Integrated Arctic Observation System

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Deliverable 6.10

Report on ecosystem management for managers

Ecological model results from the Barents Sea and Disko Bay are presented and discussed with fisheries and environmental managers at workshops respectively in Norway and on Greenland based on data emanating from the full spectrum of monitoring approaches.

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EXECUTIVE SUMMARY

This report summarizes the discussions during two virtual meetings with different stakeholders with interest in the Barents Sea and off-Greenland ecosystems, respectively. The meetings were based on the work from Task 6.8 "Demonstrations for fisheries and environmental management agencies" and Task 6.2. "Improved ecosystem understanding and management". Stakeholders represented a broad specter of marine- and maritime-related authorities in Norway, Greenland and Denmark, the fishing industry, The Conservation of Arctic Flora and Fauna (CAFF) working group of the Arctic Council, Greenland Institute of Natural Resources, INTAROS partners and participants from other EU projects. The presentations of the monitoring and model results were refined and angled to be of relevance and use for the participating stakeholders. The stakeholders were in general interested in the approach, results, and conclusions. The discussion made it clear that as users in charge of sectorial human activity management, they valued scientific testing and suggestions for improving ecosystem understanding. They recommended that the next step could be to look at not only national data set indicators, but also relate those to an Arctic international setting. The Norwegian Environmental Agency suggested that a climate approach would be useful also for the Barents Sea. Likewise, the more complex food web indicators presented for the Barents Sea could be useful to apply to the Greenland coastal system. Stakeholders from both geographic areas emphasized that data from long-term monitoring of key variables is important for their work and that models can be useful as supporting information on indicators and future scenarios if the model uncertainty is assessed and explained.

These seminars highlight the importance of inviting stakeholders responsible for all sectors of marine-related human activities to dialogues on research and monitoring of the climate, natural resources and ecosystems. In a fast-changing scientific world, with an increasing amount of knowledge, it is important to make available, timely and in the right format, the best possible information.

TABLE OF CONTENTS

1. Introduction

The objective of this study is to provide a scientific basis for better-informed decisions and better-documented processes for managers and policy-makers on local, regional and pan-arctic scales. This report presents ecological and food web model results from the Barents Sea and the Disko Bay (Figure 1) were presented and discussed with fisheries and environmental managers at workshops respectively in Norway and on Greenland based, as a part of the deliverances from tasks 6.2 and 6.8.

