ICES WGINOR REPORT 2013

SCICOM STEERING GROUP ON REGIONAL SEA PROGRAMMES

ICES CM 2013/SSGRSP:07

REF. SSGRSP

Interim Report of the Working Group on Integrated Ecosystem Assessments for the Norwegian Sea (WGINOR)

19–23 August 2013

Bergen, Norway

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2013. Interim Report of the Working Group on Integrated Ecosystem Assessments for the Norwegian Sea (WGINOR), 19–23 August 2013, Bergen, Norway. ICES CM 2013/SSGRSP:07. 94 pp. https://doi.org/10.17895/ices.pub.5720

Contents

Executive summary

The first meeting of Working Group on Integrated Ecosystem Assessments for the Norwegian Sea (WGINOR) was held in Bergen, Norway, 19–23 August and was chaired by Geir Huse (Norway) and Guðmundur J. Óskarsson (Iceland). The total number of participants was 21, representing Norway (16), Iceland (2) and the Faroese (3, all part-time). The objectives of the meeting was to form a group and to start to work on developing an approach to integrated assessment for the Norwegian Sea based on reviewing the work of other groups and literature studies. Before the meeting a list of terms of references (a-f) had been made, which was worked on during the meeting and addressed in this report. Presentations were made on data availability and present status of the different ecosystem components in the Norwegian Sea, i.e. climate and hydrography, plankton, fish, marine mammals and seabirds. A preliminary status of the ecosystem was established based on the available information.

Preliminary analyses of time-series of the different ecosystem components revealed both previously known and novel findings. The most relevant findings are summarized here. Multivariate analyses to link different components for facilitating integrated assessment were not done at the meeting, but will be performed in the coming years. The temperature of the Norwegian Sea is presently slightly above the normal and has had a downward trend in recent years after a peak in 2007. Analyses of data for the last 30 years, show that ocean acidification is an ongoing process in the Norwegian Sea, with pH having decreased between 0.07 and 0.1 units in parts of the area in this period. The biomass of mesozooplankton had a downward trend during 2003–2009, and has shown a slight increase in the last years. The reduction in zooplankton has been coupled to an increase in predation from planktivorous fish which took place during the same period. The absolute level of biomass of planktivorous fish is rather uncertain given the uncertain level of the mackerel stock. But it is clear that the mackerel stock and blue whiting stocks are increasing while the herring is decreasing. The length-at-age of herring has been decreasing since the 1980s, but in the two recent years it has increased. A similar shift was seen in blue whiting, which shifted to an increase in length-at-age in 2008 when the stock biomass reached a very low level. For mackerel on the other hand there has been a decreasing trend in length-at-age since 2007. Previous research has shown that the length-at-age is density dependent, but for herring and blue whiting also dependent on interspecific competition. Around fivefold increase in beaked redfish biomass in Norwegian Sea has taken place in the last 20 years. The breeding populations of blacked-legged kittiwake, Atlantic puffin and common guillemot in seabird colonies along the Norwegian coast has declined since the monitoring started in 1980. The causes are not fully understood, and possible causes are reduced availability of juvenile herring since 2004 and increased disturbance and predation pressure from increase in white-tailed eagle abundance. Regarding the status of marine mammals, the abundance of hooded seals in the Greenland Sea area, which feed to some extent in the Norwegian Sea, has been at a low level following a major decline until 1980s. Similarly, abundance of large baleen whales has not recovered to the pre-commercial whaling period, even if recent surveys suggest some changes in either abundance or distribution.

Further work will be undertaken during the next two years on developing the methodological approach for IA and to perform an integrated assessment for the Norwegian Sea. Included in this will be updated estimates for trophic flows in the system compared to a major synthesis on trophic relations published in 2004.

1 Administrative details

Working Group name
Working group on integrated assessment of the Norwegian Sea

Year of Appointment
2012

Reporting year within current cycle (1, 2 or 3)
1

Chairs
Guðmundur Óskarsson, Iceland
Geir Huse, Norway

Meeting venue
Bergen, Norway

Meeting dates
19–23 August 2013

2 Summary of work plan

Year 1	Focus will be on forming the group and start to work on developing an approach to integrated assessment for the Norwegian Sea based on reviewing the work of other groups and literature studies. Further work will be undertaken to perfom an integrated assessment for the Norwegian Sea and to perform simulations based on the current status of the ecosystem. Work on absolute estimates for the key ecosystem components will be develop based on tagging data and catch based summer surveys. Prepare intial draft of the Ecosystem Overview for the Norwegian Sea.
Year 2	The integrated approach will be developed further and the integrated assessment will be updated. Aleternative multispecies advice will be developed for the Norwegian Spring spawning herring, mackerel and blue whiting based on the multispecies model and presented in report. Work on absolute estimates for the key ecosystem components will be continued. Initiation of work on developing sampling requirements.
Year 3	The integrated assessment will be updated with the available information and along with updated simulations. Work on absolute estimates for the key ecosystem components and sampling requirements will be reported.

3 Opening of the meeting and adoption of the agenda

The meeting started with a welcome by Geir Huse who gave a presentation of background on integrated assessments in general and its present and future role in ICES as described in the draft ICES science plan (2014–2018). At the end there was a brief presentation of the ToRs and the approach for each of them. The rest of day one was focussed on presentations.

Hein Rune Skjoldal gave a thorough introduction to the Norwegian Sea ecosystem where he presented the key physical and biological features of the ecosystem. The system is a deep water ocean basin and very different from continental shelf areas such as the North Sea and the Barents Sea. The Norwegian Sea is dominated by Atlantic and coastal water masses in the eastern parts and Artic water masses to the west and north.

Jens Christian Holst gave a presentation of the state of the Norwegian Sea from his perspective of a need for a multispecies management for the area. He presented data to indicate that the structure of the ecosystem is unbalanced with too much planktivorous fish excreting a too strong feeding pressure on the zooplankton. This supposedly also impacts on other ecosystem components such as seabirds which have declined in recent years in the coastal populations bordering the Norwegian Sea.

Gro van der Meeren gave a presentation of the Norwegian management plan for the Norwegian Sea, which was finalised in 2010. The plan is methodologically similar to the plan for the Barents Sea and is cross sectoral and covers all major ecosystem components. The ecosystem is assessed based on indicators. The indicators are updated annually and the plan is revised every fifth year, and for the first time next year.

Morten Skogen presented the NORWECOM biophysical model, which is under development towards an end to end model for the Norwegian Sea ecosystem, covering all major ecosystem components. Model validation of the phytoplankton and *Calanus finmarchicus* component shows that model is able to capture the seasonal pattern well. Results from new multiyear simulations are now being analysed. The model presently includes the physics and covers all the trophic levels up to fish. In the next two years the model will be operational and used to test harvest strategies and their effects on the fish stocks and the other ecosystem components.

K. Utne presented the ENAC multispecies model for the pelagic complex. The model is constructed to perform management strategy evaluation (MSE) for the three stocks in the pelagic complex. The model takes into account interactions between the stocks through feeding competition and possible intraguild predation by mackerel on blue whiting and herring larvae. The latter mechanism is presently being addressed through stomachs sampled this spring. Some preliminary simulations indicate that multispecies harvest control rules taking into account the total biomass of the stocks can increase long term yield from the ecosystem, but more simulations are needed to investigate the robustness of the result and the magnitude of increase in catches and its dependence on different model assumptions. The presentations were followed by a general discussion of the presentations and the state of the ecosystem.

Tuesday morning started with a presentation by Leif Nøttestad who gave a preliminary report from the summer ecosystem survey in the Norwegian Sea, followed by a presentation by Aril Slotte on a new approach to tagging of mackerel using Radio-frequency identification (RFID) tags based. These tags are screened automatically at factories which allows a very efficient process. At the moment screening equipment is installed only on Norwegian factories, but it will be expanded next year to Icelandic, Faroese and EU factories with the aim of screening about half the catch in a few years. This method is very promising for improving abundance estimation of the mackerel stock and is described further below under ToR d.

Then presentations were given on the data availability, state and trends of the different ecosystem components:

- Climate & hydrography – Ø. Skagseth

- Plankton – E. Bagøien, H. Petursdottir
- Fish – G. Oskarsson, J.A. Jacobsen, Å. Høines, E.K. Stenevik
- Marine mammals – A. K. Frie
- Seabirds – L. Nøttestad
- Pressures on the Norwegian Sea ecosystem – G.v.d. Meeren

This is summed up under ToR b below. The rest of the meeting was carried out through working in groups and with daily plenary meetings. The meeting ended Friday at 14h.

4 Terms of reference a)–f)

ToR	Description
a	Develop an operational approach to integrated assessment of the Norwegian Sea
b	Perform up to date integrated assessment for the Norwegian Sea ecosystem
c	Utilize multispecies and ecosystem models to investigate effects of single and multispecies harvest control rules on fishing yield and ecosystem state for the purpose of developing ecosystem based advice
d	Develop absolute abundance estimates of zooplankton and pelagic fish
e	Develop sampling requirements for integrated assessment of the Norwegian Sea
f	Consider the WKECOVER report and draft sections 1, 2 and 3 of an initial Ecosystem Overview for the Norwegian Sea

A more detailed description of the ToRs is as follows:

Term of Reference a)

There are a range of different approaches to performing integrated ecosystem assessments. We will develop an approach for the WGINOR that is based on the state of the art. This will be done with input from the other regaional seas and based on the developments at WKBEMIA in November 2012.

Term of Reference b)

There have been international fish-plankton centred surveys in the Norwegian Sea in May and since the mid-1990s. In the most recent years these surveys have transitioned into ecosystem surveys that caputure most of the key components of the ecosystem. These data sets are a firm foundation for undertaking integrated assessment of ecosystem status in the Norwegaian Sea which is yet to be done. A fairly recent book on the Norwegian Sea ecosystem is a good starting point for the assessment.

Term of Reference c)

At present a multispecies fisheries model and an end to end ecosystem model are being set up for the Norwegian Sea. These models are ideal for investigating the effects of existing single species and alternative multispecies harvest control rules on the ecosystem structure and functioning. Although there is some petroleum exploration in the outskirts of the Norwegian Sea, fishing by far represents the most important antropognic impact on this ecosystem. The model analyses will be an integrated part of the assessment.

Term of Reference d)

In traditional single stock assessment it is not required to have an absolute abundance estimate,. However, when addressing multispecies interactions and carrying capacities of different trophic levels in ecosystems it becomes important to establish absolute abundance levels for the different components in order to quantify the combined effect of consumption and flows between the different trophic levels. WGINOR will therefore put an effort on providing estimates for absolute abundace of the key components in the Norwegian Sea ecosystem. This work will be based on tagging data and catch based summer surveys.

Term of Reference e)

The survey and sampling strategy should be closely related to the integrated assessment. ToR e will be deveted to developing an overview of sampling requirements for integrated ecosystem assessment. This list will be developed in dialogue with WGIPS and the final spesification will be reported to this group which has competance on survey sampling strategy.

Term of Refrence f)

The ecosystem overview is required by ACOM to help provide ecosystem input to the assessment working groups, it will also be used to head up the advice.

Sections 1, 2 and 3 of the WKECOVER overview template relate to:

1. the description of the management area (mostly a map and very little text, we create the map in the ICES secretariat)
2. the key main drivers that impact advice in the ecosystem
3. the activities and pressures in the region.

5 Progress on ToRs a)-f)

5.1 Progress report on ToR a)

In relation to tor a on development of an operational approach to integrated assessment of the Norwegian Sea the group had some discussion of which approaches to choose for doing the integrated assessment of the Norwegian Sea. The different approaches in the other ICES regional seas groups were reviewed as well as the recommendations from WKBEMIA. It was decided to initially use a fairly straight forward three step approach consisting of: 1. Data assembly; 2. Data analysis; 3. Interpretation. More detailed consideration of the different approaches available will be done next year. IEA is an important step in ecosystem approach, but there are several other steps as well as outlined in Figure 1. This cycle is in many ways similar to the socalled Levin cycle (Levin *et al.*, 2009) that NOAA uses in the US, but it is slightly simpler schematically. In the first year the focus will be on getting an overview on which data are avaiable on the different ecosystem components and presenting the status. In the next year we will put more emphasis on developing the integrated assessment approach and perform multivariate analyses.

Regarding the objecties for the ecosystem, it was agreed to adopt high level statements for the overall objetive for the Norwegian Sea ecosystem. In addition it was agreed on to only take into account specific objectives for the ecosystem elements strongly affected by human impact and thus where management of human action could be expected to have a direct impact on ecosystem components. For the Norwegian Sea, fisheries are the main pressure so only objecties for the harvested fish stocks were considered. These were the standard fMSY objectives used by ICES for the respective stocks. Also alternative ecosystem based harvest strategies and objectives were investigated under ToR c) "Objectives from the Norwegian management plan".

Objectives for the protection and sustainable use of the Norwegian Sea in the Norwegian ecosystem-based management plan (Ottersen *et al.* 2011) for the Norwegian Sea are several. Of interest here are only the goals for management of biological, geological and landscape diversity (Box 1). A problem in the follow up work of the management plan is to get data that can be used to evaluate whether these goals are met or not. A set of indicators has been established, but they do not provide the necessary information. It should be evaluated whether an integrated assessment can provide useful information for the management plan. IA may be particularly useful for some of the goals in the Norwegian management and are marked in grey. In the future we will also investigate the suitability of additional objectives for example related to zooplankton abundance or fish length at age, which can be related to the high level goals given in the management plan (Box 1).

Box 1. *From Norwegian ecosystem-based management plan for the Norwegian Sea - the goals for management of biological, geological and landscape diversity.*

Overall goal

Management of the Norwegian Sea will ensure that diversity at ecosystem, habitat, species and genetic levels, and the productivity of ecosystems, are maintained. Human activity in the area will not damage the structure, functioning or productivity of ecosystems.

Subgoal for particularly valuable and vulnerable areas and habitat types

- Activities in particularly valuable and vulnerable areas will be conducted in such a way that the ecological functioning and biodiversity of such areas are not threatened.
- Damage to marine habitats that are considered to be endangered or vulnerable will be avoided.
- In marine habitats that are particularly important for the structure, functioning and productivity of ecosystems, activities will be conducted in such a way that all ecological functions are maintained.

Subgoal for species management

- Naturally occurring species will exist in viable populations and genetic diversity will be maintained.
- Management of living marine resources will be based on the principles of sustainable harvesting.
- Species that are essential to the structure, functioning and productivity of ecosystems will be managed in such a way that they are able to maintain their role as key species in the ecosystem concerned.
- Populations of endangered and vulnerable species and species for which Norway has a special responsibility will be maintained or restored to viable levels. Unintentional negative pressures on such species as a result of activity in the Norwegian Sea will be avoided.
- The introduction of alien species through human activity will be avoided.

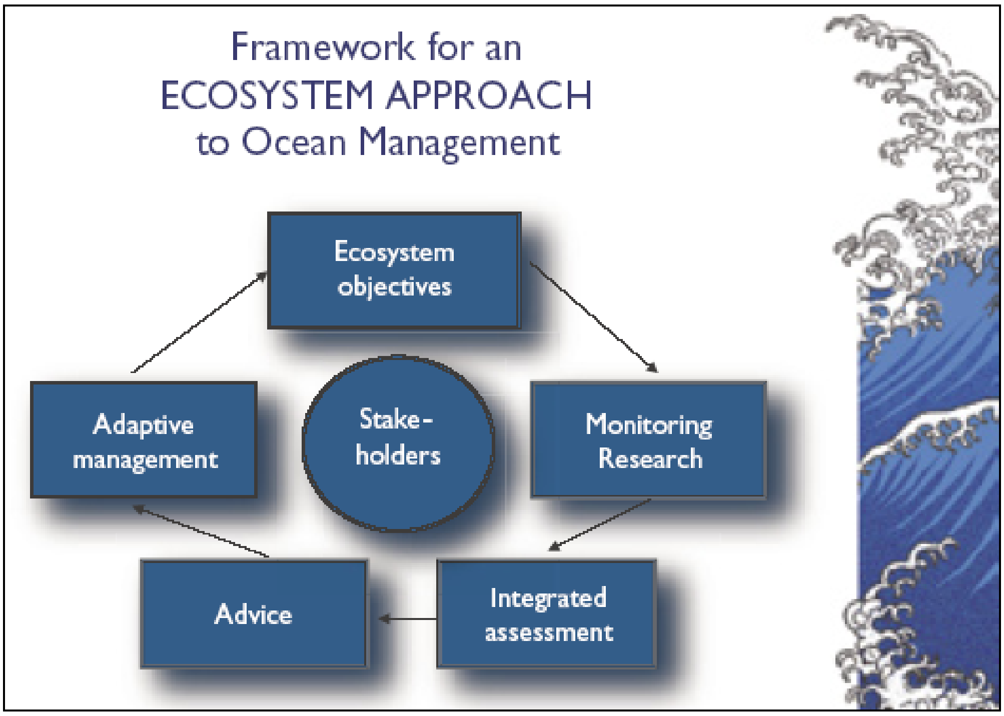


Figure 1. Steps in an ecosystem approach to ocean management (Anon., 2002).

5.2 Progress report on ToR b)

The approach taken in ToR b on performing an up to date integrated assessment for the Norwegian Sea ecosystem was to go through the data for the different ecosystem components in the Norwegian Sea and assemble the most relevant data series available (Annex 3). This was done in a standardized fashion with an initial description of the ecosystem components, a description of the data series used and brief justification for it, presentation of the data and the summary of present state and recent trends. A similar procedure was used for the pressure data. This treatment of the data was followed by some preliminary analyses and discussion of overall ecosystem status. Time did not allow for a lot of analyses so this will have to be elaborated upon next year. A preliminary assessment of the status of the different ecosystem components of the Norwegian Sea is given in Annex 6.

5.3 Progress report on ToR c)

In recent years there has been an increased focus on ecosystem based fishery management (EBFM); (Pikitch *et al.* 2004). A reason for the slow progress in implementing EBFM is the lack of proper models that can take into account the effect of altered management on the ecosystem (Bunnefeld *et al.* 2011). There are a range of approaches for multispecies modelling which have the benefits of incorporating ecological considerations in simulations with multiple species (see review in Hollowed *et al.* 2000, Plaganyi 2007). An example is the management of Northeast Atlantic cod and capelin, where the expected predation on capelin by cod is used to estimate the natural mortality of capelin on an annual basis (Gjøsæther *et al.* 2002). Another example is the OSMOSE model where ecosystem stability is estimated by using an Individual Based Model with length dependent predation (Shin and Cury 2001).

Large stocks of planktivorous fish can have interactions that have a negative effect on the stocks, evident at reduced size-at-age or condition factor when the fish abundance is high. This can at least theoretically lead to increased natural mortality for species unable to handle the competition. Such large effects are normally seen in freshwater systems or in smaller semi-closed marine ecosystems (Link 2002), but there are strong indications of such effects in the Baltic (Casini *et al.* 2011) and the Norwegian Sea (Huse *et al.* 2012). The pelagic fish species dominating the Norwegian Sea ecosystem are presently managed with a single species approach with the goal of keeping the fish stocks above a precautionary biomass level to avoid stock collapse. Several important variables for the planktivorous fish, such as prey abundance and water temperature, and their effect on the harvested stocks are discussed in the ICES working group reports (e.g. ICES 2011) for these species. However, these factors do not affect the quotas recommended by the working group.

Management strategy evaluation (MSE) is a method to examine the consequences of different management strategies for a set of assumptions using simulation models. It will reveal the tradeoffs in performance across selected management objectives (Smith *et al.* 2009) for comparison between different strategies (Bunnfeld *et al.* 2011). The normal procedure is to have a setup with 4 different models; an operational model, a management model, a harvest operating model and a resource operating model. This system makes it possible to theoretically test of out how the HCRs perform under different states of the ecosystem without the risk of degrading fish stocks and reducing the expected long term yield.

There exist several ecosystem models for the Norwegian Sea. Among these are Ecopath (Dommasnes *et al.* 2001) and Atlantis (unpublished). The ecopath model is not up to date and Atlantis is ready to be used yet, and these models will not be used by this working group. Instead, WGINOR will focus on the use of two different models; Enac and Norwecom. These models are suitable for addressing the challenges raised in ToR c, and can easily be run and modified by members of WGINOR. Additional details on the NORWECOM and ENAC models are given in Annex 7.

5.4 Progress report on ToR d

One of the planned tasks of WGINOR was to explore other estimates of fish abundance than the official WGWIDE assessment. Tenningen *et al.* (2010; Figure 2) demonstrated that estimate of SSB based on tagging data with internal steel tags, recovered with metal detectors at commercial factories from 1986–2006, showed large fluctuations in the stock: starting with high levels of around 7 million tons around 1990, down to 3 million tons around 2000, and rising again to 7 million tons in 2006. In comparison, the official estimate from WGWIDE has been relatively flat around 2.5 million tons over the entire period. This discrepancy has led to the start of a project to improve the tagging method with the aim to include this data in the assessment of the stock. In 2011 Institute of Marine Research (IMR) in Bergen started using new tagging technology with RFID (Ratio frequency identification), and over the years 2011–2013 as many as 104835 mackerel has been tagged with the new tags. More than 100 of these tags have been recaptured by RFID antenna and reader systems at 8 factories along the Norwegian coast in mid-2013. Tagged fish are automatically recovered by these systems and updating a database at IMR at the same time. There is a web based software solution that is used to track the different systems, import data on catch information, and biological sampling data of released fish and screened catches. Based on this information the system can estimate numbers released and screened by year class in a known biomass landed, which is used to estimate abundance by year class and the total stock size. The system is currently under quality checks, fixing errors etc., and hence estimates of abundance were not available during WGINOR, but they will be made available to the group when ready. The number of tag returns relative to the screened catch does however indicate that the biomass have increased significantly from the 7 million tons in 2006. The plan is to have quality checked abundance estimates ready for the benchmark assessment of mackerel in February 2014.

A similar increase and levels above the official WGWIDE assessment in recent years is found in the swept area estimates from the July trawl surveys in the Norwegian Sea and surrounded areas around Iceland-Greenland Sea and southwards along GB and in the North Sea (Nøttestad *et al.* 2013; ICES. 2012). The methodology from these surveys is also under improvement with standardization of equipment and the way of trawling. The estimate has increased in recent years from 4 million t in 2007 to 5.8 million t in 2012, and 8.8 million t in 2013. Thus the results of this survey are supporting the hypothesis that the official stock assessment is an underestimate of the biomass feeding in the Norwegian Sea.

WGINOR would strongly benefit from improved absolute estimates of fish stock size feeding in the Norwegian Sea Ecosystem to be able to model the predatory role of the mackerel with regard to consumption etc. Hence, such information as gathered during the July trawl survey and the tagging data, indicating much higher abundance the official data, is considered important and may be used in modelling and analyses of the ecosystem to get closer to the actual situation. Hence, future WGINOR meetings will certainly review and discuss the data available that may improve the whole integrated assessment of the Norwegian Sea Ecosystem, and looks forward to get a full review of the swept area data and tagging data in the 2014 benchmark.

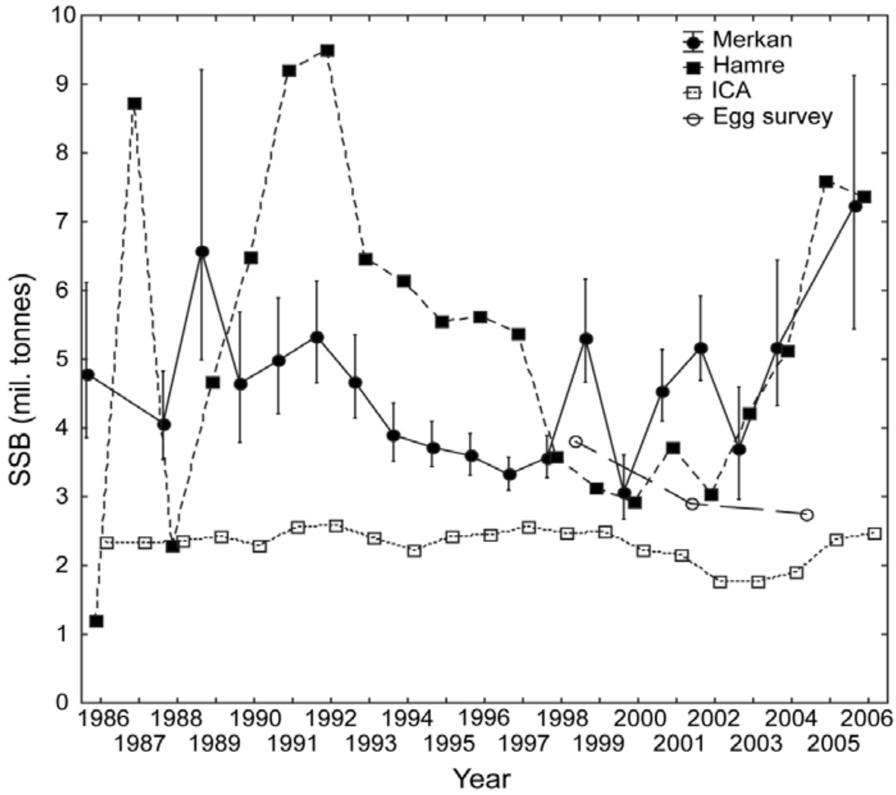


Figure 2. Estimates of SSB in the North east Atlantic mackerel; comparison between the official ICES ICA assessment, egg survey and estimates based on the tagging data (Merkan method and Hamre method).

5.5 Progress report on ToR e)

ToR e concerns development of sampling requirements for integrated assessment of the Norwegian Sea. During the WGINOR meeting, data availability and status of ecosystem components within the different disciplines were introduced, which are candidates for indicators for integrated ecosystem assessment for Norwegian Sea. Several gaps in data sampling and availability were recognized. A list presenting these gaps was therefore prepared (Table 1) and it is requested that recommendations concerning them will be handled adequately by the different groups and the relevant institutes in order to facilitate further developments of an integrated ecosystem assessment of the Norwegian Sea.

Table 1. List of gaps in data sampling and availability of relevant ecosystem components for integrated assessment of the Norwegian Sea.

Ecosystem component	Recommendation/request of sampling/analyses	To whom
Phytoplankton	1. Data on chlorophyll (fluorescent) and nutrients are not routinely collected by all participants in the IESNS survey in May (e.g. Iceland). It is recommended that such sampling takes place by all participants.	WGIPS and Institutes participating in the IESNS survey.

	2. There is very little data on primary production from monitoring surveys. New fluorescence based instruments, such as the FRRF (Fast Repetition Rate Fluorometer) (Kromkamp and Forster, 2003) allows improved estimation of primary productivity and WGINOR propose to establish a routine data collection of primary productivity based on such technology.	
Zooplankton	3. Large zooplankton such as krill, amphipods and juvenile *Gonatus fabricii* are poorly represented in WP2 nets. They need to be sampled in a quantitative manner with the new macroplankton trawl. It is recommended that such sampling will take place in the IESNS survey in May at some stations (min. 5 tows per vessel).	WGIPS and Institutes participating in the IESNS survey.
	4. IESNS survey data for some earlier years in the time-series on zooplankton in the NAPES database in Faroe Island are missing. It is recommended that they will be uploaded by the responsible nations before the end of year 2013.	ICES WGIPS and Institutes participating in the IESNS survey.
	5. There are indications for some differences in methodology in zooplankton dry weighting among nations participating in the IESNS and IESSNS (i.e. removal of phytoplankton from the samples prior to drying). This needs to be fully standardized and described in Manuals for the surveys. It is strongly recommended that this is fully described in the manuals and fulfilled during the surveys. Work on updating the manual for the July-August survey is in progress and this request should be included in this manual.	ICES WGIPS and Institutes participating in the IESNS and IESSNS surveys.
Fish	6. The stomach fullness of pelagic fish is not recorded by all participants in the IESNS and IESSNS surveys. It is recommended that it will be done by all participants in the future surveys.	WGIPS and Institutes participating in the IESNS and IESSNS surveys.
	7. During IESNS survey in May, some acoustic registrations are interpreted as meso-pelagic fish. However, these registrations have never been quantified systematically in the survey reports or by other means. These information might be relevant for WGINOR and it is requested that some analyses of these data takes place, i.e. prepare figures/data with mean acoustic values in rectangles that can be used to calculate total echo abundance for meso-pelagic fish in Norwegian Sea interannually.	SCICOM/ACOM, ICES WGIPS and Institutes participating in the IESNS survey.
Sea birds	8. It is recommended that relevant scientist specialised in sea birds ecology becomes member of the WGINOR group, especially from Norway, Faroe Island and Iceland.	Relevant National Institutes, NINA (Norway)
	9. Existing data on annual estimates of number of breeding pairs and breeding success of sea birds around the Norwegian Sea needs to be made accessible to WGINOR. It is requested that involved institutes attain these data from appropriate sources.	Relevant Faroese and Icelandic Institutes
Marine mammals	10. Whales are important top predators in the Norwegian Sea ecosystem. In order to improve understanding and quantification of their predatory effects WGINOR propose to establish routine whale counting on May and July surveys in the Norwegian Sea.	ICES WGIPS and Institutes participating in the IESNS survey.

5.6 Progress report on ToR f)

Term of Reference (f) is to prepare an intial draft of the Ecosystem Overview for the Norwegian Sea, following the structure and criteria given in WKECOVER report 2013 (ICES 2013d). Section 1 and 2 are prioritized while Section 3 is preliminary and incomplete. The working group participants defined the sections and sub-sections they would like to see included in the overview and developed and populated draft overviews for the Norwegian Sea. The ecosystem overview of the Norwegian Sea provides a concise and informative introduction to the ecoregion (e.g. Large Marine Ecosystems-LMEs) considered in the ICES advice. Regional integrated assessment groups, like WGINOR, are key players to elevate signals from the environment and ecosystem to 'key' and to lead to an entry identifying these signals in Section 2, to screen the wide range of environmental and ecosystem signals and to identify those that would have a significant effect on the way in which other Expert Groups would develop advice. More details on the work on the ecosystem overview of the Norwegian Sea are given in Annex 8 including a preliminary ecosystem overview of the Norwegian Sea (A8.6).

6 Next meeting

The next meeting will be held in Torshavn, Faroese Islands, 18 to 22 August.

7 References

Anker-Nilssen, T. & Aarvak, T. 2009. Effects of White-tailed Eagles on the reproductive performance of Black-legged Kittiwakes; indications from a 26-year study in North Norway. In: Stienen, E., Ratcliffe, N., Seys, J., Tack, J. & Dobbelaere, I. (eds.)., Provincial Court, Brugge, Seabird Group 10th International Conference Belgium, 27–30 March 2009. VLIZ Special Publication 42: 3.

Anon 2013–14. Fiskeriaktiviteten i Norskehavet, chapter 3 of the evaluation report for the Norwegian management plan Norwegian Sea (in prep.)(in Norwegian)

Anon 2008. Fiskeriaktivitet i Norskehavet, delrapport til det felles faktagrunnlaget for Forvaltningsplanen Norskehavet. Directorate of Fisheries, Norway Part report for the Management Plan Norwegian Sea (in Norwegian)

Authro, 2002. Priority scientific issues for North Sea ecosytem management. Bergen, Norway.

