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Report of the Working Group on Integrated Assessments of the North Sea (WGINOSE)

11–15 February 2013

Lisbon, Portugal

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The Working Group on Integrated Assessments of the North Sea (WGINOSE) met in Lisbon, Portugal from 11 – 15 February 2013. The meeting was co-Chaired by Dr A. Kenny (UK) and Dr M. Dickey-Collas (Denmark). There were 9 participants representing 6 nations. WGINOSE is a working group which works to develop the science-base for Integrated Ecosystem Assessments (IEA) in the North Sea. The group works towards this goal in cooperation with similar groups within the ICES SCICOM Steering Group on the Regional Seas Programme (SSGRSP). The broad objectives of the group are

i. to develop and inform links between ecosystem assessment objectives and operational monitoring requirements,

ii. to develop approaches and use of models to inform on the possible outcomes of management actions at the ecosystem level and **iii.** to coordinate and contribute to the preparation of ecosystem overviews to inform management advice.

An important output of this meeting was the establishment of a 'core' set of ecosystem variables/components covering a range of industrial sector, human activities and pressures. The data associated with this list should be operationally updated and assessed annually by WGINOSE so as to provide the necessary input to the ecosystem overviews required by ICES for advice. This will require close coopertation with the ICES data centre and other relevant expert groups of ICES, in addition to external groups such as SAHFOS and OSPAR ICG-Cumulative Effects.

WGINOSE working in partnership with expertise from OSPAR ICG Cumulative Effects determined the most important sectoral activities (fishing, construction, maritime transport, offshore oil and gas, tourism and recreation, navigation dredging, telecommunications and aggregate extraction) and associated pressures (abrasion, smothering and substrata loss) acting on the North Sea ecosystem.

The development of a Baysian network model for the North Sea was discussed and a plan established for its development over the next 3 years – this was seen as essential to provide a tool to support cumulative effects assessments.

Recommendation	For follow up by:
WGINOSE recommends that the ICES data centre consider working with WGINOSE to develop a plan for establishing a regioal (North Sea) IEA 'core' dataset which can be operatinally updated annually. This would ensure the continuity of work by the group and improve operational efficiency in updating the ecosystem overviews.	ICES Data Centre

1 Opening of the meeting

The 2013 meeting of WGINOSE was organized back-to-back with the Western Waters Regional Working Group (WGEAWESS). The meeting was kindly hosted by the Instituto Portugues do Mar e da Atmosfera, I.P (IPMAR) in Lisbon, Portugal, from 11th to 15th February, 2013. Participants of the meeting (Annex 1) were welcomed by Dr A. Kenny (co-Chair of WGINOSE) and Dr M. F. Borges (Co-Chair of WGEAWESS). This year Dr M. Dickey-Collas was acting as interim co-Chair as Dr C. Möllmann (co-Chair WGINOSE) was unfortunately not able to attend. The agenda for WGINOSE, including the joint sessions with WGEAWESS, is given in Annex 2.

The first day was devoted to 'keynote' presentations made in plenary to both regional assessment groups concerning initiatives of strategic importance, namely;

- Benchmark Assessments of Regional Integrated Ecosystem Assessments (WKBEMIA)
- Ecosystem Overviews (WKECOVER)
- Cumulative Effects: Overview of Current Thinking (OSPAR, ICG Cumulative Effects)

The three presentations provided a good opportunity to open discussions concerning the future direction, role and purpose of WGINOSE. It was apparent that three 'key' areas (see below) emerged as priorities for action and these could provide the purpose and focus for WGINOSE activities over the next 3 years (and possibly also other regional groups too), namely;

1. To develop and inform links between ecosystem assessment objectives and operational monitoring requirements.
2. To develop approaches and use of models to inform on the possible outcomes of management actions at the ecosystem level.
3. To coordinate and contribute to the preparation of ecosystem overviews to inform management advice.

It was also highlighted that these three priority areas of work are not mutually exclusive, indeed they are part of a single overall coordinated process of assessment, e.g. the monitoring programmes (1) provide the empirical evidence upon which the models (2) are developed which in turn provide the objective rationale for identifying the key signals included in the ecosystem overviews (3) and how these relate to changes in human activity.

2 Adoption of the agenda

The agenda (see Annex 2) was unanimously adopted by the group after a short discussion.

3 Introduction to meeting

WGINOSE is a working group which works to develop the science-base for Integrated Ecosystem Assessments (IEA) in the North Sea. The group works towards this goal in cooperation with similar groups within the ICES SCICOM Steering Group on the Regional Seas Programme (SSGRSP).

This, the 3rd meeting of WGINOSE, had the objective to refocus activity on Integrated Ecosystem Assessments (IEA) for the North Sea using the groundwork of the previous 2 meetings, the ICES REGNS group and WGHAME (as forerunners of WGINOSE), but importantly to take into consideration the objectives and policy requirements as set out by the initiatives described above e.g. WKBEMIA, WKECOVER, OSPAR – ICG Cumulative Effects.

Participation in this years meeting was lower than in previous years (e.g. 9 scientists from 6 countries), perhaps reflecting some loss in a clear purpose of what the group is required to do. Nevertheless, the group however attracted a broad range of technical interests and expertise allowing some (if not complete) progress to be made against each of the Terms of Reference (ToR), with the exception of ToR a (Section 7). In this respect it was noted that the ToRs for the meeting (Annex 3) matched well with the priorities for the groups anticipated work programme over the next 3 years as described above in Section 1 of this report.

The order of the report sections follows that of the agenda and not the order of the ToRs.

4 Further develop and apply a Bayesian belief network model as a tool to support integrated ecosystem assessments (TOR c)

At last years meeting it was agreed to explore the use of Bayesian Network (BN) technology for a representation of interrelationships between different variables that describe various aspects of the North Sea ecosystem. A presentation was given by Ulrich Callies (Helmholtz Zentrum Geesthacht) which highlighted the interpretation of conditional independence constraints in this context. A second presentation was also made by Marcos Llope (IEO) on behalf of Chris Lynam (Cefas) who, with co-workers, has been using a threshold-Generalized Additive Model (tGAM) to model the relationships between functional groups and drivers (e.g. temperature, fishing pressure etc.) in the North Sea. Using the tGAM solely on monitoring and assessment data, the key links in the system can be modelled and used to separate the confounding influences of climate and fishing. The tGAM approach is useful in helping to structure the BN model in terms of model node connections so further work to integrate the tGAM analysis with the BN approach would likely be useful (see section 4.2).

Furthermore, WGINOSE believes the development of a BN model for the North Sea to be particularly important in fulfilling the objectives of the group over the medium to long-term, e.g. the model will provide an essential link between the operational monitoring and the content of the ecosystem overviews, and management advice, especially in relation to assessing the cumulative effects of fishing and other human activities acting on the ecosystem (see Section 5).

4.1 Bayesian belief network model development

BNs use probability as a measure of uncertainty. Beliefs about values of variables are expressed as probability distributions which are model 'nodes'. The higher the uncertainty the wider the probability distribution. The real power of a BN is in its ability to determine the likely status of any given variable in a complex system given its dependence on the probability distributions of other variables defined within the model structure. In order to develop a realistic and appropriate BN model for the North Sea an in depth understanding of the cause/effect pathways has to be first established.

This particular issue was the subject of a presentation by Ulrich Callies who introduced the concept of conditional independence and how such constraints can be derived from correlation matrices. Although the reference to correlation matrices is not appropriate in case of non-linear behaviour, it must be kept in mind that many other popular approaches like principal component analysis, for instance, are formulated on the same basis. It has been argued that conditional correlations reflect direct relationships between variables that, given a properly designed graphical model, may better agree with the notion of causality than marginal correlations do.

Missing edges in undirected graphical models correspond to conditional correlations being negligible. Figures 1 and 2 present examples of how directed graphs (i.e. BNs) and corresponding undirected conditional independence graphs are related to each other. The first example (Figure 1) refers to the situation that two causes (C1, C2) produce the same effect (E). The two alternative directed graphs displayed use a process and a monitoring oriented formulation, respectively. The example shows that only the process oriented graph on the left is able to visualize uncorrelated causes (C1, C2). After the reversal of any of its two directed links, the third edge in the graph on the right hand side is needed to represent conditional dependence between the causes given evidence of the effect (E).

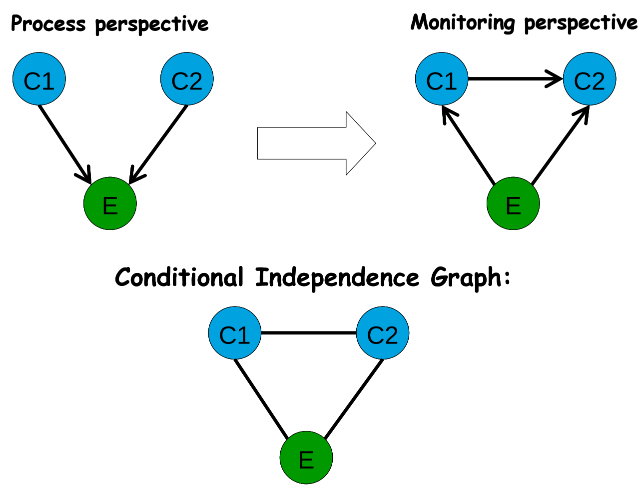

Figure 1. Two versions of a directed graph to represent two independent causes (C1, C2) that produce the same effect (E). The undirected graph at the bottom represents conditional dependences between the three variables.

Figure 2 shows a second situation with one cause producing two effects (E1, E2). In this case only the two graphs on the left and in the middle, respectively, are able two visualize conditional independence between E1 and E2.

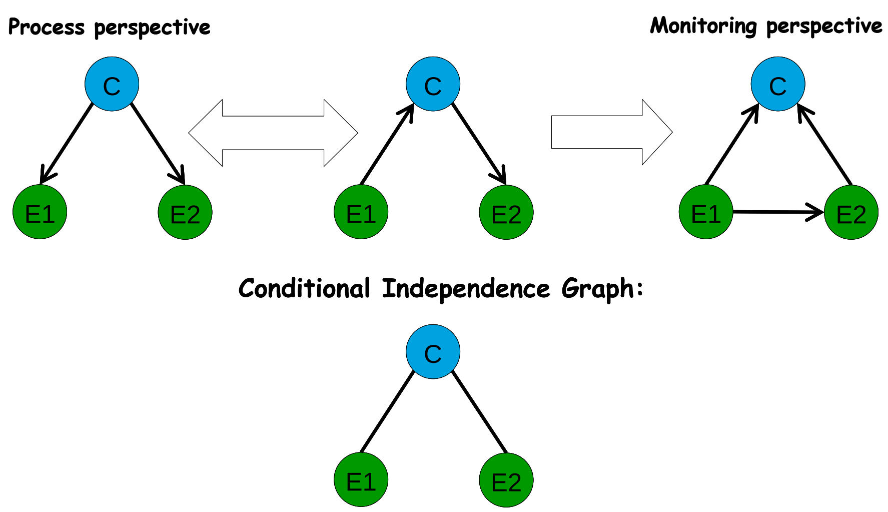

Figure 2. As Figure 1 but now for one cause (C) producing two different effects E1 and E2.

Preliminary graphical models developed for a couple of small examples were discussed. The first example dealt with the interrelationships between spring means of just four variables Elbe river discharge, amplitude of a characteristic marine current anomaly, salinity at Helgoland Roads and, finally, nitrate at the same station. A second example referred to interannual variations of spring means of five different CPR data (Phytoplankton colour index, *Calanus helgolandicus*, *Calanus finmarchicus*, *Pseudocalanus sp.*, and total abundance of copepods). To show how graphs can be established step by step, information on marine currents and phytoplankton observations at Helgoland were added as further information from other sources. All examples were preliminary since very different results can emerge from aggregating the data in different ways or if the data are detrended.

