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2nd Interim Report of the Working Group on Integrated Assessments of the Norwegian Sea (WGINOR)

18–22 August 2014

Torshavn, Faroe Islands

ICES
International Council for the Exploration of the Sea
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Executive summary

The second meeting of Working Group on Integrated Ecosystem Assessments for the Norwegian Sea (WGINOR) was held in Torshavn, Faroese Islands, 18–22 August and was chaired by Geir Huse, Norway, and Guðmundur J. Óskarsson, Iceland. The total number of participants was 7, representing Norway (4), Iceland (1) and the Faroese (2; Annex 1). In addition another eight Norwegian researchers participated by correspondence. The objectives of the meeting were to continue the work on developing an approach to integrated assessment for the Norwegian Sea based on reviewing the work of other groups and literature studies, and undertake an integrated assessment for the Norwegian Sea ecosystem. Presentations were made on the present status of the different ecosystem components in the Norwegian Sea, i.e. climate and hydrography, plankton, fish, marine mammals and seabirds based on two recent surveys in the Nordic Seas in May and July August 2014 and other annual surveys.

Preliminary analyses of time-series of the different ecosystem components revealed both previously known and novel findings. The most relevant findings are summarized here. The temperature of the Norwegian Sea is currently slightly above the normal and has had a downward trend in recent years after a peak in 2007. The biomass of mesozooplankton had a downward trend during 2003–2009, and has shown an increase in the last years and is now back to the level before the decline started. 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 unknown level of the mackerel stock. Nevertheless, it is clear that the mackerel stock and blue whiting stocks are increasing while the herring stock continues to decrease. The length-at-age of herring has been decreasing since the 1980s, but in the three 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 (Huse *et al.*, 2012). An preliminary analysis show a weak relationship between interannual level in zooplankton biomass and maximum chlorophyll concentration, indicative of bottom up forcing. The results therefore so far indicate that the Norwegian Sea ecosystem alternates between bottom up and top down forcing.

The data compilation is considered more or less finished and thorough multivariate analyses will be one of the main tasks in 2015 to carry out an integrated assessment for the Norwegian Sea ecosystem. Furthermore, ecosystem modelling and other outstanding tasks from the terms of reference will be dealt with. The third WGINOR meeting will be held in Reykjavik, Iceland from Monday 7 to Friday 11 December 2015.

1 Administrative details

Working Group name
Working group on Integrated Assessments of the Norwegian Sea

Year of Appointment
2012

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

Chairs
Guðmundur Oskarsson, Iceland
Geir Huse, Norway

Meeting venue
Torshavn, Faroese Islands

Meeting dates
18–22 August 2014

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 focused on presentations.

Guðmundur Oskarsson presented the results from this year's surveys in the Norwegian Sea, in May and July. This resulted in lengthy discussions about the state of the ecosystem and the ongoing processes with warming north of Iceland and expansion of the mackerel distribution as key features.

Hein Rune Skjoldal provided an overview of the main concepts involved in integrated ecosystem assessments, using the Norwegian Sea as an example. He advocated application of a straightforward approach consisting of data assembly, data analysis and interpretation. There was a discussion about how to approach this for the Norwegian Sea ecosystem.

The rest of the meeting was carried out through working in groups and with daily plenary meetings. The meeting ended Friday at 13H.

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 statey 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 regional 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 capture most of the key components of the ecosystem. These datasets are a firm foundation for undertaking integrated assessment of ecosystem status in the Norwegian 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 anthropogenic 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 abundance 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 devoted to developing an overview of sampling requirements for integrated ecosystem assessment. This list will be developed in dialogue with WGIPS and the final specification will be reported to this group, which has competence on survey sampling strategy.

Term of Reference 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 at the first meeting to initially use a straightforward three-step approach consisting of: 1. Data assembly, 2. Data analysis, 3. Interpretation. IEA is an important step in ecosystem approach, but there are several other steps as well as outlined in last year's report (ICES, 2013e). This cycle is in many ways similar to the so-called Levin cycle (Levin *et al.*, 2009) that NOAA uses in the US, but it is slightly simpler schematically. In the first year, the focus was on getting an overview on which data are available on the different ecosystem components and presenting the status. This year we have put more emphasis on developing the integrated assessment approach by putting the different variables together and perform multivariate analyses.

Regarding the objectives for the ecosystem, it was agreed to adopt high-level statements for the overall objective 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 objectives 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".

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 dataseries available (Table A3.1, Figure. A3.1). This was done in a standardized fashion with an initial description of the ecosystem components, a description of the dataseries 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 were 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.

Zooplankton

As presented in last WGINOR report, three datasets of zooplankton abundance are particularly relevant to integrated assessment. They are WP2-plankton nets sampling in the May (IESNS) and July August (IESSNS) surveys, and MOCNESS sampling in the Norwegian part of the surveys. Data from the whole IESNS time-series from 1995–2014 was successfully recovered by WGINOR in 2014 and will be evaluated in more details and will be central in the WGINOR work in 2015. Preliminary analysis of the recovered time-series shows a similar trend as the former series (Figure 1). The two other time-series were only updated from last year.