Authro, 2002. Priority scientific issues for North Sea ecosytem management. Bergen, Norway.

Authro, 2012. Report of the Workshop 3 on Implementing the ICES Fmsy Framework , 9–13 January 2012.

Authro, 2012. Report of the Workshop 3 on Implementing the ICES Fmsy Framework , 9–13 January 2012.

Bagøien, E., Melle, W., Kaartvedt, S. 2012. Seasonal development of mixed layer depths, nutrients, chlorophyll and Calanus finmarchicus in the Norwegian Sea – a basin-scale habitat comparison. Progress in Oceanography 103:58–79.

Baranov, F.I. 1918. On the question of the biological basis of fisheries. Izvestiya, 1, 81–128. (Translated from Russian by W.E.Ricker, 1945) Beverton, R.J.H. and Holt, S.J. (1957) On the dynamics of exploited fish populations. Fish. Invest., London 19(2), pp 1–533.

Barrett, R., Anker-Nilssen, T., Bustnes, J.O., Christensen-Dalsgaard, S., Descamps, S., Erikstad, K.E., Lorentsen, S.-H., Lorentzen, E., Strøm, H. & Systad, G.H. 2013. Key-site monitoring in Norway 2012, including Svalbard and Jan Mayen. SEAPOP Short Report 1-2013, 13 pp.

Bjelland, O., and Holst, JC. 2004. Other fish species and communities. In: HR Skjoldal editor. The Norwegian Sea Ecosystem. Trondheim: Tapir Academic Press.

Blindheim, J., *et al.* 2000. Upper layer cooling and freshening in the Norwegian Sea in relation to atmospheric forcing, Deep Sea Research, Part I, 47, 655–680.

Broms, C., Melle, W. 2007. Seasonal development of Calanus finmarchicus in relation to phytoplankton bloom dynamics in the Norwegian Sea. Deep-Sea Research Part II, 54: 2760–2775.

Broms, C., Melle, W., Kaartvedt, S. 2009. Oceanic distribution and life cycle of Calanus species in the Norwegian Sea and adjacent waters. Deep-Sea Research Part II, 56: 1910–1921.

Bunnefeld, N., E. Hoshino, and E. Milner-Gulland. 2011. Management strategy evaluation: A powerful tool for conservation? Trends in Ecology & Evolution 26:441–447.

Casini, M., Kornilovs, G., Cardinale, M., Möllmann, C., Grygiel, W., Jonsson, P., Raid, T., Flinkman, J., Feldman, V. 2011. Spatial and temporal density dependence regulates the condition of central Baltic Sea clupeids: compelling evidence using an extensive international acoustic survey. Population Ecol. 53, 511–523.

Chambers, RC. 1993. Phenotypic variability in fish populations and its representation in individual-based models. Transactions of the American Fisheries Society 122:404–14.

Chen, Y., Jackson, D. A., Harvey, H. H. 1992. A comparison of von Bertalanffy and polynomial functions in modelling fish growth data. Can. J. Fish. Aquat. Sci. 49, 1228–1235.

Cury, P.M., Boyd, I.L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R.J.M, Furness, R.W., Mills, J.A., Murphy, E.J., Österblom, H., Paleczny, M., Piatt, P.F., Roux, J.-P., Shannon, L. & Sydeman, W.J. 2011. Global seabird response to forage fish depletion – one-third for the birds. Science 334: 1703–1706.

Dale, T., Kaartvedt, S., Ellertsen, B., Amundsen, R. 2001. Large-scale oceanic distribution and population structure of *Calanus finmarchicus*, in relation to physical environment, food and predators. Marine Biology, 139:561–574.

Dommasnes, A., Christensen, V., Ellertsen, B., Kvamme, C., Melle, W., Nøttestad, L., Pedersen, T., Tjelmeland, S., and Zeller, D. 2001. An Ecopath model for the Norwegian Sea and Barents Sea. 2001. Fisheries Impacts on North Atlantic Ecosystems. In Fisheries Centre Research Reports, 9(4), pp. 213–240. Ed. by S. Gue´nette, V. Christensen, T. Pitcher, and D.Pauly.

Fiksen, O., and Slotte, A. 2002. Stock-environment recruitment models for Norwegian Spring Spawning herring (*Clupea harengus*). Canadian Journal of Fisheries and Aquatic Sciences, 59: 211–217.

Frederiksen, M., Anker-Nilssen, T., Beaugrand, G. & Wanless, S. 2013. Climate, copepods and seabirds in the boreal Northeast Atlantic – current state and future outlook. Global Change Biology 19: 364–372.

Gjøsæter, H., Bogstad B., Tjelmeland S. 2002a. Assessment methodology for Barents Sea capelin, Mallotus villosus (Müller). *ICES J. Mar. Sci*. 59, 1086–1095.

Hátún, H., Payne, M. R., & Jacobsen, J. A. 2009. The North Atlantic subpolar gyre regulates the spawning distribution of blue whiting (*Micromesistius poutassou*). Canadian Journal of Fisheries and Aquatic Sciences, 66, 759e770.

Hátun, H., Sandø, A.B., Drange, H., Hansen, B., and H. Valdimarsson (2005) Influence of the Atlantic Subpolar Gyre on the thermohaline circulation, Science, 309, 1841–1844.

Head, E.J.H., Melle, W., Pepin, P., Bagøien, E., Broms, C. 2013. On the ecology of Calanus finmarchicus in the Subarctic North Atlantic: A comparison of population dynamics and environmental conditions in areas of the Labrador Sea-Labrador/Newfoundland Shelf and Norwegian Sea Atlantic and Coastal Waters. Progress in Oceanography 114:46–63.

Hjøllo, S.S., Huse, G., Skogen, M.D., Melle, W. 2012) Modelling secondary production in the Norwegian Sea with a fully coupled physical/primary production/individual-based *Calanus finmarchicus* model system. Marine Biology Research 8:508–526.

Hollowed, A.B., Bax, N., Beamish, R., Collie, J., Fogarty, M., Livingston, P., Pope, J., Rice, J.C. 2000. Are multispecies models an improvement on single-species models for measuring fishing impacts on marine ecosystems? ICES J. Mar. Sci. 57, 707–719.

Hurrell, J.W. 1995. Decadal Trends in the North Atlantic Oscillation: Regional Temperatures and Precipitation. Science: Vol. 269, pp.676–679

Huse, G., Holst, J.C., Utne, K., Nottestad, L., Melle, W., Slotte, A., Ottersen, G., Fenchel, T., Uiblein, F. 2012. Effects of interactions between fish populations on ecosystem dynamics in the Norwegian Sea - results of the INFERNO project Preface. Mar. Biol. Res. 8, 415–419.

Huse, G., Holst, J.C., Utne, K., Nottestad, L., Melle, W., Slotte, A., Ottersen, G., Fenchel, T., Uiblein, F. 2012. Effects of interactions between fish populations on ecosystem dynamics in the Norwegian Sea - results of the INFERNO project Preface. Mar. Biol. Res. 8, 415–419.

ICES 2011a. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 15–19 August 2011, St. Andrews, Scotland, UK. ICES CM 2011/ACOM:22. 64 pp.

ICES 2011b. Report of the Working group on Seabird Ecology (WGSE), 1–4 November 20122, Madeira, Portugal. ICES CM 2011/SSGEF:07: 87 pp.

ICES. 2012. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 21 - 27 August 2012, Lowestoft, United Kingdom. ICES CM 2012/ACOM:15. 645 pp.

ICES. 2013a. Report of the Arctic Fisheries Working Group (AFWG), 18–24 April 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:05.

ICES. 2013b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013. ICES CM 2013/ACOM:13.

ICES. 2013c. Report of the North-Western Working Group (NWWG), 26 April–3 May 2013. ICES CM 2013/ACOM:07.

ICES. 2013d. Report of the Working Group on the ICES ACOM/SCICOM Workshop on Ecosystem Overviews (WKECOVER), 7 – 11 January 2013,ICES HQ Copenhagen Denmark.

ICES. 2013e. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 27 August – 2 September 2013, ICES Headquarters, Copenhagen, Denmark. ICES CM 2013/ACOM:15. 950 pp.

Kaartvedt, S., Røstad, A., Fiksen, Ø, Melle, W, Torgersen, T., Tiseth Breien, M., and Klevjer, TA. 2005. Marine Ecology Progress Series 299:1–5.

Kromkamp, J.C., Forster, R.M. 2003. The use of variable fluorescence measurements in aquatic ecosystems: differences between multiple and single turnover measuring protocols and suggested terminology. Eur. J. Phycol. 38, 103–112.

Kromkamp, J.C., Forster, R.M. 2003. The use of variable fluorescence measurements in aquatic ecosystems: differences between multiple and single turnover measuring protocols and suggested terminology. Eur. J. Phycol. 38, 103–112.

Levin, P.S., Fogarty, M.J., Murawski, S.A., Fluharty, D. 2009. Integrated Ecosystem Assessments: Developing the Scientific Basis for Ecosystem-Based Management of the Ocean. PLoS Biol. 7, 23–28.

Levin, P.S., Fogarty, M.J., Murawski, S.A., Fluharty, D. 2009. Integrated Ecosystem Assessments: Developing the Scientific Basis for Ecosystem-Based Management of the Ocean. PLoS Biol. 7, 23–28.

Link, J.S. 2002. Ecological considerations in fisheries management: when does it matter? Fisheries 27, 10–17.

Melle, W., Ellertsen, B., and Skjoldal, H.R. 2004. Zooplankton: The link to higher trophic levels. In The Norwegian Sea Ecosystem. pp. 137–202. Ed. by HR Skjoldal. Tapir Academic Press, Trondheim, 559 pp.

Mork, K.A. and J. Blindheim. 2000. Variations in the Atlantic inflow to the Nordic Sea, 1955–1996. Deep Sea Research, Part I, 47, 1035–1057.

Mork, K.A., Skagseth, Ø. 2005 Annual sea surface height variability in the Nordic Seas. In The Nordic Seas: An Integrated Perspective, AGU Monograph 158, 51–64

Nøttestad, L., Utne, K.R., Oskarsson, G.J., Jónsson, S.Þ., Debes, H., Jacobsen, J.A. *et al.* 2013. Cruise report from the coordinated ecosystem survey (IESSNS) with M/V "Libas", M/V "Eros"; M/V "Finnur Fríði" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters, 1 July - 9 August 2013. WD to ICES Working Group on Widely distributed Stocks (WGWIDE), ICES Headquarters, Copenhagen, Denmark, 27 August-2 September 2013.

Orvik, K.A. and P. Niiler. 2002. Major pathways of Atlantic water in the northern North Atlantic and Nordic Seas toward Arctic. Geophysical Research Letters, 29(19), 1896, doi:10.1029/2002 GL015002.

Ottersen, G., Olsen, E., van der Meeren, G.I., Dommasnes, A., Loeng, H. 2011. The Norwegian plan for integrated ecosystem-based management of the marine environment in the Norwegian Sea. Mar. Policy 35, 389–398.

PAME 2013. Large Marine Ecosystems (LMEs) of the Arctic area. Revision of the Arctic LME map 15th of May 2013. Arctic Council, 2013: 24 pp.

Payne, M.R., Egan, A., F€assler, S.M.M. *et al.* 2012. The rise and fall of the NE Atlantic blue whiting (*Micromesistus poutassou*). Mar. Biol. Res. 8:475–487.

Pikitch, E.K., Santora, E.A., Babcock, A., Bakun, A., Bonfil, R., Conover, D.O., *et al.* Ecosystem-based fishery management. Science 2004; 305: 346–7.

Plagányi, É.E., Rademeyer, R.A., Butterworth, D.S., Cunningham, C.L., Johnston, S.J. 2007. Making management procedures operational – innovations implemented in South Africa. ICES J. Mar. Sci. 64, 626–632.

Polyakov, I.V, *et al.* 2005. One more step toward a warmer Arctic. Geophysical Research Letters, 32,L17605, doi:10.1029/2005GL023740.

Rey, F. 2004. Phytoplankton: The grass of the sea. In The Norwegian Sea Ecosystem. pp. 97–136. Ed. by H. R. Skjoldal. Tapir Academic Press, Trondheim, 559 pp.

Rey, F. 2012. Declining silicate concentrations in the Norwegian and Barents Seas. *ICES Journal of Marine Science*, 69(2), 208–212. doi:10.1093/icesjms/ fss007.

Scheffer, M., Baveco, J.M., Deangelis, D.L., Rose, K.A., Vannes, E.H. 1995. Super-individuals: A simple solution for modelling large populations on an individual basis. Ecological Modelling 80:161 70.

Shin, Y., Cury, P. 2001. Exploring fish community dynamics through size-dependent trophic interactions using a spatialized individual-based model. Aquat. Living Resour. 14 (2), 65–80.

Simmonds, E. J., Portilla, E., Skagen, D., Beare, D., and Reid, D. G. 2010. Investigating agreement between different data sources using Bayesian state-space models: an application to estimating NE Atlantic mackerel catch and stock abundance. *ICES Journal of Marine Science*, 67: 1138–1153.

Skagen, D.W., Skern-Mauritzen, M., Dankel, D., Enberg, K., Kjesbu, OS., Nash, RDM. 2013. A simulation framework for evaluating fisheries management decisions using environmental information. Ices Journal of Marine Science 70(4), p 743–754.

Skagseth, Ø., Orvik, K.A., and T. Furevik. 2004. Coherent variability of the Norwegian Atlantic Slope Current derived from TOPEX/ERS altimeter. Geophysical Research Letters, 31, L14304, doi:10.1029/2004GL020057.

Skjoldal, H.R., Bagøien, E. 2013. Zooplankton biomass in the Norwegian Sea - 1991–2013. Working document, prepared for use by ICES WGINOR; version 220913

Working document, prepared for use by ICES WGINOR; version 220913 Skjoldal HR, Dalpadado P, Dommasnes A. (2004). Food webs and trophic interactions. In The Norwegian Sea Ecosystem. pp. 447–506. Ed. by HR Skjoldal. Tapir Academic Press, Trondheim, 559pp.

Skjoldal, H.R., Wiebe, P.H., Postel, L., Knutsen, T., Kaartvedt, S., Sameoto, D.D. 2013. Intercomparison of zooplankton (net) sampling systems: Results from the ICES/GLOBEC seagoing workshop. Prog. Oceanogr. 108, 1–42.

Skjoldal, H.R, Wiebe, P.H, Postel, L., Knutsen, T., Kaartvedt, S., Sameoto, D.D. 2012. Intercomparison of zooplankton (net) sampling systems: Results from the ICES/GLOBEC sea-going workshop. Progress in Oceanography, 108: 1–42.

Skjoldal, H.R., Dalpadado, P., Dommasnes, A. 2004. Food webs and trophic interactions, in: Skjoldal, H.R. (ed.), The Norwegian Sea ecosystem. Tapir Academic Press, Bergen, pp. 447–506.

Tenningen, M., Slotte, A., Skagen, D. 2011. Abundance estimation of Northeast Atlantic mackerel based on tag recapture data–A useful tool for stock assessment? Fisheries Research 107: 68–74.

Toresen, R., and Østvedt, O.J. 2000. Variation in abundance of Norwegian spring-spawning herring (Clupea harengus, Clupeidae) throughout the 20th century and the influence of climatic fluctuations. Fish and Fisheries 1: 231–256.

Vikebø, F.B., Korosov, A., Stenevik, E.J., Husebø, Å., Slotte, A. 2012. Spatio-temporal overlap of hatching in Norwegian spring-spawning herring.

Annex 1: List of participants

Name	Country	Institute	Email
Jan Arge Jacobsen	Faroe Islands	Faroe Marine Research Institute	janarge@hav.fo
Anna Olafsdottir	Faroe Islands	Faroe Marine Research Institute	annao@hav.fo
Hjalmar Hatun	Faroe Islands	Faroe Marine Research Institute	hjalmarh@hav.fo
Gudmundur Johann Oskarsson	Iceland	Marine Research Institute	gjos@hafro.is
Hildur Petursdottir	Iceland	Marine Research Institute	hildur@hafro.is
Geir Huse	Norway	Institute of Marine Research	geir.huse@imr.no
Anne Kirstine Frie	Norway	Institute of Marine Research	anne.kirstine.frie@imr.no
Hein Rune Skjoldal	Norway	Institute of Marine Research	hrs@imr.no
Kjell Utne	Norway	Institute of Marine Research	kjell.utne@imr.no
Erling Kåre Stenevik	Norway	Institute of Marine Research	erling.kare@imr.no
Øistein Skagseth	Norway	Institute of Marine Research	oistein.skagseth@imr.no
Morten Skogen	Norway	Institute of Marine Research	morten.skogen@imr.no
Aril Slotte	Norway	Institute of Marine Research	aril.slottte@imr.no
Åge Høines	Norway	Institute of Marine Research	age.hoines@imr.no
Are Salthaug	Norway	Institute of Marine Research	are.salthaug@imr.no
Leif Nøttestad	Norway	Institute of Marine Research	leif.nottestad@imr.no
Gro van der Meeren	Norway	Institute of Marine Research	grom@imr.no
Petter Fossum	Norway	Institute of Marine Research	petter.fossum@imr.no
Espen Bagøien	Norway	Institute of Marine Research	espen.bagoien@imr.no
Espen Strand	Norway	Institute of Marine Research	espen.strand@imr.no
Per Arneberg	Norway	Institute of Marine Research	per.arneberg@imr.no

Annex 2: Agenda

Agenda, WGINOR meeting 19–23 August

Location: IMR Bergen, Nordnesgaten 33, meeting room “Store Dypet”

Monday

1300 Welcome, brief round of introduction, housekeeping matters, and presentation of WGINOR ToRs, G. Oskarsson & G. Huse

Presentations related to ToRs (about 20 min. each, break when needed):

-Introduction to the Norwegian Sea ecosystem, H.R. Skjoldal
-Pathway towards a balanced ecosystem based management of the Norwegian Sea, J.C Holst
-Norwegian management plan for the Norwegian Sea, G. v.d. Meeren
-Presentation of NORWECOM biophysical model, M. Skogen
-Presentation of ENAC multispecies model for the pelagic complex, K. Utne
-Discussion
1700 Pizza
1800 Socialiser at Henrik øl og vinstue

Tuesday

0900 Plenary session

Data availability and present status of ecosystem components

-Preliminary report from the summer ecosystem survey in the Norwegian Sea, L. Nøttestad
-RFID tag based abundance estimates for NA mackerel, A. Slotte
-Climate & hydrography – Ø. Skagseth
-Plankton – E. Bagøien, H. Petursdottir
-Fish – G. Oskarsson, J.A. Jacobsen, Å. Høines, E.K. Stenevik
-Marine mammals – A. K. Frie
-Seabirds – L. Nøttestad?
-Pressures on the Norwegian Sea ecosystem – G. v.d. Meeren
-Discussion and planning of work process

1200 Lunch
-Working in groups
1700 end of day

Wednesday

0900 Plenary: report on progress & discussion
-Working in groups
1200 Lunch
-Working in groups
1500 Plenary

1700 end of day

Thursday
0900 Plenary: report on progress & discussion
-Working in groups
1200 Lunch
-Working in groups
1700 End of day
1930 Working group dinner at Spisekroken

Friday
0900 Plenary: review draft report
-Working on reporting and any other business
1200 Lunch
1300 Plenary review and finalisation of report
1400 End of meeting

Annex 3: WGINOR data tables

Table A1. **Climate and hydrography indices related to Norwegian Sea and adjacent waters.**

YEAR	Nao_djfm	dp : Agmasalik-Stykkis	dp: Scoresbysund-Jan Mayen	dp: Danmarkstrait-Svalbard	spg-index	Norw-Lof gyre index	Svinøy-coreT	Svinøy-coreS	Areal for S>35 (km2)	Herring habitat *10^5 km^2	Blue Whiting Habitat *10^5 km^2	Mackrel habitat *10^5 km^2	East Icelandic Current *10^4 km^2
1950	1.4000	1.7546	6.1563	8.8073		0.1259							
1951	-1.2600	3.7979	9.6341	10.3201		1.0229							
1952	0.8300	1.9613	7.6723	9.1261		0.6434							
1953	0.1800	-1.4352	5.7453	9.9565		0.1686							
1954	0.1300	-2.4363	2.1694	6.0735		-1.3545							
1955	-2.5200	2.1551	6.8884	10.3754		0.7373							
1956	-1.7300	-1.8403	4.2077	5.9184		-0.5951							
1957	1.5200	1.1288	5.8680	5.6570		0.0189							
1958	-1.0200	1.0841	6.4586	7.8000		0.6960							
1959	-0.3700	-3.4424	4.8057	9.5546		-1.0081							
1960	-1.5400	-0.1791	4.2964	5.4733		-0.2974							
1961	1.8000	-0.9302	5.8587	8.3832		-0.1165							
1962	-2.3800	0.1707	5.9722	10.0271		-0.0562							
1963	-3.6000	-1.0052	3.0346	4.5793		-1.3475							
1964	-2.8600	-4.5859	1.8556	6.2407		-2.3955							
1965	-2.8800	-0.3563	5.2676	8.4114		-0.8674							
1966	-1.6900	3.0841	6.4291	6.7065		-0.2568							
1967	1.2800	1.6395	7.0341	7.9542		0.7600							
1968	-1.0400	1.0980	7.2424	10.3560		0.9975							
1969	-4.8900	1.5299	6.0287	9.1184		1.3782							
1970	-1.8900	2.6093	5.7506	6.1783		-0.1446							
1971	-0.9600	1.0873	6.4618	8.1707		-0.9315							

1972	0.3400	-3.0575	2.1602	5.2754		-2.3461							
1973	2.5200	-0.5907	5.7231	8.2554		0.4642							
1974	1.2300	1.5112	4.6273	4.3011		0.2896							
1975	1.6300	-1.0954	6.9348	11.3832		1.4675							
1976	1.3700	-2.4137	3.1826	3.8048		-0.0124	7.4	35.119					
1977	-2.1400	0.9540	5.1055	4.7121		0.3599	7.52	35.141					
1978	0.1700	1.3209	5.2303	7.4886		-0.6613	7.45	35.093	77.53				
1979	-2.2500	-0.8501	5.1596	3.5615		0.3921	7.32	35.123	72.47				
1980	0.5600	-2.3514	2.1794	3.6177		-0.7593	7.49	35.195	96.08				
1981	2.0500	2.6465	7.0727	9.4345		-0.0627	7.78	35.245	120.58				
1982	0.8000	1.9993	5.5150	7.5606		-0.1058	8.05	35.257	125.40				
1983	3.4200	0.2437	6.2298	9.5570		0.5152	8.19	35.269	82.37				
1984	1.6000	-0.8987	4.3571	5.4403		-0.6264	7.89	35.248	97.56				
1985	-0.6300	-3.3769	2.3137	2.9144		-0.2943	7.49	35.216	105.49				
1986	0.5000	-1.4467	3.0704	4.9972		-1.1747	7.88	35.246	116.71				
1987	-0.7500	-2.6385	1.6202	1.3857		-0.7751	7.66	35.222	117.09				
1988	0.7200	0.1269	5.7963	6.0780		0.6261	7.53	35.191	103.40				
1989	5.0800	1.2357	6.7292	8.6526		1.0033	7.9	35.192	102.68				
1990	3.9600	2.8775	7.3475	5.9550		2.3681	8.14	35.252	95.62				
1991	1.0300	-2.4841	2.8162	5.5133		-0.9848	8.06	35.26	113.08				
1992	3.2800	-2.9127	4.0689	9.4793		-0.6629	7.61	35.207	84.11				
1993	2.6700	-1.9732	5.7872	9.9656	-0.3439	1.5225	7.69	35.169	76.69				
1994	3.0300	2.0792	7.0457	8.3881	-0.5297	1.6897	7.48	35.164	80.31				
1995	3.9600	3.2558	9.9412	12.6461	-0.4366	2.0433	7.93	35.227	80.84	6.0231	6.0071	2.5298	2.4273
1996	-3.7800	-3.9550	0.5917	4.1420	-0.0573	-2.2709	7.86	35.208	106.35	5.9783	6.0488	2.4176	1.6565
1997	-0.1700	-0.0576	4.3926	6.7181	0.0324	-0.1871	8.08	35.212	110.33	5.6037	6.0648	2.0173	4.5761
1998	0.7200	0.0764	6.0805	4.8353	0.0931	1.3845	8.25	35.255	101.02	6.2185	6.1224	3.1252	2.8331
1999	1.7000	2.3498	7.5529	7.6378	-0.0570	1.3148	7.92	35.234	85.74	6.1416	6.1961	3.1573	2.6527
2000	2.8000	0.6105	6.9995	12.6498	-0.2761	0.3067	8.37	35.257	104.97	6.1384	6.1000	2.5072	1.9599
2001	-1.9000	-0.5766	5.0798	7.5427	0.0452	-0.6485	8.28	35.239	112.56	6.2345	6.1000	3.0100	1.0186
2002	0.7600	-1.3151	5.7159	8.9096	0.0184	-0.6742	8.82	35.275	103.63	6.1128	6.0103	3.7240	1.8336

2003	0.2000	-3.8020	2.5248	5.1806	0.1937	-1.6238	8.68	35.284	116.96	6.6251	6.4106	3.8745	0.5832
2004	-0.0700	-0.4799	6.4203	7.5648	0.1692	0.2821	8.31	35.283	104.21	6.4554	6.4811	3.9290	0.3195
2005	0.1200	-1.0405	6.0992	9.2563	0.1469	0.6081	8.24	35.275	107.60	6.2089	6.3818	3.1349	0.0889
2006	-1.0900	-0.5719	3.9489	6.0309	0.1487	-0.5633	8.59	35.273	108.90	6.4682	6.3113	3.5351	0.4643
2007	2.7900	-0.1827	5.9526	8.9971	0.0751	0.2956	8.83	35.284	123.00	6.3754	6.3081	3.5960	0.6452
2008	2.1000	-1.3123	4.2227	8.9023	0.0297	0.1370	8.17	35.266	94.33	6.3273	6.2409	3.2117	0.4494
2009	-0.4100	-0.7440	4.9935	7.4653	0.0477	-0.4785	8.76	35.324	100.01	6.4586	6.2025	3.8457	0.6860
2010	-4.6400	-0.6364	4.3909	7.5159	0.3158	-0.3540	8.42	35.317	125.57	6.3466	6.4106	3.3398	0.2532
2011	-1.5700	0.0378	4.7543	7.3948	0.3003	0.7459	8.53	35.308	124.24	6.3978	6.1384	3.1541	0.1998
2012	3.1700	-2.1929	3.8039	6.7177	0.0845	0.2143	8.27	35.276	92.57	6.1512	6.1961	2.6738	0.7839
2013	-1.9700	-0.2610	4.2420	6.4643		-0.8049			120.30	6.3850	6.2953	3.0132	0.1462

Table A2. Zooplankton biomass in sub-Arctic LMEs.

LME	Region	Biomass (dw m^{-2})		Reference
Bering Sea	0–150 m	9 (37 g ww, 4.5 g C)	Mean of 15 years (1956–1970), summer	Motoda and Minoda 1974, Ikeda and Motoda 1978
	Slope ('Green Belt')	20–40 (100–200 g ww)	Max value in spring; oceanic copepods *Neocalanus* spp.	Cooney and Coyle 1982, Vidal and Smith 1986, Coyle *et al.* 1996, Springer *et al.* 1996
	Northern shelf	2.5–6		Motoda and Minoda 1974
		5	Mean in Anadyr Water, mid summer	Springer *et al.* 1989
	Middle and inner shelf	1–2		Cooney 1981, Vidal and Smith 1986
Chukchi Sea	S and NE	2		Hopcroft *et al.* 2010
	E	2.5–5.5		Turco 1992a, b, cited by Hopcroft *et al.* 2010
Canadian Arctic Archipelago	Barrow Strait (Resolute)	0.5–2 (max 7)		Conover and Huntley 1991, Conover *et al.* 1991, Conover and Siferd 1993, Fortier *et al.* 2002, Michel *et al.* 2006
	E Lancaster Sound-W Baffin Bay	Ca. 8		Buchanan and Sekarak 1982
Iceland	South	Ca. 5	Annual mean, upper layer	Gislason 2002
	North	Ca. 2		
	North (Siglunes)	4–5	Summer	
	NE (Langanes)	14–17	May-June	
	N of Iceland	2–10	Means for 1980–1997	Astthorsson and Gislason 1994, Astthorsson and Vilhjalmsson 2002
Barents Sea	Central	2–3 (max 7)	1983–84, 0–200 m	Rey *et al.* 1987, Skjoldal *et al.* 1992, Blindheim and Skjoldal 1993
	Whole surveyed area	3–6	1988–1992	Skjoldal *et al.* 1992, Gjøsæter *et al.* 2000
		7–13	1993–2000	Dalpadado *et al.* 2003
		6–9	2001–2010	Dalpadado *et al.* 2012
Storfjorden Møre		1–2	Sea-going workshop	Skjoldal *et al.* 2013

Table A3. Recruitment of herring (1988 onwards), mackerel and blue whiting taken from the 2012 ICES assessments. Herring data for the period 1907–1987 are taken from Toresen and Østvedt (2000).

Year class	Herring[1]	Blue whiting[2]	Mackerel[3]
1907	34.14		
1908	42.40		
1909	29.95		
1910	58.33		
1911	29.52		
1912	53.56		
1913	137.32		
1914	33.36		
1915	30.14		
1916	88.38		
1917	123.04		
1918	238.29		
1919	206.69		
1920	198.40		
1921	96.45		
1922	264.30		
1923	441.49		
1924	100.06		
1925	363.59		
1926	143.61		
1927	34.22		
1928	135.28		
1929	38.09		
1930	562.56		
1931	95.52		
1932	225.98		
1933	156.73		
1934	249.50		
1935	167.83		
1936	99.81		
1937	538.60		
1938	408.41		
1939	185.49		
1940	212.79		
1941	147.11		
1942	81.89		
1943	285.88		
1944	250.94		
1945	118.83		
1946	79.14		
1947	183.07		
1948	107.71		
1949	70.03		
1950	750.04		
1951	140.57		
1952	96.46		
1953	85.98		
1954	42.07		
1955	24.97		
1956	29.86		
1957	25.39		
1958	29.99		

1959	412.47		
1960	197.51		
1961	76.10		
1962	19.00		
1963	168.93		
1964	93.90		
1965	8.49		
1966	51.41		
1967	3.95		
1968	5.19		
1969	9.79		
1970	0.66		
1971	0.24		
1972	0.96		2058690
1973	12.73		4668008
1974	8.62		3886135
1975	2.97		4828718
1976	10.07		4858871
1977	5.10		925473
1978	6.20		3184579
1979	12.23		5245061
1980	1.55	3981	5473224
1981	1.10	5325	7134107
1982	2.34	21253	1973245
1983	376.59	20563	1526942
1984	15.95	10059	7306312
1985	98.18	6983	3247226
1986	5.42	8641	3359654
1987	15.46	6175	5047012
1988	26.07	8495	3539141
1989	72.57	17646	4364707
1990	109.44	9157	3120536
1991	313.11	7117	3594934
1992	371.62	5288	4452452
1993	115.13	7312	5221402
1994	39.47	9645	4321617
1995	19.60	28832	3933811
1996	58.60	45399	3950114
1997	34.87	28036	3101805
1998	258.97	20957	3058022
1999	180.82	36071	3160861
2000	65.35	57311	2173242
2001	40.42	47299	4400312
2002	399.29	50983	6770497
2003	161.72	33599	3656264
2004	293.72	19482	4865420
2005	56.33	7217	7600021
2006	67.44	3937	7735634
2007	22.37	4718	4742898
2008	18.92	5005	4626598
2009	42.18	15887	3294467
2010	5.44	24594	4731644
2011	11.87	24594	3887096

[1]age 0 in billions, [2]age 1 in millions, [3]age 0 in thousands

Table A4. Biomass (in million tons) of fish components in the Norwegian Sea. Data for herring (1988 onwards), mackerel and blue whiting are taken from the 2012 ICES assessments while saithe and beaked redfish data are taken from the 2013 assessments. Herring data for the period 1907–1987 are taken from Toresen and Østvedt 2000.