The last example addressed the problem of including model data into the analysis. A key question in this context is whether the patterns of covariation within model output and observations, respectively, correspond to each other. In the example, output taken from the ecosystem model ECOSMO was compared with observational data from station Helgoland Roads. It was discussed that differences found may be due to coastal influences that affect observations at Helgoland Roads but are not sufficiently represented in the model focusing on the North Sea as a whole.

4.2 Using the North Sea tGAM analysis to inform the structure and content of a North Sea BN model.

WGINOSE proposes to use the preliminary North Sea tGAMs results as a starting point for the development of a Bayesian Network (BN) representation of interrelationships in the important North Sea ecosystem variables (Figure 3).

BNs factorize the joint distribution of multivariate data in terms of conditional probabilities being represented graphically. The most efficient (in terms of the number of links in the graph) way to establish a BN is its formulation following the concept of causality. Having established the BN, however, any new information entered into the BN will be propagated throughout the whole network, irrespective of the orientation of connections defined. This consequence of the mathematical Bayesian inversion process corresponds to the idea of any monitoring activity trying to infer unobserved processes (or causes) simply from the observations of their anticipated consequences (effects).

Largely based upon the tGAM analysis (Lynam pers. comm.) the North Sea foodweb complexity will be compartmentalised into 10 components across 5 trophic levels; namely:

- **i.** primary producers (composed of 3 phytoplankton groups),
- **ii.** primary consumers (composed of 3 zooplankton groups),
- **iii.** secondary consumers (composed of planktivorous fish and sandeels),
- **iv.** top predators (piscivorous fish) and **v.** a proposed foodweb indicator (EC, 2010) 'seabird productivity' that does not feed back into the foodweb. The model will also be driven by climate forcing and fishing pressure.

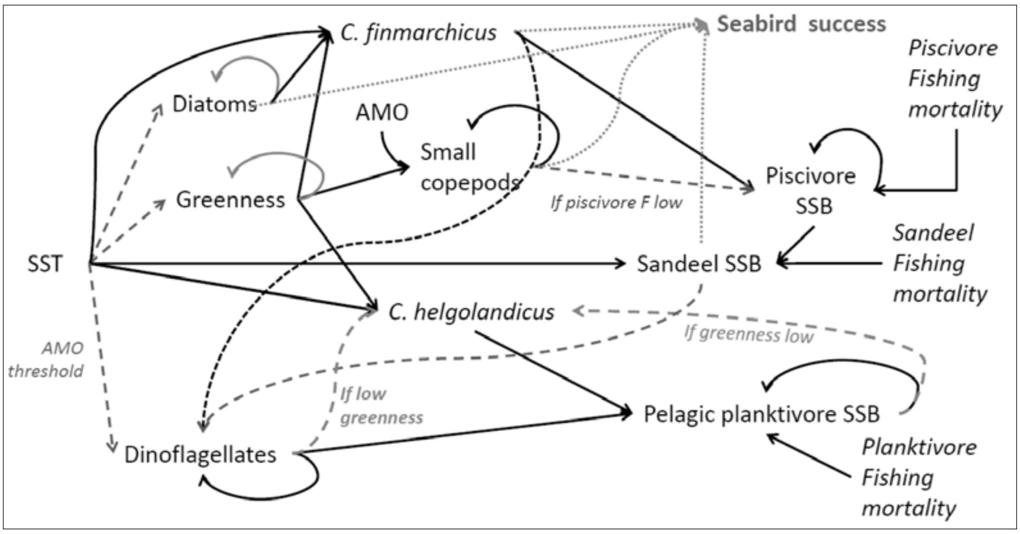

Figure 3 Diagrammatic representation of the significant relationships modelled between functional groups and drivers as defined by the tGAM analysis. Where present thresholds in the relationships are indicated by dashed lines and population delay terms are shown as loops. Lines point from the *predictor* to the *response* and may include time-lags.

The first step to develop a BN will be to try to reconstruct the four submodels used in the tGAMs approach. The raw data have to be processed to be homogenized and the spatio-temporal resolution selected to create the gridded data which has to be carefully defined. Due to their specific oceanographic features, the northern and southern parts of the North Sea should be distinguished in order to improve the model performance. Addressing the spatio-temporal issues will be especially important if several datasets are to be used at the same time (e.g. CPR database in conjunction with the Helgoland time-series).

It will also be important to investigate how to incorporate seasonality without introducing over-fitting in terms of specification of high dimensional conditional probability tables. However, finding a method to take into account the temporal correlations between months will be crucial in obtaining an accurate model, but this might be difficult to implement.

The main feature of the tGAM analysis is the ability to define thresholds of response between two or more variables which in turn can be used to better describe the link between the key components of the system. It appears to be a fairly straightforward approach to implement that feature in a BN in terms of conditional probabilities. The probability of a given event will simply be a function of the state of a given parameter that will be associated to different classes (e.g. low AMO). An attractive feature of the BN and including a tGAM threshold analysis is the identification of the presence/absence of a regime shift in probabilistic terms given a certain level of environmental and fishing pressure forcing.

The crucial and probably most difficult part of the process of BN development appears to be the definition of the overall structure of the BN with a proper amount of complexity. A number of constrains exist while dealing with BNs (e.g. the direct graphs must not contain cycles), but it seems that none of them constitute a limiting factor in the approach we propose.

WGINOSE will therefore start with a subset of variables for which data are most reliable and then extend the BN step by step. It is hoped that this work will be progressed intersessionally by Cefas, HZG and SAHFOS so that a provisional BN model can be presented at the next meeting.

5 Produce an approach for monitoring and developing assessment methods for the top three anthropogenic pressures on ecological characteristics described in the national MSFD reports (TOR e)

In addressing this task the group found it useful to clarify the intended use of various terms used to describe, human activities, pressures and their effects on the ecosystem. For example, various industrial 'sectors' operate in the North Sea (e.g. fishing, shipping etc.) and these give rise to a number of associated activities or 'human activities'. These in turn give rise to a number of 'pressures' which in turn cause some change in a biological receptor (Figure 4).

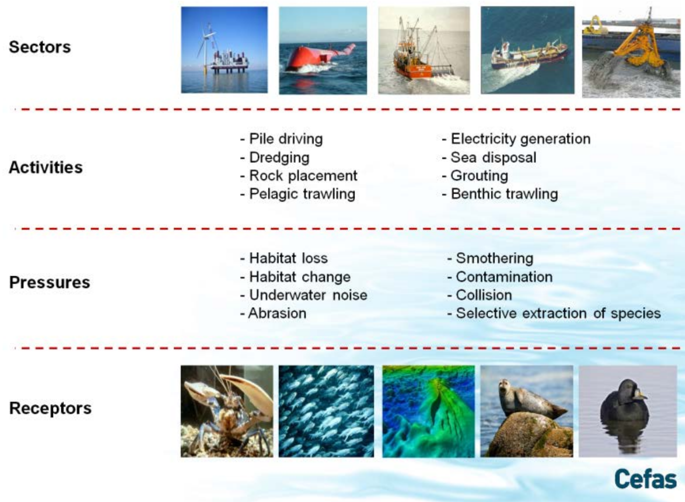

Figure 4. The definition of terms and their relationship as used in this report; sectors, activities, pressures and receptors.

The group then compiled a table of the most important sectors operating in the North Sea. To achieve this it was necessary to review the various national MSFD reports relevant to the North Sea. The national MSFD reports, along with other relevant regional assessment reports, varied considerably in their quality, scope and content. Nevertheless, we were lucky to have enough language skills in the group to undertake this task and so produce a table of the most important[1] sectors operating in the region (Table 1). From this we identified; fishing, construction, maritime transport, offshore oil and gas, tourism and recreation, navigation dredging, telecommunications and aggregate extraction as the most important sectors operating in the North Sea. We also noted that several reports made specific reference to pressures (rather than sectors) such as noise, litter, nutrients and hazardous substances as important potential sources of pollution.

Having identified the most important sectors WGINOSE then considered the associated pressures. For this we made use of work being done under the EU FP7 programme project ODEMM[2] and the work of the OSPAR Intersessional Correspondence Group on Cumulative Effects. From this, a matrix of sectors and cor-

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[1] Human activities which are most widespread, persistent and give rise to many stressors on the ecosystem.

[2]Options for delivering ecosystem based marine management.
http://www.liv.ac.uk/odemm/about_odemm/

responding pressures was edited so as to include only those sectors relevant to the North Sea, this is shown in Table 2. For a description and explanation of the pressure categories please see Annex 3. From Table 2 we deduce that the top three acute[3] pressures acting on the North Sea ecosystem are;

- **i.** abrasion,
- **ii.** smothering
- **iii.** substrata loss, and that these are caused by a combination of aggregate extraction, navigational dredging, coastal infrastructure (e.g. ports and harbours), fishing, oil and gas, renewable energy, shipping, telecoms, tourism and recreation.

In terms of managing ecosystem effects, it is the assessment of these pressures and the corresponding sector activities which should take priority for the North Sea. However, not all sectors are equal in terms of the magnitude of the pressure they give rise to. For example, aggregate dredging occurs in relatively small number of discrete locations in the North Sea and although the site-specific impacts associated with extraction can be significant they are unlikely to have a detectable impact at the scale of the North Sea. By contrast, bottom-trawling activities cover a much large area of the North Sea and have the potential to affect a much wider range of habitats, thus bottom fishing could be argued as having a greater potential impact than aggregate extraction when assessed at the scale of the North Sea. This distinction is important, as it is fundamental in terms of prioritizing the sectorial activities which should be the focus of management action. Clearly to advance the work needed to address the ecosystem effects of human activities it is necessary to spatially and temporally map the sector activities (and the associated pressures).

To some extent this work has been done by national governments, but it requires further work, especially to complete the picture for the North Sea, which WGINOSE understands is a task currently being led by OSPAR. Cumulative sector specific pressure data can be assessed using GIS techniques, basically to evaluate areas of overlapping sector specific pressures which define potentially high impact sites. However, there is a big gap in the assessment methodology required to go from producing a reasonably realistic map of overlapping pressures at the North Sea scale to an assessment of their cumulative effect.

[3] The degree of impact definitions in Table 2 (acute, chronic & low severity) are taken from: Robinson L.A. and A.M. Knights. 2011. ODEMM Pressure Assessment Userguide. ODEMM Guidance Document Series No.2. EC FP7 project (244273) 'Options for Delivering Ecosystem-based Marine Management'. University of Liverpool. ISBN: 978-0-906370-62-9, 12 pp. http://www.liv.ac.uk/media/livacuk/odemm/docs/Pressure_Assessment_Guidance.pdf

Table 1 Lists of national MSFD and OSPAR activities in the North Sea (highlighted as priorities in the reports).

Assessment Document	Sector#1	Sector#2	Sector#3	Sector#4	Sector#5	Sector#6	Sector#7
OSPAR QSR 2010 Greater North Sea	Fishing	Construction	Maritime transport (shipping)	(Noise) [4]	(Litter)		
UK Initial Assessment and Good Environmental Status [5]	Fishing	Construction	Maritime transport (shipping)	(Noise)	(Litter)		
Netherlands Marine Strategy for The Netherlands part of the North Sea 2012 – 2020 Part 1.	Shipping and Ports	Oil and Gas Extraction	Sand Extraction	Fisheries			
Germany, Implementation of the MSFD	Shipping	Offshore wind	Offshore Oil and Gas	Aggregate Extraction	Cable/Pipelines	Fishing	Tourism
Sweden, Initial Assessment of Swedish waters under the MSFD	Fishing	(Nutrients and Organic Enrichment)	(Hazardous Substances)				
Belgium, Initial Assessment for the Belgium Marine Waters under the MSFD	Fishing	Aggregate Extraction	Sea Disposal	Navigation Dredging	Shipping and Ports	Construction	
Denmark, Denmark Marine Strategy, Initial Assessment under the MSFD.	Fishing	(Nutrients and Organic Enrichment)	(Hazardous Substances)				

[4] Sector descriptions enclosed in parenthesis are in-fact pressures, but in the various national reports these have been highlighted as important causes of ecosystem impact. Construction includes offshore windfarms, tidal barrages, tidal farms, and other significant marine infrastructures.

