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Title: Integrated Ecosystem Assessments in Norway: Comparison over three different ecosystems

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Summary
As is becoming the norm in marine management, the Norwegian government has a requirement that the marine ecosystems around the Norwegian coast be monitored and assessed. Norway was perhaps slower than some countries to push for the integrated ecosystem assessments (IEA) and integrated ecosystem management IEM), because the current single and multispecies assessment and management is perceived to have worked well for the major stocks. Thus IEA (and IEM) are seen as desirable additions to existing successful management rather than as potential solutions to major problems. Norwegian IEMs are therefore not legally binding, but exist for counseling and advice purposes. Yet, the IEM for the Barents Sea, approved in 2005-2006, was one of the first IEMs in Europe and by 2013 all open seas within the Norwegian EEZ had dedicated IEMs. This presentation highlights the need for IEA and IEM to be tailored to the specifics of each ecosystem and management regime, rather than trying to following a "one size fits all" approach.

Norway has exclusive economic zones covering almost 2m km² of the three seas adjoining Norway: the Barents Sea, the Norwegian Sea, and the North Sea. With a population of 5m people, this large area of productive seas has led to fisheries being both economically and politically important in Norway over a long period. The sagas document an export fishery at least 1000 years ago, and fishing remains an important source of food, revenue and employment in Norway. For the Norwegian regions of these waters there are common national political drivers and Norwegian national management plans. However none of these seas are exclusively Norwegian. The Barents Sea is shared with Russia, Norwegian waters comprise only a minority of the North Sea, and the Norwegian Sea extends into international waters. Each of these Seas differs in ecology, human influence, data availability and political structure. As a consequence the IEAs for each region will be different, despite the common Norwegian legal framework for all of these regions. The Institute of Marine Research monitors and provides science based management advice for these areas. Each sea has an ICES working group of integrated ecosystem assessment (WGIBAR, WGINOR and WGINOSE), involving international collaboration. While WGINOSE (North Sea) has existed for many years, WGINOR (Norwegian Sea) started in 2013 and WGIBAR (Barents Sea) started in 2014, and are thus "in the making". Within the Norwegian context the funding for each project is rather small. The focus is therefore on synthesizing existing knowledge and identifying priorities for future investigation, rather than conducting major new research.

The Barents Sea

The Barents Sea is a high latitude ecosystem, with large biomasses of a few dominant species. Fisheries are, for the most part, targeted single species fisheries. In addition there are harvests of marine mammals. The sea is extensively studied through cooperation between Norway and Russia. In general Norwegian-Russian research and management collaboration has been close and effective for many years in the Barents Sea, even during the cold war, giving a relatively coherent coverage of the ecosystem. For the past decade, and since the establishment of the IEM in 2006, a joint Ecosystem Survey has been conducted annually in later summer/early autumn. This survey covers almost all of the Barents Sea, and aims to sample from plankton and benthos through fish to mammals and sea birds, as well as collecting abiotic data. There are a number of additional surveys, and studies of the

Barents Sea cod stock are some of the earliest fisheries studies in the world, and there is therefore a long time series of data, in addition to extensive current data collection. Human impacts other than fisheries have been rather minor. There is a low population density along the Norwegian and Russian coast forming the southern boundary of the sea, and elsewhere only minor settlements on the arctic islands. Thus shipping is so far the main human activity in the region other than fishing. Lately, the oil and gas industry has started to search for and develop gas and oil production in smaller parts of the Barents Sea, without any known impacts on the ecosystem. On the other hand, as an ice-influenced arctic ecosystem sitting at the northern extreme of the gulf stream, the Barents Sea is susceptible to changes in climate, with clear evidence that species distribution is already changing. The Barents Sea has an excellent data series for forming the basis of an ecosystem assessment. One could say that in many ways the Barents Sea has had an ecosystem assessment for a number of years, and the challenge here is to find ways of integrating this that fit with management schemes in the two countries.

The North Sea

The North Sea also has a long history of detailed studies giving a large amount of information on the state of the ecosystem. However the large number of countries bordering the North Sea has led to this being perhaps rather more fragmented than in the Barents Sea. As a result of the long history of multiple nations fishing in the North Sea there is a much more complex pattern of fishing fleets than in the Barents Sea. The diversity of species with significant biomasses is also higher than in the Barents Sea, and the region is characterized by extensive mixed fisheries. The diversity of countries, combined with Norway's minority share of the sea, also means that any assessment must be less tailored to the Norwegian management scheme than in other seas discussed here. As a sea bounded by several densely populated coastlines, other human impacts are also much more important than in the other two seas. In addition, the North Sea is at the northern extreme for some stocks and the southern extreme for others, meaning that changing climate can be expected to change both the species distribution and the mix of species present. Here again the main task is to integrate the existing data into a coherent whole, but this is complicated by the more diverse nature of the data, food web, fisheries, other human impacts, particularly oil and gas and shipping, and the political structure.

The Norwegian Sea

Finally, the Norwegian Sea presents very different challenges. The fisheries and the food web are assumed to be relatively simple, especially compared to the North Sea. Human influences, outside climate related effects, are largely confined to the coast. However the region has significantly less data available than the other regions discussed. Much of the biomass is in migratory pelagic stocks, where collecting data presents a greater challenge than in the continental shelf seas in the other regions. Major stocks, (mackerel, herring and blue whiting), are wide ranging and variable, and many of the top predators (e.g. minke whales) are also migratory spending only part of their time in the region. The Norwegian Sea is for a large part also a very deep sea, with very little knowledge the widely distributed meso-pleagic stocks below the photic zone and the bottom dwelling societies in deep waters. Human harvesting of the ecosystem runs from plankton (with a small but expanding Calanus fishery) through to marine mammals (minke whales). In this region the challenge is to integrate the available knowledge, but also to highlight the priorities for further research and data collection.

Conclusion

In some respects the three IEA groups have similar aims and challenges in each area, with an overall goal of combining the extensive existing monitoring and assessment activities into a more coherent whole. As such this can be seen as being at the more pragmatic end of the spectrum of possible IEAs. At the same time there are important differences between the cases, including differences in ecology, target species, fisheries structure, anthropogenic drivers, scientific knowledge, data availability, and political considerations. This highlights the need for IEAs to be tailored to the specifics of each ecosystem and management regime, rather than trying to following a "one size fits all" approach.