Year	Herring	Blue whiting	Mackerel	Beaked redfish	Saithe
1907	1.58				
1908	2.05				
1909	2.74				
1910	3.94				
1911	4.64				
1912	4.61				
1913	4.23				
1914	3.78				
1915	3.35				
1916	3.14				
1917	3.06				
1918	3.11				
1919	3.11				
1920	2.22				
1921	2.45				
1922	3.12				
1923	4.22				
1924	5.64				
1925	6.92				
1926	7.97				
1927	9.26				
1928	10.78				
1929	12.50				
1930	13.52				
1931	13.75				
1932	13.19				
1933	12.02				
1934	11.27				
1935	10.18				
1936	10.97				
1937	10.81				
1938	9.95				
1939	8.76				
1940	9.13				
1941	8.69				
1942	11.74				
1943	14.01				
1944	15.64				
1945	16.19				
1946	14.38				
1947	13.89				
1948	12.98				
1949	13.09				
1950	13.98				
1951	12.44				
1952	11.48				
1953	10.61				
1954	9.45				
1955	10.22				
1956	11.74				
1957	10.13				
1958	9.28				

1959	7.35				
1960	5.82				
1961	4.23				
1962	3.47				
1963	2.64				
1964	2.80				
1965	3.07				
1966	2.60				
1967	1.15				0.15
1968	0.22				0.13
1969	0.08				0.14
1970	0.03				0.19
1971	0.01				0.22
1972	0.00				0.23
1973	0.07				0.26
1974	0.09				0.25
1975	0.09				0.28
1976	0.15				0.29
1977	0.28				0.26
1978	0.35				0.26
1979	0.69				0.19
1980	0.47		1.99		0.17
1981	0.50	3.42	2.00		0.15
1982	0.50	2.82	1.94		0.13
1983	0.57	3.08	2.25		0.10
1984	0.59	3.36	2.28		0.07
1985	0.49	3.48	2.21		0.07
1986	0.41	3.23	2.25		0.05
1987	1.03	2.77	2.26		0.06
1988	2.05	2.38	2.26		0.04
1989	3.33	2.40	2.34		0.03
1990	3.91	2.43	2.22		0.03
1991	3.81	3.15	2.47		0.04
1992	3.89	3.66	2.49	0.13	0.04
1993	3.83	3.53	2.32	0.17	0.06
1994	3.96	3.35	2.13	0.22	0.06
1995	3.92	3.34	2.28	0.26	0.04
1996	4.41	3.75	2.26	0.25	0.03
1997	5.64	5.51	2.33	0.30	0.03
1998	6.34	6.99	2.24	0.35	0.04
1999	6.47	7.42	2.28	0.44	0.06
2000	5.51	7.38	2.07	0.54	0.10
2001	4.49	9.07	2.03	0.48	0.15
2002	3.95	10.05	1.69	0.60	0.17
2003	4.90	12.08	1.68	0.69	0.15
2004	6.16	10.69	1.72	0.69	0.12
2005	6.31	8.61	2.11	0.76	0.12
2006	6.65	7.95	2.26	0.71	0.15
2007	7.49	6.00	2.49	0.87	0.16
2008	8.08	4.51	2.76	0.79	0.17
2009	9.05	3.56	3.11	0.91	0.17
2010	8.33	3.93	2.97	0.81	0.17
2011	7.06	4.83	3.04	0.79	0.19
2012	6.14	6.31	2.68	0.75	0.15

Table A5. Herring. Weight at age in the stock (kg).

	AGE															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1950	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1951	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1952	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1953	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1954	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1955	0.001	0.008	0.047	0.100	0.195	0.213	0.260	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1956	0.001	0.008	0.047	0.100	0.205	0.230	0.249	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1957	0.001	0.008	0.047	0.100	0.136	0.228	0.255	0.262	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1958	0.001	0.008	0.047	0.100	0.204	0.242	0.292	0.295	0.293	0.305	0.315	0.330	0.340	0.345	0.352	0.363
1959	0.001	0.008	0.047	0.100	0.204	0.252	0.260	0.290	0.300	0.305	0.315	0.325	0.330	0.340	0.345	0.358
1960	0.001	0.008	0.047	0.100	0.204	0.270	0.291	0.293	0.321	0.318	0.320	0.344	0.349	0.370	0.379	0.378
1961	0.001	0.008	0.047	0.100	0.232	0.250	0.292	0.302	0.304	0.323	0.322	0.321	0.344	0.357	0.363	0.368
1962	0.001	0.008	0.047	0.100	0.219	0.291	0.300	0.316	0.324	0.326	0.335	0.338	0.334	0.347	0.354	0.358
1963	0.001	0.008	0.047	0.100	0.185	0.253	0.294	0.312	0.329	0.327	0.334	0.341	0.349	0.341	0.358	0.375
1964	0.001	0.008	0.047	0.100	0.194	0.213	0.264	0.317	0.363	0.353	0.349	0.354	0.357	0.359	0.365	0.402
1965	0.001	0.008	0.047	0.100	0.186	0.199	0.236	0.260	0.363	0.350	0.370	0.360	0.378	0.387	0.390	0.394
1966	0.001	0.008	0.047	0.100	0.185	0.219	0.222	0.249	0.306	0.354	0.377	0.391	0.379	0.378	0.361	0.383
1967	0.001	0.008	0.047	0.100	0.180	0.228	0.269	0.270	0.294	0.324	0.420	0.430	0.366	0.368	0.433	0.414
1968	0.001	0.008	0.047	0.100	0.115	0.206	0.266	0.275	0.274	0.285	0.350	0.325	0.363	0.408	0.388	0.378
1969	0.001	0.008	0.047	0.100	0.115	0.145	0.270	0.300	0.306	0.308	0.318	0.340	0.368	0.360	0.393	0.397
1970	0.001	0.008	0.047	0.100	0.209	0.272	0.230	0.295	0.317	0.323	0.325	0.329	0.380	0.370	0.380	0.391
1971	0.001	0.015	0.080	0.100	0.190	0.225	0.250	0.275	0.290	0.310	0.325	0.335	0.345	0.355	0.365	0.390
1972	0.001	0.010	0.070	0.150	0.150	0.140	0.210	0.240	0.270	0.300	0.325	0.335	0.345	0.355	0.365	0.390
1973	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.404	0.461	0.520	0.534	0.500	0.500	0.500	0.500
1974	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1975	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433
2004	0.001	0.010	0.055	0.106	0.149	0.212	0.241	0.279	0.302	0.337	0.354	0.355	0.360	0.371	0.400	0.429
2005	0.001	0.010	0.046	0.112	0.156	0.234	0.267	0.295	0.330	0.363	0.377	0.414	0.406	0.308	0.420	0.452
2006	0.001	0.010	0.042	0.107	0.179	0.232	0.272	0.297	0.318	0.371	0.365	0.393	0.395	0.399	0.415	0.428
2007	0.001	0.010	0.036	0.086	0.155	0.226	0.265	0.312	0.310	0.364	0.384	0.352	0.386	0.304	0.420	0.412
2008**	0.001	0.010	0.044	0.077	0.146	0.212	0.269	0.289	0.327	0.351	0.358	0.372	0.411	0.353	0.389	0.393
2009***	0.001	0.010	0.044	0.077	0.141	0.215	0.270	0.306	0.336	0.346	0.364	0.369	0.411	0.353	0.389	0.393
2010****	0.001	0.01	0.044	0.077	0.188	0.22	0.251	0.286	0.308	0.333	0.344	0.354	0.373	0.353	0.389	0.393
2011	0.001	0.01	0.044	0.118	0.185	0.209	0.246	0.277	0.310	0.322	0.339	0.349	0.364	0.363	0.389	0.393
2012	0.001	0.01	0.044	0.138	0.185	0.256	0.273	0.290	0.305	0.330	0.342	0.361	0.390	0.377	0.389	0.393

**** mean weight at ages 11 and 13 are mean of 5 previous years at the same age. These age groups were not present in the catches of the wintering survey from which the stock weight are derived.**

***** derived from catch data from the wintering area north of 69°N during December 2008 – January 2009 for age groups 4–11.**

******derived from catch data from the wintering area north of 69°N during January 2010 for age groups 4–12**

Table A6. Blue whiting. Weight at age in catch (kg) (assumed equal to weights in stock).

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1981	0.052	0.065	0.103	0.125	0.141	0.155	0.170	0.178	0.187	0.213
1982	0.045	0.072	0.111	0.143	0.156	0.177	0.195	0.200	0.204	0.231
1983	0.046	0.074	0.118	0.140	0.153	0.176	0.195	0.200	0.204	0.228
1984	0.035	0.078	0.089	0.132	0.153	0.161	0.175	0.189	0.186	0.206
1985	0.038	0.074	0.097	0.114	0.157	0.177	0.199	0.208	0.218	0.237
1986	0.040	0.073	0.108	0.130	0.165	0.199	0.209	0.243	0.246	0.257
1987	0.048	0.086	0.106	0.124	0.147	0.177	0.208	0.221	0.222	0.254
1988	0.053	0.076	0.097	0.128	0.142	0.157	0.179	0.199	0.222	0.260
1989	0.059	0.079	0.103	0.126	0.148	0.158	0.171	0.203	0.224	0.253
1990	0.045	0.07	0.106	0.123	0.147	0.168	0.175	0.214	0.217	0.256
1991	0.055	0.091	0.107	0.136	0.174	0.190	0.206	0.23	0.232	0.266
1992	0.057	0.083	0.119	0.140	0.167	0.193	0.226	0.235	0.284	0.294
1993	0.066	0.082	0.109	0.137	0.163	0.177	0.200	0.217	0.225	0.281
1994	0.061	0.087	0.108	0.137	0.164	0.189	0.207	0.217	0.247	0.254
1995	0.064	0.091	0.118	0.143	0.154	0.167	0.203	0.206	0.236	0.256
1996	0.041	0.080	0.102	0.116	0.147	0.170	0.214	0.23	0.238	0.279
1997	0.047	0.072	0.102	0.121	0.140	0.166	0.177	0.183	0.203	0.232
1998	0.048	0.072	0.094	0.125	0.149	0.178	0.183	0.188	0.221	0.248
1999	0.063	0.078	0.088	0.109	0.142	0.170	0.199	0.193	0.192	0.245
2000	0.057	0.075	0.086	0.104	0.133	0.156	0.179	0.187	0.232	0.241
2001	0.050	0.078	0.094	0.108	0.129	0.163	0.186	0.193	0.231	0.243
2002	0.054	0.074	0.093	0.115	0.132	0.155	0.173	0.233	0.224	0.262
2003	0.049	0.075	0.098	0.108	0.131	0.148	0.168	0.193	0.232	0.258
2004	0.042	0.066	0.089	0.102	0.123	0.146	0.160	0.173	0.209	0.347
2005	0.039	0.068	0.084	0.099	0.113	0.137	0.156	0.166	0.195	0.217
2006	0.049	0.072	0.089	0.105	0.122	0.138	0.163	0.19	0.212	0.328
2007	0.050	0.064	0.091	0.103	0.115	0.130	0.146	0.169	0.182	0.249
2008	0.055	0.075	0.100	0.106	0.120	0.133	0.146	0.16	0.193	0.209
2009	0.056	0.085	0.105	0.119	0.124	0.138	0.149	0.179	0.214	0.251
2010	0.052	0.064	0.110	0.154	0.154	0.163	0.175	0.187	0.200	0.272
2011	0.055	0.079	0.107	0.136	0.169	0.169	0.179	0.189	0.214	0.270

Table A7. Mackerel. Weight at age in stock (kg).

	Age										
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1972	0.132	0.178	0.243	0.411								
1973	0.132	0.177	0.242	0.301	0.438							
1974	0.13	0.173	0.238	0.296	0.322	0.469						
1975	0.129	0.171	0.236	0.294	0.318	0.365	0.497					
1976	0.128	0.17	0.236	0.293	0.318	0.365	0.419	0.512				
1977	0.127	0.167	0.233	0.289	0.313	0.361	0.416	0.446	0.53			
1978	0.111	0.175	0.238	0.3	0.346	0.382	0.41	0.432	0.451	0.514		
1979	0.11	0.174	0.237	0.299	0.345	0.38	0.408	0.43	0.449	0.504	0.516	
1980	0.109	0.173	0.236	0.297	0.343	0.379	0.407	0.429	0.448	0.503	0.508	0.518
1981	0.087	0.186	0.252	0.313	0.323	0.378	0.419	0.434	0.449	0.443	0.523	0.531
1982	0.086	0.135	0.221	0.28	0.385	0.353	0.408	0.437	0.446	0.479	0.526	0.534
1983	0.086	0.172	0.235	0.28	0.339	0.377	0.404	0.439	0.503	0.473	0.555	0.563
1984	0.081	0.194	0.253	0.295	0.324	0.393	0.436	0.441	0.479	0.52	0.51	0.55
1985	0.085	0.165	0.293	0.306	0.341	0.384	0.43	0.459	0.468	0.559	0.579	0.607
1986	0.077	0.179	0.267	0.304	0.356	0.351	0.416	0.473	0.443	0.468	0.497	0.575
1987	0.078	0.148	0.24	0.286	0.374	0.386	0.411	0.429	0.482	0.499	0.47	0.549
1988	0.072	0.156	0.237	0.301	0.329	0.423	0.445	0.432	0.455	0.522	0.589	0.632
1989	0.076	0.177	0.244	0.306	0.352	0.38	0.429	0.474	0.457	0.466	0.51	0.595
1990	0.074	0.138	0.222	0.287	0.339	0.373	0.414	0.409	0.437	0.514	0.523	0.529
1991	0.075	0.155	0.23	0.307	0.357	0.409	0.432	0.502	0.541	0.566	0.566	0.594
1992	0.078	0.212	0.259	0.31	0.362	0.402	0.424	0.462	0.487	0.522	0.552	0.583
1993	0.078	0.197	0.268	0.315	0.36	0.416	0.454	0.465	0.484	0.511	0.585	0.577
1994	0.079	0.178	0.237	0.301	0.361	0.413	0.466	0.47	0.483	0.55	0.608	0.584
1995	0.081	0.164	0.267	0.326	0.398	0.448	0.491	0.508	0.546	0.514	0.619	0.639
1996	0.076	0.133	0.251	0.317	0.366	0.444	0.462	0.501	0.565	0.573	0.611	0.632
1997	0.076	0.186	0.228	0.296	0.361	0.402	0.445	0.478	0.519	0.537	0.532	0.585
1998	0.077	0.149	0.223	0.285	0.342	0.4	0.426	0.466	0.502	0.549	0.524	0.58
1999	0.081	0.194	0.242	0.301	0.353	0.396	0.423	0.44	0.485	0.498	0.465	0.565
2000	0.074	0.185	0.235	0.289	0.35	0.39	0.426	0.447	0.485	0.492	0.532	0.544
2001	0.078	0.164	0.241	0.342	0.39	0.446	0.459	0.499	0.529	0.576	0.603	0.586
2002	0.078	0.181	0.239	0.311	0.364	0.411	0.436	0.462	0.5	0.522	0.533	0.565
2003	0.074	0.181	0.273	0.316	0.371	0.446	0.446	0.475	0.584	0.527	0.599	0.61
2004	0.059	0.138	0.246	0.313	0.355	0.412	0.463	0.462	0.508	0.52	0.538	0.59
2005	0.074	0.168	0.238	0.336	0.381	0.401	0.481	0.501	0.55	0.55	0.576	0.59
2006	0.076	0.178	0.228	0.297	0.345	0.391	0.436	0.458	0.517	0.523	0.578	0.614
2007	0.064	0.169	0.225	0.277	0.308	0.363	0.439	0.448	0.498	0.517	0.542	0.565
2008	0.071	0.157	0.198	0.27	0.323	0.339	0.413	0.431	0.457	0.463	0.506	0.531
2009	0.071	0.174	0.221	0.268	0.317	0.359	0.395	0.449	0.46	0.517	0.551	0.545
2010	0.071	0.15	0.211	0.254	0.299	0.351	0.393	0.414	0.445	0.484	0.552	0.571
2011	0.071	0.188	0.244	0.272	0.341	0.362	0.372	0.406	0.43	0.488	0.526	0.547

Table A8. Mean lengths at age (length) for herring, blue whiting and mackerel. The standard errors (std) and number of samples (N) are included.

	Herring				Blue whiting			Mackerel		
Year	Length	std	N	Growth	Length	std	N	Length	std	N
1982	34.72	1.07	559	0.79	32.53	2.28	327	36.85	2.71	101
1983	34.35	1.25	337	1.05	32.6	1.99	78	37.7	2.54	10
1984	33.93	1.22	572	1.27	32.74	1.71	187	37	1.78	13
1985	34.18	0.97	1153	0.52	31.88	1.48	49	36.09	2.13	53
1986	33.41	1.3	139	1.11	33.2	1.72	27	36.07	1.97	311
1987	33.37	1.43	79	1.33	30.73	2.74	15	37.27	1.61	124
1988	32.23	1.4	86	1.02	29.53	2.37	32	36.94	2.28	17
1989	31.67	0.93	2757	1.28	31.65	2.01	68	36.67	1.63	24
1990	32.51	1.45	75	1.3	32.13	2.3	60	35.56	1.67	84
1991	33.43	1.06	261	0.85	31.86	1.93	156	35.96	1.91	108
1992	32.73	1.63	77	2.48	32.96	2.24	66	36.25	1.52	84
1993	34.01	0.88	90	1.06	33.43	2.75	68	36.44	1.65	186
1994	33.57	1.34	555	0.67	32.98	1.87	31	36.61	1.45	238
1995	32.73	1.21	3228	0.74	31.98	2.04	218	37.25	1.68	141
1996	31.74	1.09	2588	0.97	31.9	2	176	36.44	1.54	103
1997	30.88	1.17	2970	1.07	31.69	2.02	53	35.97	1.52	187
1998	30.99	1	6001	1.34	32.84	2.2	22	36.67	1.31	148
1999	31.48	1	1169	0.95	31.29	2.21	12	36.6	1.4	236
2000	32.38	1.36	337	0.89	31.19	1.74	59	35.98	1.57	152
2001	32.48	1.43	41	0.83	30.73	2.79	47	36.76	1.51	328
2002	32.09	1.14	750	1.14	30.6	1.9	37	36.81	1.74	103
2003	32.26	1.02	313	0.94	30.68	1.91	194	37.27	1.4	124
2004	31.79	1.18	1432	0.83	30.89	2.32	101	37.29	1.63	115
2005	31.76	1.12	1283	0.99	29.85	2.48	188	35.86	1.94	80
2006	31.95	1.05	204	0.49	29.34	2.3	189	36.85	1.46	27
2007	31.51	1.15	103	1.09	28.83	1.88	321	36.6	1.77	299
2008	31.35	1.12	1569	0.81	29.2	1.95	134	36.42	1.53	299
2009	30.99	1.17	280	1.19	29.94	1.33	88	35.73	1.69	99
2010	30.84	1.16	1152	1.19	30.04	2.09	28	35.55	1.78	29
2011	30.75	1.18	89		32.2	0.97	5	34.6	1.25	45
2012	31.41	1.29	319		32.5	2.06	38	34.77	1.24	189
2013	32.32	1.01	113		33.68	2.49	193	34.56	1.48	153

Table A9. Development in breeding pairs of seabirds along the Norwegian Sea.

Year	Atlantic Puffin	Kitiwake	Guillemots
1980	1519084	257202	129146
1981	1612170	240492	129645
1982	1552096	229685	115262
1983	1263631	230062	130389
1984	1000037	168624	115108
1985	881297	197241	99765
1986	779978	138858	84397
1987	646616	135702	69028
1988	653708	206421	61854
1989	932772	192105	70087
1990	962526	183971	58618
1991	900624	161114	62154
1992	965057	159925	64718
1993	913565	153890	68837
1994	911609	148635	71255
1995	956026	140753	72299
1996	902370	140282	62434
1997	1027844	133415	61324
1998	953807	122745	74628
1999	973941	117931	78751
2000	960085	112982	101004
2001	852154	92230	47621
2002	859223	84697	52918
2003	922870	72562	43680
2004	837704	60313	16719
2005	800000	80000	5000
2006	810102	72930	10139
2007	842005	60918	1947
2008	723647	58077	426
2009	564353	57567	1103
2010	643396	52690	814
2011	567959	52428	878
2012	373847	57726	645

Annex 4: WGINOR terms of reference for the next meeting

WGINOR have been given three years terms of references as given below, and will continue to work on these in 2014.

WGINOR will meet in Torshavn, Faroese Islands, 18–22 August 2014.

Supporting information

Priority	WGINOR aims to conduct and further develop Integrated Ecosyste Assessments for the Norwegian Sea, as a step towards implementing th ecosystem approach.
Scientific justification	**Term of Reference a)** There are a range of different approaches to performing integrated ecosystem assessments. We will develop an approach for the WGINOR that is based on the state of the art. This will be done with input from the other regaional seas and based on the developments at WKBEMIA in November 2012. **Term of Reference b)** There have been international fish-plankton centred surveys in the Norwegian Sea in May and since the mid 90s. In the most recent years these surveys have transitioned into ecosystem surveys that caputure most of the key components of the ecosystem. These data sets are a firm foundation for undertaking integrated assessment of ecosystem status in the Norwegaian Sea which is yet to be done. A fairly recent book on the Norwegian Sea ecosystem is a good starting point for the assessment. **Term of Reference c)** At present a multispecies fisheries model and an end to end ecosystem model are being set up for the Norwegian Sea. These models are ideal for investigating the effects of existing single species and alternative multispecies harvest control rules on the ecosystem structure and functioning. Although there is some petroleum exploration in the outskirts of the Norwegian Sea, fishing by far represents the most important antropognic impact on this ecosystem. The model analyses will be an integrated part of the assessment. **Term of Reference d)** In traditional single stock assessment it is not required to have an absolute abundance estimate,. However, when addressing multispecies interactions and carrying capacities of different trophic levels in ecosystems it becomes important to establish absolute abundance levels for the different components in order to quantify the combined effect of consumption and flows between the different trophic levels. WGINOR will therefore put an effort on providing estimates for absolute abundace of the key components in the Norwegian Sea ecosystem. This work will be based on tagging data and catch based summer surveys. **Term of Reference e)** The survey and sampling strategy should be closely related to the integrated assessment. ToR e will be deveted to developing an overview of sampling requirements for integrated ecosystem assessment. This list will be developed in dialogue with WGIPS and the final spesification will be reported to this group which has competance on survey sampling strategy. **Term of Refrence f)** The ecosystem overview is required by ACOM to help provide ecosystem inpu to the assessment working groups, it will alos be used to head up the advice. Sections 1, 2 and 3 of the WKECOVER overview template relate to: 1. the description of the management area (mostly a map and very little text, w create the map in the ICES secretariat) 2. the key main drivers that impact advice in the ecosystem

	3. the activities and pressures in the region.
Resource requirements	Several national and international research projects support the activiti indicated and no further resources are needed in the short term. In the lor term the group should try to develop an integrated project
Participants	We expect around 15 people to attend.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisoi committees	It is very important to link this group to ACOM and ensure cooperatic between science and advice.
Linkages to oth committees or groups	There are linkages to the other regional seas programmes and WPIPS whic is the survey planning group and WGWIDE where the stock assessment f the key pelagic Norwegian Sea stocks is performed. A preliminary report w be sent to WGWIDE which will meet shortly after WGINOR.
Linkages to oth organizations	No recognised links.

Annex 5: Recommendations

No recommendations given.

Annex 6: State of ecosystem components

A6.1 Climate and hydrography

The Norwegian Sea, the Greenland Sea and the Iceland Sea comprise the Nordic Seas, which are separated from the rest of the North Atlantic by the Greenland– Scotland Ridge (Figure 2). The Norwegian Sea consists of two deep basins, the Norwegian Basin and the Lofoten Basin, and is separated from the Greenland Sea to the north by the Mohn Ridge. To the west, the basin slope forms the transition to the somewhat shallower Iceland Sea. The upper ocean of the Nordic Seas consists of warm and saline Atlantic water to the east, and cold and fresh Polar water from the Arctic to the west.

The Norwegian and Barents seas are transition zones for warm and saline waters on their way from the Atlantic to the Arctic Ocean. The major current, the Norwegian Atlantic Current (NwAC), is a poleward extension of the Gulf Stream and the North Atlantic Current, that acts as a conduit for warm and saline Atlantic Water from the North Atlantic to the Barents Sea and Arctic Ocean (Polyakov *et al.* 2005). As Figure 2 shows, the North Atlantic Current splits into two branches in the eastern North Atlantic before entering the Norwegian Sea over the Iceland–Faeroe Ridge close to the eastern coast of Iceland, and through the Faeroe–Shetland Channel close to Shetland (Orvik and Niiler 2002). The water then continues in two branches through the entire Norwegian Sea toward the Arctic Ocean (Orvik and Niiler 2002). The western branch is a jet associated with the Arctic Front. It tends to feed the interior of the Norwegian Sea via several recirculation branches. The eastern branch, known as the Norwegian Atlantic Slope Current (NwASC), is an approximately 3500 km long, nearly barotropic shelf edge current flowing along the Norwegian shelf break, that tends to flow into the Barents Sea and Arctic Ocean. The NwASC is thus the major link between the North Atlantic, and the Barents Sea and Arctic Ocean.

The large-scale atmospheric circulation changes influence the currents and hydrographic conditions. Since the 1960s, changes in the large-scale wind pattern, principally the North Atlantic Oscillation (NAO), have resulted in a gradual change of the water mass distribution in the Nordic Seas. In particular, this is manifested by the development of a layer of Arctic intermediate waters, deriving from the Greenland and Iceland Seas and spreading over the entire Norwegian Sea (Blindheim *et al.* 2000). In the Norwegian Basin it has resulted in an eastward shift of the Arctic front and, accordingly, an upper layer cooling in wide areas due to increased Arctic influence. Blindheim *et al.* (2000) also found that the westward extent of Atlantic water in the Norwegian Sea was less during the high phase of the North Atlantic Oscillation than during the low phase, with the difference between its broadest recorded extent in 1968 and its narrowest extent in 1993 exceeding 300 km. This implies that a stronger cyclonic atmospheric circulation pattern would move the surface waters to the east. This would decrease the area of Atlantic water and thus reduce ocean-to-air heat loss.

Data series

The selected indices chosen to resolve key aspects of the ocean variability in the Norwegian Sea are presented in table A1 in Annex 3.

The **North Atlantic Oscillation Winter Index** (Hurrell 1995) to a large degree captures the strength of the westerlies in the Norwegian Sea. A positive NAO give a stronger Slope Current (Skagseth *et al.*, 2004), and an eastward contraction of the Atlantic Water extent (Blindheim *et al.*, 2000; Mork and Blindheim, 2001). Data from http://climatedataguide.ucar.edu/guidance/hurrell-north-atlantic-oscillation-nao-index-station-based.

The Sup-polar gyre index: Represents strength of the cyclonic circulation in the western North Atlantic. A weak gyre (positive gyre index) means a weaker and warmer gyre, and associated warmer and more slaine Atlantic Water inflow to the Norwegian Sea (e.g. Hatun *et al.* 2005). Data: Satellite sea surface height data, data available on internet. 1993–2012 (1 year delay). Source aviso.oceanobs.com

East Greenland Current pressure differences: Atmospheric pressure differences along the East Greenland Current, representing the northerly wind, are found of main importance for the relative importance of Arctic Water in the Norwegian Sea (Blindheim *et al.*, 2000). Estimated using the NCEP/NCAR monthly gridded MSLP data. 1948-present.

Source: http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html

The wind stress curl in the Norwegian – Lofoten Basin: The area integrated wind stress curl over the 2000m depth contour defining these basins are the key forcing spinning up the cyclonic gyre circulation (e.g. Mork and Skagseth, 2005) with a clear winter amplification.). Estimated using the NCEP/NCAR 6-hourly gridded wind-stress data. 1948-present.

Source: http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html

Hydrography in Svinøy section: The properties of the Atlantic Water that enters the Norwegian Sea is captured in this section occupied about 4–6 times per year. From these data we define indicies for core temperature and salinity, and area of Atlantic water defined as $S > 35$ (Mork and Blindheim, 2001). Source: www.imr.no

Habitat area of the main pelagic species: Based on the gridded annual hydrographic data during spring we estimate the suitable habitat area for a) Norwegian Spring Spawning Herring ($T > 2$, and depth range [25–100]m, b) Blue Whiting ($T > 1$, and depth range [150–400]m, and 3) Mackrel ($T > 6$, and depth range [10–100]m. Source: PGNAPES and ARGO, ++. Period: annually 1995 to present

East Icelandic Current index: The strength of the East Icelandic Current into the Southern Norwegian Sea is represented by the area in the southern Norwegian Sea occupied with water with $S < 34.9$ in the depth range 150–300m based on the gridded annual hydrographic data during spring since 1995. Source: PGNAPES and ARGO, ++. Period: annually 1995 to present. Table of the data is given in Table A.1 in Annex 3.

State and recent trends

The NAO-index during the last 10 years shows year to year variability but signals that extend over consecutive years appear not prominent compared to earlier periods (Figure 3). The wind conditions along the East Greenland Current have been remarkable stable over the period 2003–13 (Figure 4). The Sub-polar gyre index indicates a further weakening in 2010–11 (Figure 5 upper). The area of the Atlantic Water follow the changes in the NAO (Figure 5 middle), hence showing fluctuations from year to year. The gyre circulation index in the Norwegian-Lofoten basin has been rather stable the last 10 years (Figure 5 lower). The hydrographic conditions in the Svinøy section show that the transition toward warmer and more saline Atlantic water from 1995–2004 (Figure 6) is at least partly connected to the change in the SPG, but again indications of a decreasing trend during the last years. The habitat area for herring, blue whiting and mackerel in the Norwegian Sea show similar evolution and have increased from 1995 to a maximum in 2003–4 and subsequently a slight decrease but still relative high values (Figure 7). The hydrography indicates that the influence of the East Icelandic Current into the southern Norwegian Sea was strong in the late 1990s, and with generally low values over the last 10 years (Figure 8).