[5] MSFD reporting on Initial Assessments (Art. 8), Good Environmental Status (Art.9), Env. Targets & associated indicators (Art.10) & related reporting on geographic areas and regional cooperation

Table 2. Derived from ODEMM pressure assessment[6] and the MSFD national reports.

	Aggregates	Coastal Infrastructure	Fishing	Navigational Dredging	Oil & Gas	Renewable Energy	Shipping	Telecom	Tourism/ Recreation	Acute	Chronic	Pressure count
Abrasion	X	X	X	X	X	X	X	X	X	**8**	1	9
Smothering	X	X	X	X	X	X		X	X	**8**	0	8
Substrate Loss	X	X	X	X	X	X		X	X	**8**	0	8
Death or injury by collision			X		X	X	X	X	X	5	0	6
Selective Extraction of Non living	X	X		X	X	X			X	3	0	6
Selective extraction of species	X		X						X	3	0	3
Input of organic matter	X		X	X	X				X	2	0	5
Introduction of microbial pathogens		X	X		X		X		X	2	3	5
Underwater noise	X	X	X	X	X	X	X	X	X	2	0	9
Water flow rate changes	X	X	X	X	X	X			X	2	3	7
Change in wave exposure		X		X		X				1	1	3
Barrier to species movement			X		X	X				0	2	3
Changes in siltation	X	X	X	X	X	X		X	X	0	0	8
Electromagnetic changes						X		X		0	0	2
Emergence regime change		X				X				0	2	2
Introduction of non-indigenous species		X	X				X		X	0	4	4
Introduction of non synthetic compounds	X		X	X	X	X	X		X	0	7	7
Introduction of radionuclides	X			X	X					0	3	3
Introduction of Synthetic compounds	X	X	X	X	X	X	X		X	0	8	8
Marine Litter		X	X		X		X	X	X	0	3	6
Nitrogen and Phosphorus enrich			X						X	0	2	2
pH changes									X	0	0	1
Salinity regime changes		X			X	X				0	0	3
Thermal regime changes		X			X					0	1	2
Acute Effects	5	4	7	4	6	6	2	3	7			
Chronic Effects	4	5	7	3	5	4	5	0	7			
Total Activity Counts	**12**	**15**	**16**	**12**	**17**	**15**	**8**	**8**	**17**			

A severe acute interaction is described as a severe impact over a short duration. In the case of habitats, such interactions cause immediate change in habitat type. A severe-acute interaction can occur after just one event.

A severe chronic interaction is described as an impact that will eventually have severe consequences if it occurs often enough and/or at high enough levels. No inference is made as to when the pressure impact becomes severe, simply that at some frequency and intensity, a pressure can lead to severe impacts.

A low severity interaction never causes high mortality or does not result in loss of habitat, change in typical species or functioning, irrespective of the frequency or magnitude.

[6] Koss, R.S., Knights, A.M., Eriksson, A. and L.A. Robinson. 2011. ODEMM Linkage Framework Userguide. ODEMM Guidance Document Series No.1. EC FP7 project (244273) 'Options for Delivering Ecosystem-based Marine Management'. University of Liverpool, ISBN: 978-0-906370-66-7. http://www.liv.ac.uk/media/livacuk/odemm/docs/ODEMM_Linkage_Framework.pdf

To address the cumulative effects gap in understanding first requires greater clarity in the definition and use of terms so that sound problem formulations can be set (this is currently being progressed by OSPAR). Second, the application of models, not only conceptual models of cause and effect, but also stochastic and statistical models such as those described in section 4. What is clear is that there are significant benefits to be had in coordinating the work of WGINOSE with that of OSPAR and other groups to ensure that expert efforts are not wasted. For example, there is no need for WGINOSE, or ICES, to spend a lot of time gathering data and information on sectorial activities which are being gathered by other groups (e.g. OSPAR). Rather WGINOSE should focus on those sectors which it has expertise (e.g. fisheries, aggregates) and then coordinate with other groups (outside ICES) to provide a complete picture of sector activity for each region.

An outline framework for the development of cumulative effects assessment methodologies, which also reflects areas where ICES and OSPAR may work together for mutual benefits, is provided in Figure 5.

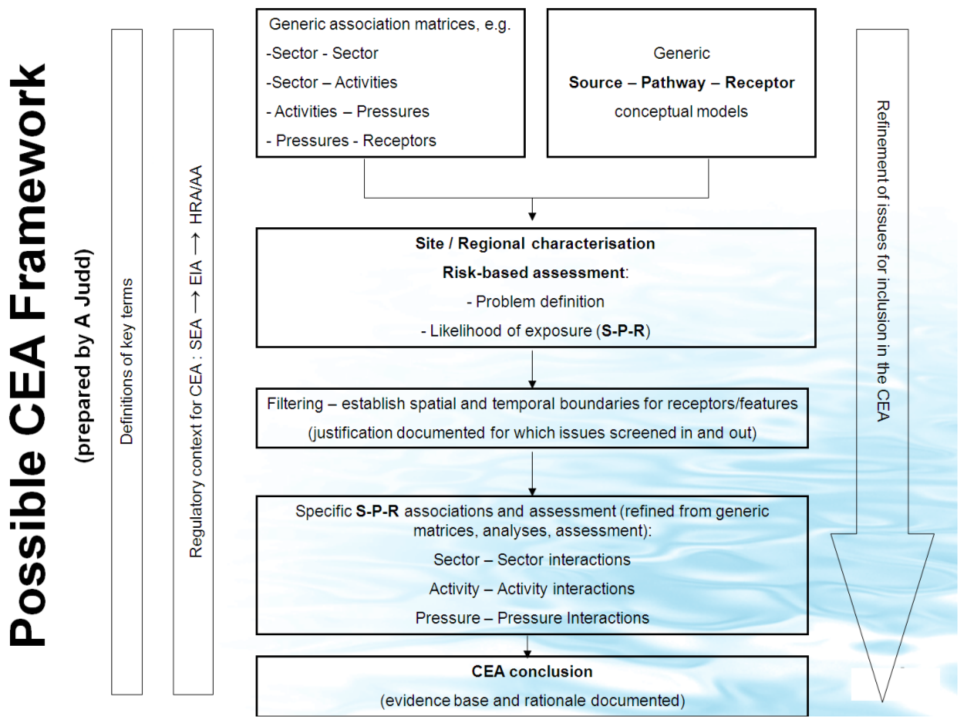

Figure 5. Proposed framework for the development of cumulative effects assessment.

This demonstrates the importance of understanding the regulatory context for undertaking this work to ensure that outputs are appropriately targeted to address the needs of marine managers. The framework also indicates where broad scale 'generic' assessments may be progressed in parallel with more sophisticated modelling approaches to refine and ground-truth analytical and expert judgement assessments. This refinement both distils the complexity of issues (based on risk assessment principles) into a manageable subset of determinants as well as improving the scientific rigour of the assessment.

6 Identify potential regional observing assets (both inside and outside ICES necessary to support the development of regional ecosystem assessments (TOR d)

WGINOSE approached this ToR by first listing what components and associated variables of the North Ecosystem have been, and are currently, included in the annual assessments of status and trends by WGINOSE (WGINOSE, 2012), by virtue of their broad spatial and temporal coverage. It was noted that the type and extent of data routinely used by the group in its assessment of trends, tends to reflect its status as part of an existing and established monitoring programme or the data are generated by models for forecasting purposes (see Table 3 under the heading of routinely collected). However, it was also noted that there are ecosystem components/variables which are not routinely included in WGINOSE, but should be, and these have also been identified in Table 3 (e.g. not yet – routine category). What is immediately apparent from Table 3 is that only about half of the components/variables which should be included in the annual assessments are in fact routinely included.

WGINOSE therefore concludes that progress has to be made in establishing links with the relevant expert groups (internally and externally to ICES) to obtain the necessary data and input required for continued success of WGINOSE, particularly as an assessment of the additional data on human activities and pressures is very much part of the requirements of the ecosystem overviews.

WGINOSE also concludes that the list of variables in Table 3 should constitute the 'core' set of data used for its annual Integrated Ecosystem Assessments and that the 'core' data should be updated operationally annually. This should ideally be dome through the ICES data centre since the vast majority of the data are already coordinated by, and accessed via, the data centre – this would essentially create a regional subset of data formatted in a way which makes it readily useable by WGINOSE to update its trend analysis on an annual basis and to use this to update inputs into the ecosystem overviews, again an annual requirement. Given the majority of data are already held by ICES this should not be an onerous task, but it would greatly facilitate operational delivery of WGINOSE assessments if this could be set up.

WGINOSE understands that not all the data required is accessible via the ICES data centre and that some variables will be provided directly by expert working groups both within and outside ICES, e.g plankton data from SAHFOS, some oceanographic indicators of state such as thermal stratification timing and duration. Arrangements will therefore have to be established with the relevant groups for obtaining the relevant data and ensuring experts from those groups are invited to WGINOSE.

Table 3. List of variables and components routinely included in North Sea IEAs by WGINOSE (highlighted in green). The table also highlights (in orange) important components/variables which are known to be operationally collected, but are not routinely included in the North Sea assessments, but should be. Only one component/variable identified as important was listed as not operationally collected which was *benthic meiofauna*.

Components/ variables	NNS	SNS	North Sea		Source/Expert Group	Other Sources	Routinely Included	Repre-sentative	Notes
Hydroclimatic									
Winter NAO	x	x	x	1st Q	NOAA		Yes		Needs to be derived consistently
AMO	x	x	x	annual	NOAA		Yes		Needs to be derived consistently
Surface Temperature	x	x	x	1st Q	Model	IBTS/CTD	Yes	yes	
Bottom Temperature	x	x	x	1st Q	Model	IBTS/CTD	Yes	Yes	
Surface Salinity	x	x	x	1st Q	Model	IBTS/CTD	Yes	Yes	
Bottom Salinity	x	x	x	1st Q	Model	IBTS/CTD	Yes	Yes	
Temperature Index of Stratification	x	x	x	2nd Q	Model	IBTS/CTD	Yes	Yes	
Nutrient Concentrations (NO3, PO4, Si; empirical/model)					Model/EMECO		No yet	No	Gaps in nutrients data and associated monitoring programmes at the scale of the NS.
Water transport on fixed sections (NOOS)	x	x	x	Monthly	NORWECOM		Not yet	yes	

Oxygen Concentration					ICES DataCentre?	Not yet	No	Gaps in oxygen data and associated monitoring programmes at the scale of the NS, relevant to certain areas.
Chlorophyll Concentration	x	x	x	Monthly	Satellite/MUMM	Not yet	Yes	
Timing of spring bloom	x	x	x	Annual	Satellite/MUMM	Not yet	Yes	
Sediment/Seabed Habitat Type	x	x	x	one off	MESH	Not yet	Yes	
Bathymetry	x	x	x	one off	GEBCO	Not yet	Yes	
Tide Generated Bottom Stress	x	x	x	Monthly	GETM/Model	Not yet	Yes	
Wave Generated Bottom Stress	x	x	x	Monthly	WaveNet (UK)	Not yet	Yes	
Freshwater Flows (river run-off, Scottish Coastal Current etc)	x	x	x	Monthly	National programmes, E-HYPE model, obs?	Not yet	Yes	All rivers (SMHI)
Total Suspended Solids (TSS; organicvs.inorganic)					satellite? In situ obs?	No yet		
Biological Response								
Zooplankton								
Pseudocalanus elongatus	x	x	x	2nd Q	SAHFOS/CPR	Yes	Yes	
Temora longicornis	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Oithonia spp.	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Arcatia spp.	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Cladocera	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Limacina spp.	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Echinodermata larvae	x	x	x	2nd Q	SAHFOS	Yes	Yes	