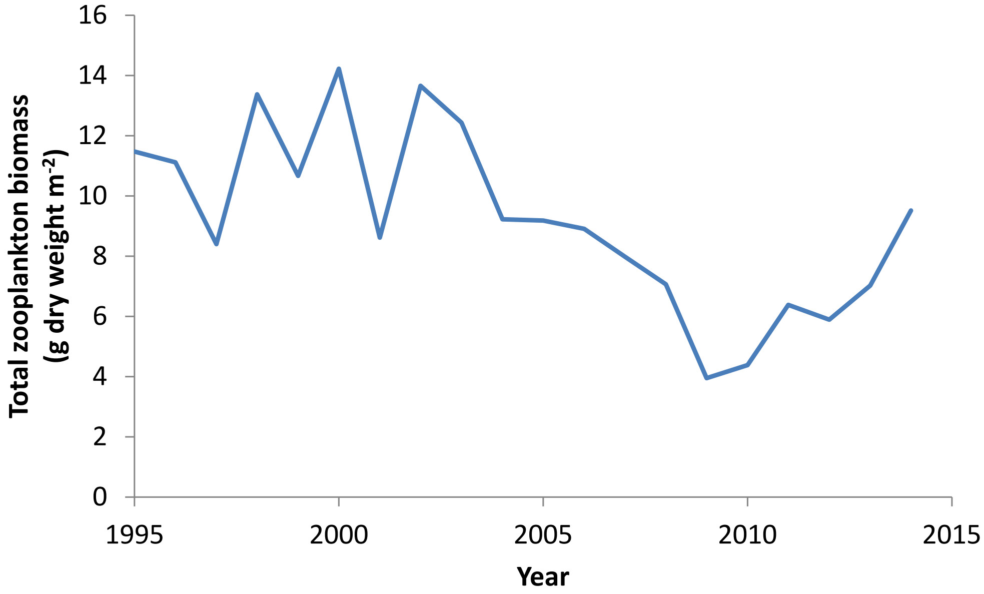

Figure 1. Total zooplankton biomass (g m^{-2}) in the Norwegian Sea in May.

Pelagic fish

The data for the three large pelagic fish stocks, Norwegian spring-spawning herring (*Clupea harengus*), blue whiting (*Micromesistius poutassou*) and mackerel (*Scomber scombrus*), as well as for beaked redfish (*Sebastes mentella*) and saithe (*Pollachius virens*), which were introduced in last year's WGINOR report were updated with new data points during the 2014 meeting. The only major revision of the datasets was related to the assessment of mackerel, where the recruitment and SSB represents now the results of the analytical assessment of the stock by the ICES working group Benchmark Workshop on Pelagic Stocks (WKPELA; ICES, 2014). The estimates derived from a state–space model (SAM). The input data in the model includes: Catch-at-age matrix from 1980–2012 (down weighed catches in years before 2000 to reduce the influence of the unaccounted removals in the historic period); SSB-index derived from triennial egg survey; age-disaggregated density indices for age 6+ from the International Ecosystem Summer Survey in Nordic Seas (IESSNS); Tagging dataseries from Norway (recaptures after 2007 withheld because of deterioration of the model fit –meaning that tag-recapture information from the new RFID tags are not included but will be re-evaluated in future when more data on RFID tagging becomes available); recruitment index (age 0) derived from the International Bottom Trawl Surveys (IBTS). The benchmarked assessment for NEA mackerel changes the perception of the development of the stock over time, compare to previous assessments, whereby the biomass both in the early period (1980s) and more recently is higher than previously estimated, and F lower.

The updated data for NSS herring and blue whiting did not change the perception of the stocks size development, while the new analytical assessment for NEA mackerel did, whereby the biomass both in the early period (1980s) and more recently is higher than previously estimated (Figure 2). The results of the IESSNS survey and the tag-recapture methods indicate that the present stock size is even higher than the analytical assessment shows. The mackerel stock consist now of several strong year-classes, including those from 2010 and 2011, which have recently and currently entered to the SSB. Both catch data and results of IESSNS show the existence of these large year-classes from 2010 and 2011 (ICES, 2013b; 2014).