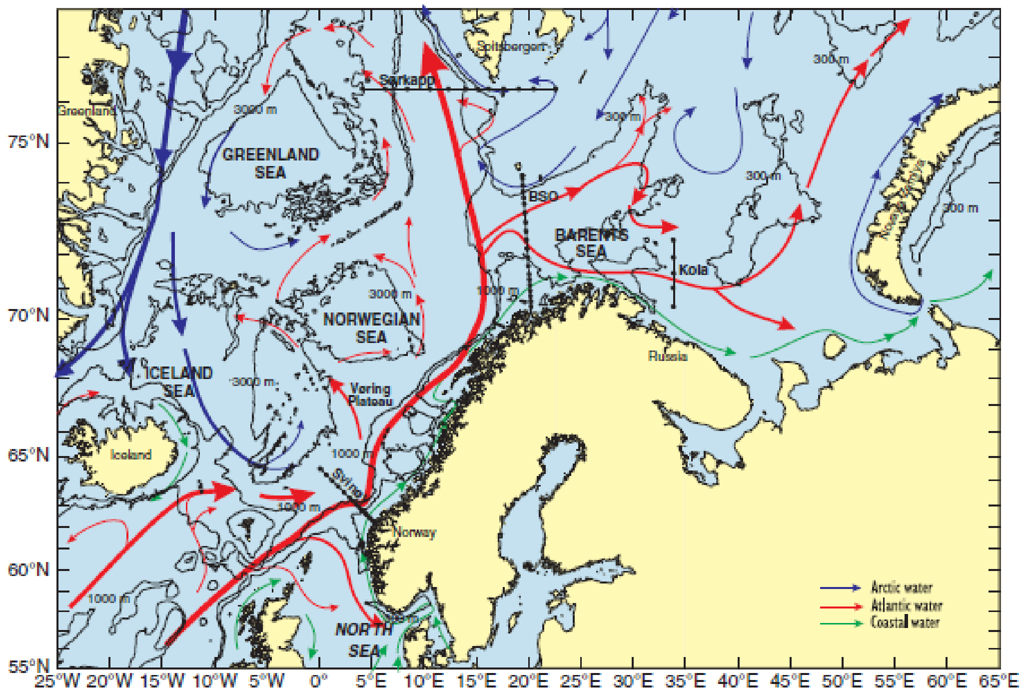


Figure 2. Schematic of surface currents in the Norwegian Sea where red arrows represent warm Atlantic Water and blue arrows denote Polar Water.

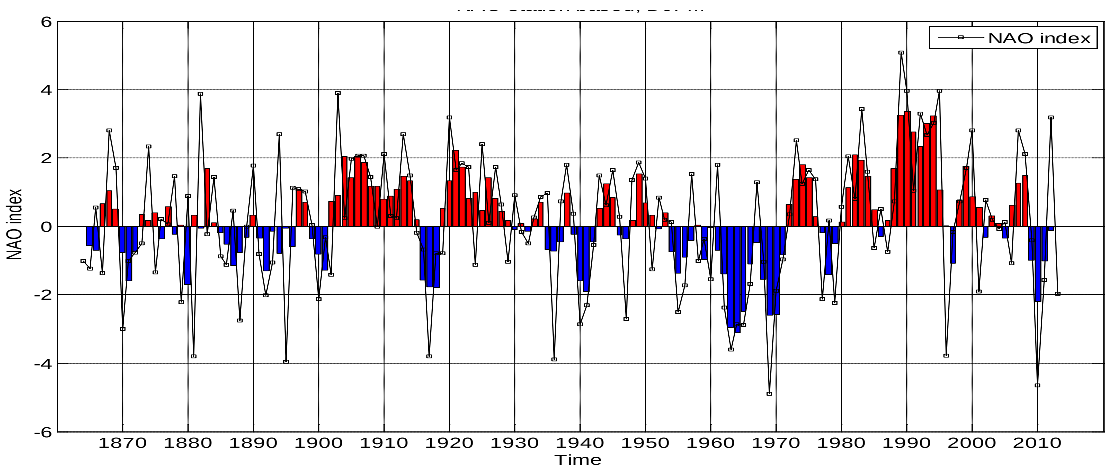


Figure 3. The long-term climate evolution represented by the North Atlantic Oscillation winter index (Hurrell, 1995).

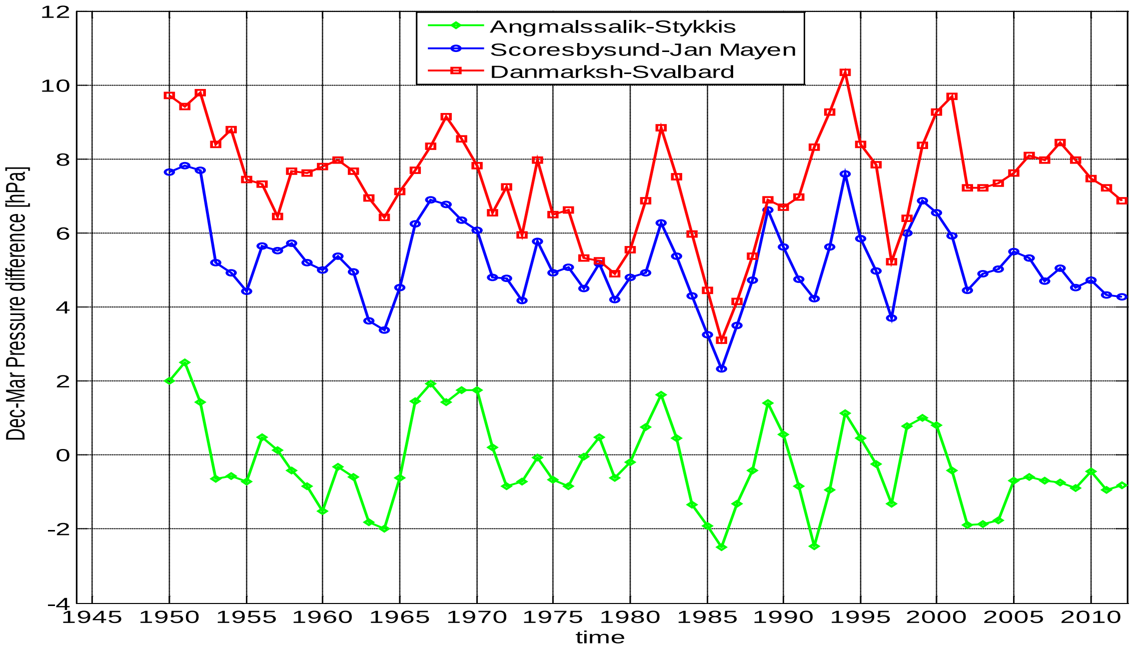


Figure 4. Pressure difference along the East Greenland Current.

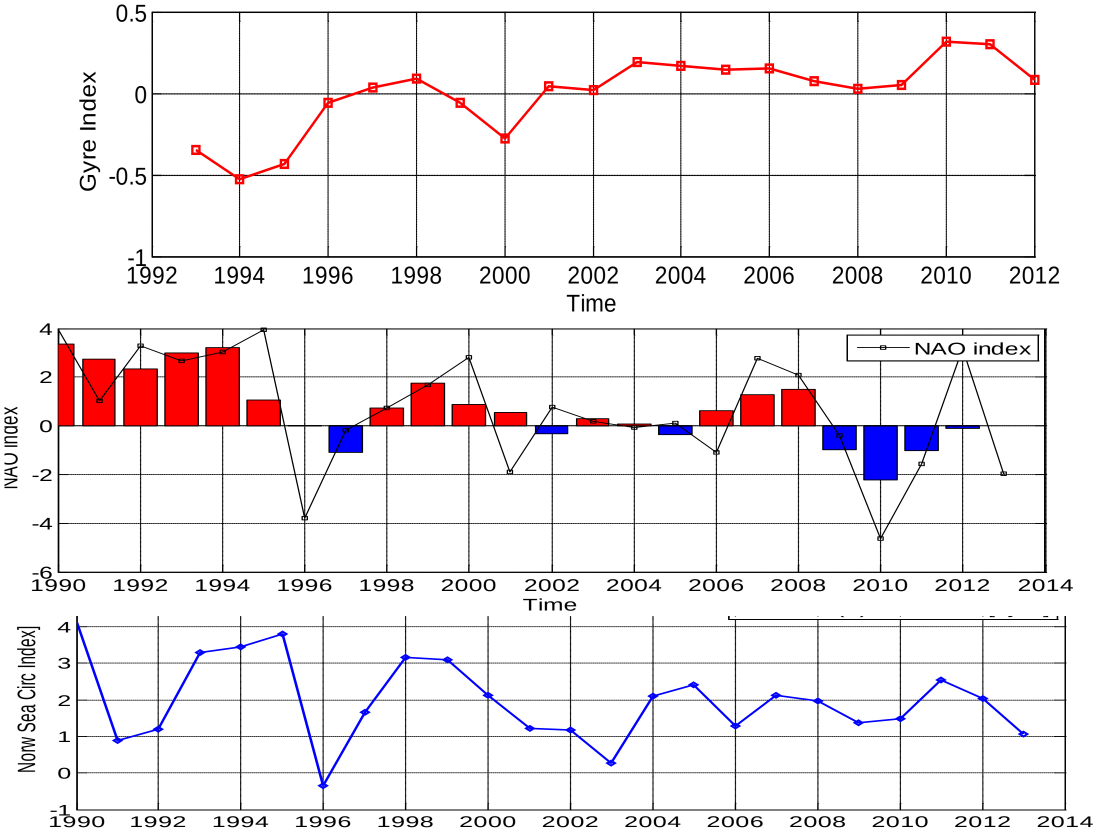


Figure 5. Upper) the sub-polar gyre index; middle) NAO-djfm index; lower) gyre circulation index in the Norwegian –Lofoten Basin.

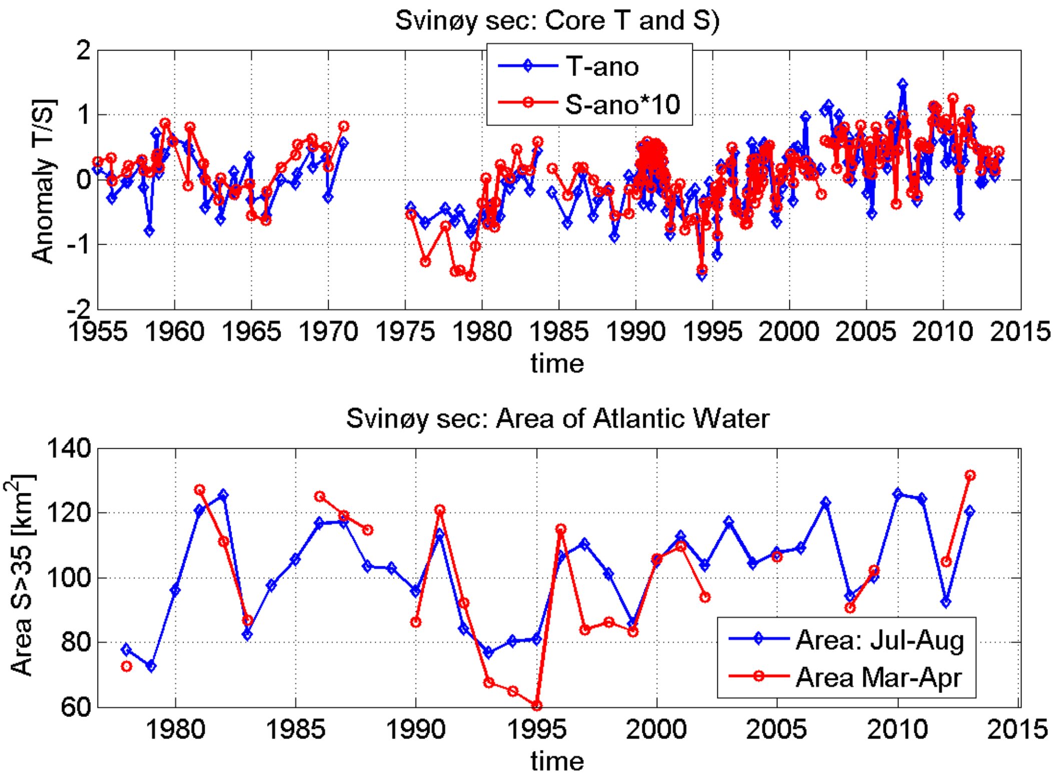


Figure 6. Upper Core Temperature and Salinity in the Svinøy section, and lower Area of Atlantic Water in the Svinøy section.

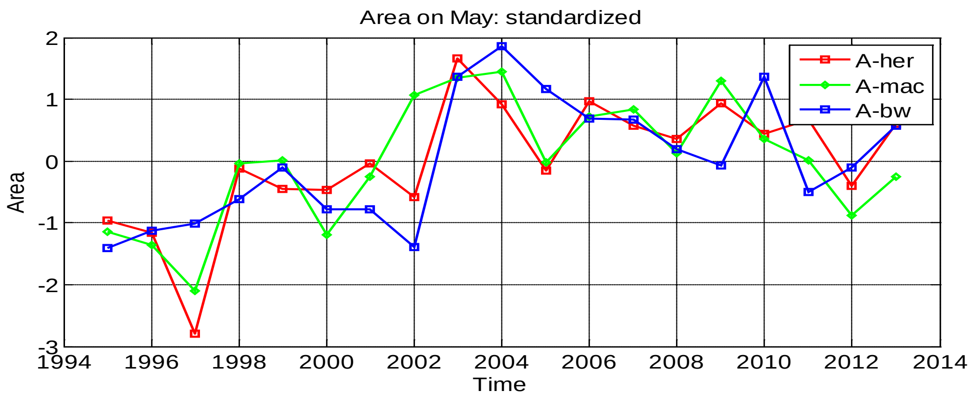


Figure 7. Suitable habitat area in km^2 for Herring, Blue Whiting and Mackerel.

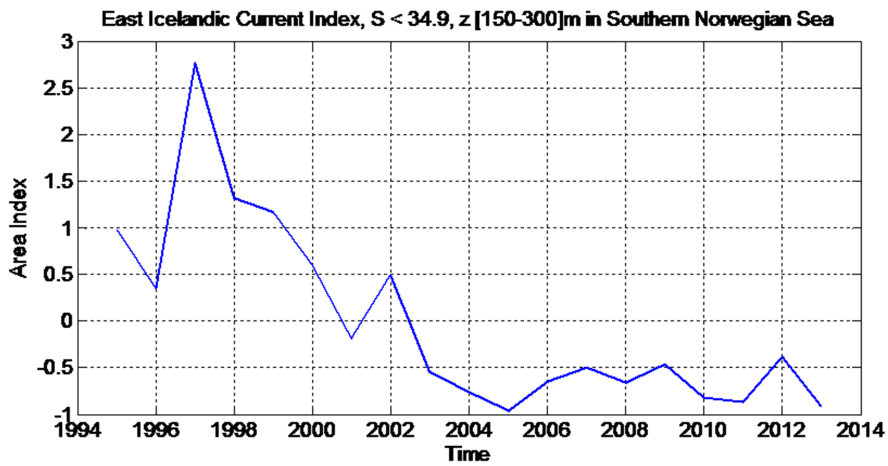


Figure 8. Area in km^2 occupied by water S<34.9 in the southern Norwegian Sea between 150–300m.

A6.2 Ocean chemistry

Nutrients such as nitrate, silicate, and phosphate in Atlantic Water masses typically peak early in spring (February-March) due to winter mixing processes. Therefore, we suggest that the data from this seasonal period are used for assessing the annual time-series (maximum values of the year). The high values observed in early spring are considered to represent, or be a proxy for, the potential for new phytoplankton production in the following months.

Data series

IMR holds a dataset representing depth-specific concentrations of various nutrients including nitrate, silicate, and phosphate for the Norwegian Sea. These data are collected by Norwegian vessels, generally from the early nineteen-nineties up to and including 2010. Nutrient collection and measurement is a standard procedure at most CTD stations, both during monitoring of transects (including "Svinøy" and "Gimsøy") and on regional cruises. The data made available to WGINOR were extracted from the IMR databases with the spatial area between 58 and 90 °N and between -20 and 30 °E. Data for the years 2011–2013 are not yet available from the Chemistry Department, but will be provided to WGINOR when ready.

State and recent trends

Francisco Rey (2012) presented between-year trends in spring (~ March) silicate levels for various monitoring sections as well as Ocean Weather Station Mike (St. M) for the period 1990–2010. There is a between-year trend of decreasing silicate concentrations in early spring (Figure 9). Rey also mentions decreases for nitrate, though much weaker. WGINOR has access to the nutrient data, and is therefore in a position in look into other possible nutrient trends in the Norwegian Sea, including the years to come.

Declining silicate concentrations in the Norwegian and Barents Seas

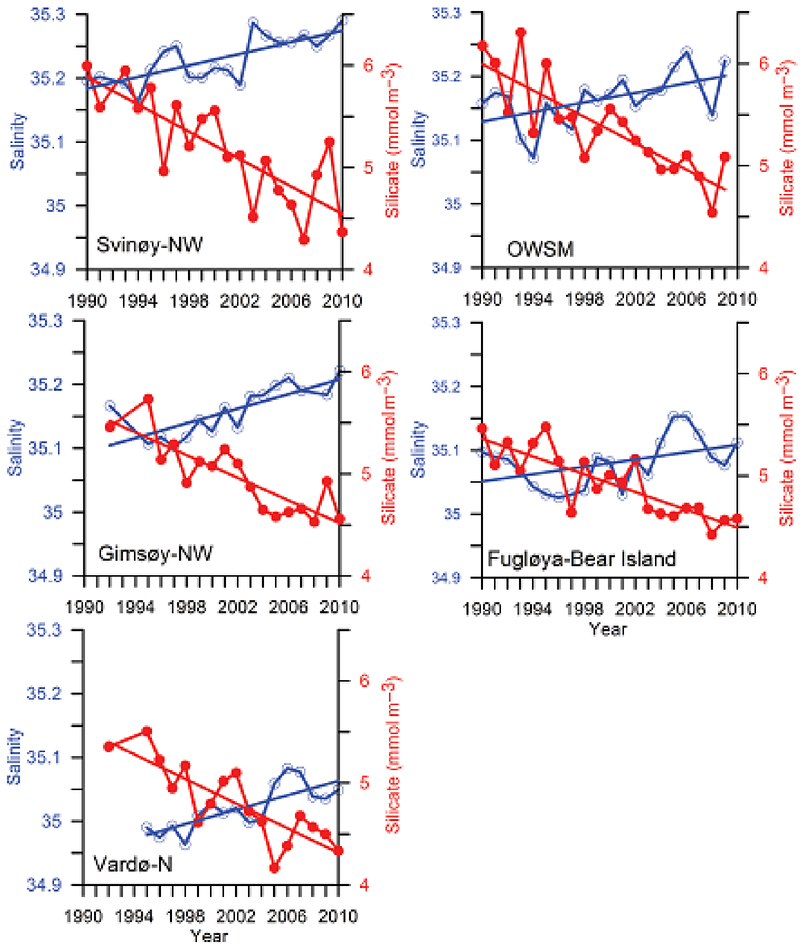


Figure 2. Time-series of salinity (open blue circles) and silicate (closed red circles) at different places in the Norwegian and Barents Seas. Locations of the sections are shown in Figure 1. Results of the regression analysis are shown in Table 1.

Figure 9. From Rey, 2012.

Ocean acidification

Regular monitoring of ocean acidification started in the Norwegian Sea in 2010. In addition, data from various research projects have been assembled, allowing for analyses of time-series going back to 1981.

Results from the monitoring show that there is large seasonal and spatial variation in pCO_2 and pH in the Norwegian Sea. Aragonite is an important carbonate material used by calcifying organism. Acidification of the oceans will cause saturation of aragonite to decrease, and degree of saturation of this mineral is therefore measured. Degree of saturation of aragonite decreases from the ocean surface, and at large depths undersaturation occurs. The depth where this happens is termed the saturation horizon. Both degree of saturation of aragonite and the saturation horizon varies in time and space in the Norwegian Sea.

Analyses of time-series from 1981 to present have been done for the Lofoten basin and the Norwegian basin. During the last 30 years, pH has decreased significantly in most water layers in both basins. Average decrease is 0,11 pH units in the Norwegian basin and 0,07 units in the Lofoten basin. This is similar to the average global decrease since the start of the industrial revolution. During the last 30 years, the saturation horizon for aragonite has increased slightly in the Norwegian basin while no increase has been detected in the Lofoten basin.

In addition to uptake of CO_2 from the atmosphere, a number of other factors may affect pH and carbon systems in the ocean, such as temperature, salinity and alkalinity. Analyses have therefore been performed to disentangle the influence of atmospheric CO_2. The results show that increased uptake of atmospheric CO_2 is the most important factor in the Norwegian Sea, explaining 50–90% of the changes in pH in the water.

A6.3 Phytoplankton

WGINOR considers chlorophyll *a* to be the most useful measure for phytoplankton biomass available. This variable is measured on the cruises on a routine basis, while surface chlorophyll can also be interpreted by remote sensing (e.g. Vikebø *et al.* 2012). Chlorophyll is an indirect measure of phytoplankton biomass. The timing of the chlorophyll spring peaks and maximums may differ between years and areas, thereby making it difficult to compare the results for different years based on cruise monitoring.

Data series

WGINOR has access to an IMR-dataset representing depth-specific concentrations of chlorophyll and phaeophytin for the Norwegian Sea area. These data are collected by Norwegian vessels, generally from the early nineteen-nineties up to and including 2010. The data extraction was made from the IMR databases with the spatial area restricted to within 58 and 90 °N and between -20 and 30 °E. Data for the years 2011–2013 are not yet available from the Chemistry Department, but will be delivered to the marine data department (NMD) when ready. Chlorophyll collection and measurement is standard procedure at most CTD stations, both on monitoring of transects (including "Svinøy" and "Gimsøy") and on regional cruises.

State and recent trends

WGINOR needs to process available data to construct relevant time-series on chlorophyll. This is a necessary precursor for assessing possible trends in phytoplankton biomass, both between and within years. Due to between-year variability in both timing of the blooms and cruise periods, the maximum values and development of the phytoplankton community may prove difficult to assess. For next year we plan to gather data from remote sensing of primary productivity and phytoplankton biomass (c.f. Vikebø *et al.*, 2012).

A6.4 Zooplankton

The zooplankton plays an important role in the ecosystem by transferring energy from the phytoplankton to higher trophic levels. One of the most important zooplankton groups in the Norwegian Sea is the genus *Calanus,* both in numbers and biomass (c.f. Melle *et al.* 2004). This genus displays strong seasonal vertical migrations as part of its life cycle. However, there are also many other important groups of zooplankton such as other copepods, krill and amphipods (Melle *et al.* 2004, Skjoldal *et al.* 2004).

Data series

WGINOR has identified three data sets that are particularly relevant for the integrated assessment. Two of the time-series /data sets are based on regional coverage's, and represent May and July/August, respectively. The sampling is made by WP2 nets from 200m (or bottom when shallower) to the surface. Each sample is as routine split in two parts, one used for taxonomic/stage processing and the other half for size-fractioned biomass measurements. Due to the time and cost-consuming taxonomic analysis, only selected samples are processed with respect to species and stage composition. In contrast, the biomass values are readily available for all samples.

For some regional coverage, as well as along the standard IMR monitoring transects, selected stations are also sampled with MOCNESS. This gear provides depth-stratified samples, in contrast to the WP2. Due to the comparatively much fewer samples, the MOCNESS data need to be aggregated in time and space. The MOCNESS may provide supplementary information to the WP2 because it is used to sample much deeper (typically to 600–700m in deep areas) than the 200m lower sampling-depth used as a standard for the WP2.

1) ICES coordinated ecosystem survey for the Nordic seas

WGINOR suggests evaluating the ICES biomass dataset for May in more detail. It would be useful, if possible, to analyse the raw data more specifically regarding ocean sub-areas and also biomass size-fractions. The survey coverage and horizontal distribution of zooplankton in 2013 are shown on Figure 10 and Figure 11.

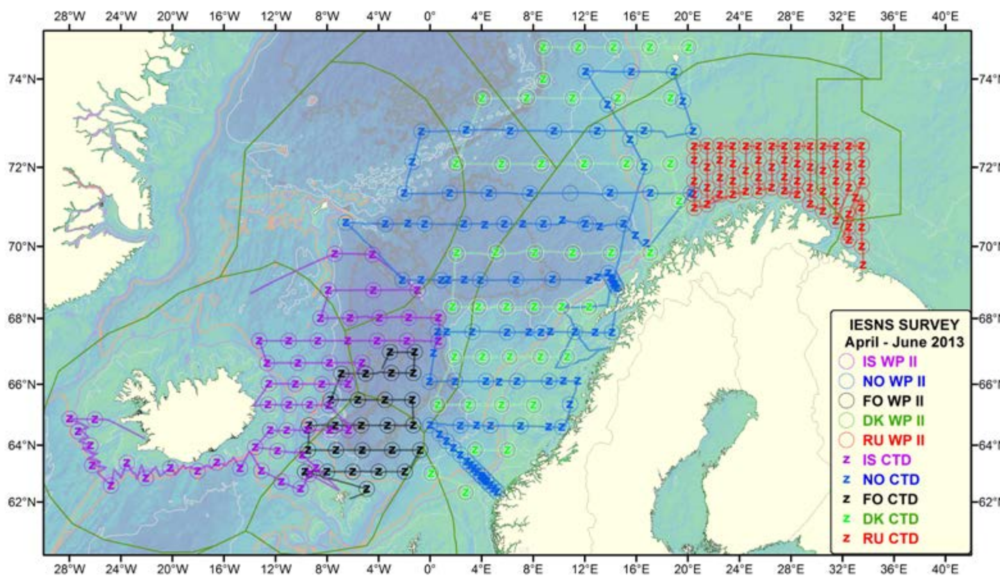


Figure 10. Cruise track, CTD and WP II stations by country for the International ecosystem survey in the Nordic Seas in April-June 2013 (ICES data).

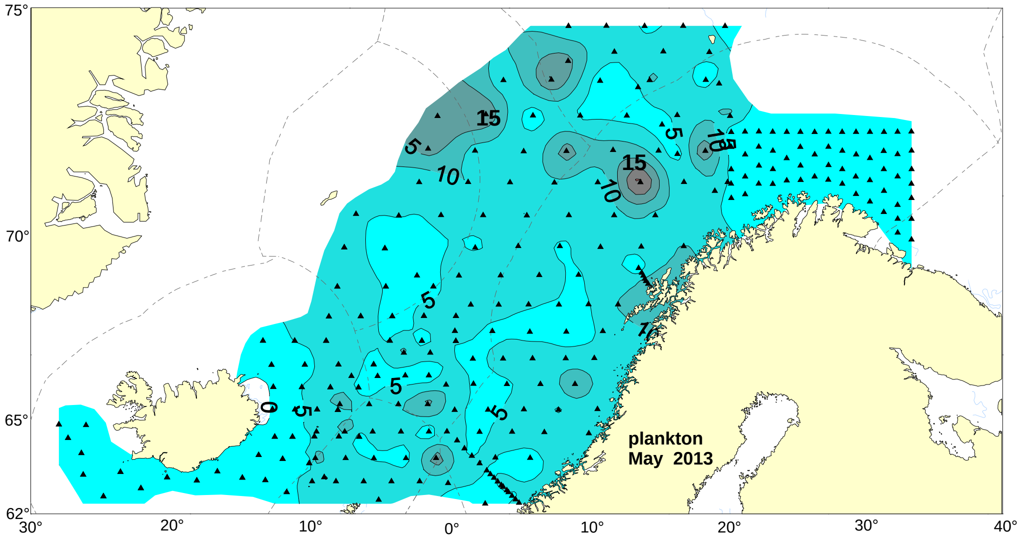


Figure 11. Zooplankton biomass (g dw m-2; WP2, 200–0m) from the international ecosystem survey in the Nordic Seas in April-June 2013(ICES data).

2) Zooplankton biomasses from July/August regional cruises

This may be the beginning of a time-series, but at present there are only data back to 2009/2010. However, Norwegian data do exist for earlier years (before Iceland and the Faroese entered the arena), although these are not ready for presentation at this stage. Before average values for plankton abundances based on these cruises can be presented, and the results from different years compared, a thorough standardization of the data is needed. An example of results from the 2013 cruise is included for visualization purposes only (Figure 12). The sampling was made by WP2 from 200m to the surface.

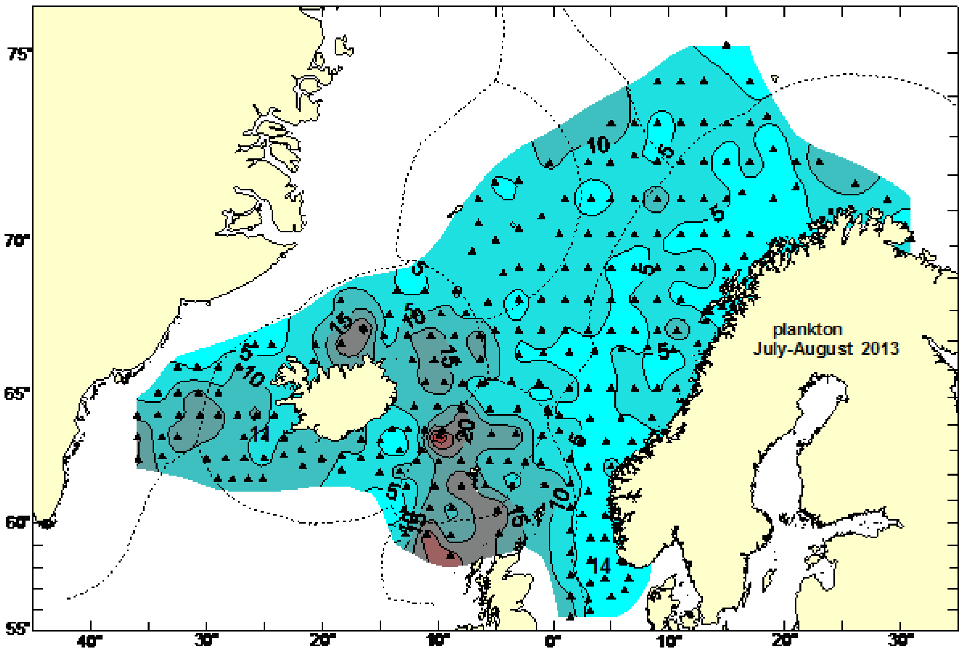


Figure 12. Zooplankton biomass (g dw/m², 0–200 m) in the Norwegian Sea and surrounding waters, 2 July – August 2013.