Calanus helgolandicus	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Calanus finmarchicus	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Metridia lucens	x			2nd Q	SAHFOS	Yes	Yes	
Decapoda larvae	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Euphausiaceae	x			2nd Q	SAHFOS	Yes	Yes	
Ichthyoplankton (mackerel, eel, plaice etc)	x	x	x	Variable	SGSIPS/ICES Data Centre	Not yet	Yes	(Herring, cod, mackerel, eel, plaice)
Phytoplankton								
Dinoflagellata	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Diatomeae	x	x	x	2nd Q	SAHFOS	Yes	Yes	
Phytoplankton Colour Index	x	x	x	2nd Q	SAHFOS	Yes	Yes	
HAB	x	x	x		PML/EA/Met. Office (AlgaRisk)	Not yet	Yes	To check if this is an operational product/programme
Benthic Invertebrates								
Benthic Macrofauna					National programmes,BEWG, WK-Benthic Climate	No yet	No	Gaps in macrobenthic data and associated monitoring programmes at the scale of the NS.
Benthic Meiofauna						No	No	Gaps in meiofauna data and associated monitoring programmes at the scale of the NS.
Fish stocks (cpue)								
Clupea harengus	x	x	x	1st Q	IBTS/WGIPS	Yes	Yes	

Dicentrarchys labrax		x		1st Q	IBTS	Yes	Yes
Engraulis encrasicolus	x	x	x	1st Q	IBTS	Yes	Yes
Eutrigia gumardus	x	x	x	1st Q	IBTS	Yes	Yes
Gadus morhua	x	x	x	1st Q	IBTS	Yes	Yes
Hippoglossoides platessoides	x	x	x	1st Q	IBTS	Yes	Yes
Lepidorhumbus whiffiagonis	x	x	x	1st Q	IBTS	Yes	Yes
Limanda limanda	x	x	x	1st Q	IBTS	Yes	Yes
Melanogrammus aeglefinus	x	x	x	1st Q	IBTS	Yes	Yes
Merlangius merlangus	x	x	x	1st Q	IBTS	Yes	Yes
Platichtyes flesus		x		1st Q	IBTS	Yes	Yes
Pleuronectes platessa	x	x	x	1st Q	IBTS	Yes	Yes
Pollachius virens	x			1st Q	IBTS	Yes	Yes
Solea vulgaris		x		1st Q	IBTS	Yes	Yes
Sprattus sprattus	x	x	x	1st Q	IBTS/WGIPS	Yes	Yes
Trisopterus esmarkii	x	x	x	1st Q	IBTS	Yes	Yes
Trigla lucerna	x	x	x	1st Q	IBTS	Yes	Yes
Scophthalmus maximus	x	x	x	1st Q	IBTS	Yes	Yes
Scyliorinus spp.	x	x	x	1st Q	IBTS	Yes	Yes
Raja radiata	x	x	x	1st Q	IBTS	Yes	Yes
Mullus sumuletus	x	x	x	1st Q	IBTS	Yes	Yes
Elasmobranchs				Bi-Triennial	WGEF	Not yet	Yes
Mean Pelagic Fish Length	x	x	x		cpue Surveys/ICES Data Centre	Not yet	Yes
Mean Demersal Fish Length	x	x	x		cpue Surveys/ICES Data Centre	Not yet	Yes

Outputs of multispecies models			x	Annual every 3 years	WGSAM		Not yet		12 species of fish and top-predators (from 1970, F, R, SSB, T B)
Top predators									
Breeding seabird populations			x	Annual	WGSE/ESAS		Not yet	Yes	Single Index - 7 gulls, 4 terns, 2 cormorant, etc.
Grey Seals Pup Preduction NS UK colonies			x	Annual	WGMME		Not yet	yes	
Harbour porpoise			x	Annual	WGMME/SCANS		Not yet	yes	
Sectors/Activities/Pressures									
ICES Fish Landings (Iva,b,c)	x	x	x	Annual	ICES data centre also RDCs	Other MS	Yes	Yes	By commercial species e.g. demersal and pelagic species.
VMS data	x	x	x	Annual	National datasets, future ICES?	MS, data centres	Not yet	Yes	
Fishing Mortality			x	Annual	ACOM		Not yet	Yes	
Catch	x	x	x	Annual	ACOM		Not yet	for some spp, but not all, likely to change because of discard ban	
Discards	x	x	x	Annual	ACOM		Not yet		for some spp, but not all, likely to change because of discard ban
Sea Mammal and Reptile Bycatch			x	Annual	WGBYC		Not yet		No database as yet
Tourism/Recreational Pressures	?	?	?	Annual	WGRFS		Not yet		recreational fisheries group in ICES

Aggregate Pressures	x	x	x	Annual	WGEXT	Not yet	No database as yet	
Oil/Gas Pressures	x	x	x	Annual	OIC (OSPAR)	Not yet	Yes	OSPAR Offshore Industries Committee. Production by country
Renewable Energy Pressures	x	x	x	Annual	EIHA (OSPAR)	Not yet	Yes	OSPAR Environmental Impacts of Human Activities Committee. Annual database of windfarm areas

7 Explore MSFD indicator based trend assessments for the southern and northern North Sea (TOR a)

The initial approach taken to address this ToR was to identify and tabulate what is currently and routinely included in the annual assessments of the North Sea ecosystem (see previous WG reports, e.g. WGHAME 2009, WGINOSE 2012 and table 3 above) and to then cross reference the list with the variables and associated indicators described for each descriptor of the MSFD. However, following a brief discussion it was concluded that this task was premature as there is currently no agreed list of variables or indicators defined by the MSFD with which to cross reference, so this task has been deferred until such a time as a list of variables and indicators is available.

8 Provide input to ecosystem overviews to provide environmental information to fish stock assessment working groups (ToR b)

WGINOSE reviewed the work of WKECOVER for the North Sea and agreed that improvements to the content could be made to Sections 1, 2, 3 and (in part) 4; namely the sections addressing; a description of the ecoregion, the key signals, activities and pressures and (in part) the state of the system. In support of the update, especially in relation to the key biotic signals, a presentation was made by Santiago Alvarez on long-term trends in the North Sea plankton (see Annex 6). There was also a discussion about the need to define appropriate subregions of the North Sea for assessment purposes (e.g. see Annex 7 on Skagerrak and the Kattegat subregion). The subregions defined are Northern NS (ICES IVa1, IVa2), Southern NS (ICES IVb1, IVb2, IVc), the Skagerrak and the Kattegat (ICES IIIa) and the Eastern English Channel. The updated sections of the North Sea ecosystem overview are presented in Annex 4.

9 Conclusions and Actions

WGINOSE concluded that the focus for its work over the next 3 years should be:

- to make operational the collation and updating of the 'core' set of North Sea ecosystem variables/indicators/components as defined in Table 3 of this report. It is only with the full range of state, pressure and human activity variables included in the integrated assessments that progress can be made towards operationally supporting the management needs of ICES and others e.g. OSPAR.
- to better understand the cause/effect mechanizms driving the observed ecosystem state changes, priority should be given to develop modelling tools (such as BBNs) including their operationally application in support of management advice options.

WGINOSE also concluded that:

- the tGAM analysis should be integrated with the BN model development and that this should start with a subset of North Sea variables for which data are most reliable and then to extend the BN step by step. It is hoped that this work can be progressed intersessionally by Cefas (UK), HZG (Germany) and SAHFOS (UK) so that a provisional BN model can be presented at the next meeting.
- there are significant benefits in coordinating the work of WGINOSE with that of the OSPAR ICG Cumulative Effects group (ICG-CE) to ensure our respective effort is not duplicated.
- the list of variables in Table 3 should constitute a 'core' set of data used for the purpose of annual North Sea IEAs updated annually with the assistance of the ICES data centre.
- arrangements should made between WGINOSE and data providers where the ICES data centre is not the main provider, e.g. SAFOS for CPR data and ICES Expert Groups for other components.

10 Recommendations

Recommendation	For follow up by:
WGINOSE recommends that the ICES data centre consider working with WGINOSE to develop a plan for establishing a regioal (North Sea) IEA 'core' dataset which can be operatinally updated annually. This would ensure the continuity of work by the group and improve operational efficiency in updating the ecosystem overviews.	ICES Data Centre

11 References

EC, (2010). COMMISSION DECISION of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters. COM (2010) L 232/14.

ICES, (2009). Report of the working group on holistic assessments of regional marine ecosystems (WGHAME). ICES CM. 2009/RMC:13, 76pp.

ICES, (2012). Report of the working group on integrated assessments of the North Sea (WGINOSE). ICES CM 2012/SSGRSP, 47pp.

Annex 1: List of WGINOSE participants

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Annex 2: Agenda

ICES Working Group on Integrated Assessments of the North Sea [WGINOSE]; Lisbon, Portugal 11-15 February 2013

(back-to-back meeting with the ICES WGEAWESS

AGENDA

Monday 11 February

13.00 Opening – joint plenary session WGEAWESS and WGINOSE
13.05 Welcome to IPMAR (*Maria Fatima Borges, House Keeping*)
13.15 Tour de Table
13.30 Joint session objectives and organization (*AK, MFB*)
13.45 Benchmark workshop on IEAs (WKBEMIA) (*MD-C*)
14.30 Ecosystem overviews (WKECOVER) (*AK*)
15.15 OSPAR ICG Cumulative Effects – "Cumulative Effects: Overview of Currtent Thinking" (*AJ*)
16.00 Coffee
16.30 General discussion – way forward for ICES Regional Assessment WG's (*MD-C, AK,MFB)*
17.30 Close

Tuesday 12 February

09.00 Introduction to WGINOSE ToRs and organization of meeting agenda (*AK*)
09.10 ToR c (modelling tools to support IEAs)
North Sea BBN – *Ulrich Callies*
North Sea tGAM- *Marcos Llope*
10.30 *Coffee*
Discussion on links with cumulative effects assessments (ToR e)
12.30 Lunch
14.00 ToR e (developing assessment methods for top 3 anthropogenic pressures on ecological characteristic described in the national MSFD reports)
Review natonal reports on SharePoint site – evidence – (all)
15.00 Tea/coffee
Discuss/Agree top 3 pressures in North Sea
Decide/Agree the best way for assessing cumulative effects of these pressures and potential gaps in monitoring data.
Agree way forward which complements work of OSPAR ICG cumulative effects/timeline
17.30 Close

Wednesday 13 February

09.00 Introduction to day (*AK*)
09.10 ToR d (identify regional observing assets to support regional IEAs)
ToR a (MSFD indicator based trend assessments)
To discuss and identify what we currently and can possibly utilize by way of data assets and how those match to the current set of MSFD indicator needs. Do the models indicate a potential gap in what is essentially required here?
10.30 Coffee
11.20 Cont. task above and agree way forward for organising the work ToR drafting
12.30 Lunch
14.00 Subgroup working/drafting (*agree subgroup leads*)
15.00 Tea/coffee
15.30 Subgroup initial reports to plenary (c. 10 minutes each) (*subgroup leads*)

16.10 Subgroup working/drafting
17.30 Close
19.00 Workshop Dinner?

Thursday 10 January

09.00 Introduction to day (*AK*)
09.10 ToR b (update on North Sea ecosystem overview)
Review North Sea overview document on SharePoint
10.30 Coffee
Discuss additions/improvements to the existing overview
12.30 Lunch
14.00 Subgroup working/drafting (*subgroup leads*)
15.00 Tea/coffee
15.30 Review of report
16.50 Reflections on progress and issues to address (*AK*)
17.00 Close

Friday 15 January

09.00 Joint pleanry session WGEAWESS and WGINOSE (*AK, MFB*)
09.10 Highlights of WGINOSE outcomes – future actions (*AK*)
10.30 Coffee
11.00 Highlights of WGEAWESS outcomes – future actions (*MFB*)
12.30 Plenary discussion
13.00 Close

Annex 3: Intersessional Correspondence Group on Cumulative Effects – Amended 25th March 2011

Pressure list and descriptions

This is an amended version of the document submitted to both EIHA and ICG-COBAM based on comments received from the Netherlands, Spain, Germany, France ICG-COBAM and the UK. Given the range of responses not all suggested revisions have been applied verbatim, however, it is believed that the spirit and intention of all the recommendations from Contracting Parties listed above have been included