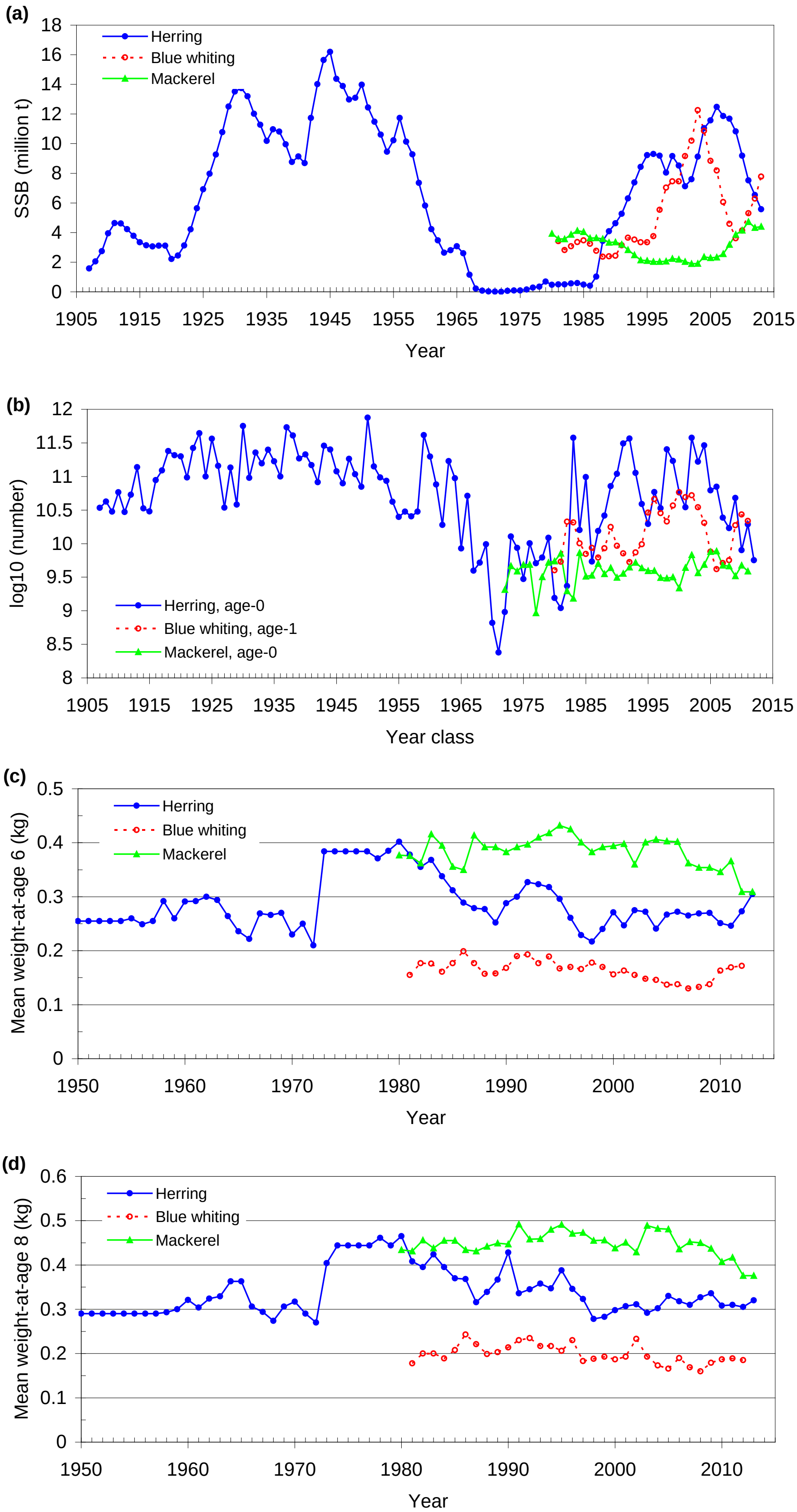

Figure 2. Historical development in SSB (a), recruitment (b), mean weight-at-age 6 (c) and age 8 (d) of Norwegian spring-spawning herring, blue whiting and mackerel in according to ICES assessment (ICES 2013; ICES, 2014d).

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 sandeel), crustaceans and molluscs, and typically feeds at depths down to 30 meters. Average lifespan is around 12 years for black-legged kittiwake and around 25 years for common guillemot and Atlantic puffin. Kittiwakes typically lay two eggs while guillemot and Atlantic puffin lay a single egg. Except for the breeding season, all three species spend their entire life at sea.

Dataseries

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 3, 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.

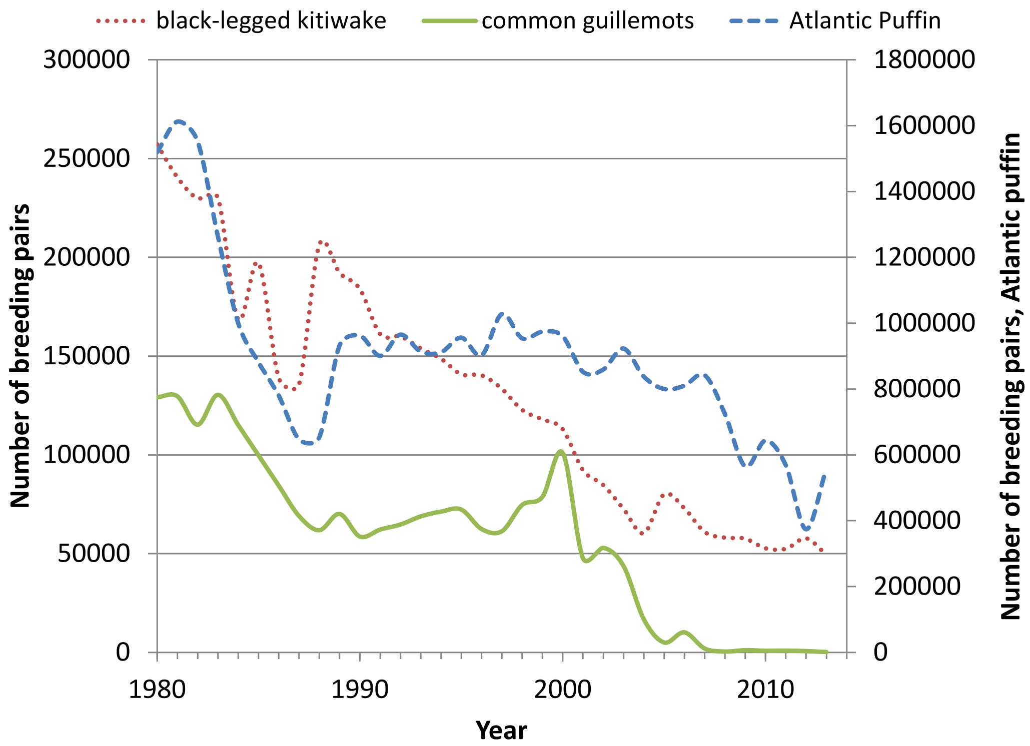

Figure 3. Development in the breeding populations of black-legged kittiwake, common guillemot and Atlantic puffin in the Norwegian Sea in the period 1980–2013.

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 and 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 and Aarvak, 2009).