The average plankton biomass was 8.6 g/m^2 over all stations throughout the survey area in July/August 2013. The plankton concentrations were lowest in the central Norwegian Sea and highest in Faroese and Icelandic waters in addition to northern EU waters. The zooplankton samples for species identification have not been examined, and this is to be considered as a very preliminary result of work in progress.

3) MOCNESS biomass results from about 1990 – to the present

The MOCNESS is commonly used to get a profile of zooplankton down to 500 to 600 m. The 1-m2 MOCNESS filters about 25 times as much water as the WP-2 Net, which is the standard net used to sample zooplankton in the upper 200 m. This is due to the larger opening (WP-2 is 0.25 m2) and oblique vs. vertical towing. In an extensive zooplankton sampling gear inter-comparison we have shown that the two nets give comparable results for mesozooplankton biomass (Skjoldal *et al.* 2013). Here we report the MOCNESS data, but we plan eventually to analyse combined MOCNESS and WP-2 data sets.

The zooplankton samples are collected and treated according to the standard IMR method which is described in some detail by Melle *et al.* (2004). The method involves splitting the sample in two halves, one for biomass determination and the other fixed with formaldehyde and stored for eventual analysis. The portion for biomass is screened successively through 2000, 1000 and 180 um mesh screens, transferred to pre-weighed Al trays, dried and then weighed.

This method of determining zooplankton dry weight biomass in size fractions was used as the basic method in a comprehensive zooplankton gear inter-comparison study carried out with two ships in Storfjorden at Møre in Norway, June 1993. The method was found to be robust and reproducible and associated with relatively low variance generated by the various steps (splitting, sieving, drying, weighing) of the procedure (Skjoldal *et al.* 2013).

The MOCNESS is a multiple opening and closing net system with a 1 m^2 opening that is towed obliquely from the deepest layer at about 1.5 knot speed with nets successively opened and closed at predetermined depths by signals through a cable from the ship. The MOCNESS was used with nets of 180 or 200 um mesh on most cruised but nets of 300 or 333 um mesh were also used on some cruises. Below the Biomass in the south east part of the Norwegian Sea is shown taken from the work region

Zooplankton biomass as g dry weight m^{-2} in the 0–200 m layer in the southeastern region are shown in Figure 13 for April (upper), May (middle), and June–August (lower panel). The biomass in April was about 6 g dw m-2 in the 1990s, and increased to about 10–12 g dw m-2 in the 2000s (*n* were 122, 50, 8, and 9 for the four periods). The biomass in May was about 10–11 g dw m-2 from 1991 to 2005, while being somewhat lower (about 8 and 6.5 g dw m-2) in 2006–10 and 2011–13 (*n* were 17, 110, 33, 21, and 15 for the 5 time periods). The biomass in June–August decreased from 10 g dw m-2 in 1991–95 (*n* = 80) and 6 g dw m-2 in 1996–2000 (*n* = 97), to around 3 g dw m-2 during the 2000s (n = 15, 12, and 8).

In the June–August series there is a progression towards later sampling, with many June samples taken during the 1990s (38 and 21), and a shift to only August samples in the last years (see Skjoldal & Bagøien 2013). However, recalculating the data for July only did not change the trends much, with values still decreasing from about 8.5 g dw m-2 in 1991–95 to about 3 g dw m-2 in the 2000s (Figure 2).

The biomass in the deeper layer between 200 and 500 m depth varied around about 5 g dw m-2 in April, May and June–August (Figure 13). The biomass was lowest in the last three years (2011–13) for the Series (3.7 g dw m-2, n=15), while it was similar to the periovious time periods for the June–August series (5.3 g dw m-2, n=21).

The size distribution of the zooplankton in the deeper layer differed from that in the upper layer by more dominance by larger forms. The largest fraction (>2 mm) made up from about 50 to 70 % of the total biomass in May, when the medum fraction constituted about 25–50 % and the smallest fraction made up only about 5%. In June–August, the smaller fractions had increased in relative importance, with about 12–20 % of the total biomass in the smallest and about 35–45 % in the medium size fraction.

The sum of the biomass in the deeper (200–500 m) and upper (0–200 m) layers was typically 11–16 g dw m-2 in April and May and somewhat lower, 7–16 g dw m-2 (Figure 13). The lowest biomass values (7–9 g dw m-2) were observed after 2000, reflecting the lower biomass in the upper 200 m.

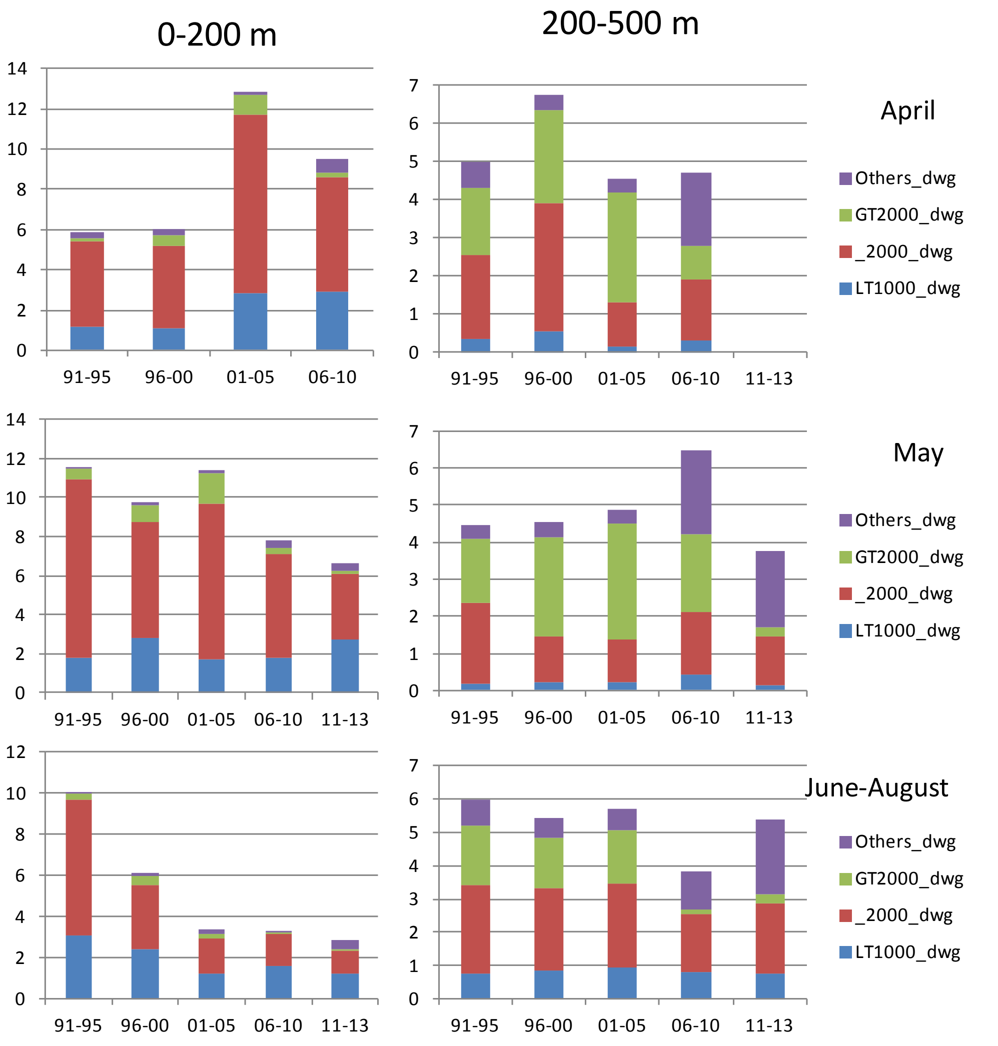


Figure 13. Zooplankton biomass (g dry weight m-2) in size fractions (<1mm - blue; 1–2 mm -red; >2mm - green; others are taxa sorted from the >2mm fraction) in the 0–200 m (left column) and 200–500 m (right column) depth intervals in the southeastern region of the Norwegian Sea in April (upper), May (middle), and July-August (lower). Values are means over 5 years period from 1991 to 2010 plus the last 3 years (2011–2013).

State and recent trends

With respect to the time-series for the ICES coordinated May cruises presented above, the reported biomasses for the uppermost 200m across the whole coverage area show a declining trend from the early 2000s, but with the levels increasing again since 2010 (Figure 14). In May 2013, the estimated average for the total area covered was estimated at 7.2 g dry weight per square meter, as compared to the minimum level of 3.9 in 2009 (Figure 14 and Table 1). The MOCNESS data gives the same picture for May, with a decreased biomass in recent years. The data indicates an increased biomass for April. It needs to be investigated whether this is caused by an earluier peak in the zooplankton succession, or there are other causes for this. The number of MOCNESS hauls is much lower in the last two periods so that also needs to be looked into (Skjolda & Bagøien 20013). For the May and July periods there is a marked decrease in later years for the upper 200m, whereas for the 200–500 m depth the trends are less clear.

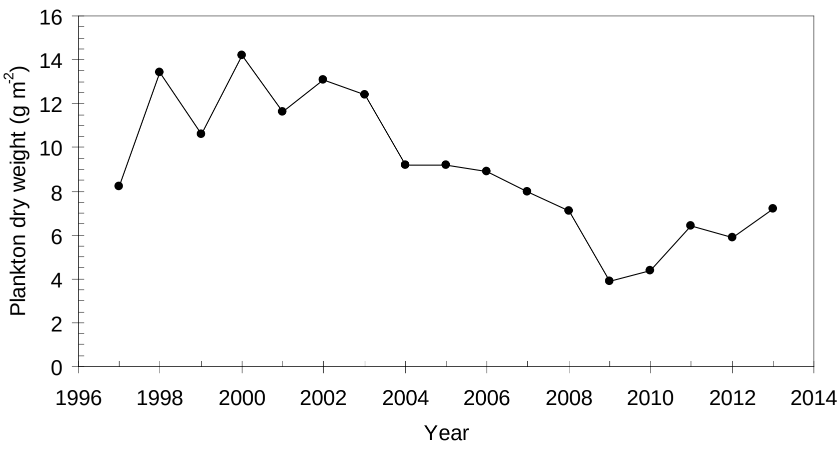


Figure 14. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2013 (ICES data).

Table 1. The annual mean dryweight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2013 (ICES data).

Year	DW Total (g/m^2)	Region W of 2°W	Region E of 2°W
1997	8.2	9.1	7.5
1998	13.4	13.4	14.4
1999	10.6	13.5	10.2
2000	14.2	15.7	11.8
2001	11.6	11.4	8.7
2002	13.1	13.7	13.6
2003	12.4	14.6	9.0
2004	9.2	9.2	8.0
2005	9.2	10.7	8.2
2006	8.9	12.6	4.8
2007	8	10.3	5.6
2008	7.1	7.1	7.1
2009	3.9	4.4	3.3
2010	4.4	2.9	5.9
2011	6.4	6.8	6.0
2012	5.9	6.7	4.7
2013	7.2	6.8	7.4

A6.5 Mesopelagic fish

There are presently no available time-series on the abundance of mesolpelagic fish, even though this is an important component of the ecosystem. Potentially acoustics data on mesopelagic fish can be be used to estimate abundance backwards in time. This will be addressed on the next working group meeting along with analyses of frequency of occurrence in midwater trawl hauls.

A6.6 Pelagic fish

Norwegian spring-spawning herring

The Norwegian spring spawning herring (*Clupea harengus*) is the largest herring stock in the world and is widely distributed and highly migratory throughout large parts of the NE Atlantic during its lifespan (based on Stock Annex provided in ICES 2012). This makes it important component of the Norwegian Sea ecosystem. The herring spawns along the Norwegian west coast in February-April and the larvae drift north and northeast and distribute as 0–group in fjords along the Norwegian coast and in the Barents Sea, the latter being by far the most important juvenile area for the large year classes. With maturation the young herring start joining the adult feeding migration in the Norwegian Sea. The feeding migration starts just after spawning with the maximum feeding intensity and condition increase occurring from late May until early July. The feeding migration is in general length dependent, meaning that the largest and oldest fish perform longer and typically more western migrations than the younger ones. After the dispersed feeding migration the herring concentrate in one or more wintering areas in September-October. These areas are unstable and since 1950 the stock has used at least 6 different wintering areas in different periods. Considering its life-history, four time-series are considered important for integrated assessment purpose, (a) total biomass, (b) recruitment index (number-at-age 0), (c) weight-at-age representing condition and feeding success, and (d) length-at-age representing growth rate.

Data series

The data on herring includes spawning stock biomass (SSB), recruitment, weights at age and lengths at age (Annex 3; Figure 15). Recruitment and SSB represents the results of the analytical assessment of the stock by the ICES working group on widely distributes stocks (WGWIDE) in 2012 (ICES 2012) for the years 1988–2012 and an older VPA run for 1950–1987 (Toresen and Østvedt 2000). The estimates derive from the VPA population model TASACS. The input data are both catch-at-age from the fishery and number-at-age from the various research surveys, where the IESNS survey in May get most weight. Thus, this series is representative for developments in stock size and recruitment in the stock. Weights at age are taken from the assessment input data in ICES (2012). The data of length at age is retrieved from IMRs database. The sampled fish are either from regular surveys or from commercial catches, where a sample is sent to IMR for analyses. All individuals that are age-determined by using either scale or otholits during the period 01.10.year$_x$ - 01.04.year$_{x+1}$ are included in the dataset. There are no restrictions on the area the fish are sampled from. Herring is not feeding and have therefore no individual growth in this period. Any change in weight in this period doesn't affect the dataset as only length measurements are retrieved. The fish that are sampled in the autumn year$_x$ are given age +1 to make them comparable to those sampled in spring year$_{x+1}$. For all individuals with the same age the mean length and standard deviation is calculated and the number of fish is counted. The dataset includes the consecutive years from 1981/1982 to 2012/2013. The length at age 6 is presented together with the standard error in Figure 15.

State and recent trends

Historically, the size of the stock has shown large variations and dependency on the irregular occurrence of very strong year classes (Figure 15). In the absence of strong year classes after 2004, the stock has declined since 2009 and is expected to decline further in the near future even when fishing according to the management plan.

Blue whiting

Blue whiting (*Micromesistius poutassou*) is a pelagic gadoid that is widely distributed in the eastern part of the North Atlantic (based on Stock Annex provided in ICES 2012). The highest concentrations are found during spawning along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where most of the spawning takes place between March and April. Juveniles are abundant in many areas, with an important nursery area believed to be the Norwegian Sea, at least in times of high abundance. Adults reach maturation at 2–7 years old and undertake long annual migrations from the feeding grounds in the Norwegian Sea and adjoining waters to the spawning grounds. Thus, Norwegian Sea is an important feeding area for the blue whiting stock and considered its total biomass, blue whiting is an important component in the ecosystem in Norwegian Sea. Considering its life-history, four time-series are considered important for integrated assessment purpose, (a) total biomass, (b) recruitment index (number-at-age 0), (c) weight-at-age representing condition and feeding success, and (d) length-at-age representing growth rate.

Data series

The data on blue whiting includes spawning stock biomass (SSB), recruitment, weights at age and lengths at age (Annex 3; Figure 15). Recruitment and SSB represents the results of the analytical assessment of the stock by the ICES working group on widely distributes stocks (WGWIDE) in 2012 (ICES 2012). The estimates derive from the SAM model, where the input data are both catch-at-age from the fishery and number-at-age from the IBWSS survey on the spawning grounds in March/April. Thus, this series is representative for developments in stock size and recruitment in the stock. The data of length at age is retrieved from IMRs database. The sampled fish are either from regular surveys or from commercial catches, where a sample is sent to IMR for analyses. All individuals that are age-determined by using otholits during the period 01.01–01.04 are included in the dataset. There are no restrictions on the area the fish are sampled from. Blue whiting is not feeding and have therefore no individual growth in this period. Any change in weight in this period doesn't affect the dataset as only length measurements are retrieved. For all individuals with the same age the mean length and standard deviation is calculated and the number of fish is counted. The dataset includes the consecutive years from 1982 to 2013. The length at age 6 is presented together with the standard error in Figure 15.

State and recent trends

The stock size started to increase drastically in the late 1990s due to strong year classes appearing all the years from 1996–2005 (Figure 15). The year classes 2005–2008 were in the very low end so the spawning stock size started to decline in 2007. Information from recent IBWSS survey, as well as IESNS survey in May 2012 and 2013 show that the 2011 year class is strong and 2010 is moderate, thus the total biomass and SSB are increasing again.

Northeast Atlantic mackerel

Northeast Atlantic mackerel is found in the area extending from the Iberian peninsula in the south to the northern Norwegian Sea in the north, and Iceland in the west to western Baltic Sea in east (based on Stock Annex provided in ICES 2012). The spawning occurs widely on the shelf from Biscay to the Norwegian Sea and in to the North Sea during January to July. After spawning, fish from southern and western areas migrate to feed in the Norwegian Sea and the North Sea during the second half of the year. The Norwegian Sea, and adjacent waters since the mid-2000s, is the main feeding ground of the stock and therefore important component of the ecosystem. Considering its life-history, four time-series are considered important for integrated assessment purpose, (a) total biomass, (b) recruitment index (number-at-age 0), (c) weight-at-age representing condition and feeding success, and (d) length-at-age representing growth rate.

Data series

The data on mackerel includes spawning stock biomass (SSB), recruitment, weights at age and lengths at age (Annex 3; Figure 15). Recruitment and SSB represents the results of the analytical assessment of the stock by the ICES working group on widely distributes stocks (WGWIDE) in 2012 (ICES 2012). The estimates derive from the integrated catch-at-age model ICA, where the input data are both catch-at-age from the fishery and SSB estimates from the triennial Mackerel Egg survey as the tuning index. The most recent survey data in the 2012 assessment were from 2010. However, as stated by WGWIDE (ICES 2012) there are serious concerns about this assessment time-series because of: (a) Seriously large unreported catches in the time-series causing underestimation of stock size in the analytical assessment; (b) The only tuning series used in the analytical assessment of the stock is the egg survey which only provides estimates every third year and that the assessment model would benefit from the inclusion of a tuning series available on an annual basis. Promising fishery independent abundance estimates applicable to future assessment of the mackerel stock, and to WGINOR, include abundance estimates from tag-recapture methods (Tenningen *et al.* 2011) and swept area biomass estimations from the IESSNS survey July/August (Nøttestad *et al.* 2013). Inclusion of these time-series will be explored in Benchmark assessment of the stock planned in January/February 2014. The data of length at age is retrieved from IMRs database. The sampled fish are either from regular surveys or from commercial catches, where a sample is sent to IMR for analyses. All individuals that are age-determined by using otholits during the period 01.10.year$_x$ - 01.05.year$_{x+1}$ are included in the dataset. There are no restrictions on the area the fish are sampled from. Herring is not feeding and have therefore no individual growth in this period. Any change in weight in this period doesn't affect the dataset as only length measurements are retrieved. The fish that are sampled in the autumn year$_x$ are given age +1 to make them comparable to those sampled in spring yearx$_{+1}$. For all individuals with the same age the mean length and standard deviation is calculated and the number of fish is counted. The dataset includes the consecutive years from 1981/1982 to 2012/2013. The length at age 6 is presented together with the standard error in Figure 16.

State and recent trends

Historically, there are only small fluctuations in the abundance estimates of mackerel in the assessment time-series and no strong trends, in other words the estimates are relatively flat (Figure 15). It is a consequence of poor quality data used in the analytical assessment (see above). The results of IESSNS survey and the tag-recapture methods indicate that the stock size has been at higher levels, had more fluctuations and are much larger presently than the analytical assessment shows (ICES 2012).

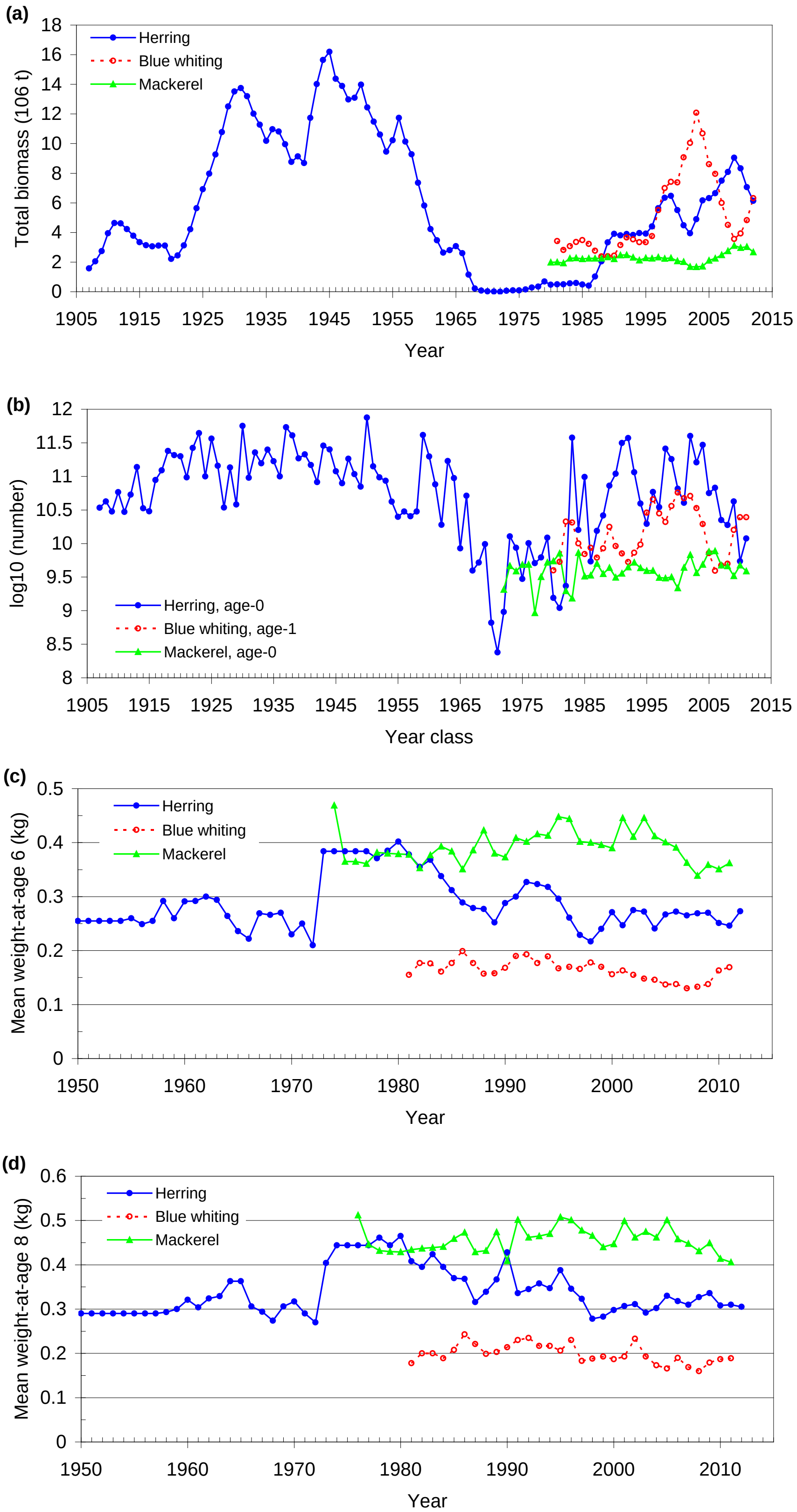


Figure 15. Historical development in SSB (a), recruitment (b), mean weight-at-age 6 (c) and age 8 (d) of Norwegian spring-spawning herring, blue whiting and mackerel in according to ICES assessment (ICES 2012).

Trends in growth of the three pelagic fish stocks

There has been a downward trend in the length at age in herring over time as reported in (Huse *et al.*, 2012). Figure 16 below shows that this trend seems to have been reversed in the recent two years. For mackerel on the other hand a downward trend was started in 2006 and has been maintained since (Figure 16). The blue whiting showed a downward trend until 2007, but has since showed an upward trend with the strong reduction in the stock. The stock is increasing strongly at present so it will be interesting to see how this develops in the coming years.

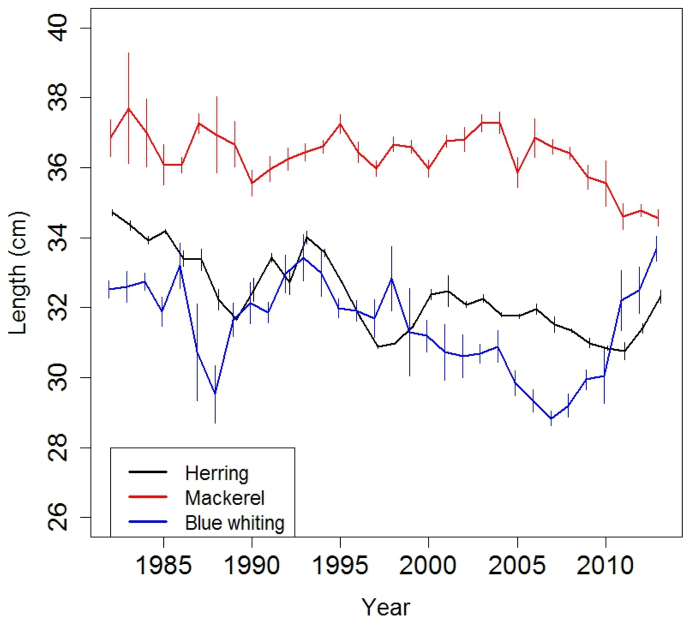


Figure 16. The length at age six years for herring, mackerel and blue whiting.

Beaked Redfish

Adult individuals of beaked redfish (*Sebastes mentella*) are found scattered throughout the open waters of the Norwegian Sea (Bjelland and Holst 2004). It is assumed to be a planktivore feeding on crustacean macrozooplankton (Bjelland and Holst 2004).

Data series

Spawning stock biomass of beaked redfish is included (Annex 3; Figure 17). The SSB time-series was taken from the SCAA-assessment in ICES (2013a).

State and recent trends

The state of the stock is unknown, but the SSB appears to have been on a fairly stable level in recent years (Figure 17).

Saithe

Large saithe (*Pollachius virens*) is probably a significant component of the pelagic complex in the Norwegian Sea as it is frequently caught in pelagic trawl hauls (Bjelland and Holst 2004). Though the information regarding its feeding ecology in the

Norwegian Sea is sparse, blue whiting (Kaartvedt *et al.* 2005) and herring (Bjelland and Holst 2004) seems to comprise an important part of the diet.

Data series

Stock biomass of saithe is included (Annex 3; Figure 17). Three saithe stocks were considered relevant for the Norwegian Sea ecosystem: (1) saithe in Subareas I and II (Northeast Arctic), (2) saithe in Division Vb (Faroe platau) and (3) saithe in Subarea IV (North Sea), Division IIIa (Skagerrak), and Subarea VI (West of Scotland and Rockall), hereafter referred to as (1) Northeast arctic saithe, (2) Faroe saithe and (3) North Sea saithe. To select "large saithe" from these stocks age groups with an average weight above 5 kg was, somewhat arbitrary, chosen. This correspond to ages older than 8 years (9+) for Faroe and North Sea saithe and older than 9 years (10+) for Northeast arctic saithe. The biomasses of these components were obtained by multiplying the stocks weights at age with the corresponding estimated numbers at age. Data were taken from the latest ICES stock assessments (ICES 2013a; ICES 2013b, ICES 2013c).

State and recent trends

All three saithe stocks are currently estimated at or slightly above B_{pa}, and all SSBs have been declining in recent years (Figure 17).

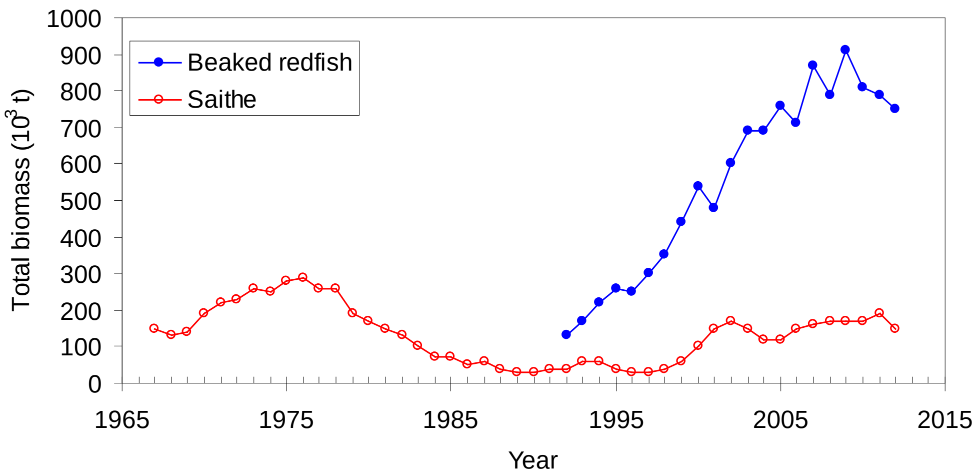


Figure 17. Historical development in biomass of beaked redfish and saithe in Norwegian Sea (see details in text).

A6.7 Marine mammals

Baleen whales are mainly present in the Norwegian Sea during summer while toothed whales are generally present year round (Christensen *et al.* 1992a). Hooded seals from the Greenland Sea breeding unit spend about 60% of their time on feeding excursions in the Norwegian Sea and adjacent continental slope areas (Folkow *et al.* 1996).

The most commonly occurring baleen whale in the Norwegian Sea is the minke whale, followed by fin and humpback whales. Stomach samples suggest a minke whale summer diet completely dominated by herring in the Norwegian Sea (Windsland *et al.* 2007). Based on visual observations, pelagic fish are also likely the main prey of fin and humpback whales in the central Norwegian Sea (Nøttestad *et al.*

2002, Nøttestad, this meeting?). In more southern and northern areas, however, krill appears to be a more dominant prey for all three species (Ingebrigtsen 1929; Sigurjonsson and Vikingson 1997; Windsland *et al.* 2007).

Other pelagic feeding marine mammals in the Norwegian Sea area are killer whales, white beaked dolphins, harbour porpoises, grey seals and harbour seals.

Due to their large biomass, sperm whales are the ecologically most important deep diving mammals in the Norwegian Sea. Stomach data from the Northeast Atlantic generally suggest a diet comprised by deepwater squid and mesopelagic fish, most notably lumpsucker (Martin and Clarke 1986; Christensen *et al.* 1992b). Other deep diving predators in the Norwegian Sea are hooded seals, northern bottlenose whales and pilot whales, which are all thought to feed on a mixture of squid and fish.