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Hydrological changes (inshore/local)	Temperature changes - local	H1	Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational sub sea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale (and as such are addressed under the climate change pressures).	Significant changes in thermal regime (e.g. by outfalls from power stations)
Hydrological changes (inshore/local)	Salinity changes - local	H2	Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydromorphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages or weirs that alter freshwater/seawater flow/exchange rates. The pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.	Significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Hydrological changes (inshore/local)	Water flow (tidal current) changes – local, including sediment transport considerations [possibly split water flow and sediment transport, i.e. separate into 'Hydrological' and 'Physical']	H3	Changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. Tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation and/or structures may alter flow speed and direction; managed realignment (e.g. Wallasea, England). The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substrata, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.	X
Hydrological changes (inshore/local)	Emergence regime changes – local, including tidal level change considerations [possibly split emergence regime and tidal level changes]	H4	Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of immersion is dependant on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependant on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, managed realignment, saltmarsh creation. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise which is considered under the climate change pressures.	X

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Hydrological changes (inshore/local)	Wave exposure changes - local	H5	Local changes in wavelength, height and frequency. Exposure on an open shore is dependant upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.	X
Pollution and other chemical changes	Transition elements and organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	P1	The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, e.g. Imposex in molluscs.	Introduction of non-synthetic substances and compounds (e.g. heavy metals, hydro-carbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration, atmospheric deposition, riverine inputs)
Pollution and other chemical changes	Hydrocarbon and PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	P2	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures: - straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation) - multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation) These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): - petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off) - pyrogenic hydrocarbons (from combustion of coal, woods and petroleum) - biogenic hydrocarbons (from plants and animals) Ecological consequences include tainting, some are acutely toxic, carcinomas, growth defects.	Introduction of non-synthetic substances and compounds (e.g. heavy metals, hydro-carbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration, atmospheric deposition, riverine inputs)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Pollution and other chemical changes	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.	P3	Increases in the levels of these compounds compared with background concentrations. Synthesized from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) and 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Includes: insecticides, herbicides, rodenticides and fungicides. Pharmaceuticals and Personal Care Products originate in veterinary and human applications compiling a variety of products including, Over the counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).	Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant to the marine environment such as pesticides, antifoulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances)
Pollution and other chemical changes	Introduction of other substances (solid, liquid or gas)	P4	The 'systematic or intentional release of liquids, gases …' (from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry. It should therefore be considered in parallel with P1, P2 and P3.	Introduction of other substances, whether solid, liquid or gas, in marine waters resulting from their systematic and/or international release into the marine environment, as permitted in accordance with other Community legislation and/or international conventions

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Pollution and other chemical changes	Radionuclide contamination	P5	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ships crew is 10 μSv or less in a year; (ii) the collective effective dose to the public or ships crew is not more than 1 man Sv per annum, then the material is deemed to contain de minimiz levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700 μSv/a. Ports and coastal sediments can be affected by the authorized discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.	Introduction of radio-nuclides
Pollution and other chemical changes	Nutrient enrichment	P6	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. wastewater run-off, terrestrial/agricultural run-off, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	Inputs of fertilizers and other nitrogen - and phosphorous-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition)
Pollution and other chemical changes	Organic enrichment	P7	Resulting from the degraded remains of dead biota and microbiota (land and sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural run-off. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	Inputs of organic matter (e.g. sewers, mariculture, riverine inputs)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Pollution and other chemical changes	Deoxygenation	P8	Any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substrata due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords).. This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.	X
Physical loss (Permanent Change)	Physical loss (to land or freshwater habitat)	L1	The permanent loss of marine habitats. Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.	Sealing (e.g. by permanent constructions)
Physical loss (Permanent Change)	Physical change (to another seabed type)	L2	The permanent change of one marine habitat type to another marine habitat type, through the change in substatum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrata habitats, removal of coarse substrata (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil and gas activities could fit this pressure type, however, there may be an additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed.	Smothering (e.g. by man made structures, disposal of dredge spoil)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Physical damage (Reversible Change)	Habitat structure changes - removal of substratum (extraction)	D1	Unlike the "physical change" pressure type where there is a permanent change in seabed type (e.g. sand to gravel, sediment to a hard artificial substrata) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonize; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanizms so the sediment typology is not changed.	Selective extraction (e.g. by exploration and exploitation of living and non-living resources on seabed and subsoil)
Physical damage (Reversible Change)	Penetration and/or disturbance of the substrata below the surface of the seabed, including abrasion	D2	The disturbance of sediments where there is limited or no loss of substrata from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the seabed surface layers (typically up to 50cm depth) Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonization remain suitable or relatively localized activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrata would adversely affect herring spawning grounds.	Abrasion (e.g. impact on the seabed of commercial fishing, boating, anhoring)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Physical damage (Reversible Change)	Changes in suspended solids (water clarity)	D3	Changes in water clarity from sediment and organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilizing it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed and direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources mostly short lived and over relatively small spatial extents.	X

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Physical damage (Reversible Change)	Siltation rate changes, including smothering (depth of vertical sediment overburden)	D4	When the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the seabed. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden. "Light" smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the seabed. For "light" smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. "Heavy" smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the seabed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under L2. Eleftheriou and McIntyre, 2005 describe that the majority of animals will inhabit the top 5-10 cm in open waters and the top 15 cm in intertidal areas. The depth of sediment overburden that benthic biota can tolerate is both trophic group and particle size/sediment type dependant (Bolam, 2010). Recovery from burial can occur from: - planktonic recruitment of larvae - lateral migration of juveniles/adults - vertical migration (see Chandrasekara and Frid, 1998; Bolam et al., 2003, Bolam and Whomersley, 2005). Spatial scale, timing, rate and depth of placement all contribute the relative importance of these three recovery mechanizms (Bolam et al., 2006). As such the terms "light" and "heavy" smothering are relative and therefore difficult to define in general terms. Bolam, 2010 cites various examples: - H. ulvae maximum overburden 5 cm (Chandrasekara and Frid, 1998) - H. ulvae maximum overburden 20 cm mud or 9 cm sand (Bijerk, 1988) - S. shrubsolii maximum overburden 6 cm (Saila et al., 1972, cited by Hall 1994) - N. succinea maximum overburden 90 cm (Maurer et al 1982) - gastropod molluscs maximum overburden 15 cm (Roberts et al., 1998). Bolam, 2010 also reported when organic content was low: - H. ulvae maximum overburden 16 cm - T. benedii maximum overburden 6 cm	Changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal or dredge spoil)

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Other physical pressures	Litter	O1	Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear etc and their degraded components, e.g. microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).	Marine litter
Other physical pressures	Electromagnetic changes	O2	Localized electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).	X
Other physical pressures	Underwater noise changes	O3	Increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence (Richardson et al 1995) are temporary or permanent hearing loss, discomfort and injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependant on a number of variables, including the sound pressure, loudness, sound exposure level and frequency. High amplitude low and mid-frequency impulsive sounds and low frequency continuous sound are of greatest concern for effects on marine mammals and fish. Some species may be responsive to the associated particle motion rather than the usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and seabed topography. Noise levels associated with construction activities, such as pile-driving, are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).	Underwater noise (e.g. from shipping, underwater acoustic equipment)
Other physical pressures	Introduction of light	O4	Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil and gas facilities etc. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may lead to increased algal growth.	X

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Other physical pressures	Barrier to species movement	O5	The physical obstruction of species movements and including local movements (within and between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, whales). Both include up river movements (where tidal barrages and devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species affected are mostly birds, fish, mammals.	X
Other physical pressures	Death or injury by collision	O6	Injury or mortality from collisions of biota with both static and/or moving structures. Examples include: Collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish and mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.	X
Biological pressures	Visual disturbance	B1	The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings etc), increased personnel movements, increased tourism, increased vehicular movements on shore etc disturbing bird roosting areas, seal haul out areas etc	X
Biological pressures	Genetic modification and translocation of indigenous species	B2	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). Former related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practises employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration. Movement of native species to new regions can also introduce different genetic stock.	X
Biological pressures	Introduction or spread of non-indigenous species	B3	The direct or indirect introduction of non-indigenous species, e.g. chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and outcompeting of native species. Ballast water, hull fouling, stepping stone effects (e.g. offshore wind farms) may facilitate the spread of such species. This pressure could be associated with aquaculture, mussel or shellfishery activities due to imported seed stock imported or from accidental releases.	Introduction of non-indigenous species and translocations

Pressure theme	Pressures	Code	Pressure Descriptor	MSFD Annex III Table 2
Biological pressures	Introduction of microbial pathogens	B4	Untreated or insufficiently treated effluent discharges and run-off from terrestrial sources and vessels. It may also be a consequence of ballast water releases. In mussel or shellfisheries where seed stock are imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.	Introduction of microbial pathogens
Biological pressures	Removal of target species	B5	The commercial exploitation of fish and shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on seabed communities are addressed by the "abrasion" pressure type D2, so B5 addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through foodwebs and the size and age composition within fish stocks.	Selective extraction of species, … (e.g. by commercial and recreational fishing)
Biological pressures	Removal of non-target species	B6	Bycatch associated with all fishing activities. The physical effects of fishing gear on seabed communities are addressed by the "abrasion" pressure type (D2) so B6 addresses the direct removal of individuals associated with fishing/ harvesting. . Ecological consequences include foodweb dependencies, population dynamics of fish, marine mammals, turtles and seabirds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic).	Selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing)

Annex 4: ICES North Sea Ecosystem Overview

Draft 15 Feb 2013

Preamble

This document represents the development of the ICES ecosystem overview of the North Sea ecoregion. It is one of a set of overviews being produced by ICES to cover all ecoregions within the ICES area.

The overviews are to become a central component of the ICES advice and exist for four purposes:

1) to describe the location, scale, management and assessment boundaries of the ecoregion
2) to alert ICES expert groups to situations within the environment and ecosystems that are expected to significantly influence their advice
3) to describe the distribution of human activity and resultant pressure (in space and time) on the environment and ecosystem
4) to describe the state of the ecosystem (in space and time) and to comment on pressures accounting for changes in state

This current document should be seen as a 'work in progress'. The completed overviews should be seen as living documents.

The intended audiences for the ecosystem overviews will include regional commissions and the ICES community and networks. Owing to the range of audiences, the overviews will be evolving documents, driven by top down processes (advisory requests and ICES decisions about strategic direction) and bottom up processes (information streams high-lighting 'new' issues from the ICES community and network). The overviews will highlight the capacity of ICES to provide integrated advice that will be required to meet the future needs of the recipients of ICES advice.

1 Description of the Ecoregion

1.1 Ecoregion boundaries and geography

The North Sea ecoregion has been recently delineated in a number of ways (Figure 1). The ICES ecoregion, the ICES fishing area, the OSPAR region II and the new MSFD greater North Sea ecoregion all differ slightly (Figure 1). The distinguishing differences are found at the boundaries. The MSFD region of North Sea includes the Skagerrak and Kattegat and most off the English Channel. The section of the previous ICES ecoregion northwest of (and including) the Shetland and Orkney Islands is considered part of the western area (as described in the UK Charting Progress initiative).

For the purpose of the overview the North Sea will be considered to consist of four areas:

1) Northern North Sea, including the Norwegian deep, (>50m depth)

2) Southern North Sea (<50m),

3) Skagerrak and Kattegat

4) English Channel

1.2 Ecoregion management

The greater North Sea falls within the EEZs of Belgium, Denmark, France, Germany, Norway, Sweden, The Netherlands and the UK. This also means that the European Union and Norway share competency for its management. The majority of the area falls into the competency of OSPAR (OSPAR Region II) with the Kattegat falling into the HELCOM area. In EU waters the management of fisheries in the region is influenced by the North Sea Rational Advisory Council (RAC) and the Pelagic RAC.