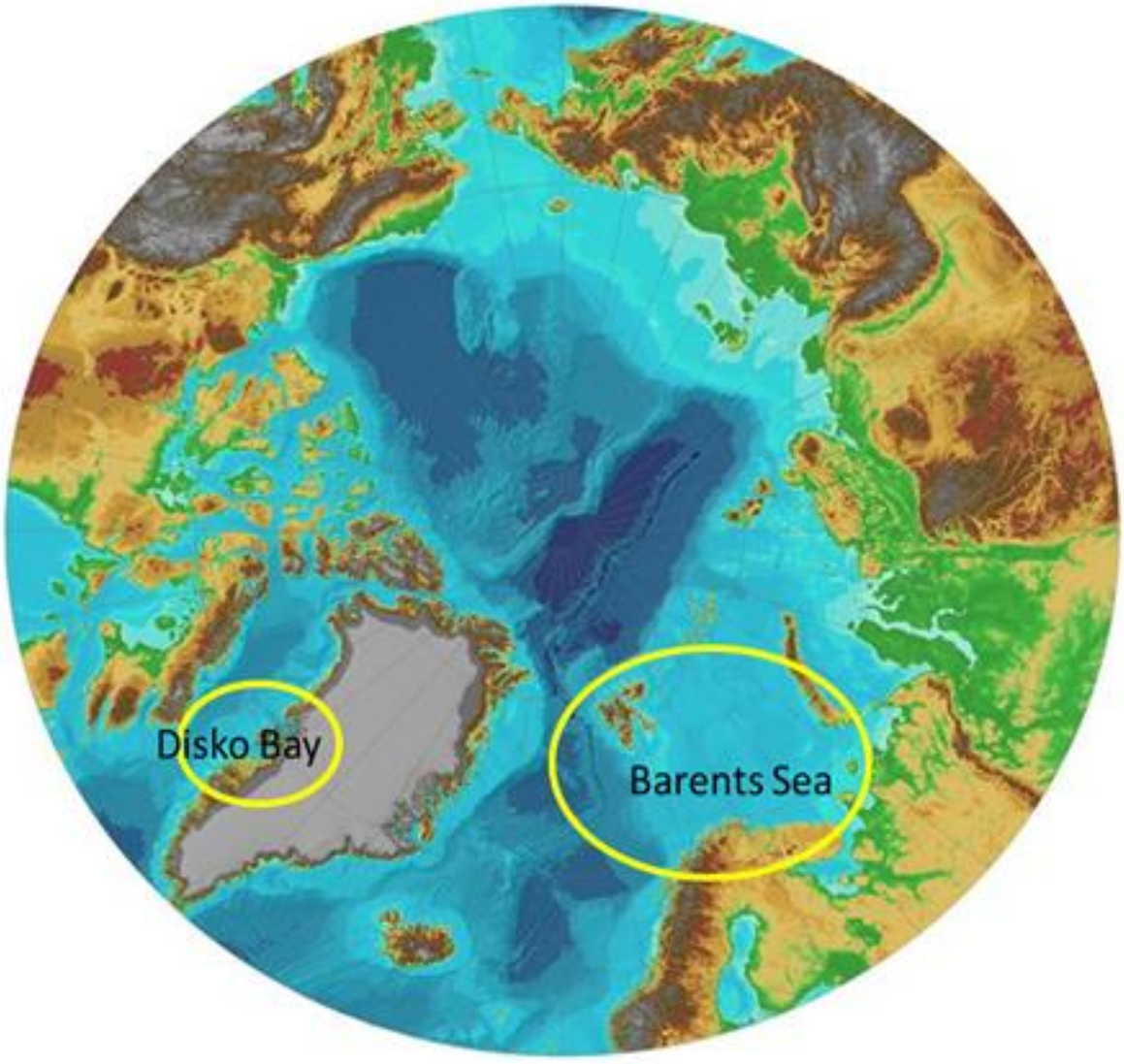

Figure 1. Overview over the two study case areas; the Barents Sea and Disko Bay, Greenland

2. Barents Sea stakeholder workshop

2.1. Workshop content

Institute of Marine Research (IMR) invited Norwegian marine and maritime-related authorities and directorates for a stakeholder seminar, presenting the outcome of Task 6.2 and inviting for comments, requests and an open discussion on the results from Task 6.2 and the work in Task 6.8 can be refined and angled to be of relevance and use for these stakeholders. The digitally arranged seminar had 34 participants from seven national authorities and three scientific institutions. The good participation and fruitful outcome from the workshop is partly due to existing long-term relations between scientists and stakeholders already being established through collaboration on holistic environmental management plans for the seas around Norway. INTAROS also contributed to and benefitted from earlier workshops with the same people run by the Research Council of Norway funded project BarentsRISK.

Key notes from presentations:

- **Marie Maar, AU, The Greenland case**: The newly developed FlexSem-ERGOM model was applied to Disko Bay, W Greenland, in high spatial resolution for the years 2004 to 2018. The model was used to estimate the relative importance of sea ice cover and freshwater discharge to the primary productivity. Disko Bay is one of the most important areas for biodiversity and fisheries around Greenland. Glacier runoff had a strong local effect near the glacier, but when considering the primary productivity at bay scale, sea ice cover was the most important factor. The importance of obtaining detailed forcing data and biological information for best possible description of environmental and ecological processes and changes was highlighted in the discussion.

- **Morten Skogen/Cecilie Hansen, IMR, the Barents Sea case:** The established ecosystem models NORWECOM.E2E (NORWegian ECOlogical Model; a coupled 3 dimensional physical, chemical, biological model system for studying of primary production and dispersion of particles) and The Nordic and Barents Seas Atlantis model (NoBa; both end-to-end ecosystem models) were employed to integrate data from the Barents Sea, and partly the Norwegian Sea, originating from a range of in-situ and remote sensing platforms and geographically different locations. In general, models could provide more knowledge and more knowledge should reduce the risk for cross-sectorial conflicts and unresolved questions. Use of thresholds for setting and assessing indicator values was found of limited value for users in several of the selected indicators. Environmental data and primary production/biomass are very sensitive to time and place, as well as highly fluctuating between years and seasons, making threshold setting difficult and inaccurate. Time trends are found more robust and easier to interpret for separate and congregated indicators over time.