Data series

Minke whales and Greenland Sea hooded seals are the only marine mammal species within the WGINOR core area, which are regularly monitored by dedicated surveys. The shipboard sightings surveys for minke whales in the Norwegian Sea is part of a 6 year monitoring cycle aiming to estimate the total summer abundance of minke whales in the Norwegian and Barents Seas as well as the area around Jan Mayen. Other marine mammal species encountered during these surveys are also recorded and it is believed that the surveys give reasonably reliable data on the summer occurrence of fin whales and humpback whales within the study area. Sperm whales are also sighted and recorded but so far no estimates have been corrected for the reduced sightability caused by the prolonged dives performed by this species. Correction factors from 1.5 to 9 have been reported in the literature (Gunlaugsson *et al.* 2009; Sigurjonsson and Vikingsson 1997). In their uncorrected form, however, the sperm whale estimates may serve as indicators of relative occurrence. No abundance estimates are derived for other species due to very low numbers of primary sightings (blue whales, sei whales, Northern bottlenose whales, harbour porpoises) or problems with estimation of group sizes (whitebeaked dolphins, whitesided dolphins, pilot whales and killer whales).

Abundance is regularly estimated for harbour and grey seals along the Norwegian coast, but these species are so far considered to be outside the core area of WGINOR. Based on available satellite tracking data, harp seals are also generally expected to be distributed outside the WGINOR core area (Folkow *et al.* 2004; Nordøy *et al.*, 2008).

Based on ecological relevance and data availability, the working group decided to limit its focus on marine mammals to minke whales, fin whales, humpback whales, sperm whales and hooded seals.

Table 2. Data availability on abundance of marine mammal species selected for inclusion in the work of WGINOR. All data sets are collected by the IMR.

Species	**Abundance estimates**
Fin whale	1987–89; 1995; 1996–2001; 2002–2007; 2008–2013
Humpbacks	1987–89; 1995; 1996–2001; 2002–2007; 2008–2013
Minke whales	1987–89; 1995; 1996–2001; 2002–2007; 2008–2013
Sperm whales	1987–89; 1995; 1996–2001; 2002–2007; 2008–2013
Hooded seals	1945–2013 (model estimates), 2005, 2007, 2012 (surveys)

State and recent trends

Table 2 shows the most recent published abundance estimate and estimated total biomass of the 5 selected species of marine mammals. Mean weights are taken from Dommasnes *et al.* (2000).

Table 3. Most recently published abundance estimates for focal marine mammal species and total estimated biomass. Sources: [1]Øien, 2009, [2]Bøthun *et al.* 2008., [3]ICES, 2011., [4]Dommasnes *et al.* 2000.

Species	**period**	**Est. Abundance**	**Mean Weight (Kg)**	**Est. Total Biomass (tonnes)**
Fin whales	1996–2001	6409[1]	42279[4]	270966.1
Humpback whales	1996–2001	1450[1]	31782[4]	46083.9
Minke Whales	2002–2007	44445[2]	5251[4]	233128.1
Sperm Whales	1996–2001	6207[1]	34322[4]	213842.0
Hooded seals	2007	91000[3]	262[4]	23842

For all species more recent data are available and are currently being analysed. These data will be made available to WGINOR as soon as possible.

Presently, no clear trends are known for the available data series of whale occurrence in the Norwegian Sea. Preliminary analyses of the most recent surveys may, however, suggest changes in either abundance or distribution (Nils Øien, pers. comm.). In a wider historical perspective it is, however, clear that the abundance of large baleen whales and sperm whales were reduced during the period of commercial whaling and have not recovered to previous levels. For hooded seals, catch based modelling shows a dramatic decline in abundance over the period 1945–1980 (see Figure 18). This decline is thought to be mainly catch-driven. The catches were significantly reduced from the early 1980s to 2006, but may nevertheless have been an important factor for the lack of recovery. Other factors such as possible changes in food availability and natural mortality can, however, also not be ruled out. Hooded seals have been completely protected since 2007.

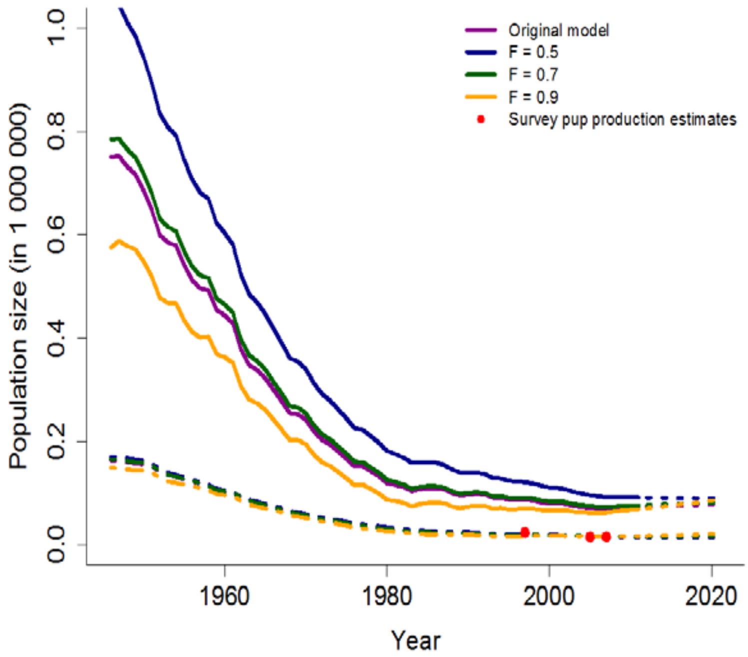


Figure 18. Modelled abundance of Greenland Sea hooded seals. F refers to different options for pregnancy rates. Currently a pregnancy rate of 0.7 is assumed for this population (from ICES, 2011).

A6.8 Seabirds

Seabirds

Three species of seabirds feeding in the pelagic part of the ecosystem have been selected to be included in the analyses. These are black-legged kittiwake (*Rissa tridactyla*), Atlantic puffin (*Fratercula arctica*) and common guillemot / common murre (*Uria aalge*). The reason for selecting these species is that they feed in different parts of the pelagic ecosystem. The kittiwake obtains its food on the surface of the sea in the form of young year-classes of capelin and polar cod, along with crustaceans. The guillemot is a fish specialist which, in the breeding season, chiefly lives on pelagic fish such as capelin and herring and typically feeds at depths of 20–80 meters. The Atlantic puffin lives mainly on small fish (in particular herring larvae, capelin and sand eel), crustaceans and mollusks, and typically feeds at depths down to 30 meters. Average life span is around 12 years for black-legged kittiwake and around 25 years for common guillemot and Atlantic puffin. Kittiwakes typically lay two eggs while guillmot and Atlantic puffin lay a single egg. Except for the breeding season, all three species spend their entire life at sea.

Data series

Time-series of abundance of populations breeding along the Norwegian coast is assessed from estimated size of the populations in 2005 (Barret *et al.* 2006) and relative changes in populations size in selected breeding colonies (Figure 19); (performed through the SEAPOP programme). The monitored colonies along the Norwegian Sea coastline in Norway are Runde (all species), Sklinna (kittiwake and Atlantic puffin), Røst (all species) and Anda (kittiwake and Atlantic puffin). Guillemots at Sklinna have not been included. This may be done, but will change the overall estimate very little. For guillemots, no monitoring was done in the years 1984–1987, and index values have been estimated assuming a constant change between these years.

State and recent trends

Kittiwake

The breeding population in the Norwegian Sea has declined with 78 % since monitoring started in 1980.

Atlantic Puffin

For the Atlantic puffin the breeding population in the Norwegian Sea has declined with 75 % since monitoring started in 1980

Guillemot

The breeding population has declined considerably (99 %) since monitoring started in 1980 and the species may disappear as a breeding species along the Norwegian coast of the Norwegian Sea.

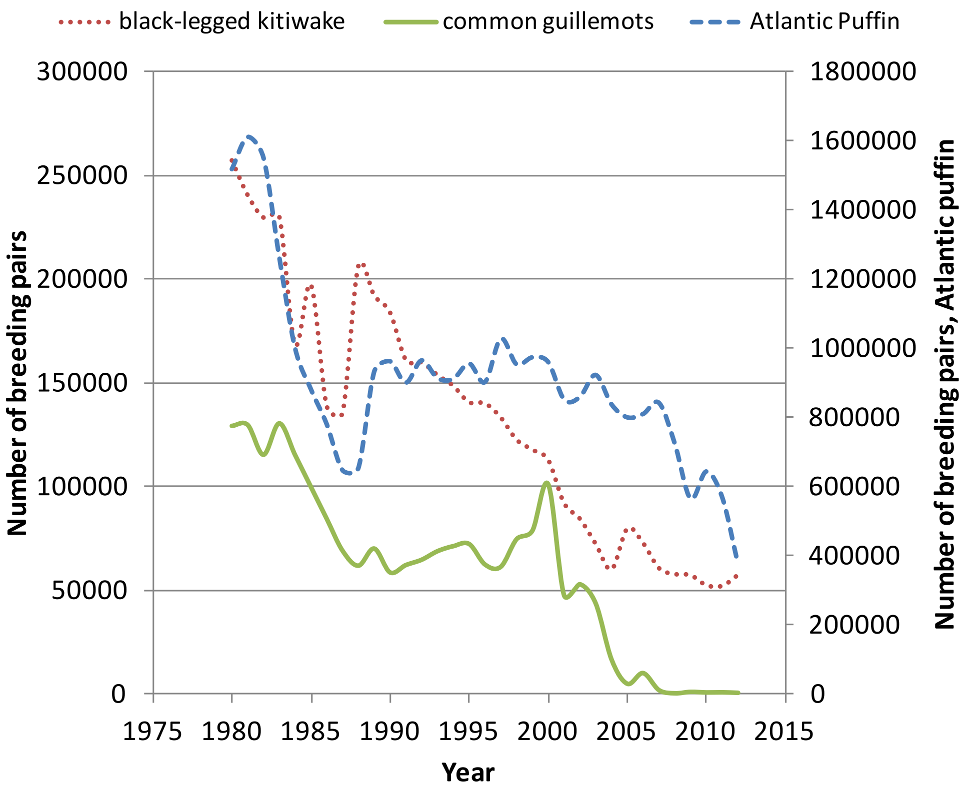


Figure 19. Development in the breeding populations of black-legged kittiwake, Atlantic puffin and common guillemot in the Norwegian Sea in the period 1980–2012.

The causes for the negative trends registered for breeding seabirds in the Norwegian Sea are not fully understood. At the SEAPOP key sites on the Norwegian coast (i.e. Runde, Sklinna, Helgeland, Røst og Anda), numbers of most species have dropped drastically over the last decade, although common guillemots and razorbills have been doing reasonably well where they breed in shelter (Barrett *et al.* 2013). Access to shallow coastal waters and fjord systems in close vicinity of the colonies seems however to be of extra value when the supply of pelagic prey fails. A key factor in this context is the long-term lack of 0-group herring, perhaps the most important food source for pelagic seabirds along the mainland coast of the Norwegian Sea. Breeding failure has been observed as the typical result for both Atlantic puffins and black-legged kittiwakes when herring year class strength drops below one third of its historical maximum (Cury *et al.* 2011). The Norwegian spring-spawning herring has not produced a strong year class since 2004, and none of the breeding seasons after 2006 can be termed as successful for pelagic seabirds in this part of the Norwegian Sea. This is surprising as the general environmental conditions for the production of *Calanus finmarchicus* were seemingly reasonably adequate over the same period (Frederiksen *et al.* 2012). It is therefore of extra interest to know to what extent the failing recruitment of herring can be attributed to the extreme expansion and stock increase of mackerel in the Norwegian Sea since 2007.

In contrast to puffins and kittiwakes, breeding common guillemots and razorbills are able to forage efficiently in shallow waters where they can access and utilize other prey such as sandeels (including greater sandeel) and 0-group saithe. As these large auks are doing better where they breed in shelter, the decrease of their populations on exposed ledges is probably also an effect of increased disturbance and predation pressure from non-breeding white-tailed eagles that boosted in numbers on the Norwegian coast in the late 1990s (Hipfner *et al.* 2012). This effect is also documented as a very significant factor for chick production of kittiwakes (Anker-Nilssen & Aarvak 2009).

A6.9 Human pressures

The most prominent and most influential pressure in the Norwegian Sea is fishing. Also shipping and non-renewable energy production, oil and gas, is other larger activities, but in spatial scale these activities are not regarded as significant pressures on the Norwegian Sea ecosystem. The fisheries will therefore be the only human activity to be dealt with here. The fisheries in the Norwegian Sea are constantly developing and are dependent of the mobility and spatial availability of the fish stocks, economic conditions, fisheries regulations, market option etc. It changes within and between years and on longer time periods. The Norwegian fishery in the Norwegian Sea is to a large extent by purse seines while the rest of the European fishing fleet uses pelagic trawl. Some jigging is also used, but purse seining and pelagic trawl are the greatest pressures on the Norwegian Sea ecosystem. The blue whiting is mainly harvested on the spawning grounds to the west of the British Isles while the herring is harvested at the wintering and spawning grounds along the Norwegian Coast. Annual mackerel landings were stable until 2008. The actual landings were probably higher in this period due to large black landings (Simmonds *et al*. 2010; ICES. 2013e). After 2007 the landings increased, mainly due to an Icelandic fishery that was initiated in addition to the quotas set by ICES. Annual landings of blue whiting were large between 1998 and 2007 due to strong recruitment and lack of quota agreement between the countries participating in the fishery (Payne *et al.* 2012, Standal 2006). Annual landings of herring have been high since 1995, but the landings are expected to decrease the following years due to poor recruitment reducing the stock size. The weighted F for each of the three species is given in Figure 20.

Data series

The fisheries are reported through the national fisheries authorities and is statistically treated and stored in the ICES by the working group on widely dispersed stocks (WGWIDE).

State and recent trends

Summary of present state and recent trends of landings and fishery mortality

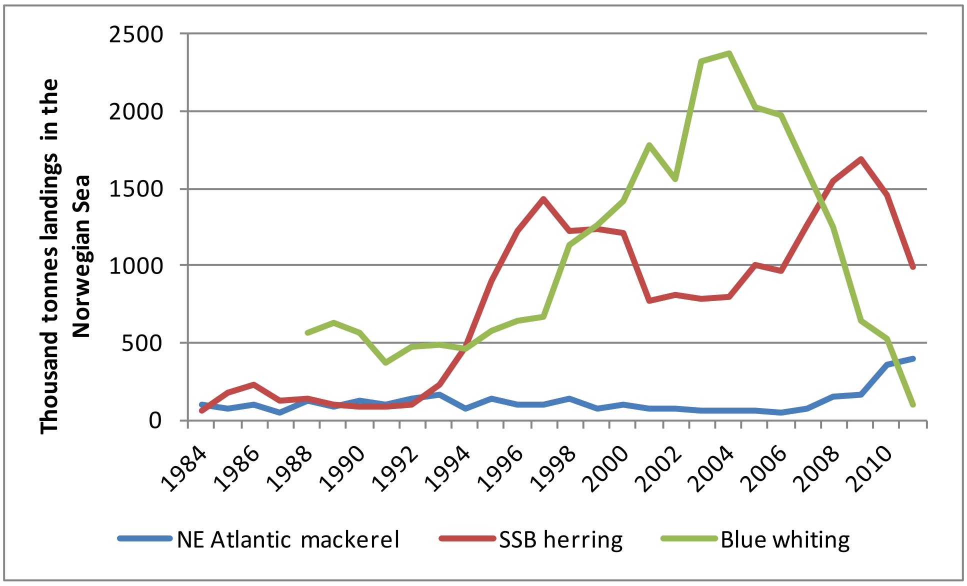
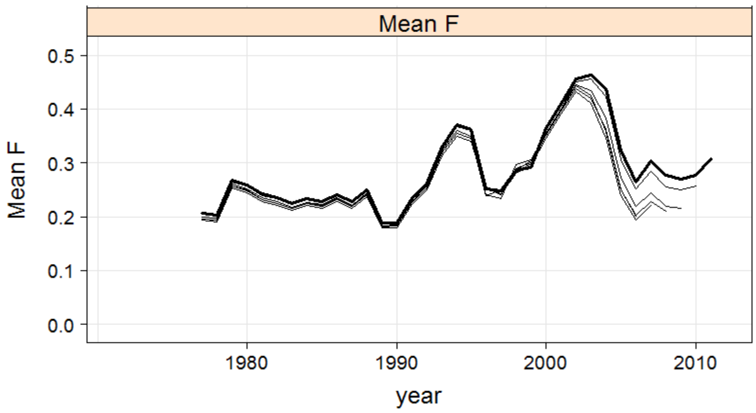
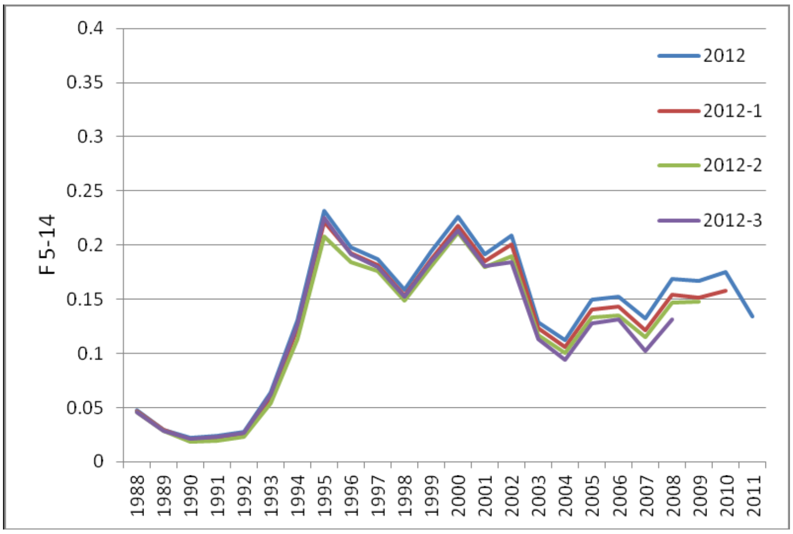


Figure 20. Historical development of the landings of NE Atlantic Mackerel, herring and blue whiting (Source: ICES WGWIDE 2012).

a) NEA Mackrel



b) SSB herring



c) Blue whiting

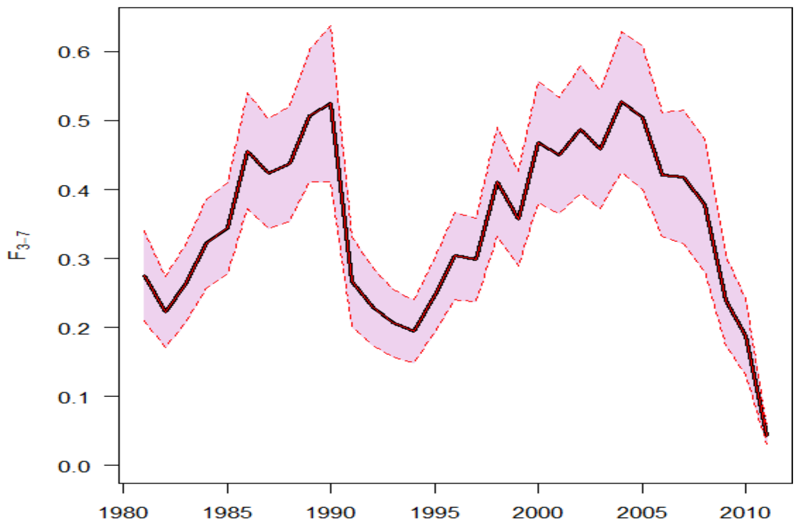


Figure 21. Historical development of the weighted F of a) NE Atlantic Mackerel, b) herring and c) blue whiting (Source: ICES WGWIDE 2012).

Interactions between ecosystem components and overall ecosystem trends

A fair amount of work has been done in the past to explore the interaction between the ecosystem components in Norwegian Sea and a general overview been provided by Skjoldal *et al.* (2003); (Figure 22). Different environmental pressures are affecting these different ecosystem components in various ways. The following discussion represents some very preliminary and not yet fully analysed results on compiled data by WGINOR of relevant ecosystem components in Norwegian Sea and their interaction.

In the period from mid 1980s to 2009, the total biomass of herring increased gradually but there have been a downward trend in recent years due to poor recruitment since 2005 (Figure 15). During the same period there have been the opposite trend for the individual length at age (Figure 16) and the zooplankton index in the Norwegian Sea (Figure 12). Similar pattern was observed for mackerel, or a negative relationship between the total biomass and zooplankton (Figure 23), and decreasing trend in length-at-age since mid-2000s. The blue whiting shows however, an opposite trend or positive relationship between total stock biomass and zooplankton in the Norwegian Sea (Figure 23), and is probably reflecting a different diet preferences of larger zooplankton species that are poorly represented in the zooplankton index. Thus, the biomass of zooplankton is apparently affected by the biomass of mackerel and herring, while strong interpretation from the results should not be drawn until a more comprehensive analyses have taking place.

The negative trend in average biomass of zooplankton in the total area in May from around 2002 until 2009 (Figure 12) was in the WGWIDE report 2012 (ICES 2012) suggested to be a consequence of overgrazing of the Norwegian Sea by the large pelagic fish stock feeding in the area. However, since 2010–2013, an upward trend has been observed in the plankton biomass index (Figure 12). An upward trend of zooplankton abundance was also observed in the IESSNS surveys in July/August for the years 2011–2013 (Nøttestad *et al.* 2013). At the same time (2011–2013), weight-at-age (Figure 15) and length-at-age (Figure 16) in the herring stock are showing increasing trend. Thus, there are no clear signs that the Norwegian Sea is being overgrazed at present by the pelagic fish stocks in the area, nor that there is an increased natural mortality in the herring stock in recent years because of starvation, as was also hinted at in last year's WGWIDE report (ICES 2012). Further work on the zooplankton index is needed and is planned to be addressed by WGINOR 2014. It involves revision of the data and producing indices for the different areas, as well as explorations of their relation to growth, abundance and spatial distribution of pelagic fish stocks feeding in the area. A more comprehensive analyses of the ecosystem are then required, including incorporating other relevant ecosystem and environmental components, which represents one of the most important tasks of WGINOR in the coming years.

The numbers of breeding pairs of three species of seabirds have been declining more or less the whole time-series from early 1980s. The main diet of these species varies from zooplankton, fish larvae and juveniles, to adult pelagic fish (guillemot). The reason for the declining seabird populations is not obvious and the reason is possibly not the same for all three seabird species.

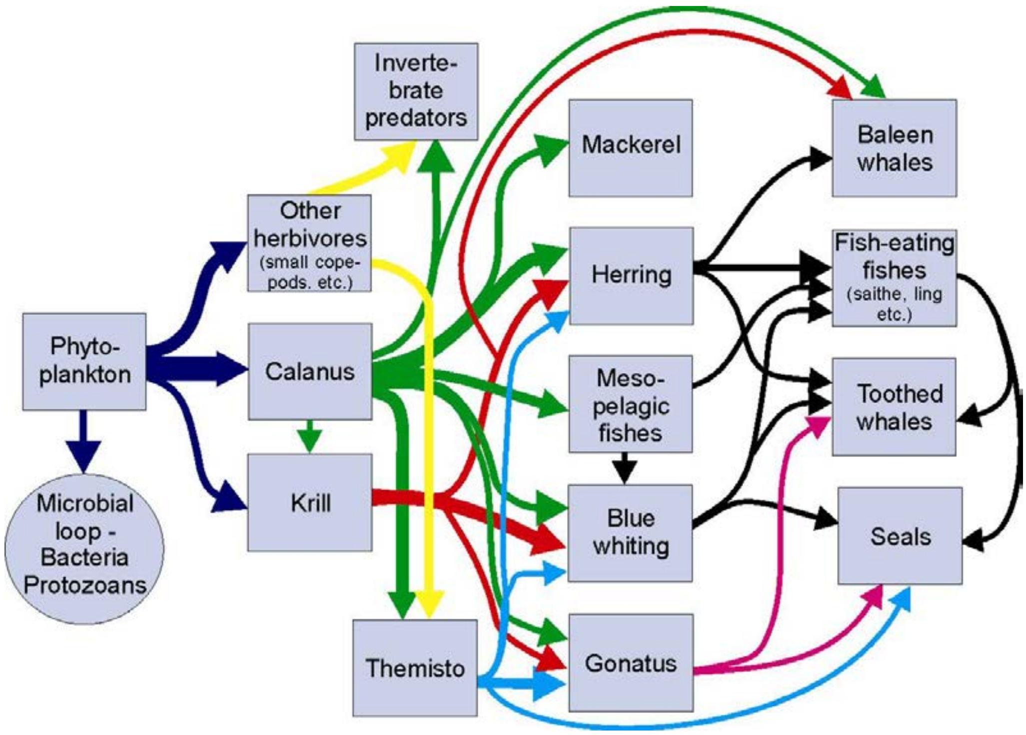


Figure 22. A conceptual diagram for the structure and functioning of the Norwegian Sea ecosystem.

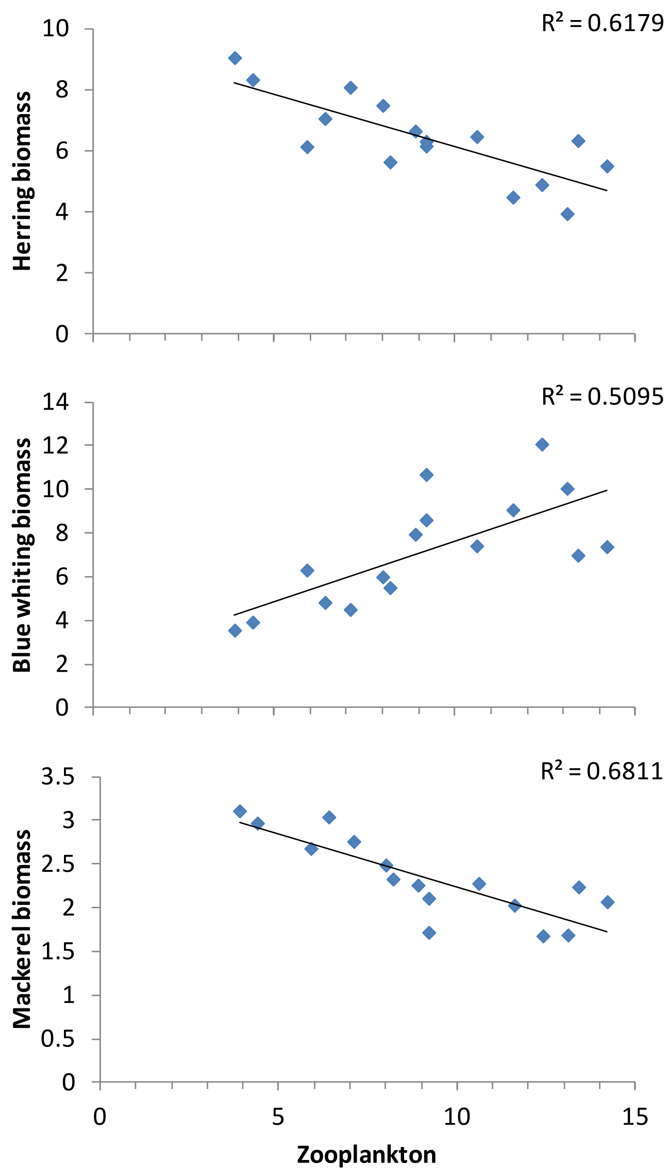


Figure 23. Scatterplot of the biomass of pelagic fish against the mesozooplankton in the Norwegian Sea.

Annex 7: Modelling approaches

A7.1.1 Background

In recent years, ICES has transition its fisheries advice to be based on maximum sustainable yield (MSY) estimation (ICES, 2012). Since the start of fishery management, most stocks have been managed with a single species approach focusing on keeping the fish stocks above a precautionary biomass level to avoid stock collapse. This can introduce biased in the expected future state of the stock, as important factors affecting stock development is ignored. In recent years there has been an increased focus on ecosystem based fishery management (EBFM); (Pikitch *et al.* 2004). In spite of the great focus on EFBM, few nations have started to use this approach. A reason for the slow progress in implementing EBFM is the lack of proper models that can take into account the effect of altered management on the ecosystem (Bunnefeld *et al.* 2011). There are a range of approaches for multispecies modelling which have the benefits of incorporating ecological considerations in simulations with multiple species (see review in Hollowed *et al.* 2000, Plaganyi 2007). An example is the management of Northeast Atlantic cod and capelin, where the expected predation on capelin by cod is used to estimate the natural mortality of capelin on an annual basis (Gjøsæther *et al.* 2002). Another example is the use of OSMOSE where ecosystem stability is estimated by using an Individual Based Model with length dependent predation (Shin and Cury 2001).

Large stocks of planktivorous fish can have interactions that have a negative effect on the stocks, evident at reduced size-at-age or condition factor when the fish abundance is high. This can theoretically lead to increased natural mortality for species unable to handle the competition. Such large effects are normally seen in freshwater systems or in smaller semi-closed marine ecosystems (Link 2002), but there are strong indications of such effects in the Baltic (Casini *et al.* 2011) and the Norwegian Sea (Huse *et al.* 2012). All fish species dominating the Norwegian Sea ecosystem are presently managed with a single species approach with the goal of keeping the fish stocks above a precautionary biomass level to avoid stock collapse. Several important variables for the planktivorous fish, such as prey abundance and water temperature, and their effect on the harvested stocks are discussed in the ICES working group reports (e.g. ICES 2011) for these species. However, these factors do not affect the quotas recommended by the working groups.

Management strategy evaluation (MSE) is a method to examine the consequences of different management strategies for a set of assumptions using simulation models. It will reveal the tradeoffs in performance across selected management objectives (Smith *et al.* 2009) for comparison between different strategies (Bunnfeld *et al.* 2011). The normal procedure is to have a setup with 4 different models; an operational model, a management model, a harvest operating model and a resource operating model. This system makes it possible to theoretically test of out how the HCRs perform under different states of the ecosystem without the risk of degrading fish stocks and reducing the expected long term yield.

A7.1.2 Available models

There exist several ecosystem models for the Norwegian Sea. Among these are Ecopath (Dommasnes *et al.* 2001) and Atlantis (unpublished). The ecopath model is not up to date and Atlantis is ready to be used yet, and these models will not be used by this working group. Instead, WGINOR will focus on the use of two different models:

Enac and Norwecom. These models are suitable for addressing the challenges raised in ToR c, and can easily be run and modified by members of WGINOR.

Norwecom

NORWECOM.E2E is a merger of two models, the NORWECOM model for the lower trophic levels and nutrient cycling (Aksnes *et al.*, 1995; Skogen *et al.*, 1995, 2007) and different individual based models (IBMs) developed initially for fish (Huse and Giske, 1998; Strand *et al.*, 2002; Huse *et al.*, 2004; Huse and Ellingsen, 2008, Utne *et al.*, 2012) and zooplankton (Huse, 2005; Samuelsen *et al.*, 2009; Huse *et al.*, 2011; Hjøllo *et al.* 2012). At present IBMs for pelagic fish (mackerel, herring, blue whiting) and *calanus finmarchicus* is running, while there are ongoing work to include IBMs for krill and capelin. The model system also has modules for ocean acidification (Skogen *et al.*, submitted) and contaminants (Green *et al.* 2012). Through NORWECOM.E2E all these models are now being integrated into a fully coupled model system.