Ecosystem interactions

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 has been provided by Skjoldal *et al.* (2004). 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. The main focus was on the key components in the ecosystem, the zooplankton and the biomass of the pelagic fish stocks.

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 2). During the same period, there have been the opposite trend for the individual length-at-age and the zooplankton index in the Norwegian Sea. Similar pattern was observed for mackerel, or a negative relationship between the total biomass and zooplankton (Figure 4), 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 4), 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.

A brief time-series of maximum chlorophyll level indicates a decline in phytoplankton production in recent years (Figure 5). There is a weak relationship (r= 0.53) between the chlorophyll level and the zooplankton biomass that could indicate a bottom up forcing of the ecosystem. This relationship will be investigated more closely next year.

The negative trend in average biomass of zooplankton in the total area in May from around 2002 until 2009 has been suggested to be a consequence of suggested to be a consequence of top down control or overgrazing of the Norwegian Sea zooplankton by the large pelagic fish stock feeding in the area (Huse *et al.*, 2012; ICES, 2013b). However, since 2010–2013, an upward trend has been observed in the plankton biomass index. An upward trend of zooplankton abundance was also observed in the IESSNS surveys in July/August for the years 2011–2014 (Nøttestad *et al.*, 2014). At the same time (2011–2013), weight-at-age (Figure 3) and length-at-age in the herring stock (Figure 5) are showing an 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, 2013b). An hypothesis discussed at the meeting is a that the herring exert the strongest predation pressure on the zooplankton in the Norwegian Sea since the herring enters the feeding grounds earlier than mackerel and blue whiting and thus feed on the *Calanus* generation ascending from overwintering. The increase in zooplankton, where Calanus is a dominant component, may therefore be linked to the pronounced decrease in the herring stock seen in recent years (Figure 2a). A revision of the zooplankton data were performed 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.

We have developed an index of available habitat for the pelagic fish stocks based on the hydrograpy data gathered during the May and July surveys (see Table A3.1). In addition it will be useful to utilize seat surface temperature data from remote sensing for this purpose which will provide a great area coverage.

The numbers of breeding pairs of three species of seabirds (kittiwake (*Rissa tridactyla*), Atlantic puffin (*Fratercula arctica*) and common guillemot / common murre (*Uria aalge*)) 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.

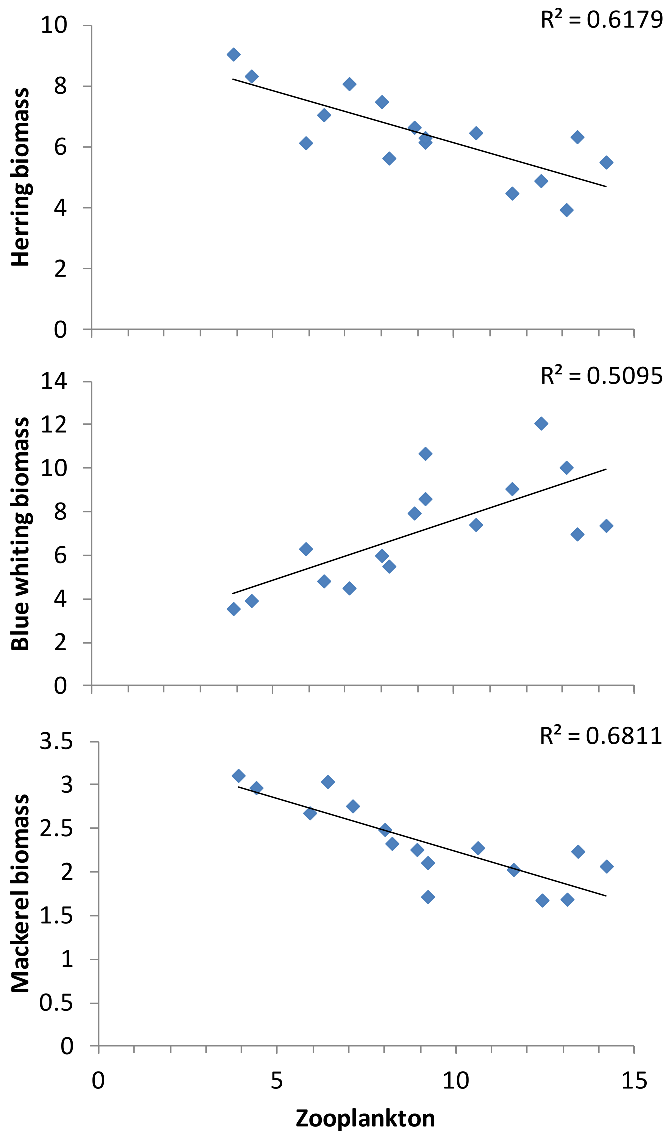

Figure 4. Scatterplot of the biomass of pelagic fish against the mesozooplankton in the Norwegian Sea.

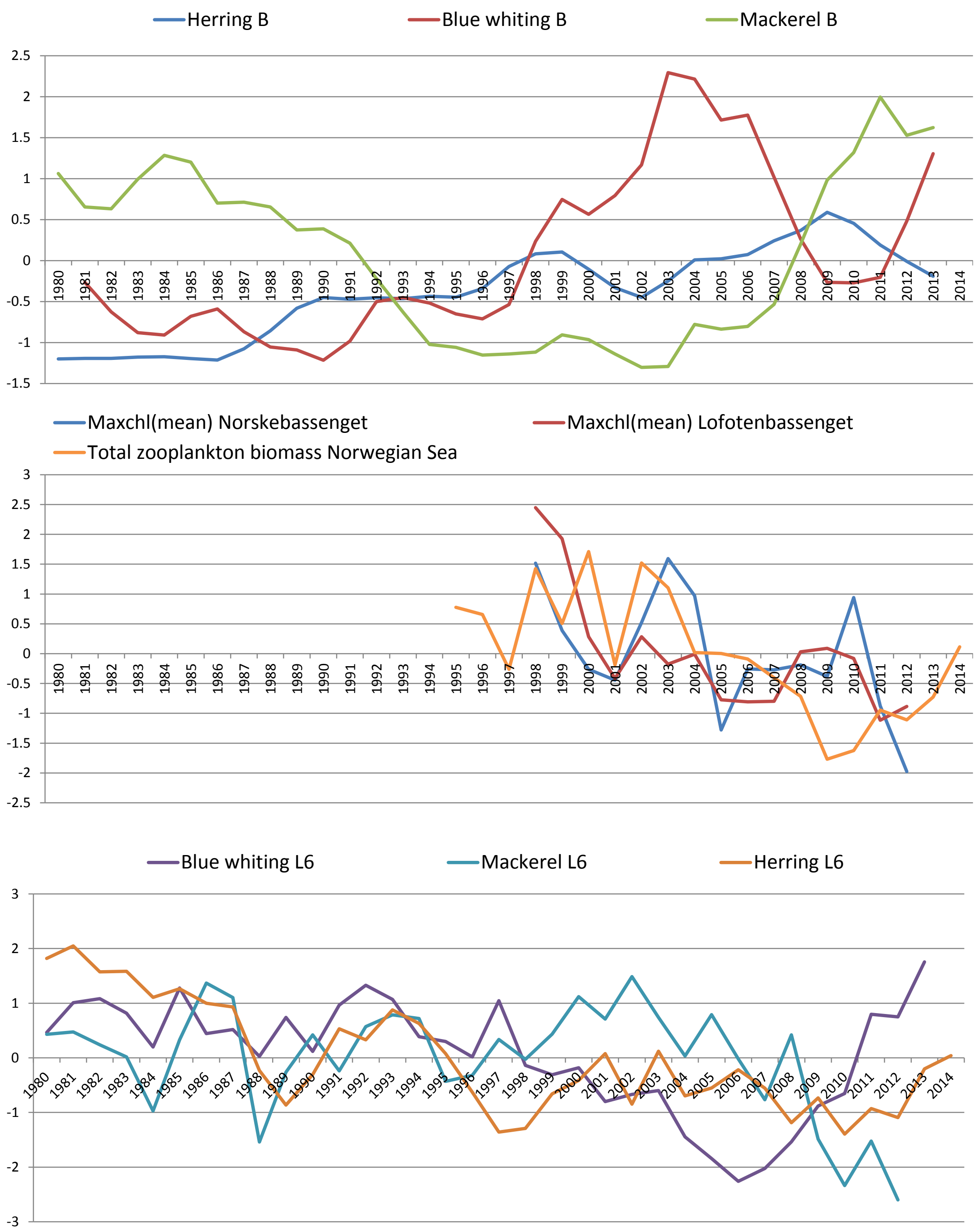

Figure 5. Anomalies of biomass of pelagic fish (top), plankton (middle) and length-at-age of pelagic fish (bottom) in the Norwegian Sea. See Table A3.1 for more information on the variables.

5.3 Progress report on Tor c

In recent years, ICES has transitioned 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). Despite 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 (Gjøsæter *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).

Analyses on average growth for the period 1980–2012 show an inverse relationship between total-stock biomass and individual growth rates for mackerel and blue whiting, and partly also for Norwegian spring-spawning herring. In traditional evaluation of harvest control rules (HCRs), density-dependent individual growth has not been implemented. We aim to investigate the effect of intraspecific competition on harvesting strategies by applying a model system with a traditional management strategy evaluation setup (Figure 6)

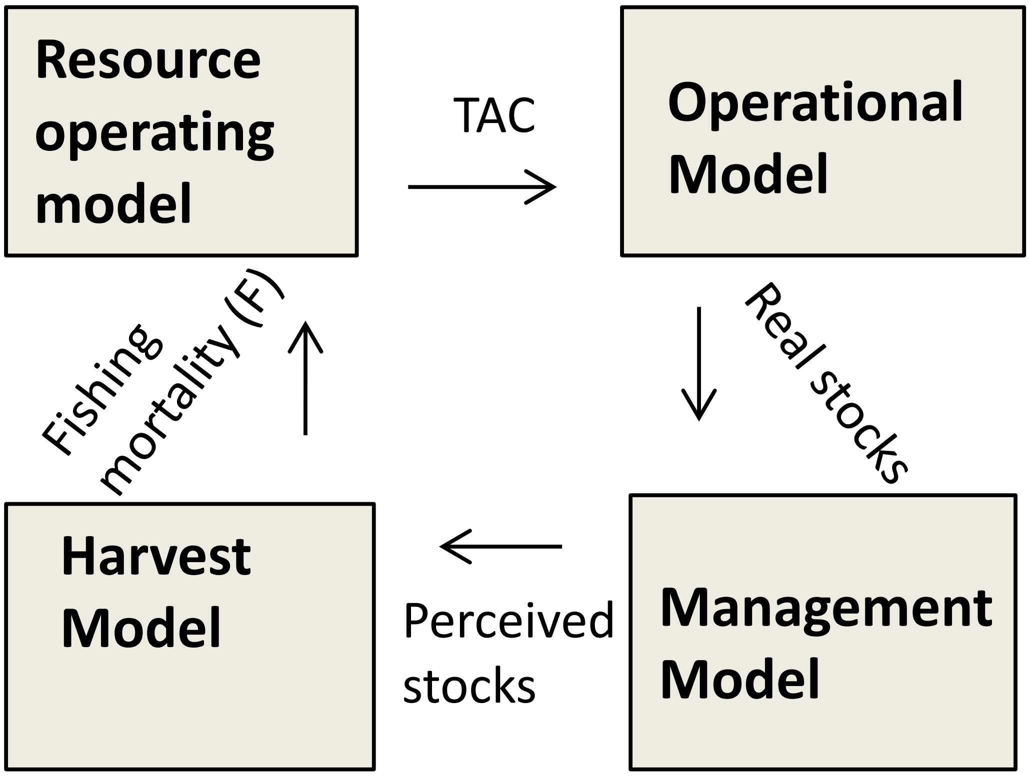

Figure 6. Overview and flow structure of the models included in the MSE.

The purpose of the model is to test how density-dependent effects on individual growth affect the evaluation of Harvest Control Rules (HCRs). The three species included in the model are NSS herring, blue whiting and mackerel. Prey or predators interacting with pelagic fish is not explicit included in the model. The model, using a MSE approach, follows the standard template (Basson, 1999, Butterworth and Punt

1999, Sainsbury *et al.*, 2000, Skagen *et al*., 2013) and consists of four different submodels; an operational model (OM), an observation model (OBM), a harvest models (HM) and a resource operating model (ROM). The OM represents the perceived "real world" where the dynamics of the stocks are described by recruitment, growth, maturation and mortality. The OBM adds random noise 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. The HM projects the development of the stocks forward in time and estimate a fishing mortality (F) based on a HCR. Here different HCRs can be tested to explore how this will affect fish abundance, Total Allowable Catch (TAC) and stock dynamics. In the ROM the actual number of fish that should be removed in the OP is calculated from the TAC, and time for removal is split into seasons to as the fisheries vary throughout the year. The model setup is presented in Figure 6. All submodels have monthly time-steps. After an initializing period of 20 years to build-up the stocks, the model is run for 100 year. The model is mainly an extension of the model published by Skagen *et al*., (2013) applied to real fish stocks. The model presented here has several modifications compared to the model by Skagen *et al*., with the greatest difference in how climate affects biological processes.

The operational model 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. Maximum lifespan is 20 years for all species in the model. Every year 100 new SI enter the population for each species in June. Recruitment was modelled with either Hockey stick or a Beverton and Holt recruitment function, and the number of new recruits were shared equally between the new SI. The stock recruitment function consists of three parts; a deterministic part derived from α and β parameters and SSB for the species in question, a random multiplier applied to the deterministic part and occasional spasmodic events. The random multiplier has a lognormal distribution which is truncated to avoid extreme values. Growth is modelled using Von Berfalanffy Growth Function (VBGF; e.g. Ricker, 1975), which is a very good approach when modelling fish growth (Chen *et al*., 1992).

We have used the following reference points to evaluate different HCRs; the risk of stock collapse should be less than 5%, TAC IAV (interannual variation) should be less than 30% and the long-term yield should be as large as possible. Generally, the levels for all criteria's increase as F increase, although the long-term yield can decrease if F is too high.

Preliminary results indicate that density-dependent growth has a limited effect on the performance of HCRs, compared to simulations were density depend growth is ignored. Although fluctuations in stock biomass can lead to large variations in individual growth rates, a normal change in fishing mortality (F) will only lead to minor changes in stock biomass and individual growth rates. More simulations are needed to make any final conclusions.

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 assessments. Tenningen *et al.* (2011) demonstrated that estimate of mackerel 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. The mackerel SSB from the new assessment of mackerel (ICES, 2014) follows the same trend but the level of SSB is around 60% lower in the assessment. The new assessment incorporates data from the tagging-recapturing program of Institute of Marine Research (IMR) in Bergen until 2007. That leaves out data from the new tagging technology with RFID (Ratio frequency identification). Over the years 2011–2013, as many as 104835 mackerel have been tagged with the new tags and hundreds have been recaptured by RFID antenna and reader systems in factories. A biomass estimate obtained from the whole tagging-recapture series will be made available for analyses in the 2015 WGINOR report.

Survey based abundance indices for the three pelagic fish stocks have also been compiled and made available on the WGINOR SharePoint. They are both based on swept-area and acoustic estimates and provide indices of total biomass, SSB, and recruitment. WGINOR relies on absolute estimates of stock size of fish feeding in the Norwegian Sea Ecosystem to be able to model the role of e.g. the mackerel with regard to consumption etc. Hence, abundance estimates from the surveys and the tagging data are considered important and may be used in modelling and analyses of the ecosystem to get closer to the actual situation.

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 2013 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 in 2013 and updated in 2014 (Annex 2). The list is directed to different ICES working groups and national institutes in order to facilitate further an integrated ecosystem assessment of the Norwegian Sea.

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, 2013c). Section 1, 2 and 3 are prioritized.

The working group participants defined the sections and subsections 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. WGINOR follows the criteria given by WKECOVER 2013 and applied to subsections within each of the first three sections.

Once a decision has been made to include a subsection, 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 subsection. 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.

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 Section 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.

Through 2013, the evolving overviews are being reviewed by the Regional Integrated Assessment Groups and the Regional Expert Groups (fish stock assessment) inclusive 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.

6 Next meeting

The next meeting will be held in Reykjavik, Iceland from Monday 7 to Friday 11 December 2015.

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Annex 1: List of participants

NAME	COUNTRY	INSTITUTION	FIELDS OF EXPERT
Guðmundur Óskarsson **Chair**	Iceland	Marine Research Institute	Fisheries biology, assessment
Geir Huse **Chair**	Norway	Institute of Marine Research	Fisheries biology, ecology
Jan Arge Jacobsen	Faroese Islands	Faroese Fisheries Research Institute	Fisheries biology, assessment
Eydna I Homrum	Faroese Islands	Faroese Fisheries Research Institute	Fisheries biology
Hein Rune Skjoldal	Norway	Institute of Marine Research	Marine ecology, integrated assessment, zooplankton
Webjørn Melle	Norway	Institute of Marine Research	Zooplankton
Øistein Skagseth	Norway	Institute of Marine Research	Oceanography
Kjell Utne (by corr.)	Norway	Institute of Marine Research	Data analysis, modelling, fisheries biology
Leif Nøttestad (by corr.)	Norway	Institute of Marine Research	Fisheries biology
Are Salthaug (by corr.)	Norway	Institute of Marine Research	Fisheries biology
Gro van der Meeren (by corr.)	Norway	Institute of Marine Research	Ecology, integrated assessment
Anne Kristine Frie (by corr.)	Norway	Institute of Marine Research	Marine mammals
Tycho Anker Nilssen (by corr.)	Norway	Norwegian Institute for Nature Research	Bird ecology
Svein-Håkon Lorentsen (by corr.)	Norway	Norwegian Institute for Nature Research	Bird ecology
Per Arneberg (by corr.)	Norway	Institute of Marine Research	Ecology, integrated assessment

Annex 2: Sampling requirements with respect to ToR e.

Table 2.1. Gaps in data sampling, sampling requirements and to whom they are directed for integrated assessment of the Norwegian Sea as reflected in Tor e of WGINOR.

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, Faroes, and EU). It is recommended that such sampling takes place by all participants and the data will be stored in the NAPES database. 2. There is very few 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.	WGIPS and Institutes participating in the IESNS and IESSNS surveys.
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. Data from IS, NO and FO have been secured to upload to the database, will data from EU are missing. It is recommended that all the plankton data will be made available and 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 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	SCICOM/ACOM, ICES WGIPS and Institutes

Ecosystem component	Recommendation/request of sampling/analyses	To whom
	fish. However, these registrations have never been quantified systematically in the survey reports or by other means. These information might be relevant to 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.	participating in the IESNS survey.
Seabirds	8. It is recommended that relevant scientist specialised in seabirds 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 seabirds 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.

Annex 3: Data overview

Table A1. Overview over biotic and abiotic variables used to characterize the Norwegian Sea ecosystem.

VARIABLE	COMMENT	PERIOD
Herring R	Recruitment per year class at age 0 in billions	1907–2012
Blue whiting R	Recruitment per year class at age 1 in millions	1980–2011
Mackerel R	Recruitment per year class at age 0 in thousands	1980–2012
Herring B	Spawning-stock biomass in million tonnes	1907–2013
Blue whiting B	Spawning-stock biomass in million tonnes	1981–2013
Mackerel B	Spawning-stock biomass in million tonnes	1980–2013
Beaked redfish B	Spawning-stock biomass in million tonnes	1992–2013
Saithe B	Large saithe (9+ for North Sea and Faroese stocks and 10+ for the Northeast Arctic stock) in million tonnes	1967–2013
Herring W6	Weight at age 6 in kg	1950–2010
Blue whiting W6	Weight at age 6 in kg	1981–2012
Mackerel W6	Weight at age 6 in kg	1980–2012
Blue whiting L6	Length-at-age 6 in cm	1972–2013
Mackerel L6	Length-at-age 6 in cm	1963–2012
Herring L6	Length-at-age 6 in cm	1944–2014
Maxchl Norwegian basin	Maximum chlorophyll a level in Norwegian basin	1998–2012
YDmaxChl Norwegian basin	Day number for peak in chlorophyll a in Norwegian basin	1998–2012
Maxchl Lofoten basin	Maximum chlorophyll a level in Lofoten basin	1998–2012
YDmaxChl Lofoten basin	Day number for peak in chlorophyll a in Lofoten basin	1998–2012
Blue whiting R index	Year-class strength at age one blue whiting Norwegian Sea survey	1999–2012
Blue whiting biomass index	Total BWH biomass Norwegian Sea survey	2000–2013
Puffin stock size	Sum of counts from Runde, Sklinna, Røst and Anda	1980–2013
Kittywake stock size	Sum of counts from Runde, Sklinna, Røst and Anda	1980–2013
Guillemoth stock size	Sum of counts from Runde and Røst	1980–2013
Nao_djfm	Hurrel winter NAO index	1907–2014
dp : Agmasalik-Stykkis	mslp(65N,37.4W) – mslp(65N,22.5W)	1949–2014
dp: Scoresbysund-Jan Mayen	mslp(70N,22W) – mslp(70N,10W)	1949–2014
dp: Danmarksh-Svalbard	mslp(77N, 20W) – mslp(78N, 15E)	1949–2014
spg_index (winter cent)	Sub-ploar gyre index from satellite ssh data, centred(Jan)	1993–2014
Norw-Lof gyre index	Area averaged windstress curl within the 2000 m isobaths Norwegian Sea	1949–2013
Svinoy-coreT	T in layer 50–200 m, using stations over 1010, 1075 and 1185 m depth in Svinoy section	1976–2014

Variable	Comment	Period
Svinoy-coreS	T in layer 50–200m, using stations over 1010, 1075 and 1185 m in depth in Svinoy section	1976–2014
Areal for S>35 (km2)	Area of water with S > 35 in Svinoy section	1978–2014
Herring habitat	*10^5 km^2: Area of water with T > 2degC at depth range 25–200 m in Norwegian Sea	1995–2014
Blue Whiting Habitat	*10^5 km^2: Area of water with T > 1degC at depth range 150–400m in Norwegian Sea	1995–2014
Mackrel habitat	*10^5 km^2: Area of water with T > 6degC at depth range 10–100 m in Norwegian Sea	1995–2014
Arctic Water in NS	*10^4 km^3 Volume of water with S < 34.9 at depth range 150–300 m in Norwegian Basin	1995–2014
Mackerel 0-group index	Mackerel 0-group index from IBTS (Quarter 4) see ICES 2014d	1998–2012
Herring B from Norwegian Sea survey	Biomass of NSS herring from Norwegian Sea survey in thousand tonnes	1996–2014
Zooplankton B	Total zooplankton biomass Norwegian Sea in g m-2	1995–2014
fsc_i_w		1960–2011
fsc_i_s		1960–2011
snw_i_w		1960–2011
snw_i_s		1960–2011
rs_i_w		1960–2011
rs_i_s		1960–2011
mr_u_w		1960–2011
mr_u_s		1960–2011
bkbi_i_w		1960–2011
bkbi_i_s		1960–2011
Herring C	Catches in tonnes	1972–2012
Mackerel C	Catches in tonnes	1969–2012
Blue whiting C	Catches in tonnes	1988–2012
Herring F	Mean fishing mortality for ages 5–14	1988–2012
Mackerel F	Mean fishing mortality for ages 4–8	1980–2012
Blue whiting F	Mean fishing mortality for ages 3–7	1981–2012

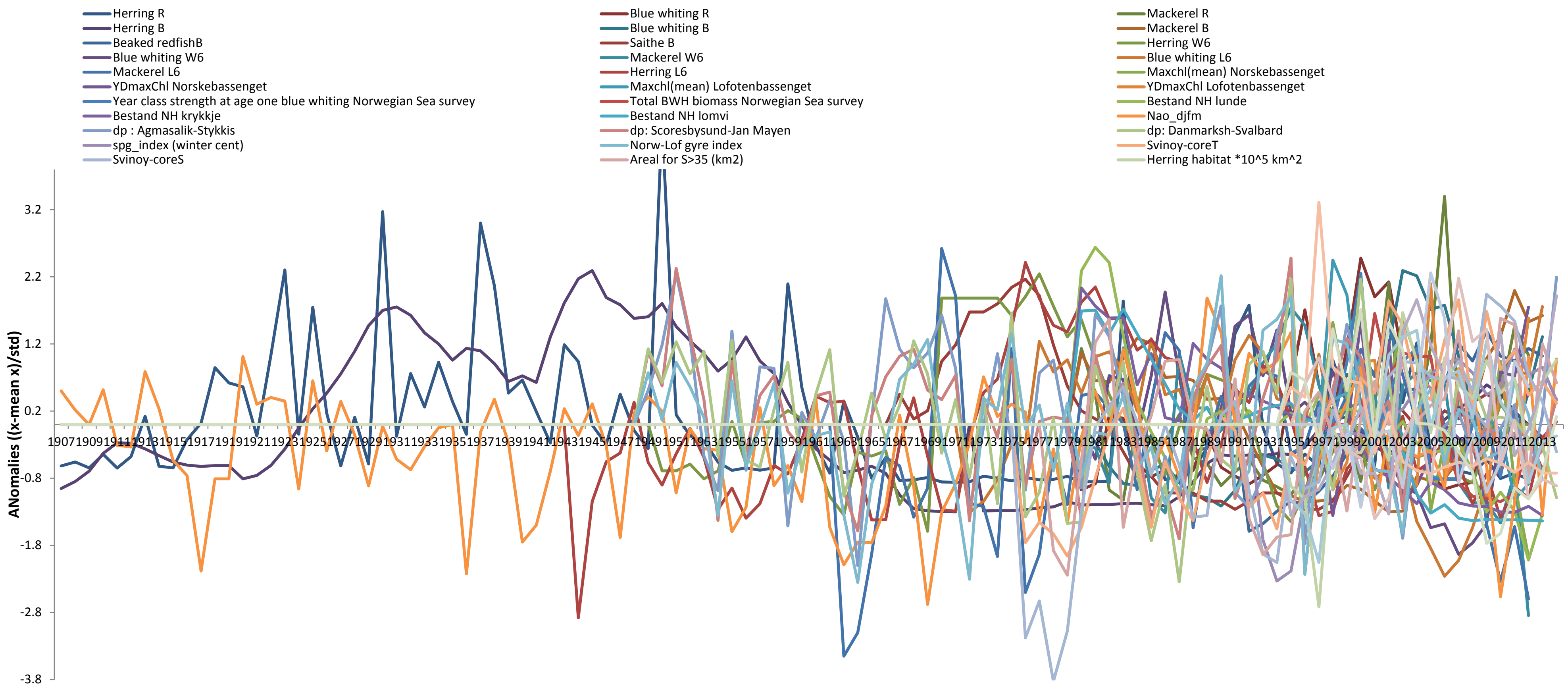

Figure A 3.1. Anomaly plot for the 53 variables used to characterize the Norwegian Sea ecosystem.