There are many seasonal closures, and technical fisheries measures in the North Sea (see ICEs advice) and recently many marine protected areas have been developed under the Natura 2000 process of the EU (Figure 1), particularly in the coastal regions and the Dogger Bank.

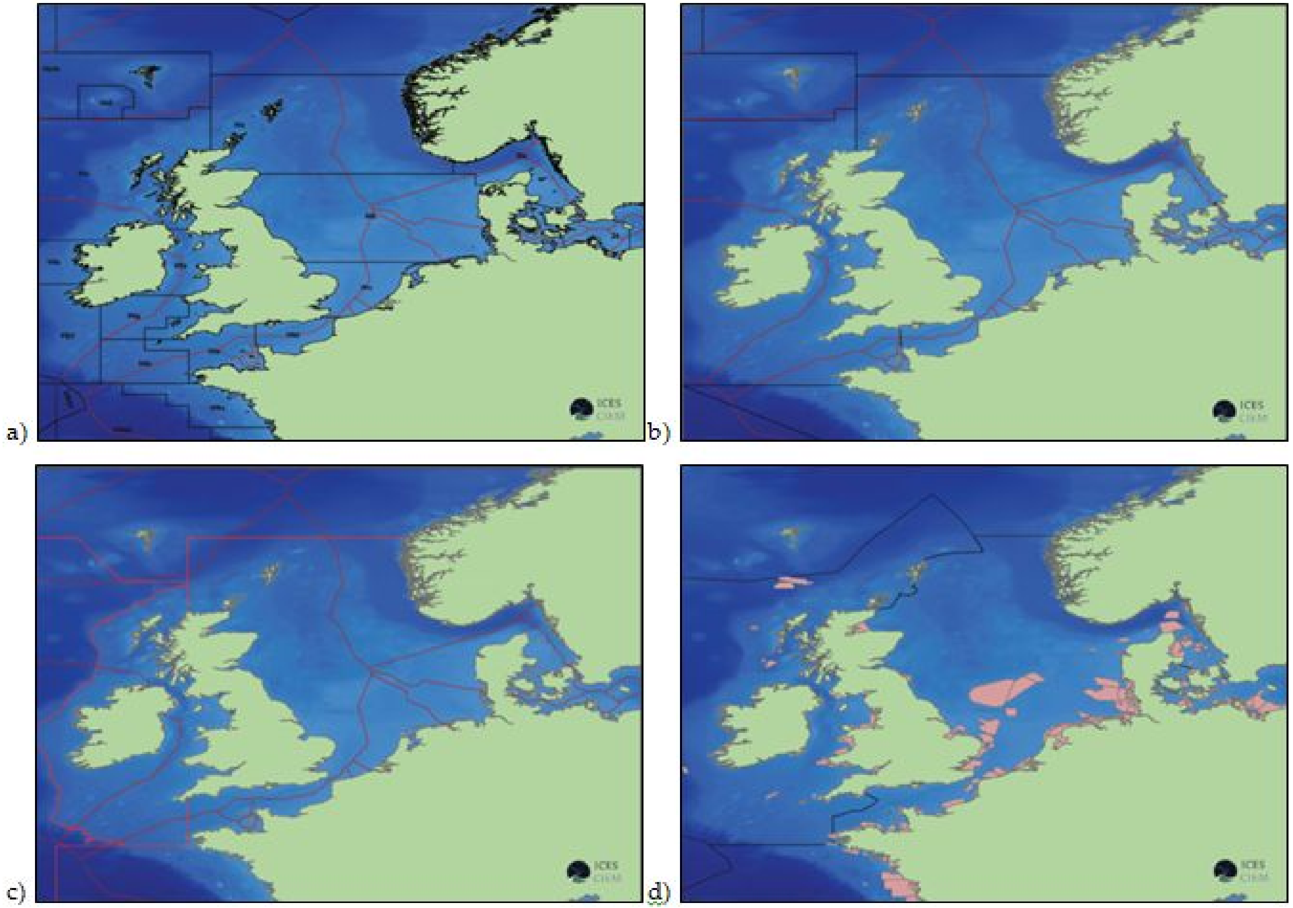


Figure 1. The Greater North Sea ecoregion with EEZs. a) ICES areas, b) ICES Ecoregion, c) OSPAR region II, d) MSFD Regional Seas and Natura 2000 sites

2 Key Signals

2.1 Physical and chemical oceanography

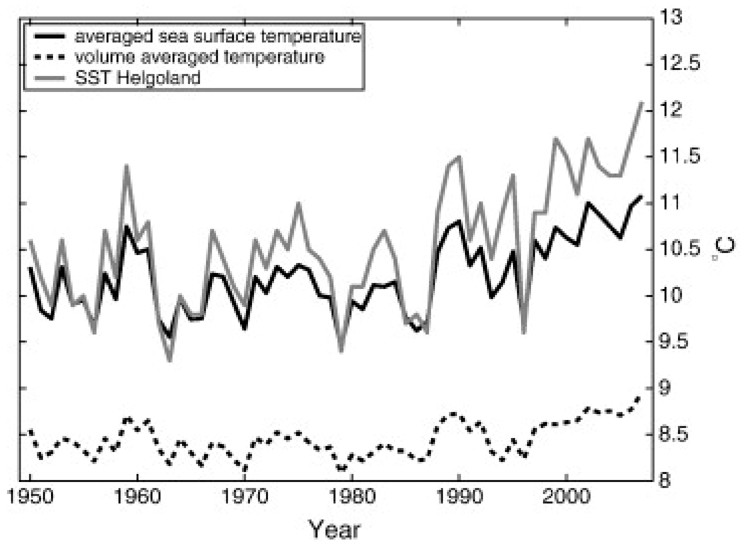
To consider 2.1. The overview requires the following products:

North Sea areas. 1. northern North Sea, including the Norwegian deep, 2. southern North Sea (<50m), 3. Skagerrak and Kattegat, 4 English Channel

Metric	Temporal measure	Definition of space	product delivered by
Temperature	Mean monthly , integrated over water column	1, 2, 3, 4	WGOOFE and WGOH
Stratification	Timing and area by year	1	WGOOFE
Nutrients (dissolved nitrogen and phosphorus)	Winter concentrations	1, 2, 3, 4	???
Bottom oxygen depletions	Events and area	2, 3	WGOOFE
Salinity events	Events and area	2, 3	WGOOFE
Estimates of flux	Trends in fluxes	1, 4	WGOOFE and WGOH

2.1.1 Seawater temperature (direction of change over-time)

http://www.bsh.de/en/Marine_data/Observations/Sea_surface_temperatures/anom.jsp#AnomJ



Other parameters that might be considered: Nutrients (e.g. Input from the Atlantic (Russell cycle?) and wind as a driver of summer stratification. Both as drivers of foodweb changes resulting in changing fish production.

Bring to the attention of WGSE, long-term increases in SST likely to reduce kittiwake breading success to below EcoQO level (Frederikson et al., 2004).

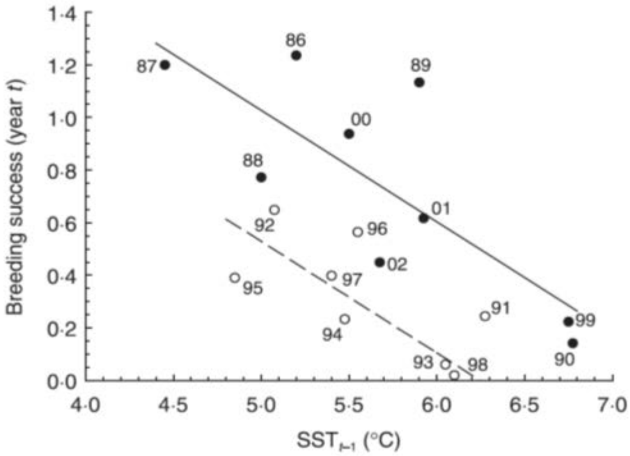


Figure XXX Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Ban kie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years (from Frederiksom et al. 2004).

Bring to the attention of the North Sea Herring Working Group. Decadal variation in SST influences small pelagic fish stock recruitment and so should influence management.

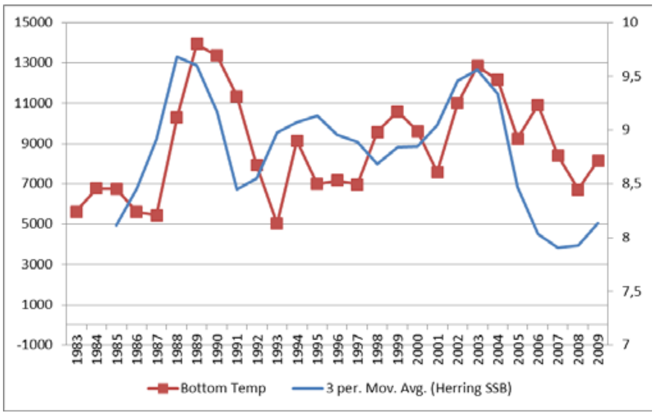


Figure 6. Average bottom water temperature and spawning-stock biomass of herring in the North Sea between 1983 and 2009 (there is data going back to 1950 for both time-series, the plot can be updated).

Reference

Frederickson, M., Wanless, S., Harris, M.P., Rothery, P. and Wilson, L.J. 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41: 1129–1139.

2.2 Biotic processes

2.2.1 Production

The North Sea LME is considered a Class I, highly productive (>300 grammes of Carbon per square meter per year), ecosystem based on SeaWiFS global primary productivity estimates. Primary production varies considerably across the North Sea. The highest values of primary productivity occur in the coastal regions, influenced by terrestrial inputs of nutrients, and in areas such as the Dogger Bank and tidal fronts.

Therefore, trends in annual mean primary production estimates for the Northern and Southern North Sea are likely to be important in determining the potential impacts and direction of change in other important biotic components of the North Sea ecosystem.

MyOcean and MUMM are mostly likely to be the providers of this information via WGOOFE.

2.2.2 Timing of spring bloom

It has been shown that the timing of the onset of the 'spring' bloom in the North Sea has potentially significant implications for the status and dynamics of other biotic components (Melle and Skjoldal, 1998). Overall spring primary production can contribute as much as a third of the total annual primary production in a shelf region (e.g. Townsend et al., 1994), often taking place in a time as short as 1 or 2 weeks.

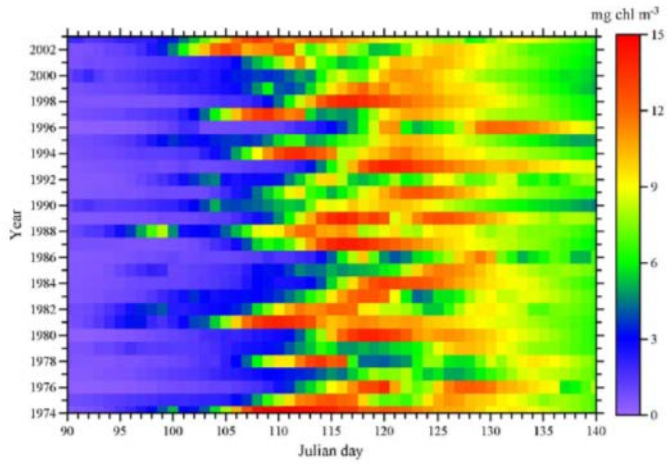


Figure 7.2.2.1. Spring changes in modelled surface chlorophyll between 1974 and 2003 for Northwestern North Sea.

MyOcean and MUMM are mostly likely to be the providers of this information for the Northern North Sea via WGOOFE.

References

Melle, W., Skjoldal, H.R., 1998. Reproduction and development of *Calanus finmarchicus, C. glacialis* and *C. hyperboreus* in the Barents Sea. Marine Ecology Progress Series 169, 211–228.

Townsend, D.W., Cammen, L.M., Holligan, P.M., Campbell, D.E., Pettigrew, N.R., 1994. Causes and consequences of variability of the timing of the spring phytoplankton blooms. Deep-Sea Research Part I 41, 747–765.