The *C. finmarchicus* IBM has been validated by Hjøllo *et al.* 2012, who used the model to study the annual cycle of production and biomass in the Norwegian Sea for the year 1997. The main conclusions were that the mean annual biomass of *C. finmarchicus* was 45 million tons (MT) wet weight with a total production of 190 MT, giving a PB-ratio of 4.3. In the work by Utne *et al.*, 2012 the two IBMs were coupled. In the Norwegian Sea the total consumption of *C. finmarchicus* from pelagic fish was 35 MT (out of a total consumption of 82 MT). The largest predator was herring (24.5 MT), while consumption by mackerel (6.5 MT) and blue whiting (4 MT) was much smaller. However, for all pelagic fish *C. finmarchicus* was the main food in parts of the year (Figure 24).

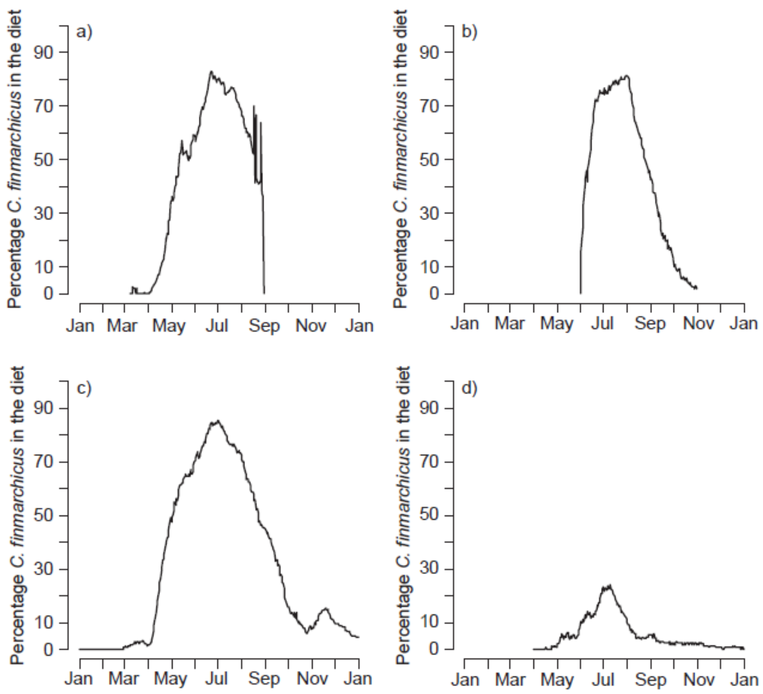


Figure 24. The percentage of *C.finmarchicus* in the diet throughout the year for (a) herring, (b) blue whiting, (c) juvenile blue whiting, and (d) adult blue whiting (Figure taken from Utne *et al.* 2012).

The main strength of models is the ability to integrate information between tropical levels, and give estimates of quantities that is hard (or impossible) to obtain from measurements alone. To make budgets it is essential to have estimates of biological production and how it varies in time and space. Long term simulations to quantify the *C.finmarchicus* production are under way. In Figure 25 integrated production over the Norwegian and Barents seas from NORWECOM.E2E are shown. The results show both a strong annual cycle and inter annual variability with more than 30% difference between the years.

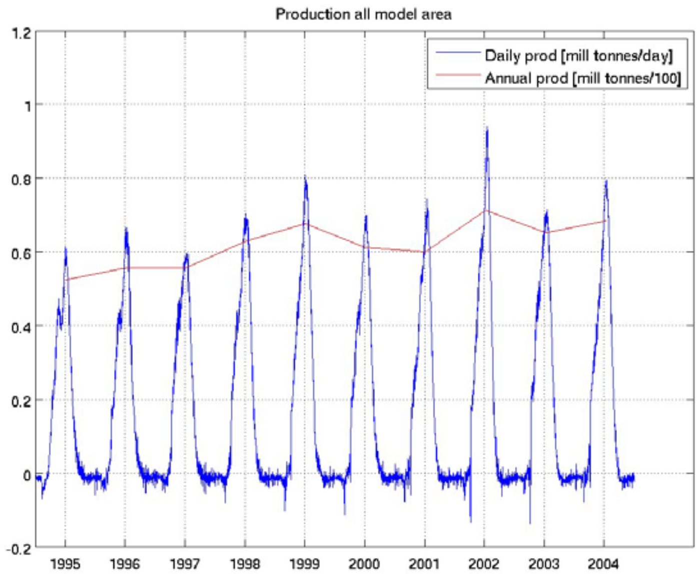


Figure 25. Daily and annual sum of dry weight production of *C.finmarchicus* in Norwegian and Barents seas from Hjøllo *et al.* (in prep).

Through so called what-if scenarios ecosystem models are useful tools to investigate effects of single and multispecies harvest control rules on fishing yield. At present there are several initiatives to use NORWECOM.E2E to contribute on developing ecosystem based advices. In the model predation on *C.finmarchicus* is separated into predation by pelagic fish, mesopelagic fish, tactil predators and krill, and in the ongoing study reported in Figure 25, additional simulations will be done to quantify the effect of a higher (and increasing) pelagic fish stock in the Norwegian Sea, to see if this has an effect of the *C.finmarchicus* production and biomass. Over the last couple of years there has also been a *C.finmarchicus* fishery (www.calanus.no) along the Norwegian coast, and a *fishery* module for NORWECOM.E2E are under development to simulate this harvesting and investigate the effect of this extra mortality.

The Enac model

Introduction

The Enac-model is still under development and has not been published yet. It is a multispecies model for the Norwegian Sea using the management strategy evaluation (MSE) approach (Bunnefeld *et al.* 2011). The model focuses on the most important pelagic fish species in the areas, and their interspecific interactions. Fish at lower or higher trophic levels are not included in the model. Zooplankton is also not included in the model directly. Instead individual growth rates are reduced with increasing stock sizes to represent competition for prey. The main purpose of the model is to test how new HCRs will affect the stock dynamics and the fisheries. The effect of climate variability and mackerel predation on herring and blue whiting recruitment success can also be tested. New HCRs to be tested include an increase in harvest rate when the total biomass of pelagic fish in the Norwegian Sea reaches an upper limit, and to include a climate index or predation on larvae index in the HCRs.

Matherial and methods

The three species included in the model are NSS herring, blue whiting and mackerel. The model consists of four different sub models; an operational model (OM), an observation model (OBM), a harvest models (HM) and a resource operating model (ROM). There are monthly time steps and no spatial resolution in all sub-models. The OM represents the perceived "real world" where the dynamics of the stocks are described by recruitment, growth, maturation and mortality. The OBM adds bias to the output from the OP to mimic that managers never have perfect knowledge of the stocks, but base their knowledge of stock indices from commercial catches, research surveys etc. These biased number at length data are then sent to the HM. The HM projects the development of the stocks forward in time and estimate a fishing mortality (F) based on a HCR. In the ROM the Total Allowable Catch (TAC) is calculated based on F from the HM, and the quotas are split into seasons to mimic the fisheries that vary throughout the year. After an initializing period, the model is run for 50 year. The model is mainly an extension of the model published by Skagen *et al.* (2013) applied to real fish stocks.

The OM projects the stocks forward in time using functions of recruitment, growth, maturation and mortality. Each process is handled using established equations with random variation to ensure a realistic representation of the modelled fish stocks. The model is both age and length structured as several processes are modelled using a length based approach.

The stocks are modelled by using Super Individuals (SI) (Scheffer 1995) with Attribute Vectors (AV) (Chambers 1993). The reason for using SI is to get a detailed representation of the stocks while maintaining some variation between individuals. Growth was modelled using Von Berfalanffy Growth Function (VBGF) (Beverton and Holt 1975?), which is a very good approach when modelling fish growth (Chen *et al.* 1992). For each time step t, a superindividual will grow according to the following equation

$$L(i,t+1) = L(i,t) + (L_{\infty}(i,t) - L(i,t)) * (1 - e^{-K(i-t)})$$

where L_{∞} is the maximum length of the fish, L is the actual length and K is the intrinsic growth rate. Species specific K and L_{∞} was applied. The model can use either a constant or a variable K, depending on the scenario run. K and L_{∞} are estimated from an extensive dataset of length at age from IMRs database, where the growth rates of more than 20 cohorts for each species are tested against a range of covariates. These analyses show that both K and L_{∞} are decrease when the total biomass of pelagic fish in the Norwegian Sea (SSB - herring, TSB – mackerel, TSB – blue whiting) increase. Growth analyses for herring needs to be run again, and the preliminary results for herring should be treated with caution.

The input in the HM is number of fish per length group from the management model and the output is an F for each species. The processes included are the same as in the OM; recruitment, growth, maturation and mortality. This model projects the stock one year forward and estimates the SSB the following year. This information is then used to calculate F according to a HCR.

Input to the ROM is F from the HM and the output is catches in number of fish. The F value is here transformed to a TAC by iteration. The output is calculated using the standard Baranov's catch equation (Baranov, 1918).

Preliminary results

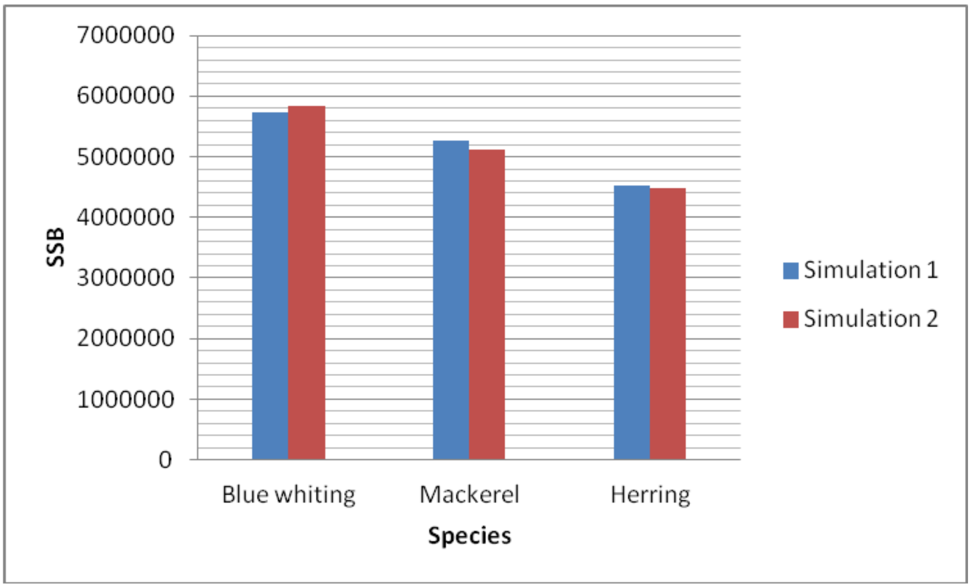
A range of simulations have been run and some preliminary results are ready. A time period of 30 years was run five times for each simulation to estimate the mean value of SSB and TAC. The simulations were the following:

1. Apply the present HCRs
2. Apply modified HCRs where F increases when the total biomass of pelagic fish in the Norwegian Sea (TSB) exceeds 17 million tonnes (TSB_{lim}), given that the SSB of all species are above B_{pa}. The increase in F when TSB exceeds 17 million tonnes are given by the following equation:

$$F = \alpha + \left(\left(\frac{TSB - TSB_{lim}}{TSB_{lim}} \right) * 0.5 * \alpha \right)$$

where α is the highest F presently applied to each species in the HCRs.

The results show the both SSB and TAC for blue whiting are higher in simulation 2 when the modified HCR were applied (Figure 26). This shows that average individual growth for blue whiting is limited due to food competition and that the growth potential for blue whiting is not utilized. Less fish in the Norwegian Sea, leading to a faster growth of blue whiting will result in a larger production of blue whiting available for fisheries. For mackerel the result was the opposite with lower TAC and SSB in simulation 2 (Figure 26). This is reasonable since mackerel growth is not affected by the abundance of other species. For herring the results showed a slightly lower TAC and SSB in simulation 2 (Figure 26). The result for herring should however be treated with caution, as the modelled growth pattern of herring needs to be revised in the model. Presently the first four years for herring is modelled only as a function of abundance of juvenile herring in the Barents Sea, while this may change to only model the length of age 1 as a function of abundance of juvenile herring, and the following years as a function of total biomass of pelagic fish in the Norwegian Sea.



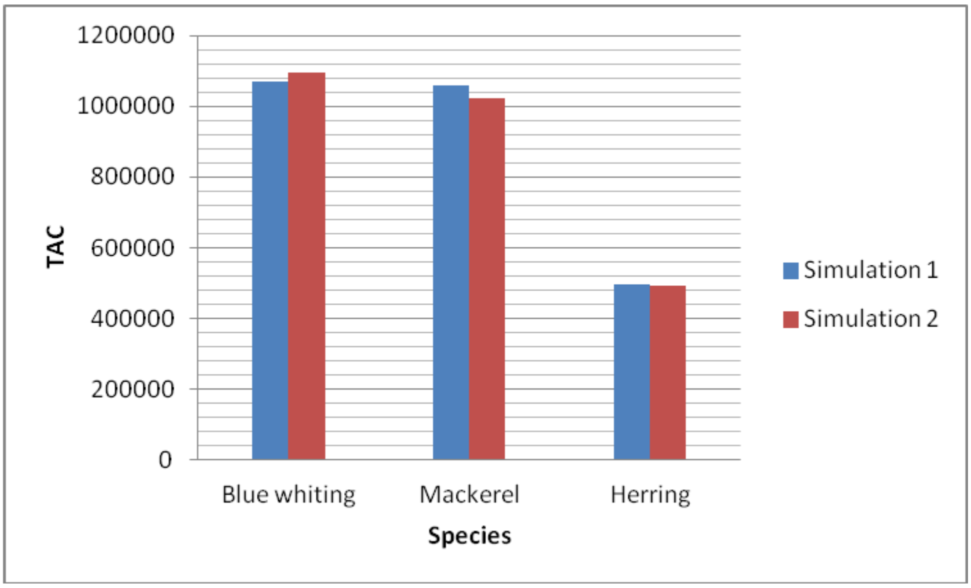


Figure 26. The mean TAC and SSB for mackerel, blue whiting and herring for simulation 1 and 2. All values are the mean over 30 years and 5 iterations.

Model extensions

As the model still is under development there are extensions which have not been tested yet. The two main extensions are the inclusion of climatic drivers and mackerel predation. Both extensions will affect recruitment success for herring and blue whiting.

Several papers have addressed the interactions between environmental conditions and recruitment success for the main pelagic species in the North Atlantic (e.g. Fiksen and Slotte 2002, Hatun *et al.* 2009). There have however not been established a clear correlation between recruitment success and environmental conditions. In the model a climate index is introduced and the recruitment success will be altered according to this index. The AMO index is used for herring, while the sub polar gyre is used for blue whiting.

There is lack of scientific knowledge to define the climatic thresholds where recruitment success change, if such thresholds even exists. The model will be run with different thresholds. The objective of these simulations is to test how pelagic fish will react to changing recruitment regimes similar to the ones observed historically, rather than to predict how the abundance of fish and quota sizes will be the next decades.

Swept area estimates from ecosystems surveys in July show that the abundance of mackerel has increased the recent years and that the stock has expanded northwards during the feeding period (Nøttestad *et al.* in prep.). This has led to speculations on a increased predation pressure on blue whiting (Payne *et al.* 2012) and herring larvae from mackerel. Predation from mackerel will be included in the model with a function as given below

$$E = 1 - \frac{SSB_{mac} - 2}{4}$$

SSB_{mac} (million tonnes) c [2, 5.2]

where E is the survival of larvae after mackerel predation. The parameters in the equation above will change between herring and blue whiting and will most likely be revised after data of mackerel predation pressure is analysed. This survival rate will be multiplied with the initial number of fish larvae given by either a Hockey-stick or Beverton and Holt stock-recruitment model.

Annex 8: Ecosystem overview

A8.1 Introduction

Term of Reference (f) is to prepare an intial draft of the Ecosystem Overview for the Norwegian Sea, following the structure and criteria given in WKECOVER report 2013 (ICES 2013d). Section 1 and 2 are prioritized while Section 3 is preliminary and incomplete.

The working group participants defined the sections and sub-sections they would like to see included in the overview and developed and populated draft overviews for the Norwegian Sea. The ecosystem overview of the Norwegian Sea provides a concise and informative introduction to ecoregion (e.g. Large Marine Ecosystems-LMEs) considered in the ICES advice.

We thank the ICES Secretariat for their support in arranging and running this workshop and for their assistance with developing maps and other output for workshop participants.

A8.2 Criteria for including information in ecosystem overviews

WGINOR follows the criteria given by WKECOVER 2013 and applied to sub-sections within each of the first three sections (Table 5).

For material to be included in the subsection, the response to question ‘a’ and at least one of the other questions ‘b’ to ‘d’ in Table 5.1 has to be ‘yes’.

Once a decision has been made to include a sub-section, it is identified by the frequency of update, the groups responsible for development and the update and the quality control processes used to review the sub-section. The three influences on the rate of update that WKECOVER considered were (1) whether a client commission cycle already defines an update rate, (2) whether an existing ICES process (e.g. frequency of EG meeting) requires updates on the same frequency and (3) knowledge of the rates of updating of data streams and analysis and expected rates of change in state or pressure.

Table 5. Questions to assess whether potential content should be included in an ecosystem overview.

Code	Question
A	Does the proposed sub-section support one of the purposes of the overview?
B	Has the ICES community identified a strategic reason why this section should be included in the overview?
C	Is the information in the proposed sub-section requested as advice by a client commission?
D	Is the information needed to support other assessments requested by client commissions?

For each subsection, the information on ‘data of inclusion and frequency of update’, ‘responsibilities’ and ‘quality control’ described in Tables 6, 7 and 8 were recorded. This is to ensure that, post workshop, there would be a ‘recipe’ available to support development of overview subsections.

Table 6. Information to collate on date of inclusion and frequency of update of sub-section.

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)
3	Are there specific formats for the inclusion or updates required by a client commission?

Table 7. Information to collate on responsibilities for sub-section.

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)
2	Identify group responsible for providing data to support update of the proposed sub-section?
3	Identify group responsible for data processing to support updates of the proposed sub-section?

Table 8. Information to collate on quality control and risk.

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)

A8.3 Subsections to be included in the Norwegian Sea overview

Based on the purpose of the overviews and the criteria for inclusion of contents, WGINOR proposed that the following subsections should be included in the ecosystem overviews (Table 9).

Once sub-sections were agreed, WGINOR used the templates developed by WKECOVER. These described the contents of the subsection, data of inclusion and frequency of update, responsibilities and quality control.

Data and information may not be sufficient to allow all subsections to be developed in the short-term. In these cases, WGINOR will flag that available data and information were inadequate. Also, the WGINOR will focus on selected key elements where appropriate and leave out subsections with no valuable information. Thus the overview will be edited from the template to a specifically suited overview for the Norwegian Sea.

The subsections included are listed in table 9.

Table 9. Subsections included in the Norwegian Sea ecosystem overview.

Section 1	LME boundaries and geography	Map
Section 1	Key signals-Physical and chemical oceanography	Trends in oceanographic data
Section 2	Key signals-Biotic processes	Selected stocks/ ecosystem elements: phytoplankton, zooplankton, planktivorous fish, piscivorous fish, sea mammals, sea birds
Section 2	Key signals-Human impacts	Fishing: potential fisheries for influence on management advice
Section 3	Activity	Fishing: Summary of the fishery activities
Section 3	Pressure	Fishing; Summary of pressures from fisheries activities

Based on the development of advice (e.g. ACOM Doc 7 ASC consultations 2012), WKECOVER recommend that Sections 1 and 2 of the overview are prioritized for short-term development. WGINOR follows this recommendation, with a priority on Section 2, while also adding a discussion and preliminary draft of Section 3 in the 2013 report. Prioritization of content for inclusion in Sections 3 is challenging because a very wide range of data could be used to describe pressure and state. However, little factual information is available for the area in addition to the fisheries data and scientific surveys for species and ecosystem evaluation. In general, participants considered that a pragmatic approach would have to be adopted here, with higher priority given to indicators that were of interest to client commissions (e.g. requirements for data to be reported through the Norwegian Sea Management Plan of Norway and for advisory purpose). Sections 3 and eventually 4 are meant to provide an opportunity to brigade indicators of likely interest to client commissions. However, including all the information in the overview that would ultimately contribute to assessments of pressure and state, for example in a cumulative impact assessment, is unlikely to be feasible or desirable.

Regional integrated assessment groups, like WGINOR, is key players to elevate signals from the environment and ecosystem to ‘key’ and to lead to an entry identifying these signals in Section 2, to screen the wide range of environmental and ecosystem signals and to identify those that would have a significant effect on the way in which other Expert Groups would develop advice.

A8.4 Draft overviews and supporting documentation

WGINOR participants developed sub-section contents and supporting information for each sub-section for the Norwegian Sea in the same way as WKECOVER did for the Baltic Sea, North Sea and Celtic Sea. This overview is preliminary in terms of content and format. As for the WKECOVER subsections, it is also not concise enough.

The breadth of expertise in WGINOR is broad and international within the regional assessment expert groups, stock assessment expert groups to make improved integrated assessments on the state of the LME (LME), but on aspects of the full range of pressures in the LMEs, expertise on other human activities than fishery was less prominent. To reflect the status as ‘works in progress’, we have included the overview in this report as an appendix.

Successful development of the overview sub-sections will require on-going and active management of the process.

A8.5 Next steps

WKECOVER proposed that Section 1 would ideally be developed for all LMEs in 2013. WGINOR is complying with this proposal from WKECOVER. WGINOR also strive to make the best possible progress with developing Section 2 and also Sections 3, where the most influential human activity is described. Section 4 has lower priority and needs to be developed in the longer-term, and with emphasis on how to approach IEA within the frame of the Norwegian management plan for the Norwegian Sea.

Developing Section 2 will involve taking the benchmark assessments as an opportunity to account for signals in the environment and ecosystem (i.e. key signals relating to 'physical and chemical oceanography', 'biotic processes' and 'human impacts'), since immediate options to account for some of these influences may be limited by the assessment models that are currently available. Material will be added to Section 2 (and the associated assessments modified) in a stepwise fashion when new benchmark assessments are available. However, in this draft existing assessment models are modified to account for key signals in the environment and ecosystem then this should be done as part of the normal assessment cycle. The full list of participating parties for collecting, analysing, assessing and archiving the human pressure data is not complete and will be developed further in the next overview.

Through 2013, the evolving overviews are being reviewed by the Regional Integrated Assessment Groups and the Regional Expert Groups (fish stock assessment) including this draft overview of the Norwegian Sea by WGINOR. Along with advices from other working groups as The Working Group on the Ecosystem Effects of Fishing Activities (WGECO) and specialist expert groups (e.g. Working Group on Operational Oceanographic Products for fisheries and environment (WGOOFE), Working Group on Oceanic Hydrography (WGOH) and Expert Groups focusing on ecosystem components: e.g. zooplankton, fish stocks, mammals, birds) we expect this will make additional contributions to the ecosystem overviews throughout 2013.

WGINOR has followed the template from WKECOVER, and made some notes on the practicability and readability of the review for the Norwegian Sea as well as the review method presented. These notes can be made available for further work on improvement of the review template.

A8.6 Preliminary ecosystem overview of the Norwegian Sea

Note that the content of the overview presented is a 'work in progress' based on the expertise present at the 2013 working group in Bergen. Because the breadth of expertise in WKECOVER was less than that was available in the broad range of expert groups, the WGINOR wants to contribute to the overview in the longer-term with some suggestions when prioritizing. Also WKECOVER participants developed these annexes based on their own expertise and by prioritizing information they had available during the workshop, but recognize that additional material will need to be considered before overview contents are finalized. WGINOR has especially focused on the contents of Section 2, and assess whether the signals currently identified are those that are most likely to have a significant effect on the advice.

Section 1

Sub-section 1.1. LME boundaries and geography.

Eco-region	Norwegian Sea
Section number	1
Sub-section number	1.1
Sub-section title	LME boundaries and geography Map
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, C, D

Description of figure/ table or other element

Three are some variations on how the Norwegian Sea is described spatially, but WGINOR is following the revised map made by PAME (Protection of the Arctic marine Environment; 2013); (Figure 28).

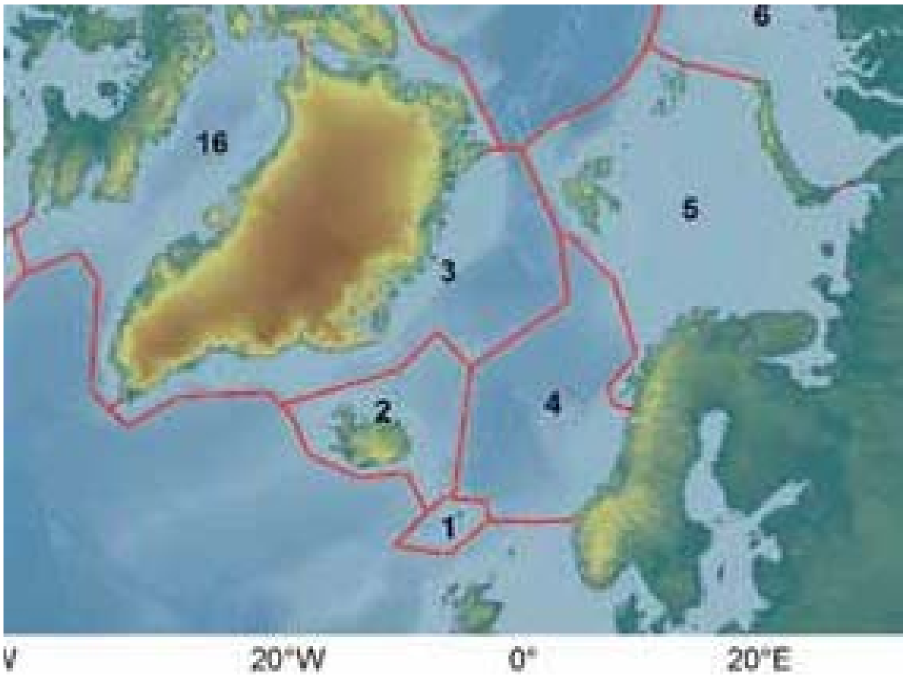


Figure 28. Natural delineations decided by the Arctic Council, April 2013. The Norwegian Sea is area 4 (Source: PAME 2013).

List of maps and links to:

PAME:http://www.arctic-council.org/index.php/en/document-archive/category/445-pame?download=1745:revision-of-the-arctic-large-marine-ecosystems-lmes-of-the-arctic-area-map.

Barentswatch: http://www.barentswatch.no/en/Kart/Temakart/Norskehavet/

Description of narrative

The Norwegian Sea is a deep sea, with a shelf area west of Norway, a sill in the southern end between Faroe Islands (1), Iceland shelf (2) and the underwater mountain ridge separating it from the Greenland Sea (3) and the North Sea plateau in the southern part. It borders to the Barents Sea (5) along the slope on the westernmost border of the Barents Sea (Figure 28).

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	NA
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	SCICOM WGINOR, ICES Secreteriat, all involved nations
2	Identify group responsible for providing data to support update of the proposed sub-section?	ICES Secreteriat, WGINOR, IMR
3	Identify group responsible for data processing to support updates of the proposed sub-section?	ICES Secreteriat, WGINOR, IMR

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	ICES Secreteriat
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGINOR
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	ICES Secreteriat
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ICES Secreteriat
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	ICES Secreteriat

Sub-section 1.2. LME management.

Eco-region	Norwegian Sea	
Section number	1	
Sub-section number	1.2	
Sub-section title	LME management	List of customers (ICES, OSPAR, the Norwegian management plan)
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, B, C, D	

List of LME management plan and statistical maps

- ICES, mostly II a and II b: http://geo.ices.dk/viewer.php?add_layers=ices_ref:ices_areas
- NEAFC, areas outside national exclusive economic zones: http://www.neafc.org/page/27
- The Norwegian management plan: http://www.environment.no/Interactive-map/
- OSPAR, central part of Region 1 and northern most tip of Region II: http://www.ospar.org/content/regions.asp?menu=00020200000000_000000_000000

Description of management zones

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	Every fifth year, or as motivated by ongoing development in the field
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	SCICOM WGINOR, ICES data centre, IMR, MRI, LIU
2	Identify group responsible for providing data to support update of the proposed sub-section?	SCICOM WGINOR, ICES data centre, IMR, MRI, LIU
3	Identify group responsible for data processing to support updates of the proposed sub-section?	SCICOM WGINOR, ICES data centre, IMR, MRI, LIU

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	ICES Secreteriat
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	SGSPATIAL
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	SGPATIAL and ACOM
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	SGSPATIAL and ICES Secreteriat

Section 2

Sub-section 2.1. Physical and chemical oceanography

Eco-region	Norwegian Sea	2013
Section number	2	
Sub-section number	2.1	
Sub-section title	Key signals-Physical and chemical oceanography	Climate and Ocean chemistry
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, B, C, D	

Description of figure/ table or other element

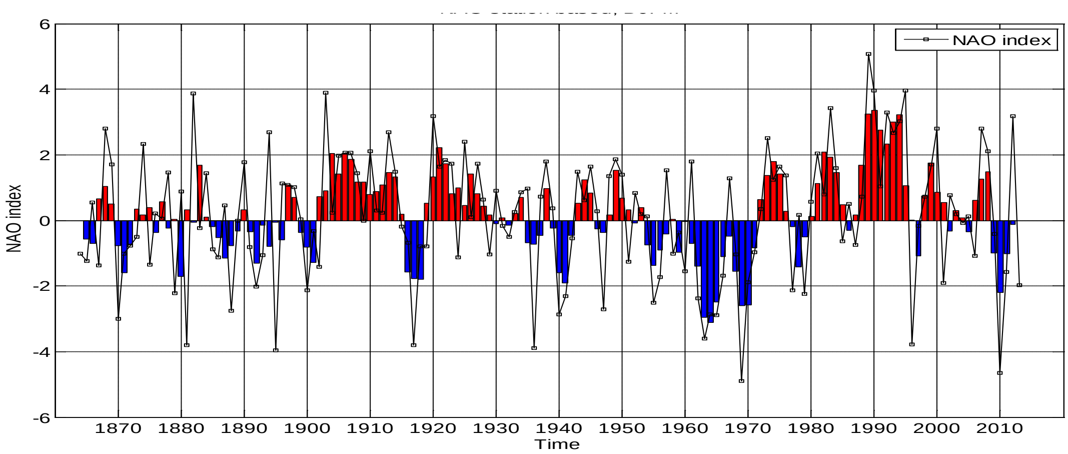


Figure 29. The long-term climate evolution represented by the North Atlantic Oscillation winter index (ToR b; Hurell, 1995).

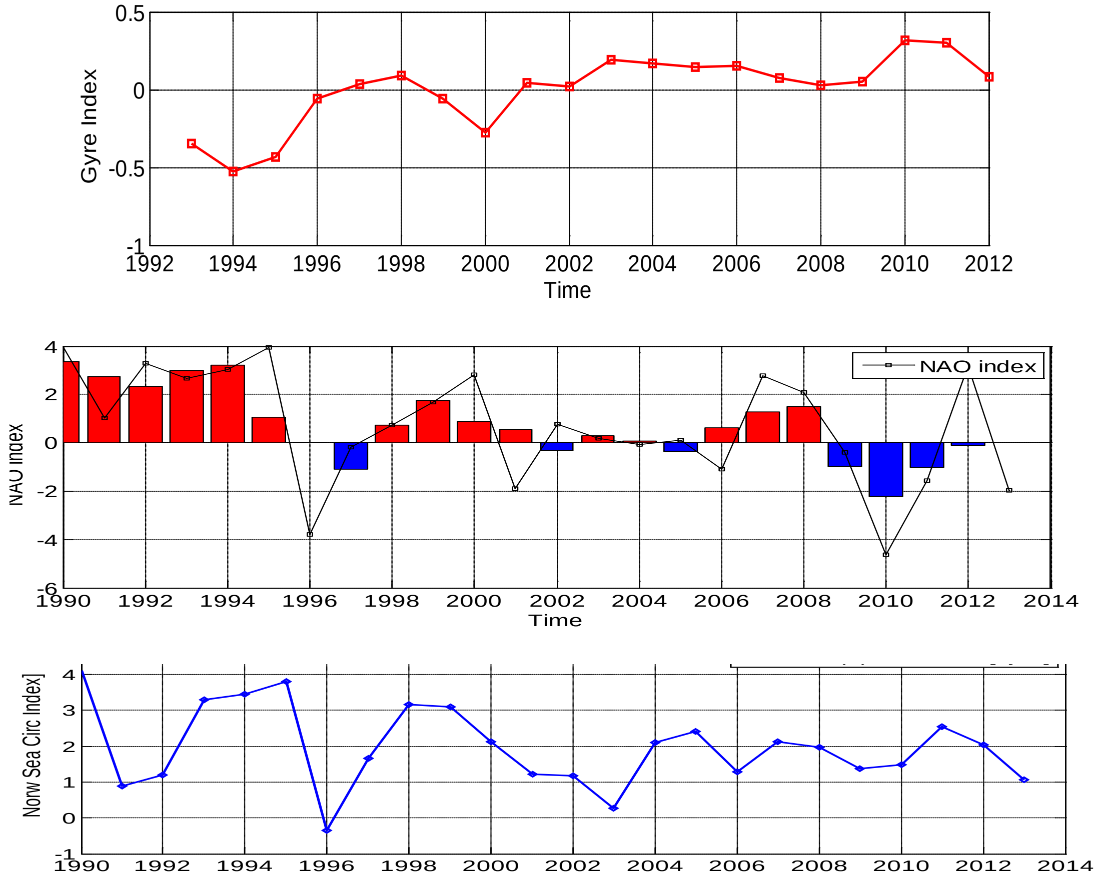


Figure 30. Upper) the sub-polar gyre index; middle) NAO-djfm index; lower) gyre circulation index in the Norwegian –Lofoten Basin (ToR b).

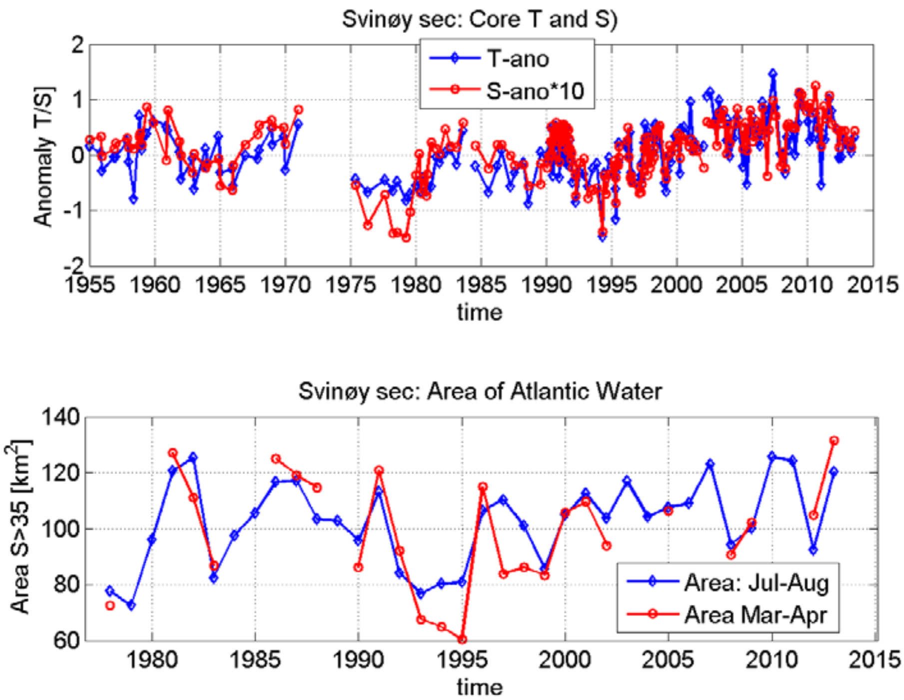


Figure 31. Upper Core Temperature and Salinity in the Svinøy section, and lower Area of Atlantic Water in the Svinøy section (ToR b).

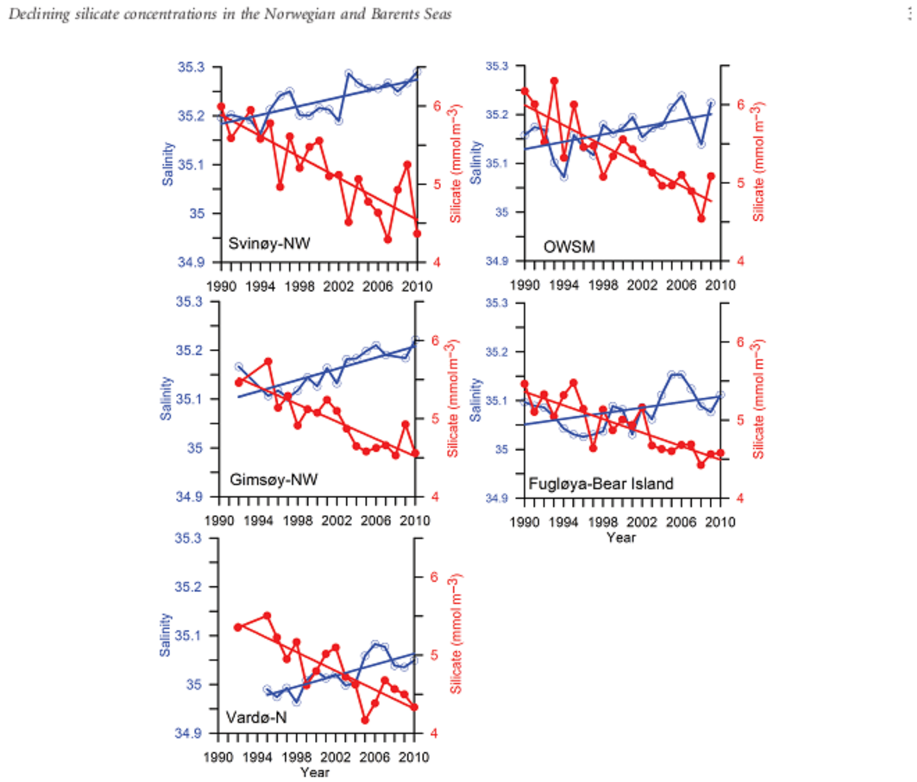


Figure 32. Time-series of salinity (open blue circles) and silicate (closed red circles) at different places in the Norwegian and Barents Sea. (ToR b; From Rey 2012).

Description of narrative

The large-scale atmospheric circulation changes influence the currents and hydrographic conditions in Norwegian Sea. Since the 1960s, changes in the large-scale wind pattern, principally the North Atlantic Oscillation (NAO), have resulted in a gradual change of the water mass distribution in the Nordic Seas. In particular, this is manifested by the development of a layer of Arctic intermediate waters, deriving from the Greenland and Iceland Seas and spreading over the entire Norwegian Sea (Blindheim *et al.* 2000). In the Norwegian Basin it has resulted in an eastward shift of the Arctic front and, accordingly, an upper layer cooling in wide areas due to increased Arctic influence. Blindheim *et al.* (2000) also found that the westward extent of Atlantic water in the Norwegian Sea was less during the high phase of the North Atlantic Oscillation than during the low phase, with the difference between its broadest recorded extent in 1968 and its narrowest extent in 1993 exceeding 300 km. This implies that a stronger cyclonic atmospheric circulation pattern would move the surface waters to the east. This would decrease the area of Atlantic water and thus reduce ocean-to-air heat loss.

The NAO-index during the last 10 years shows year to year variability but signals that extend over consecutive years appear not prominent compared to earlier periods. The wind conditions along the East Greenland Current have been remarkable stable over the period 2003–2013. The Sub-polar gyre index indicates a further weakening in 2010–2011. The hydrographic conditions in the Svinøy section show the transition toward warmer and more saline Atlantic water from 1995–2004 at least partly connected to the change in the SPG, but again indications of a decreasing during the last years. The area of the Atlantic Water follow the changes in the NAO, hence showing fluctuations from year to year. The habitat area for herring, blue whiting and mackerel in the Norwegian Sea show similar evolution and have increased from 1995 to a maximum in 2003–4 and subsequently a slight decrease but still relative high values. The hydrography indicates that the influence of the East Icelandic Current into the southern Norwegian Sea was strong in the late 1990s, and with generally low values over the last 10 years.

There is a trend of decreasing silicate concentrations in early spring (Figure 32). Rey (2012) also mentions decreases, though much weaker for nitrate. WGINOR has access to the nutrient data, and is therefore in a position in look into other possible nutrient trends in the Norwegian Sea, also including the years to come.

The data and contents of this sub-section should be drawn to the attention of NEAFC, OSPAR, WGOOFE, WGOH, WGZE, MCWG, WGPME, IMR, MRI, and LIU

Data on inclusion and frequency of up-date of subsection

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013, end of September
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	Annual up-dates
3	Are there specific formats for the inclusion or updates required by a client commission?	Unknown

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	IMR, MRI, LIU, WGOH
2	Identify group responsible for providing data to support update of the proposed sub-section?	WGINOR
3	Identify group responsible for data processing to support updates of the proposed sub-section?	WGINOR

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	WGINOR
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGECO
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	WGINOR+ ACOM and SCICOM

4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM and SCICOM
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	WGINOR

Sub-section 2.2_Biotic processes

Eco-region	Norwegian Sea	2013
Section number	2	
Sub-section number	2.2	
Sub-section title	Key signals-Biotic processes	Selected stocks/ ecosystem elements: phytoplankton, zooplankton, pelagic fish, piscivorous fish, sea mammals, sea birds
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, B, C, D	

Description of figures/ tables or other element

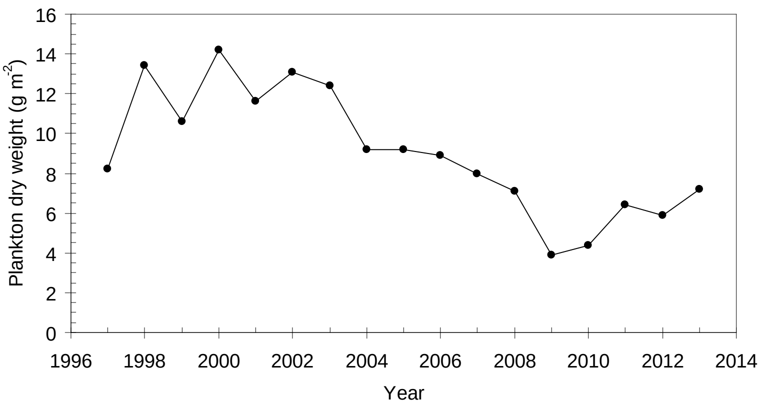


Figure 33. Sea and adjacent waters from 1997 to 2013 (ICES data, ToR b).

With respect to the time-series for the ICES coordinated May cruises, the reported zooplankton biomasses for the uppermost 200m show a declining trend from the early 2000s, though which minor increases the very last years (Figure 33). In May 2013, the estimated average for the total area covered was estimated at 7.2 g dry weight per square meter, as compared to the minimum level of 3.9 in 2009.

Pelagic fish stocks

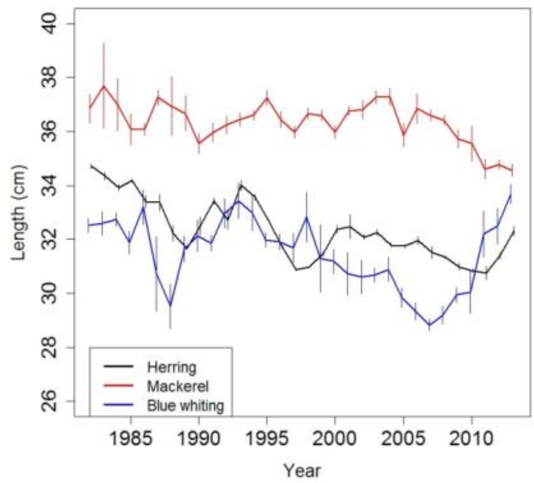


Figure 34. Development of length at age of selected pelagic fish species in the Norwegian Sea: Herring (black line), mackerel (red line) and blue whiting (blue line); (from ToR b).

There has been a downward trend in the length at age in herring over time as reported in (Huse *et al.*, 2012). Figure A7 shows that this trend seems to have been reversed in the recent two years. For mackerel on the other hand a downward trend was started in 2006 and has been maintained since. The blue whiting showed a downward trend until 2007, but has since showed an upward trend with the strong reduction in the stock. The stock is increasing strongly at present (ICES 2013) so it will be interesting to see how this develops in the coming years.

The fish stocks feeding in the Norwegian Sea are monitored by annual surveys under supervision of ICES and conducted by Norway, Iceland, Faroe Island Russia and EU. The states of the populations are reported annually through the Norwegian Sea management plan, to the ICES working group on widely distributed stocks (WGWIDE), NEAFC.

Sea birds and sea mammals

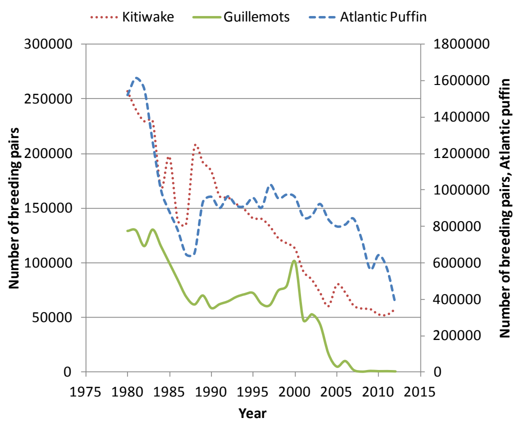


Figure 35. Development of breeding pairs of selected sea bird species feeding in the Norwegian Sea: surface feeders (Kittiwakes, red dotted line) and fish feeders (guillemots, green line and puffins, blue dotted line); (from ToR b).

The breeding population of kittiwakes on the Norwegian coast has declined since monitoring started in 1980 (Figure 35). The Atlantic Puffin breeding populations have declined since monitoring started in 1980. Also guillemot breeding populations have declined considerably since monitoring started in 1980 and the species may disappear as a breeding species along the Norwegian coast of the Norwegian Sea.

The causes for the declines are not clear, but it seems likely that they are related to the food situation which is known to affect seabird colonies rather strongly.

The sea bird population is monitored by the SEAPOP programme in Norway and the state of the populations are reported annually through the Norwegian Sea management plan, to the ICES working group on sea birds (WGSE; ICES 2011b) and OSPAR.

The data and contents of this sub-section should be drawn to the attention of NEAFC, OSPAR, WGMME, WGZE, WGINOR, WGWIDE, HAWG, WGIPS, WGPME, WGSE, WGSFD, IMR, MRI, LIU.

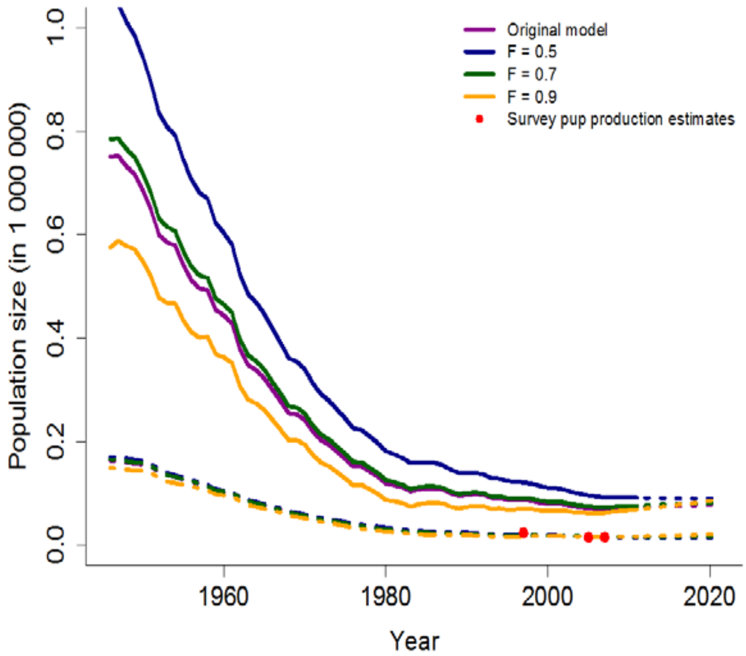


Figure 36. Modelled abundance of Greenland Sea hooded seals. F refers to different options for pregnancy rates. Currently a pregnancy rate of 0.7 is assumed for this population (from WGHARP, 2011; ToR b).

For hooded seals, catch based modelling shows a dramatic decline in abundance over the period 1945–1980 (see Figure 36). This decline is thought to be mainly catch-driven. The catches were significantly reduced from the early 1980s to 2006, but may nevertheless have been an important factor for the lack of recovery. Other factors such as possible changes in food availability and natural mortality can, however, also not be ruled out. Hooded seals have been completely protected since 2007.

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013, September

2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	Annually
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	WGINOR, WGZE
2	Identify group responsible for providing data to support update of the proposed sub-section?	WGZE, WGIPS, WGWIDE, WGSE, WGMME, IESNS, IESSNS
3	Identify group responsible for data processing to support updates of the proposed sub-section?	WGIPS, WGWIDE, WGSE, IESNS, IESSNS

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	WGINOR; WGZE, WGIPS, WGMME, WGWIDE, WGSE, IESNS, IESSNS
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGECO
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	WGINOR+ ACOM and SCICOM level activity
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM and SCICOM level activity
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	WGINOR

Sub-section 2.3_Human impacts

Eco-region	Norwegian Sea	2013
Section number	2	
Sub-section number	2.3	
Sub-section title	Key signals-Human impacts	Fishing
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A,B,C,D	

Description of figure/ table or other element:

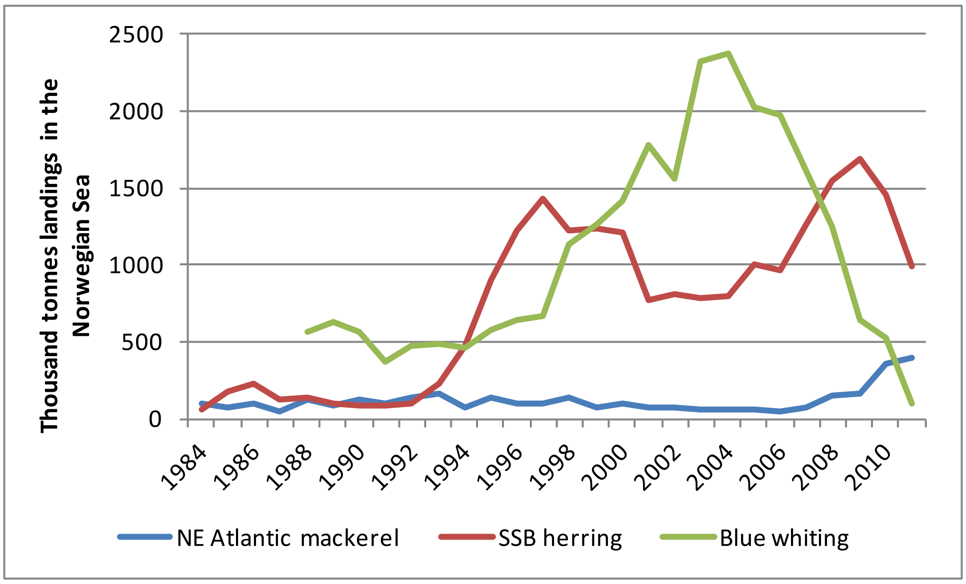


Figure 37. Historical development of the landings of NE Atlantic Mackerel, herring and blue whiting (Source: ToR b; ICES WGWIDE 2012).

Description of narrative

The data and contents of this sub-section should be drawn to the attention of NEAFC, OSPAR, WGBFAS, WGBAST, SGSPATIAL, MRI, LIU.

There has been a downward trend in the length at age in herring over time as reported in (Huse *et al.*, 2012). Figure 15 below shows that this trend seems to have been reversed in the recent two years. For mackerel on the other hand a downward trend was started in 2006 and has been maintained since (Figure 15). The blue whiting showed a downward trend until 2007, but has since showed an upward trend with the strong reduction in the stock. Date of inclusion and frequency of update of sub-section.

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	Annually
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	WGINOR
2	Identify group responsible for providing data to support update of the proposed sub-section?	WGINOR, SGSPATIAL
3	Identify group responsible for data processing to support updates of the proposed sub-section?	WGINOR, SGSPATIAL

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	WGINOR, SGSPATIAL
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGECO
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	WGINORB+ ACOM and SCICOM level activity
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM and SCICOM level activity
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	WGINOR, SGSPATIAL

Section 3

Sub-section 3.1_Activity

Eco-region	Norwegian Sea	2013
Section number	3	
Sub-section number	3.1	
Sub-section title	Activity	Fishing, nen-renewable energy, shipping, physical aleration, physical damage
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, D	

Description of figure/ table or other element

The major human activities in the Norwegian Sea are presented in table 10. Except for these, fishing, non-renewable energy and shipping, other activities which are present in a minor way include:

Table 10. The major human activities in the Norwegian Sea. Preliminary draft prep. By M. Olsen Directorate of Environment for a national ecosystem management plan report (in prep.).

Activity	Biologic impacts	Physical impacts	Releases of pollutants	Releases of nutrients and organic materials	Other impacts
Fishery	Fisheries Whaling Seal hunting Bycatch Trophical interactions Introdused species	Damage to sea beds			Marine littering (ghost fishing gear)
Petroleum	Alien species	Physical disturbance of/into the sea bed	Ordinary releases to air Ordinary releases to sea (kaks/chemicals/semen), produced water) Acute oil spill Radioactivity		Seismic activity, Littering
Shipping	Introduction of alien species / ballastwater and encrusting organisms on the hull		Ordinary releases to air Ordinary releases to sea (*gray and black water)* Acute spills Illegal spills		Ordinary releases to sea (litter) Noise and acoustic pollution from ships (engines, propellers, sonar) Collisions between ships and marine mammals

The fishery is regarded the most prominent pressure while the oil- and gas-related activity is also controversial. Areas for fisheries and non-renewable energy search and production is illustrated in Figure 5.11.

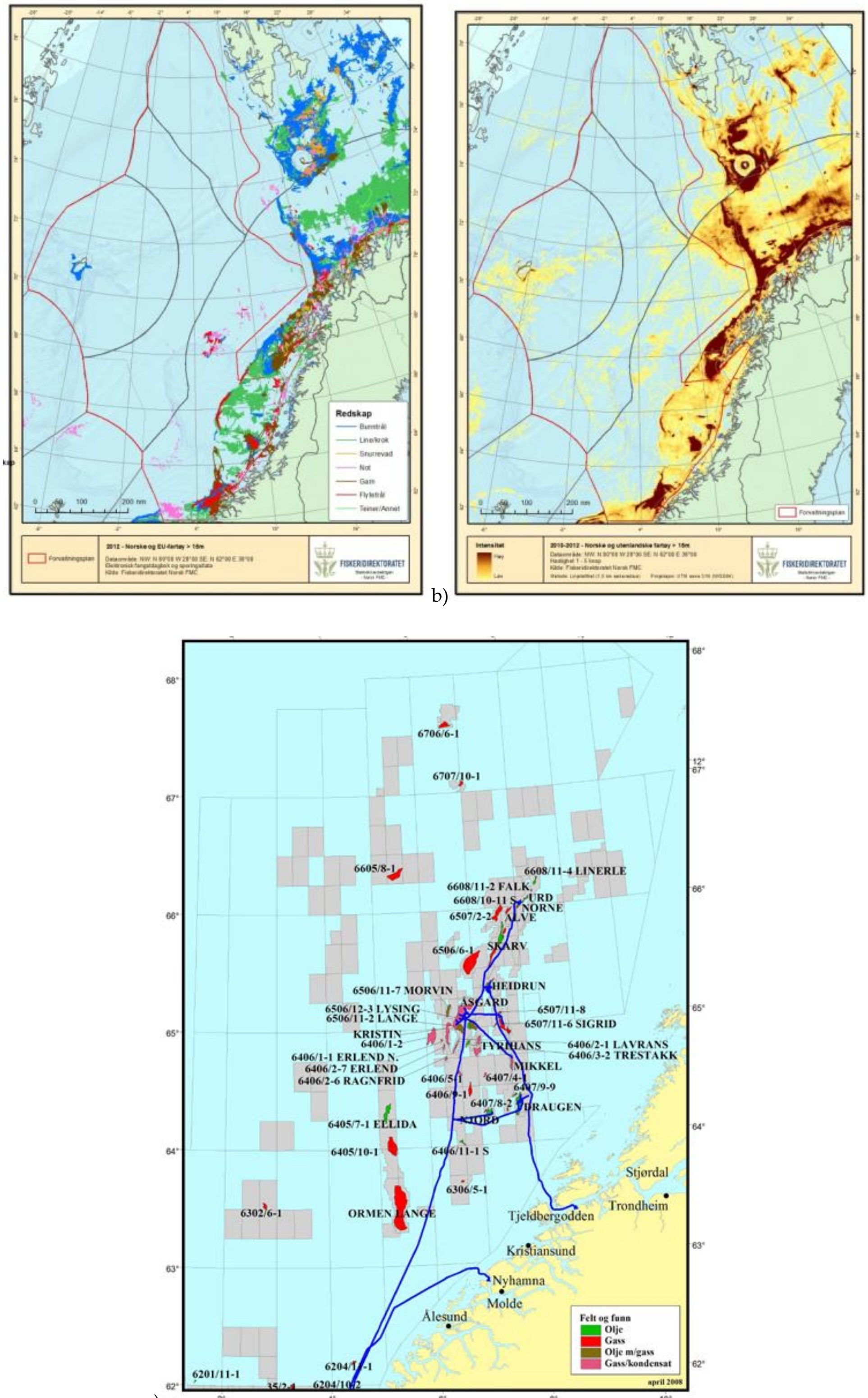


Figure 38. Fishing gear and fishing grounds in the Norwegian Sea: a) Fishing areas for different fishing gear: bottom trawl (blue), longline/angles (green); seine (yellow), purse seine (pink), nets (black), pelagic trawl (red), pots/ others (light green). b) Satellite tracking of fishing vessels > 15 m, cruising in 1- 5 knots in the Norwegian Sea and the Barents Sea (Data source and maps: The Norwegian Fisheries Directorate, 2013). c) Localization of petroleum-related activities in the Norwegian Sea, production units and available fields for extractions (Source: Directorate for oil and gas, 2008).

Description of narrative

The Norwegian fishery in the Norwegian Sea is to a large extent by purse seines while the rest of the European fishing fleet uses pelagic trawl. Some jigging is also used, but purse seining and pelagic trawl are the greatest pressures on the Norwegian Sea ecosystem (Figure 38).

The data and contents of this sub-section should be drawn to the attention of NEAFC, OSPAR, ICES, National fisheries managements.

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2013
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	Annually, as motivated by ongoing developments in the field
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES WGINOR, ACOM, Secretariat, external groups etc)	SGPATIAL
2	Identify group responsible for providing data to support update of the proposed sub-section?	SGPATIAL, SSGHIE, WGMBRED
3	Identify group responsible for data processing to support updates of the proposed sub-section?	SGPATIAL, SSGHIE, WGMBRED

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	SGSPATIAL
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGECO
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	SGSPATIAL and ACOM
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	SGSPATIAL

Sub-section 3.2_Pressure

Eco-region	Norwegian Sea	2013
Section number	3	
Sub-section number	3.2	
Sub-section title	Pressure	Fishing, table for other activities (non-renewable energy, shipping, etc (from the management plan)
Does the proposed content meet the criteria for including a sub-section on the overview?	Yes, A, B, C, D	

Description of narrative

It is an ongoing process to better describe the pressures of the human activities in the Norwegian Sea. The available data for the WGINOR is mostly on the level of activity and not on how this is translated into actual pressures on individuals, species, trophic levels and ecosystems. This sub-section will be subject for improvement on in the following WGINOR reports.

Date of inclusion and frequency of update of sub-section

1	Given available expertise and resources, when will the proposed sub- section be included in the overview? (year, month)	2014
2	What is the update frequency for updating the sub-section after first inclusion? (year, month) (drivers may be client needs, EG meeting dates or based on dates of data provision or expected rates of change in activity, state and pressure)	3 years
3	Are there specific formats for the inclusion or updates required by a client commission?	No

Responsibilities for sub-section

1	Identify group responsible for including, updating and providing context and interpretation linked to the proposed sub-section? (ICES EG names, ACOM, Secretariat, external groups etc)	WGINOR
2	Identify group responsible for providing data to support update of the proposed sub-section?	IMR, NIVA, NINA, NIFES, The Norwegian Directorate of Fisheries and coastal affairs, the Norwegian Directorate of Environment, the Directorate for Oil and Gas
3	Identify group responsible for data processing to support updates of the proposed sub-section?	IMR, NIVA, NINA, NIFES

Quality control/ risk

1	Identify group to produce and archive description of the relevant data (how they are worked up, code, quality assurance method)	To be defined
2	Identify reviewer of process and sub-section (external experts for first round, internal review for update process?)	WGECO
3	Review contents of proposed sub-section to ensure there is no inconsistency with other information in the overview or advice. If there is, correct it.	To be defined and ACOM
4	Review contents of proposed sub-section for incompatibilities with other information in the overview or advice. If there are incompatibilities, highlight them	ACOM
5	Ensure narrative captures uncertainties in the sub-section contents (e.g. IPCC guidance)	To be defined and ACOM