2.2. Stakeholder comments, requests, and evaluation of model products

Norwegian Environment Agency (NEA)

Requests:
NEA wanted to know how the results from INTAROS can be accessible for to be included in the future merging of established, planned and developing indicators. They emphasized the need to find ways to build on the INTAROS deliverables and outcome, also after the termination of the projects. The Norwegian management plan scientific and advisory committees would like to reap benefits from the project achievements in the future. The Deliverable D6.3 models and conclusion are focused on climate and fisheries impact. NEA asked for further model analyses to include indicators that may be guidelines also other human impacts. They asked for modelling, incorporating several human impacts simultaneously, to look at common impacts of more than one activity at the time.

A comparison of this work to the sections integrated in INTAROS and the Arctic Council committee *Conservation of Arctic Flora and Fauna* (*CAFF*) would be useful to look for synergy and shared information. That would be of value in further analyzes on climate change and impact over time. NEA and others have requested ecosystem modelling for a long time. In INTAROS only the IPCC RCP 4.5 "intermediate" scenario is used. NEA would like to see results also under the "very stringent" RCP2.6 scenario, to better understand the expected gains from strong mitigation as compared to milder actions.

Directorate of Fisheries

Requests:
More insights in collaboration between sectors are missing and would be useful. Also, more work by modelers to show what kind of combined data to add to the single stock data, would be usefulness for manager and therefore welcome. INTAROS Task 6.8 should look not only at national management tools and but also include international indicators, used by international organization. The scientific monitoring and management set up to meet the need from a range of international and national agencies and tractates, to monitor ecosystem changes. It would be inefficient and costly if Norway should report by different sets of ecosystem indicators, with overlapping intensions.

The Norwegian Coastal Administration and Maritime Authority

Requests:
How to connect this fisheries-based analyses to other human activities? It is and will be a growing conflict of area use conflicts between sectors, also including shipping. Connecting fisheries-based data to other human activity data series will be useful and needed in the future. With increased shipping, it will be an increase in pollution risks and actual pollution. Pollution issues would be considered for future model analyzes. Norwegian Maritime Authority offer to

share information about shipping traffic and registered environmental impact factors for further models and analyses, including shipping activity.

Norwegian Radiation and Nuclear Safety Authority

Request:
Environmental polluting components should be considered for inclusion in the ecosystem models. There are 40 different components listed as pollution indicators in the marine management plan. INTAROS look at littering and social activities for monitoring this. AT IMR, several projects, published, running and planned, study pollution impacts. This is an important field.

2.3. Plenary discussions

Three topics turned out to be of special interest for the participants.

Access to and use of data

The INTAROS data catalogue provides information about many data providers and allows users to find out who would be the best source and contact person to turn to directly.

Of particular interest for Norwegian and Danish users, Norway and Denmark will continue the collaboration also after INTAROS has ended, with continuous use of updated data sets. Request from the Norwegian Areal Tool programme. Any data on time and space should be made convertible to the Norwegian Areal Tool programme (The Norwegian Mapping Authorities) and included for this mapping service, which is made for and in increasingly degree being used by the managers for considering, preparing and put out regulations and jurisdictions for marine areal and resource exploitation.

The wish for including social economic indicators for analyzing impact and consequences of state and trends in the marine ecosystems were mentioned but was by the member of this seminar found to be better suited for followed up on outside Tasks 6.2 and 6.8. This reflects the Norwegian management models, with common management plans for the open sea, but with no jurisdiction to steer the directorates and sector authorities. Each one has the unique rights to make and sustain regulations and laws made within the leading ministry and authority for their sector activity, as well as the social economic statistics and analyzes.

Choices of indicator types and sets

Before the final set of recommendations and advices will be given by INTAROS, a wider set of indicators should be looked at and preferably analyzed in similar analyzes as the Norwegian indicators already published in deliverable D 6.3, including a wider set of indicators internationally, look for what each method presents as missing or weak information. This could include also data on other human impacts, climate and littering.

Keep in close dialogue with the Norwegian Surveillance Group, as well as keeping track of international indicator development and the project developing the Science Panel Method for

Ecosystem State Assessments, to be included in the Norwegian management plans when made operational. The classification of indicators based on reference base lines should be further investigated in relationship to both causes and consequences. This is a difficult topic but very important line of progress to improve on the reliability of such indicators. Develop the model runs for time series to capture more than the limited number of indicators and variables used so far.

Make sure to put the INTAROS indicator tests and analyses in a wider context, relating the final conclusions and advices to present indicator systems and keep in mind the user request to make sure INTAROS adds to and seek to improve on the use of indicators and will not suggest new and even more complicated indicator systems.

Data sufficiency and uncertainty within available data material

In a previous report from task 6.2 (D.6.3) it was shown that data selected for certain area or seasons may deliver general information for a wider space and time, but this may not be the case for all kind of data. It will be important to carefully test and evaluate each indicator and data set before deciding to eventually limit the time and coverage of monitoring. Another precaution for limiting the monitoring to restricted times and areas is the possibility that that would limit the possibility to observe trends in drifts and distribution ranges.

The example of modeling mackerel stock and distribution was used to show how still limitation are present to provide a reliable explanation and scenarios, because of the need for even better understanding and knowledge of ecology, physiology, life history traits and environmental impacts. Testing models to historic data and trends will continue for a long time still, for verification of the reliability of the model outcomes. They are to be used as tools, but in many cases the ecosystem models are useful as scenario builders, but not as sole input to management regulations.

In data that show large variation in time and space, a limited area and time for observation data should be avoided if the data needed by the managers are better met with more and widespread data to be sure they cover the actual information needed by the user.

New monitoring attempts should lead to economic and scientific improvements. One strength with models is the abilities to add to observations to fill in gaps in time and space. When put together with observation data, models will provide better holistic information and knowledge.

It is important to keep critical view to the model parameters and results, to avoid being led in to a model bubble out of relevance for the actual ecosystem. Well used and considered models will be valuable for making good decision for sustainable management.

2.4. Further work based on ideas for Tasks 6.8, coming out of the seminar

Ecosystem modeling:

- Running comparative tests, by analyzing among others, Joint Norwegian/Russian Environmental Commission, OSPAR, Arctic Council indicators alongside with Norwegian-developed indicators.
- Running scenarios for different range of warming scenarios
- Consider more parameters, other human impacts and see how social indicators could be included in the models. This is of general interest outside the Norwegian EEZ and could be useful when considering the final, common advice to be given by INTAROS (to be decided)

3. Greenland stakeholder workshop

3.1. Workshop content

Aarhus University (AU) and Greenland Institute for Natural Resources (GINR) invited stakeholders to a workshop on Western Greenland ecosystem patterns and drivers. Further, an example from the Barents Sea (IMR) showed how advanced food-web models can provide complex ecosystem indicators for use in management. The stakeholders were invited to give comments, requests, and open discussions on the outcome of INTAROS Task 6.2 and how the work in Task 6.8 can be refined and angled to be of relevance and use for these stakeholders. The digitally arranged seminar took place 1. June 2021, with 35 participants from four ministries (Greenland and Denmark), CAFF, Sustainable Fishery Greenland, the Greenland Ecosystem Monitoring (GEM) program, two EU projects (ECOTIP and FACEIT) and including INTAROS partners from IMR, DTU, DMI and EUROGOOS.

Key notes from presentations:

- **Mikael K. Sejr, AU:** Impact of climate change on Greenland fish distributions. Based on 24-years of fish surveys by GINR on the West Greenland Shelf, the aim of this study was to characterized biological change and to assess potential drivers of change. The data set is one of the most comprehensive biological time series from Greenland, and included after some data where discarded based on quality issues, the 34 most abundant species found in summer bottom trawls at depths from 0-600 m between 59 and 73N. We found a substantial increase in biomass throughout the region. The average size and the average trophic level also increased. Most species showed a general range expansion, but a general northern displacement was not observed. We presented spatio-temporal trends is several potential drivers; sea ice cover, run-off from the Greenland Ice sheet and shrimp trawling effort. Finally, we analyzed decadal changes in ocean temperature. Although all of the drivers showed significant changes, it was also clear that they all displaced clear gradients in their impact in the region. Based on the

preliminary analysis it was clear that the included drivers are important but vary significantly in space and time resulting in a mosaic type pattern. However, an important point is that the development of all drivers appears to exert a positive effect on the fish community, hence the apparent recovery is partly facilitated by the climate change driven melt of the sea ice and Greenland ice sheet, which have contributed to increasing the productivity of the coastal ocean off SW Greenland.

- **Eva F. Møller, AU**: Relative importance of freshwater discharge and sea ice for primary productivity in Disko Bay. During the last 50 years, the Disko Bay in western Greenland, has experienced both a large decrease in sea ice cover and an increase in freshwater from the Greenland ice sheet, e.g. the large marine terminating glacier Jakobshavn isbræ. In this study, we evaluated the relative importance of these processes for primary productivity in Disko Bay by means a coupled hydrodynamic-biogeochemical model. The model is forced by meltwater run-off from the Programme for Monitoring the Greenland Ice Sheet (PROMICE), and a sea-ice model (CICE). During 2004 -2018, the primary production varied between 100-150 gC/m/year and it correlated to both sea ice cover and freshwater discharge, although at different scales. Glacier runoff had a strong local effect near the glacier, but when considering the primary productivity at bay scale, sea ice cover was the most important factor. Considering the seasonal impact, variations in the sea ice cover had the strongest impact on spring production, whereas the changes in freshwater discharge had the largest effect on the later summer production.

- **Cecilie Hansen, IMR:** Complex ecosystem indicators for the Barents Sea. Complex ecosystem indicators for the Barents Sea: In the Barents Sea management plans, there are >70 indicators, both simple and complex. We have used two end-to-end ecosystem models to evaluate how they respond to changes in climate and fisheries management, NORWECOM.E2E and NoBa Atlantis. The complex indicators include biomass and trophic level for three different functional groups (pelagic, bentho-pelagic and benthic), and the functional relationship between these three groups (benthic biomass compared to pelagic and bentho-pelagic). We found that both the area where the indicators are being sampled, and the timing of the observations was important for their performance. The indicators give a good overview of the Barents Sea ecosystem, but the management plans lack socio-economic indicators, which prevents a holistic view of the system. For further reading, please see our paper, Assessing the state of the Barents Sea using indicators: how, when and where? https://doi.org/10.1093/icesjms/fsab053.

- **Mie Winding, GINR:** GIOS – Greenland Integrated Observing System. GIOS is a new, comprehensive, and coordinated, joint effort from the Danish realm, to provide new knowledge about the climate change in the Arctic environment, how quickly the changes occur and how they can affect the rest of the globe. GIOS boosts collaboration between all Arctic research environments within the Danish realm to ensure it maintain a leading role in Greenland environmental research and a well-informed Arctic voice in

the international debate. GIOS develop sustainable research infrastructure in and around Greenland. Where possible, GIOS stations will be supplied with green energy and will continuously monitor condition of the air, ice, sea and land. GIOS covers the entire climate gradient in the Arctic and ensures an easy, open and fast access to measured data for everyone worldwide.

3.2. Stakeholder comments, requests, and evaluation of model products

This section is written up more or less as a direct transcription of the verbal comments from the different participants, not in scientific jargon.

Aarhus University, Department of Bioscience

Several presentations (Mikael Sejr, Eva F. Møller) highlighted the importance and benefit of long time series for analyzing and understanding long-term ecosystem trends and changes. Existing marine monitoring collects data of key parameters (T, S, sea ice cover, pH, nutrients, biodiversity) in selected, but dynamical parameters (currents, tides) are currently not considered. The discussion addressed two important issues:

(1) The currently poor spatial coverage of key environmental data in Greenland waters and

(2) The requirement of additional measurements including tides and ocean currents to be included in ongoing monitoring efforts (GIOS, see Mie Winding's presentation).

Mikael Sejr pointed out that spatially gridded data would be of large value for the scientific community. This would require integrating and re-gridding all relevant data from different sources and periods into a single data service. It was commented that this was a very good point and it wassuggested to get in contact with a data service provider like CMEMS (with experience in gridded data products) for advice and inspiration. AMAP would also be competent partners.

Ministry of Environment, DK

Comments by the representative from the Ministry: "I think the most interesting thing is to share knowledge i.e. data, and especially continue to support long term monitoring such as your project, GIOS and GEM, AMAP, CAFF etc. under the environmental support and climate schemes and which research grants rarely support. The whole connection to actors, in addition to the knowledge base, must be handled very carefully, as there are different interests that we heard about today, for example, fishing and it becomes very easy politically. Greenland wants knowledge to be shared with everyone, but it must then take place on a different level. Norway is far acquainted with management plans for regions other than the Barents Sea. There will probably have to be more data before Greenland can take it on board, but this has been worked on for many years. So, my wish is that you give a presentation at the Greenland Science Week and I get the opportunity to participate physically or virtually and that you are happy to invite to more workshops".

Sustainable Fisheries Greenland (SFG)

Comments by the representative from the SFG: "When you disseminate research at a high level to stakeholders in Greenland, there is enormous potential to get the attention, as nature / climate / fauna etc. is very high on the agenda and in the general consciousness. But you must make sure that you get a starting point that people can understand. E.g. pull out some concrete examples; what will happen to the shrimp stock? Can one expect coastal fishing for halibut to be affected by increased melting? Of course, with all the uncertainty that comes with models, and especially models that are projected in a climate perspective. Here I think Cecilie had an incredibly exciting point in simulating different fishing scenarios in a model, and then come up with suggestions on what it would have of effect. It is something you can relate to.

In general, it was exciting to look at the Norwegian example. They are wildly far on the data side, and can simulate anything, but it seemed (to the extent we had time to talk about it) that there is a lack of input the other way, from the political / manager side. If no objectives or the like have been set, it is difficult to use the model's options. If it is not concrete, it can easily be marked by knowledge for the sake of knowledge, and then I think you easily lose people. An example yesterday was the copepods. They have become smaller, but is anything going well? In Greenland, another relevant example could be: why has the cod not returned despite good conditions (cf. Mikaels Sejr's presentation), when it has happened in Iceland and Norway, where there have also been favorable conditions in the last few decades. It would make Mikael's communication much stronger than just general considerations. But it might be an obvious thing for a shorter meeting with stakeholders in connection. If the cod returned as it was in the 1960s and 1970s, it would provide an income the size of the block grant (or something like that).

I think an incredibly good way to ensure a good interaction between stakeholders (in my case the fishing industry) and the researchers is a common will to involve each other. It can be through thesis / PhD students. Here, projects can be put together for the benefit of all, the profession can see a purpose in the concrete research, and it can also be a good financial angle. Another way is to involve stakeholders in e.g. steering groups, so you get stakeholder interest".

Conservation of Arctic Flora and Fauna (CAFF), working of group under the Arctic Council

The presentations were highly relevant to CAFF and AMAP work on biodiversity and drivers (with climate change as the major driver) effect on the Arctic ecosystems. Several of the talks presented data and analysis that would contribute to the ongoing work in CAFF's *Cirkumpolar Biodiversity Monitoring Programme* (CBMP). AMAP as well as CAFF/ CBMP under Arctic council are planning assessments or follow up on assessments (such as the State of The Arctic Biodiversity Report follow up and an upcoming joined AMAP/ CAFF assessment). It could be relevant to have these collaborations taken up as well.

Danish Technical University, National Institute of Aquatic Resources

A question was raised on how information from this (and similar projects) should flow to stakeholders. The main (real) objective for most such projects are to create new science and to publish this, even though the formal objective most often is to provide applied science for stakeholder use. This puts most projects in a dilemma on how to communicate their results in an understandable and usable way to stakeholders. ICES serve national clients that has requested recurrent advice on various issues within the marine environment, hereunder ecosystem overview advice. The basis for the annual ecosystem overviews are ICES Integrated Ecosystem Assessment Working Groups (IEAWG). These WGs are entirely dependent on inflow from scientists and projects that perform scientific work on ecosystems. Members of INTAROS and other projects are therefore encouraged to either participate or ensure that their results flow to these ICES IEAWGs since the ICES condensation of information for an ecoregion is a well-established and routinely advice flow to stakeholders (and the scientific community). The West Greenland area is not part of the ICES area but are within the Northwest Atlantic Fishery Organization (NAFO) convention area. Communication between ICES and NAFO is ongoing in order to establish an IEAWG for the Canadian-West Greenland ecoregion.

Greenland Institute for Natural Resources, Department of Fish and Shellfish

Comments: “GINR already has a good collaboration with the industry. Agree with SFG that the message shall be relatively simple and not too abstract, but also emphasis that it should not be too simplistic. It is important to keep the critical view on the model results and to explain model uncertainties to stakeholders. GINR has experience with a previous model study of shrimp, in which the industry showed great interest and commitment, but where the results of the model never became a reality. From GINR, we have to explain this from time to time. We therefore prefer that studies on the important commercial species should be carefully considered. In this case, researchers from outside Greenland should consider contacting GINR for a review of the presented material.”

3.3. Further work based on ideas for Tasks 6.8, coming out of the seminar

- To have a special session on the Greenland Science week, which was cancelled due to COVID-19, and thereby have a more personal and active interaction with stakeholders
- To arrange or join smaller stakeholder meetings with a more targeted focus or question, e.g. on a particular species, impacts of climate change, model uncertainty, etc.
- To continue the long-term data series and include more variables to inform management and research activities
- To continue to develop more complex models like for the Barents Sea to inform managers on foodweb interactions and potential future changes in stocks, productivity, etc.
- To collaborate more with existing working groups (ICES, CAFF) and establish new NAFO/ICES working group on the west Greenland-Canadian system.

4. Community based monitoring and citizen science

Community based monitoringcan contribute very important information about the marine and coastal ecosystems. In INTAROS, two activities were supported, one in Norway and one in Greenland.

- The IMR-portal 'Dugnad for Havet' ('Marine Citizen Science') was launched in 2020 and is gaining traction now. Here people can report their observations of marine life and see what other people have found in the sea. They can learn about new species and how the ocean is changing. The project aims to make this platform so popular that it will gradually give us a better insight into and understanding of our coastal areas. Everything is designed to work smoothly with a mobile phone, so people won't have any problems when out and about. Taxonomists check the reports coming in and confident observations will be recorded in a single database, which will in turn be linked to the Norwegian Biodiversity Information Centre. Check out the webpage: https://dugnadforhavet.no/ in Norwegian or in English.

- To obtain a better understanding of the different ways environmental observations can be obtained by citizens and used for decision-making, the INTAROS project piloted three people-based observing programs in Greenland with different levels of involvement of community members and scientists: citizen seismology with geophones, expedition cruise operator-based observing, and systematic focus group discussions with fishermen and hunters. The findings are presented in Deliverable 4.3. The focus group discussions were part of the CBM programme PISUNA (*Piniakkanik Sumiiffinni Nalunaarsuineq*). A total of 30 fishers and hunters summarized observations from 4,287 field trips, of 33 attributes including sea-ice and climate/weather, plus 10 fish, 11 mammal and 10 bird taxa, over four years. The community members used the observations as a basis for submitting 197 management proposals to the local and central authorities. The observations by the fishers and hunters are available in Greenlandic and Danish at www.pisuna.org and in English in the web-based, searchable database of local observations PISUNA-net (https://eloka-arctic.org/pisuna-net). The findings suggest that focus group discussions with resource users are useful: (1) where community members depend on living resources for their livelihood, and (2) where government policies are supportive of collaborative resource management. To achieve their full potential, focus group discussions require government staff time and funds to be prioritized for facilitating the fishers' and hunters' observing and for making decisions and taking action on the basis of the management proposals.

5. Conclusions and perspectives

The seminars provided the INTAROS team both a positive inspiration, support for the approach taken in Task 6.2 and ideas for Task 6.8 as well as provide valuable material to deliverable D.6.10. The inputs will also be kept and with the messages from the stakeholders in mind, new compilations for new model products will be run and the outcomes will be the basis for recommendations for use of indicators in arctic regions, based on iAOS data and local information (D 6.13). The Barents Sea is a relatively data-rich area with well-developed complex ecosystem and foodweb models that are ready to support management. However, the implementation and feed-back from management is still missing for this area. The Greenland coastal ecosystem is a relatively data-poor area, but here the GIOS program has started up to support, link and extent the exiting monitoring programs. Modelling of the Greenland coastal ecosystems is still at its infancy mainly aimed for research, but already shows good results on primary productivity patterns. However, more work is needed to include more components of the foodweb before model results can support specific management actions. Stakeholders from both areas emphasized that long-term monitoring data of key variables is important for their work and that models can be useful with supporting information on indicators and future scenarios if the model uncertainty is assessed and explained.

These seminars highlighted the importance to invite stakeholders responsible for all sectors of marine-related human activities to dialogues with research and monitoring of the climate, natural resources and ecosystems. In a fast-changing scientific world, with new knowledge, increasing amount of data and research, it will be important to be informed and up front to recognize and deliver the best possible information to allow for long-term sustainable use of marine resources.

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