2.2.3 Zooplankton

Zooplankton community composition shows considerable differences between areas. A pragmatic approach would be to investigate dynamics in different areas and at different spatial scales: (1) the open North Sea as an entity, (2) the open North Sea divided into a southern and northern region approximately at the depth of the 50m depth isoline but following the ICES rectangle borders, (3) the Kattegat/ Skagerrak region, (4) The English Channel, and (5) coastal areas whenever long-term dataseries are available (e.g. Helgoland Roads). The Working Group on Zooplankton Ecology (WGZE) should provide input to this issue along with their biannual production of the zooplankton status report. Further gelatinous zooplankton should be included in future ecosystem overviews.

The only comprehensive dataset covering the open North Sea and providing a long-term time-series of zooplankton that is operationally available is coming from the Continuous Plankton Recorder Survey (CPR, SAHFOS). In the survey various transects across the North Sea are sampled with ships of opportunity, thus allowing also to calculate estimates for subareas of the North Sea, including the proposed separation into a southern and northern part. *Calanus finmarchicus* and *C. helgolandicus* are one of the best investigated species in terms of spatial distribution, temporal dynamics and their role in ecosystem regime shifts (e.g. Beaugrand et al., 2002, 2010). Despite of their morphological similarity they show striking differences in their distribution (Figure# 1) and seasonal dynamics (Figure #.2), which highlights the necessity to evaluate the dynamics of North Sea subareas. Generally, since the late 1980s warm-water species seem to increase in abundance, but the importance to the ecosystem structure is regionally different and partly dependent on latitude. Further strong species-specific differences exist, e.g. illustrated by the interannual variability of *Pseudocalanus* sp. in the northern and southern North Sea (Figure #.3). For a comprehensive overview of the ecosystem status the dynamics of further key species and functional groups needs to be analysed and put into context to other ecosystem components and pressure variables.

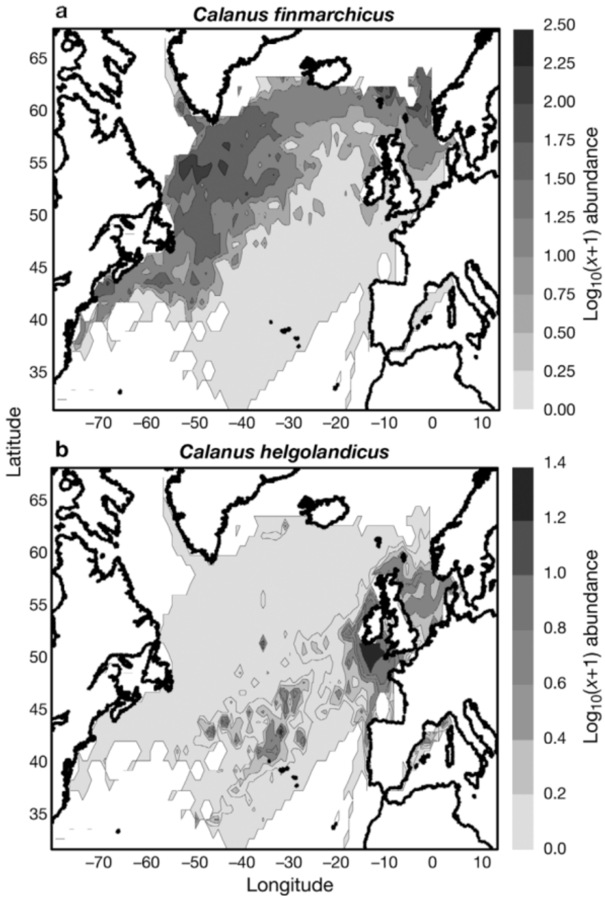


Figure 2.2.3.1: (a) *Calanus finmarchicus* and (b) *Calanus helgolandicus* distribution across the North Atlantic. Not interpolation is made. From Helaouët and Beaugrand (2007).

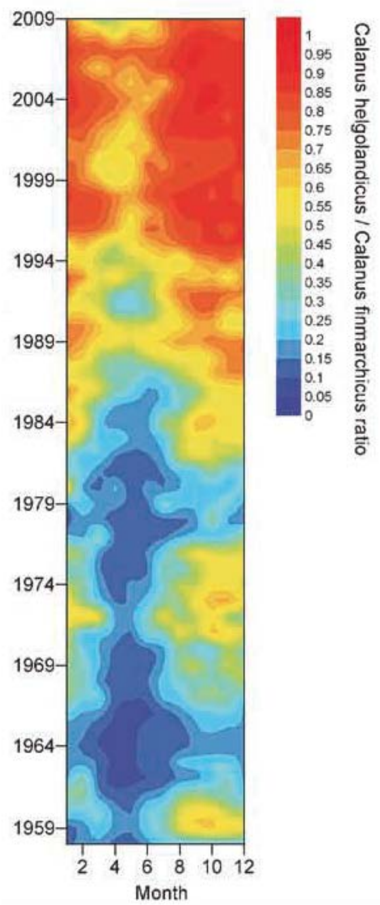


Figure 2.2.3.2: Ratio between *C. helgolandi*cus and *C. finmarchicus* per month from 1958-2009. Red indicates a dominance of *C. helgolandicus*, blue the dominance of *C. finmarchicus*. (from Edwards et al., 2011).

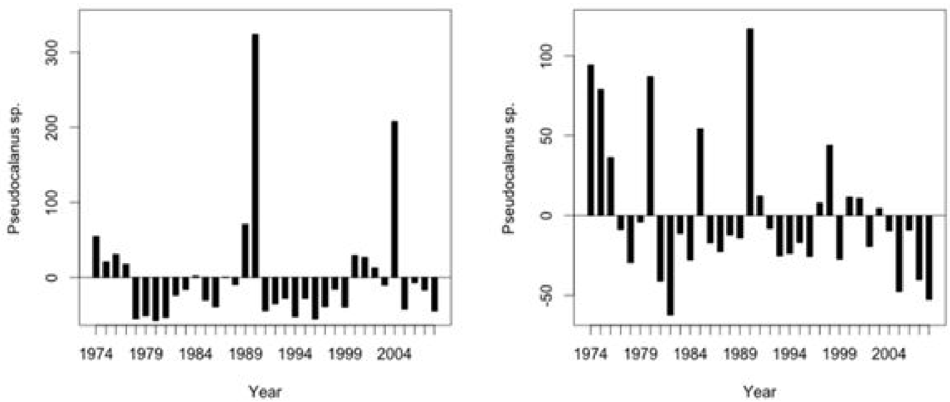


Figure 2.2.3.3: Anomalies of the relative abundance of *Pseudocalanus* sp. in the second quarter of each year estimated from the CPR survey data for the northern North Sea (left panel) and the southern North Sea from 1974 to 2008.

References

Helaouët, P., and Beaugrand, G. 2007. Macroecology of *Calanus finmarchicus* and *C. helgolandicus* in the North Atlantic Ocean and adjacent seas. Marine Ecology Progress Series 345: 147–165.

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A., Edwards, M. 2002. Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. Science 296: 1692-1694.

Beaugrand, G., and Kirby, R.R. 2010 Climate, plankton and cod. Global Change Biology 16, 1268–1280.

Edwards, M., Beaugrand, G., Johns, D.G., Helaouët, P., Licandro, P., McQuatters-Gollop, A., and Wooton, M. 2011. Ecological Status Report: Results from the CPR survey 2009/2010. SAHFOS Technical Report 8: 1-8. Plymouth, UK ISSN 1744-0750.

2.2.4 Marine mammals

Eight marine mammal species occur regularly over large parts of the North Sea: grey seal, harbour seal, harbour porpoise, bottlenose dolphin, white-beaked dolphin, Atlantic whitesided dolphin, killer whale and minke whale. There is extensive information on the distribution and abundance of grey seals around Britain from annual aerial surveys of breeding colonies and from over 100 animals fitted with satellite-relayed data loggers. Information on harbour seals is available from aerial surveys and VHF telemetry. There is also extensive information on distribution in the North Sea from a number of summer sightings surveys (SCANS-94, NASS-89 and NILS-95). Estimates of abundance are available from these surveys for some species. There are also many records from year-round surveys by the European Seabirds at Sea programme (ESAS) since 1979.

Grey seals are important marine predators off eastern Scotland. Their diet comprises primarily sandeels, whitefish and flatfish, in that order of importance, but varies seasonally and from region to region.

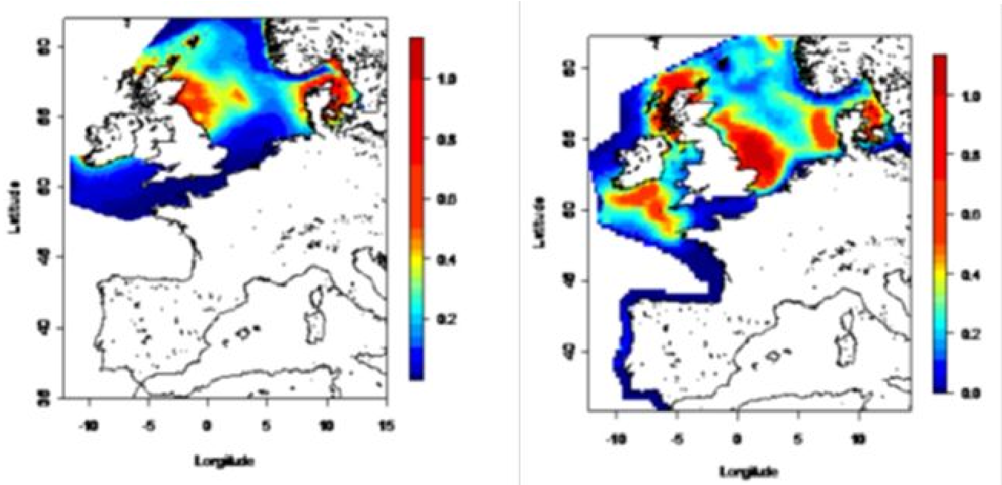


Figure 2.2.4.1. Harbour porpoise in the North Sea in 1995 and 2005.

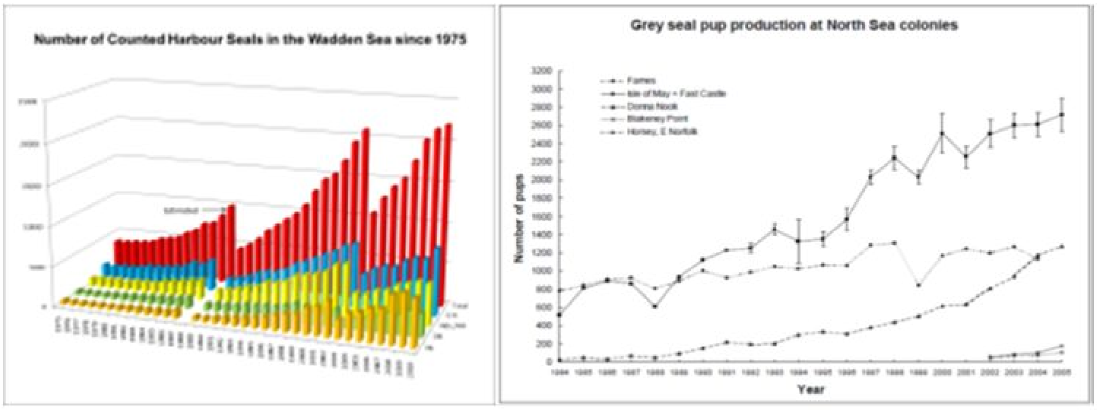


Figure 2.2.4.2. Harbour Seals in the Wadden Sea (left) and Grey Seal pups in the UK (right)

The mostly likely provider of this information for the North Sea is WGMME.

2.2.5 Seabirds

Data on breeding abundance have been widely collected and trends can be estimated relatively easily. Breeding abundance is a good indicator of long-term changes in seabird community structures where density-dependent effects may reduce the usability of other population parameters. However, seabirds are generally long-lived and reproduce at a relatively old age. Thus, changes in their breeding numbers are a poorer indicator of short-term environmental change than are other breeding parameters (e.g. breeding success).

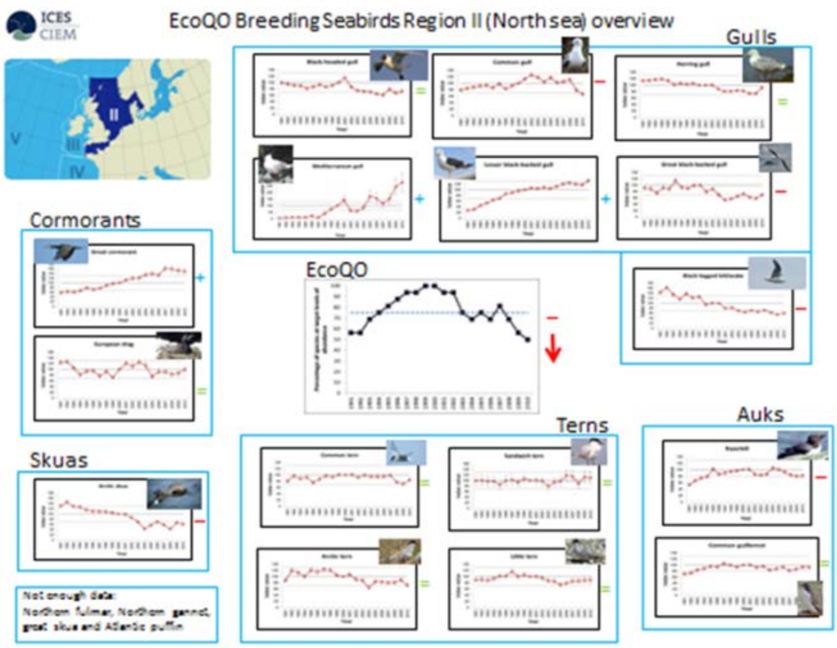


Figure 2.2.5.1. ICES EcoQO Breeding Seabirds Region II

2.2.6 Pelagic and demersal fish biomass

There is a growing understanding that exploited fish populations must be considered as integral components of ecosystem function, rather than units operating independently of their environment (Cury and Christensen, 2005).

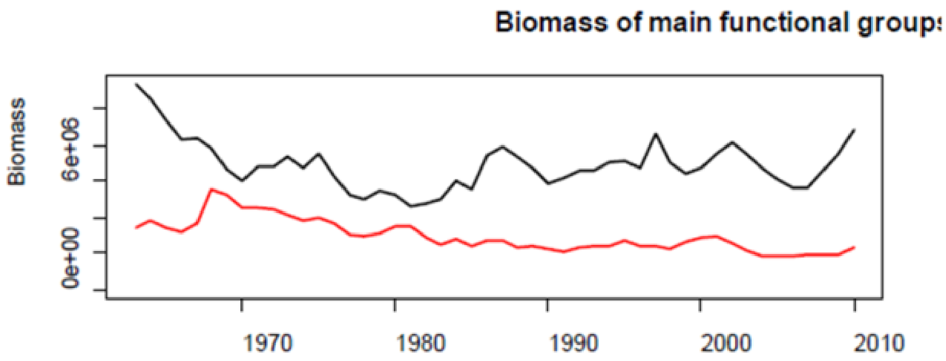


Figure 2.2.6.1. Time-series of biomass of forage fish and mackerels (black) and demersal fish (red) in the North Sea. ICES WGSAM 2012.

Increasing trends in seabird and marine mammal piscivorous predators has implications for natural mortality rates in many assessed and non-assessed fish species.

Reference

Cury, M. and Christensen, V. 2005. Quantitative ecosystem indicators for fisheries management: an introduction, Editorial. ICES Journal of Marine Science. 62: 307-310.

2.3 Human impacts

Based on a review of the national reports to the MSFD and OSPAR documents, ICES assesses the major impacts by humans on the North Sea marine ecosystem to be from fisheries, the oil and gas industries, tourism, aggregate extraction and the developing renewable energy industries. Other than fishing, it is assume that the impact of all the other activities will either stay the same or increase in the future.

These activities cause multiple pressures, some of which are considered cumulative in effect. The impact appears to be greatest in terms on the selective removable of biomass, changes to the marine habitat through destruction or adaptation and the addition of new substances into the system. Other than those caused by fishing the most impacted area appears to be the coastal areas of the North Sea.

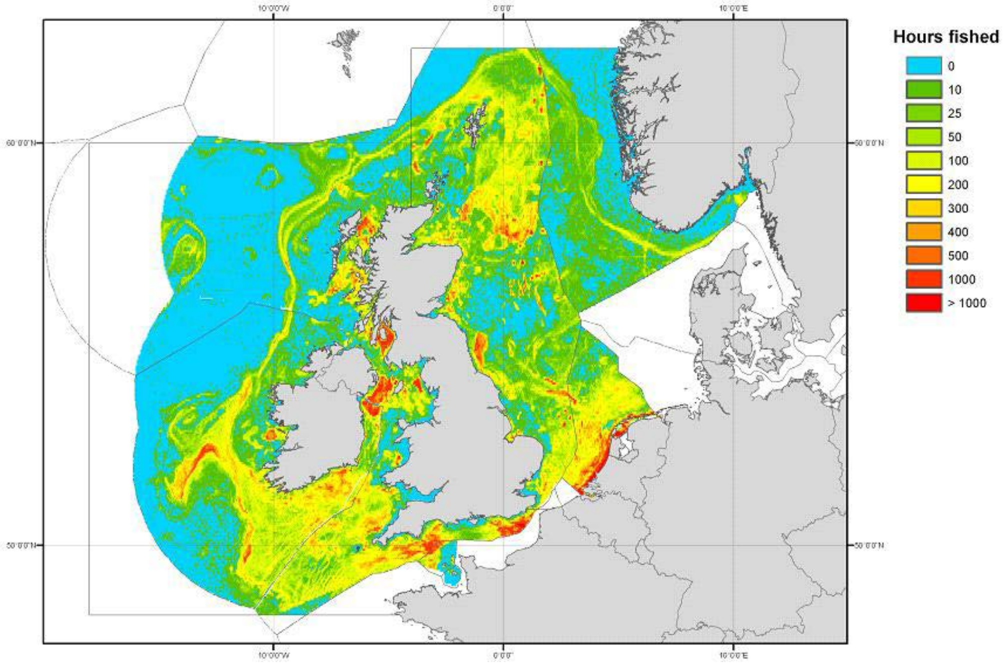
3 Activity and Pressure

3.1 Activity

3.1.1 Fisheries

The total fishing activity for all fishing gears mapped using VMS data from 2007 for Irish, UK, Dutch and Norwegian waters. The figure clearly shows a number of hot spots of fishing activity including deep-water areas along the Continental shelf margin (shelf break).

Fishing Intensity 2007; NS and NWW (all gears)



3.1.2 Oil and gas

There are a wide range of emissions and discharges associated with various offshore oil and gas activities, some of which require specific management measures. The key issues include oil and chemicals in produced water, impacts from historical cuttings piles and atmospheric emissions. Noise and light are also potentially of concern.

Offshore oil and gas activities can also physically disturb seabed habitats both during installation and decommissioning. The latter is a particular issue as many fields in the OSPAR region are near the end of their commercial lives. Accidental events may also lead to the release of oil or chemicals to the environment.

Gross production decreased but the number of installations increased between 2000 and 2007 (i.e. > effort required to extract the available resources). However, the spatial footprint of infrastructure on the seabed is relatively small (e.g. approximately 460 km2 of seabed in the UK and Norwegian sectors are impacted by oil and gas related pipelines).

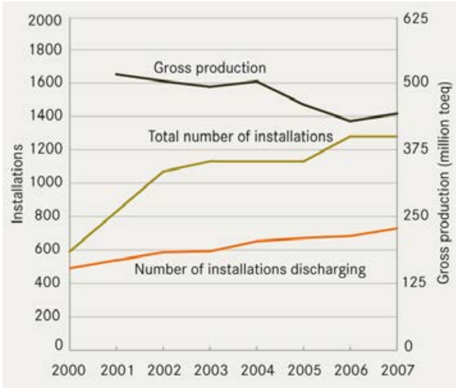


Figure 3.1.2.1. OSPAR estimates of oil and gas production and installations in the North Sea

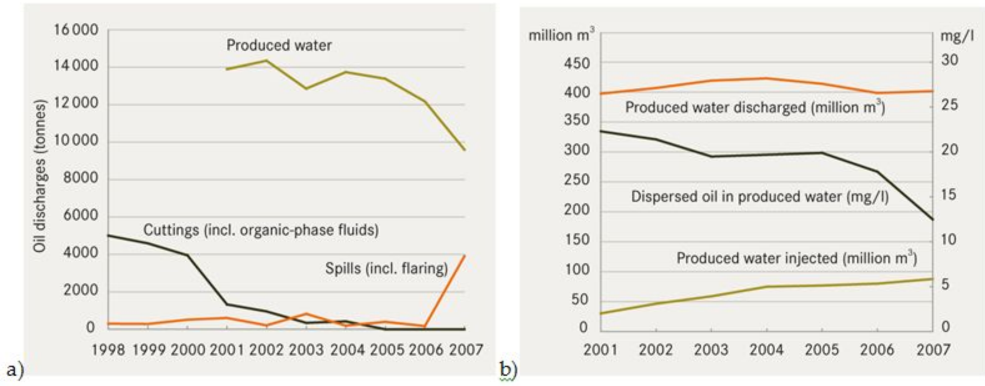


Figure 3.1.2.2. Annual discharges of oil from the different sources. b)Annual amounts of produced water discharged.

3.1.3 Tourism and recreation

Tourism in the OSPAR region is notably increasing and with it also the negative and positive implications that this activity has in the coastal and marine environment. At present, Europe is the world's largest holiday destination and it is still growing. The most popular destinations in the region are coastal zones where fragile ecosystems may suffer greatly from tourism-related impacts. With respect to tourist arrivals in the OSPAR area, Regions II and IV sustain the highest level of tourism pressure and have experienced the largest increase in the number of arrivals during the 1998-2006 period.

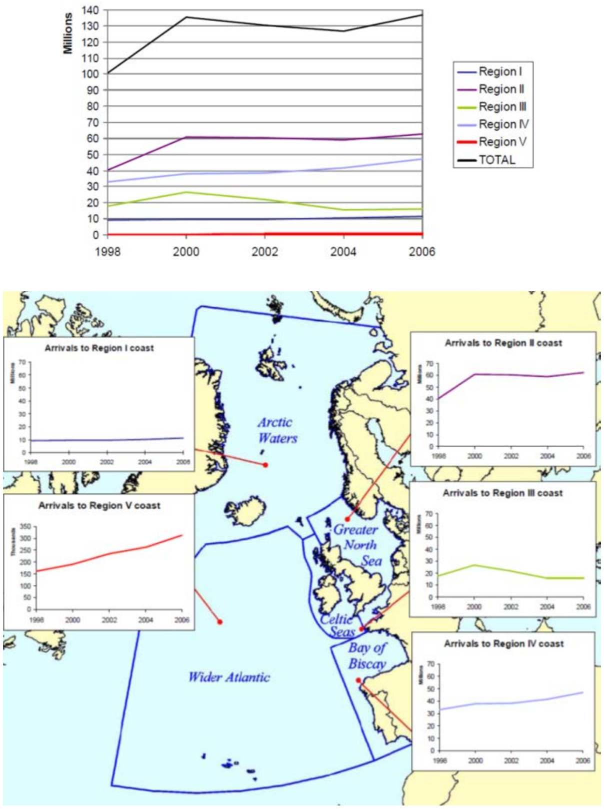


Figure 3.1.3.1. Tourist arrivals to each OSPAR coastal region and total, 1998-2006 period (Data source: EuroStat, 2007).

The most relevant problems associated with tourism are those related to the large number of tourists which, added to the coastal population, particularly in summer, greatly increases pressure on littoral ecosystems and fosters infrastructure and urban development on the coast. