of raw material and finish goods


CO2e emission per ton catch
- Differences between vessels
t CO2 e emission /t catch
2,5
2
1,5
1
0,5
0
prawn trawler, off shore
Fish trawler and longliners, off shore
coastal vessels
Pelagic vessels
2018 2019 2020 2021 2022
Results are depending of type of fishing gear, distance to fishing area, catch efficiency and time used for other activities like shipyard.


New trawlers
M/tr Sisimiut, halibut/cod/meal and oil 2019
M/tr Avataq, prawn/halibut 2020
M/tr Nataarnaq, prawn 2021
M/tr Tuugalik, fish 2022

Fossil fuel and environmental impact

Royal Greenland use Marine Gas oil

Low in sulpher content, < 1%
=> risk of acidification is reduced

Low in risk of black particles to the surroundings

BUT

The same CO_2e emission as other types of fuel!

Lisbeth Schönemann-Paul 13.09.2023 15

How to reduce the CO2e emission?

Development is necessary

Reduce fuel ->
Efficiency in transport and fishery

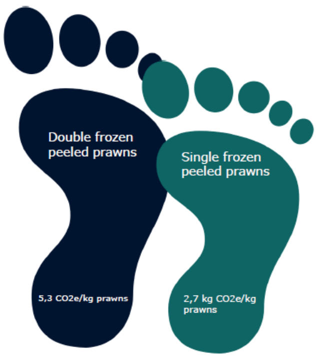
Development in fishing gears

Development in new energy systems usable for vessels

Lisbeth Schönemann-Paul 13.09.2023 16

CO_2e emission per kg finish goods

- From fishery in Greenland to gate in Germany



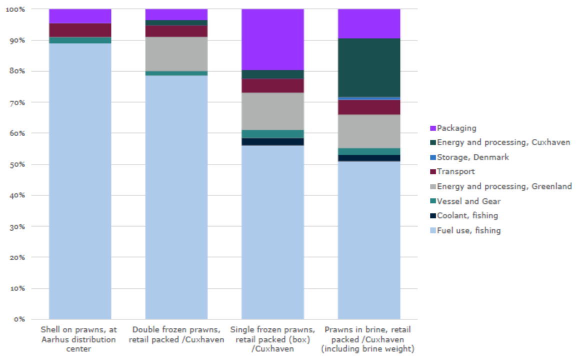
Attributional LCA based on utilisation of the goods

Ref. RISE Sweden

Lisbeth Schönemann-Paul 13.09.2023 17

Distribution of CO2e emission

- Depending of the processing



Lisbeth Schönemann-Paul 13.09.2023 18

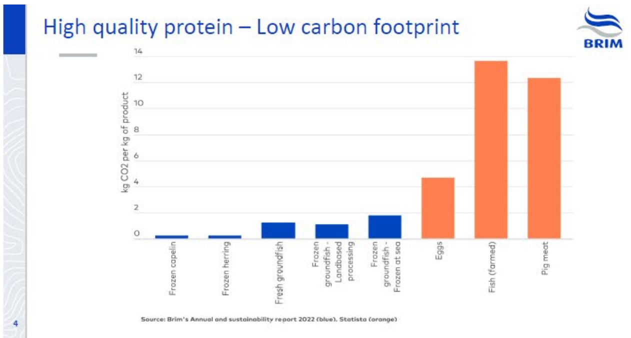
Lisbeth Schönemann-Paul 13.09.2023 19

12 Initiatives to reduce environmental impact: Sveinn Margeirsson (Brim)

Dr. Sveinn Margeirsson is the Chief Innovation Officer at Brim hf, which is among the largest seafood company in Iceland. Brim is a vertically integrated company operating six demersal trawlers, one long liner and three pelagic vessels, high tech processing, marketing and sales. The company is looking closely at its environmental footprint, focusing on a wholistic approach taking the entire value chain into consideration. Sveinn criticised in his presentation the prioritisation of energy companies, which are selling electricity to "dirty companies" while cutting off electricity to fishmeal factories at critical time of year. He also criticised the electricity companies for selling green certificates to "dirty industry" abroad instead of selling certified green energy to its customers in Iceland, thereby undermining the ongoing work in the companies to replace fissile fuels. Brim's policy is to achieve carbon neutrality and support social development and innovation while doing it, and have put forward ambitious plans for doing so.

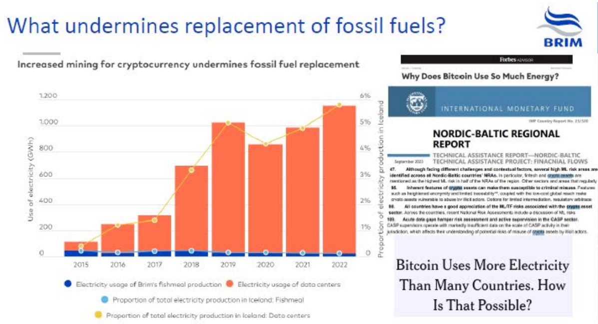
Figure 11: Dr. Sveinn Margeirsson, the Chief Innovation Officer at Brim hf

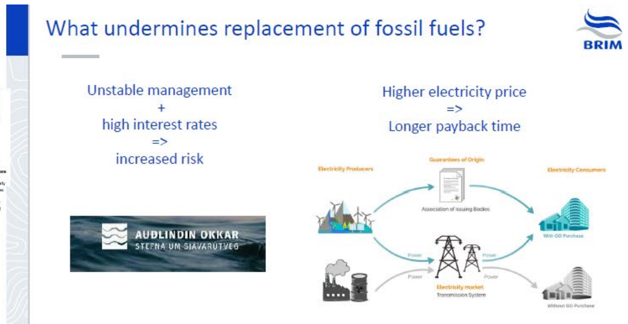

Brim: Important drivers for climate action
BRIM
CSRD
SFDR
SUSTAINABLE FINANCE DISCLOSURE REGULATION
ECONOMY
SOCIETY
ENVIRONMENT
Environment and climate policy
• Resource utilization
• Long term investments
• Unbroken value chain
• Resilient society
• Data-driven decisions
• Responsible ocean utilization
• Minimizing emissions
• Carbon neutrality
4

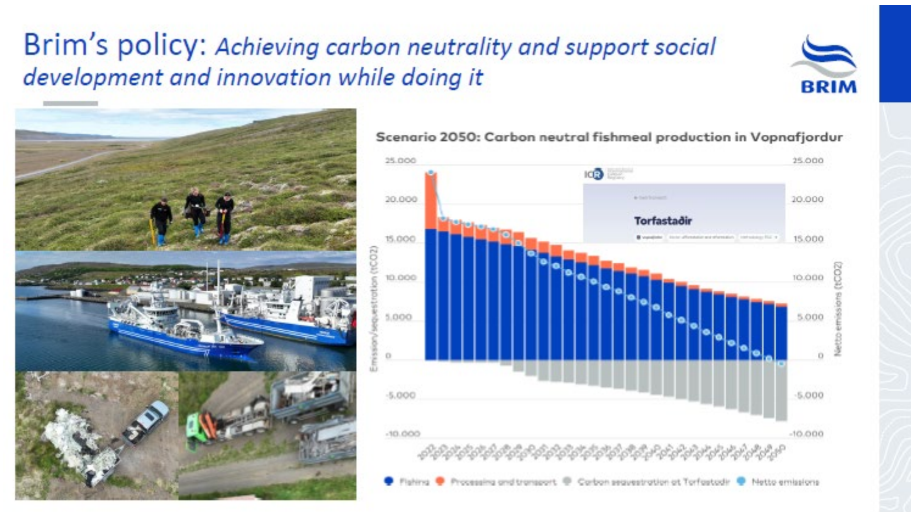

High quality protein – Low carbon footprint
BRIM
kg CO2 per kg of product
Frozen capelin
Frozen herring
Fresh groundfish
Frozen groundfish - Landbased processing
Frozen groundfish - Frozen at sea
Eggs
Fish (farmed)
Pig meat
Source: Brim's Annual and sustainability report 2022 (blue), Statista (orange)


Steering towards the future
BRIM
• Minimizing emissions
• Scope 1&2 emissions on land (processing plants, vehicles, docked vessels etc)
• Circularity – Resource utilization
• Greenhouse gas emissions originating from waste
• Long term investments
• Emissions intensity on vessels (tCo2eq/mEUR)
• Resource utilization
• Long term investments
• Unbroken value chain
• Resilient society
• Data-driven decisions
• Responsible ocean utilization
• Minimizing emissions
• Carbon neutrality


Does Iceland's policy support replacement of fossil fuels?
BRIM
Case study: Brim's pelagic plant in Vopnafjörður
• Today the capacity of the freezing plant is 350-400 metric tons per day
• Our vessels can bring 2.000 tons of cooled catch to the plant, which takes 4-5 days to process. To sustain the quality of production, the vessels have a lower limit on maximum catch; thus using more fuel
• Production of fishmeal ensures 100% utilisation of catch and was electrified in 2010 (no oil used for fishmeal production in 2011 – 4 million litres in 2022)
• Investment in a new factory will bring CO2 emissions down, increase the proportion of raw materials taken to human consumption (increase food security) and increase value creation (lower CO2/€)
• Is electricity towards utilization of Icelandic resources prioritised?
• Do "Guarantees of origin" support replacement of fossil fuels?
• Is the fisheries management system stable enough for a long-term approach?


What undermines replacement of fossil fuels?
BRIM
Increased mining for cryptocurrency undermines fossil fuel replacement
Use of electricity (GWh)
Proportion of electricity production in Iceland
Electricity usage of Brim's fishmeal production
Electricity usage of data centers
Proportion of total electricity production in Iceland: Fishmeal
Proportion of total electricity production in Iceland: Data centers
Why Does Bitcoin Use So Much Energy?
INTERNATIONAL MONETARY FUND
NORDIC-BALTIC REGIONAL REPORT
Bitcoin Uses More Electricity Than Many Countries. How Is That Possible?


What undermines replacement of fossil fuels?
BRIM
Unstable management
+
high interest rates
=>
increased risk
AUÐLINDIN OKKAR
STEFNA UM SJÁVARÚTVEG
Higher electricity price
=>
Longer payback time
Electricity Producers
Guarantees of Origin
Electricity Consumers
Association of Issuing Bodies
Electricity market
Transmission System


Brim's policy: Achieving carbon neutrality and support social development and innovation while doing it
BRIM
Scenario 2050: Carbon neutral fishmeal production in Vopnafjordur
Emission/sequestration (tCO2)
Netto emissions (tCO2)
Torfastaðir
Fishing
Processing and transport
Carbon sequestration at Torfastaðir
Netto emissions

13 The Nordic Marine Think Tank: Carl-Christian MR Schmidt (NMTT)

Carl-Christian Schmidt is the vice-chair of the Nordic Marine Think Tank (MNTT), which is a network of Nordic experts in marine and fisheries issues and international cooperation. The NMTT focuses on stewardship of healthy oceans and ecosystems, sustainable exploitation of marine living resources, better public decision-making, better use of Nordic skills and solutions in marine environment, and management issues. As part of its initiatives, the NMTT facilitated a Nordic Climate Change Forum for Fisheries & Aquaculture in 2021, and is planning another one in November 2023.

Figure 12: Carl-Christian Schmidt, the vice-chair of the Nordic Marine Think Tank

Nordic Climate Change Forum for Fisheries and Aquaculture

- Launched in 2021
- Purpose is to have a Nordic platform for the discussion and exchange of ideas of how to « understand » climate change in the fisheries and aquaculture sectors. Understanding climate change effects on the two sectors and explore ways of reducing the sector's climate change impacts
- Joint NMTT-ICES Launch meeting December 2021 with a broad explorative agenda, taking a value chain approach

Key messages

- Key drivers: severity of storms and waves, sea temperature changes, rainfall, sea level rise and ocean acidification
- Aquaculture vs. Capture fisheries
- Continue conversation among stakeholders across the value chain to build up a knowledge system
- Ensure that fisheries and aquaculture policy frameworks incorporate climate change considerations
- Review governance structures to ensure that decisions etc. take climate change considerations into account

Key messages

- Reduce food waste and fossil fuel use throughout the value chain – from fishing to table
- Gear and vessel innovations to reduce CO_2 emissions
- Common Protocol and standards needed for measuring CO_2
- More research needed, including in economics to better understand trade-offs in climate change decisions
- Competition for use of ocean space

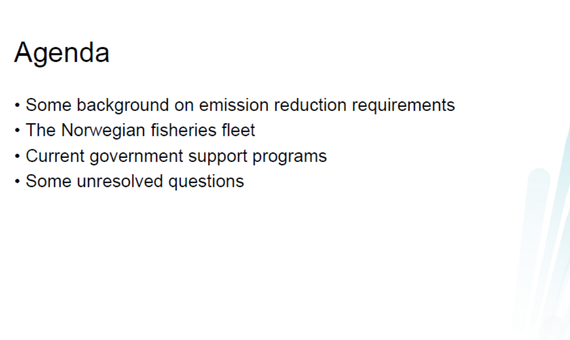
What next: Climate Change Forum II

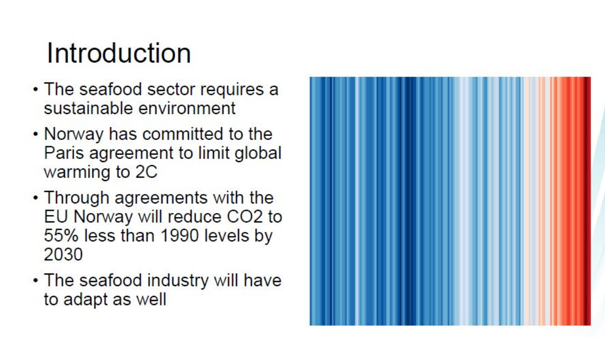
- Where: Vestlandshuset, Bergen, 22 November 2023
- What: Focus on competing uses of ocean space (fisheries, aquaculture, windmill parks etc.)
- Why: Increasingly, ocean space is taken over by green energy producers i.e., wind and waves, creating conflictual situations with other ocean user groups

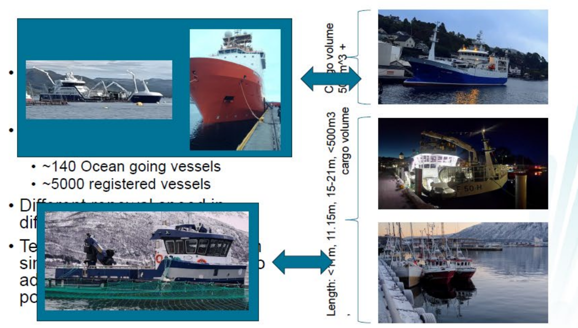
14 Policy and incentives for change: Karl Gunnar Aarsæther (UiT)

Karl Gunnar Aarsæther is an associate professor at the University of Tromsø (UiT) - The Arctic University of Norway. He has a vast experience in researching sustainability of fisheries and energy transition in the seafood industry. Karl Gunnar gave in his presentation an overview of how energy transition initiatives have been going in the Norwegian fishing fleet and the challenges faced. He informed about investment support programmes and incentives provided by the government, giving examples of how policy can have positive and negative incentives for energy transition.

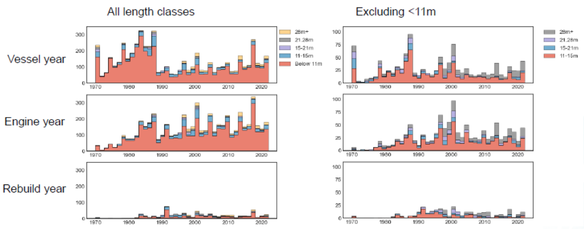
Figure 13: Karl Gunnar Aarsæther, an associate professor at the University of Tromsø (UiT)



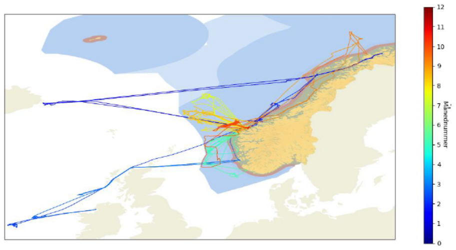




Fisheries fleet



Fisheries fleet



Investment support programs

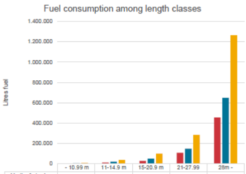

21m gillnet vessel with 270kWH battery capacity. 2X 850 KW generators and 2X 325KW electric propulsion

- CO2 reimbursement program
  - Redistributing reimbursements to more energy efficient vessels
- «Enova» government agency
  - «Electrification of Sea Transport»
    - For elimination of 10 000L fuel
    - 30% - 50% of additional costs
  - «Batteries in Vessels»
    - Direct support for battery propulsion
    - 30% - 50% of additional costs
    - Discontinued, supported approximately 10 Offshore, 240 aquaculture and 40 fisheries vessels
- (NOX fund)

Investment support programs

Investment support programs

Fuel consumption among length classes



	- 10.99 m	11-14.9 m	15-20.9 m	21-27.99	28m -
Medianforbruk	2.957	11.259	28.683	108.489	453.997
Snittforbruk	4.519	20.081	50.256	147.184	647.949
Signifikant forbruk	9.269	37.318	100.816	282.853	1.263.703

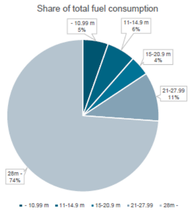
Medianforbruk Snittforbruk Signifikant forbruk

Source Adapted from [2] - SINTEF (2020)

- How much fuel can smaller vessel save?
- Support program is not designed for the smaller coastal fleet
- "Battery in vessels" was, but is discontinued as the technology was beginning to enter use in the coastal fleet

Investment support programs

- Batteries for "easy" electrification will result in 10%-15% reduction in CO2
- Not every vessel in the coastal fleet can be supported by batteries alone
- A solution for the ocean-going vessels is needed
  - Alternative fuels
  - Alternative power systems



Source Adapted from [2] - SINTEF (2020)

Alternative fuels

- LNG powered vessels proven through the NOX fund
- Ammonia, methanol and hydrogen are possible future fuels
- Less energy dense
  - More space requirement
  - New handling procedures
  - How does this
- Exchange/retrofit of existing ICE
  - Reuse existing vessel design
- Fuel cells produce electricity
  - Requires electric power distribution on vessels
- Reduced energy density should influence vessel design

Infrastructure

- Infrastructure for diesel is established, and "easy"
- How will energy be delivered and stored for zero/low-emission technology
- Electric power
  - Peak demand can power be delivered?
  - Who will own charging infrastructure?
- How will alternative fuels be distributed
  - Will it demand more services and infrastructure from the ports?
  - Will safety requirements and handling procedures put pressure on scarce areas in the port
- Will this change the movement of vessels and catches?

Summary

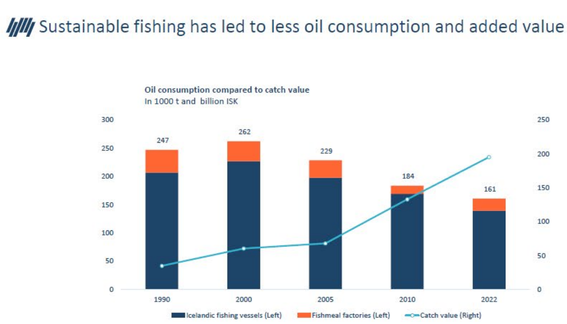
- There is a need to cut emissions also in the fisheries fleet
- There are technologies available that are successful in other ocean industries
- Support programs must be adapted to the industry
- There are new technologies possible alternative fuels that can impact the structure of the fisheries fleet

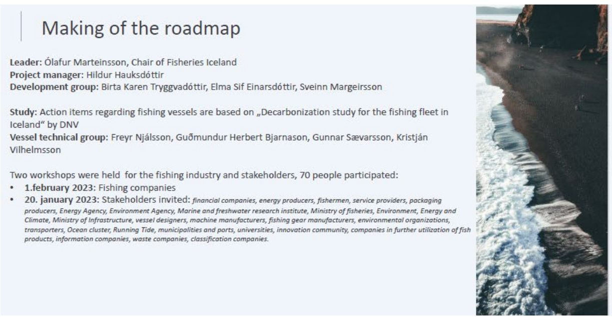
Thank you for your attention

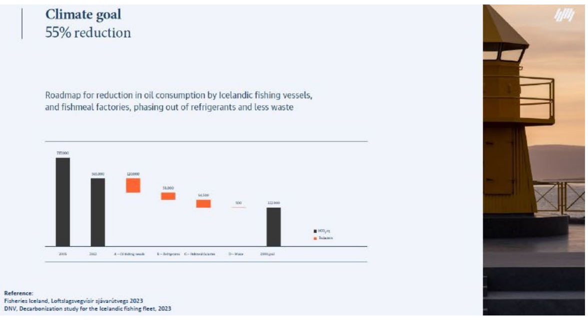
15 Policy and challenges for implementation: Hildur Hauksdóttir (SFS)

Hildur Hauksdóttir is the sustainability officer at Fisheries Iceland, which is a federation of fishing vessel owners, producers' organisations, and other companies within the value chains of fisheries and aquaculture. Its objective is to safeguard the interests of companies in the fisheries and aquaculture sectors. Hildur showed how the Icelandic seafood industry has been reducing oil consumption in the last decades and affirmed that the industry is working towards the climate goal of 55% national reduction in emission of GHG by 2030, compared to emissions in 1990. Hildur showed that there has been accelerated renewal of fishing vessels in recent years that are more energy efficient, and the SGS has provided a roadmap/action proposal for how to proceed. What she also emphasized is that the government needs to provide sufficient financial incentives for energy transition projects in the fishing industry.

Figure 14: Hildur Hauksdóttir, the sustainability officer at Fisheries Iceland (SFS







Action proposals for fishing vessels

A.1. Accelerate renewal of fishing fleet

A.2. Energy efficiency

- A.2.1. Operational measures
- A.2.2. Technical measures.
- A.2.3. Regulations and marine reasearch

A.3. Drop in fuel

A.4. Energy transition

A.1. Accelerate renewal of fishing fleet

All vessels that have reached 30 years in 2030, with focus on improved energy efficiency

Assuming the typical lifetime of ships are around 30 years, 28 ships may be due for renewal by the end of 2030. These include 11 fresh fish trawlers, 4 freezer trawlers, 6 longliners, 1 pelagic vessel and 6 smaller trawlers.

A 20% energy saving is expected when an old ship is replaced with a new one due to the choice of engine and propulsion equipment, energy management, hull shape, etc. Potentially, the benefits may be greater as the impact of replacing two smaller vessels with one larger, more efficient vessel is not taken into account.

Estimated reduction until 2030: 25.000 tCO2eq (5,5% from 2022)
Estimated cost of investment: Increased cost of renewal due to the best technology when it comes to energy efficiency is estimated 160mEUR, savings estimated 6mEUR.
Responsibility for the implementation: Fisheries with older vessels in their fleet

Improvements:
1. *Financial incentives for accelerating renewal*

Responsibility for improvements: Icelandic government

Reference: DNV, Decarbonization study for the Icelandic fishing fleet

A.2 Energy efficiency
3 proposals

A.2.1. Operational measures
Optimizing the operation of ships with respect to energy efficiency

A.2.2. Technical measures
Investments in energy efficiency through technical measures and port connections

A.2.3. regulations and sustainability
Marine reasearch and fisheries management

A.2.1. Energy efficiency - Operational measures

Measures in the operation of ships that have not reached their end of life in 2030

Operational measures may require adopting new methods and changed behavior to further minimize energy consumption.

Operational measures may require digital technology, while most actions are related to the operation of the ship such as reducing sailing speed and more frequent cleaning of the ship's hull and propeller. Estimations show that there are still opportunities for better energy efficiency related to changes in ship operation and increased management of oil consumption.

Estimated reduction until 2030: 13.000 tCO2eq
Estimated yearly operational cost of fleet: 40 million ISK in cost, yearly fuel savings estimated 500 million ISK

Improvements:
1. *Improvements relate to the operation of the ship, where changes in its management could be considered to further minimize energy use*
2. *Optimizing fishing activities and composition of catches to minimize time spent on the voyage. There are some restrictions on the system and collective agreements (see A.2.3).*
3. *Increased disclosure and increased restraint due to oil consumption*

Responsibility of improvements: Fisheries

Reference: DNV, Decarbonization study for the Icelandic fishing fleet

A.2.2. Energy efficiency – Technical measures

The technical measures are described in the DNV report. The measures differ by the type of vessel. Examples of actions from the DNV report: *Fleet management equipment, Battery hybridization, Shore power, Engine performance testing, Trawl doors, Fishing sensors, Trawl optimization, Engine performance testing and tuning, Energy efficient lighting system.*

Shore power: To ensure that the energy needs of large trawlers in ports can be met by 2023, infrastructure and energy supplies need to be secured. Land-based electricity has been available in Iceland for the past 50 years without major modernization or expansion.

Estimated reduction until 2030: 36.000 tCO2eq (thereof 12.000 tCO2eq due to shore power)
Estimated investment cost of fleet : 115 mEUR for technical measures, taken into account oil savings. Excluding cost of infrastructure in ports.
Responsibility for the implementation: Fisheries

Improvements:
1. *Analyze where infrastructure is lacking in ports*
2. *Secure funding for shore connections*
3. *Ensure sufficient energy in ports at a competitive price*
4. *Investment support for technical measures*

Reference: DNV, Decarbonization study for the Icelandic fishing fleet

Responsibility of improvements: Government, energy companies, ports and municipalities

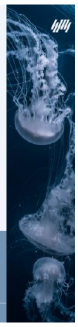
A.2.3. Energy efficiency – Regulations and sustainability

Recently there has been a repeated decline in the monitoring of fish stocks, which result in increased uncertainty. There is an opportunity to increase the knowledge on the state of fish stocks, which may lead to less energy required for fishing and in navigating between fishing areas.

Greater optimization can also be achieved by increasing flexibility in fisheries management.

Improvements:
1. *Ensure sufficient funding for marine research to carry out intensive monitoring of main fishing stocks*
2. *Increased fishing flexibility*

Responsibility of improvements: Government, Marine research institute



A.3. Drop in fuel

Using the drop in fuel for existing engines is technically possible and it results in low investment costs.

A prerequisite for the use of drop-in fuel is that the energy meets the standards of the engine manufacturers and that the supply of such energy is guaranteed.

Estimated reduction until 2030: 46.000 tCO2eq
Estimated yearly additional operational cost of fleet: 12 m EUR additional fuel cost per year

Improvements:
1. *Ensure a sufficient supply of non-emission drop in fuel, meeting engine manufacturer standards and European standards by 2030*
2. *Ensure competetive price of drop in fuel*

Responsibility of improvements: Government

Reference: DNV, Decarbonization study for the Icelandic fishing fleet

A.4. Energy transition

No significant reduction in emissions is expected for the year 2030.

All options for energy transition for fishing vessels today involve uncertainties in terms of technology, safety, availability, infrastructure and the cost of ships, machinery and energy.

Cooperation between the fishing industry and the government is essential in this matter.

Improvements:
1. *Financial incentives for energy transition projects in the fishing industry*

Responsibility of improvements: Government

Action proposals for fishing vessels

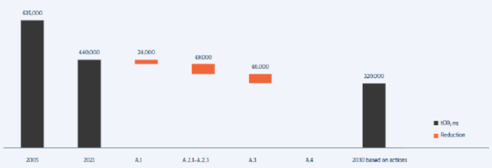
A.1. Accelerate renewal of fishing fleet

A.2. Energy efficiency

- A.2.1. Operational measures
- A.2.2. Technical measures.
- A.2.3. Regulations and marine reasearch

A.3. Drop in fuel

A.4. Energy transition



16 Panel discussions

Some of the presenters took part in panel discussions at the end of the programme. The panellists were Kaj Portin, Karl Gunnar Aarsæther, Sveinn Margeirsson, Kim Nørby Christensen and Friederike Ziegler. There were lively discussions in the panel and attending guests in the audience took part with questions and comments.

Figure 15: Panellists sharing their views and answering questions from the audience

17 Closing of the conference: Benedikt Arnason (Permanent Secretary at the Icelandic Ministry of Food, Fisheries & Agriculture)

Benedikt Arnarson, the Permanent Secretary at the Icelandic Ministry of Food, Fisheries & Agriculture, closed the conference by thanking the presenters and attendees for a very good conference. He stated that the conference had proved once again the value of Nordic cooperation and showed that the Nordic countries are among the most innovative and competitive countries in the world. The conference has showed that the Nordic countries are leaders in sustainable development and energy transition. We have come far but we still have long way to go. Fisheries are still a major contributor to GHG emissions in the Nordic countries, but we are striving to be the best. The government of Iceland has been taking steps in facilitating energy transition to reach the goal of 55% reduction in emissions by 2030. A measurable goal is also that the government is aiming for that at least 10% of new small vessels will be partially or entirely powered by electricity by 2026. The targets are ambitious, and we are working against the clock, but the challenge demands major actions.

The conference has as well demonstrated how valuable it is for us to have a Nordic Working Group for fisheries AG-fisk, under the auspices of the Nordic council, to instigate discussions and cooperation when it comes to complex issues in the seafood industries.

Figure 16: Benedikt Arnarson, the Permanent Secretary at the Icelandic Ministry of Food, Fisheries & Agriculture

18 Acknowledgements

The organising committee for the conference would like to thank The Working Group for Fisheries and Aquaculture (AG-Fisk) within the Nordic council for initiating and funding the event. The committee would also like to thank all of the presenters for their valuable input.

Figure 17: The conference was attended by about 150 persons in total, and many more have watched the recordings on the project webpage.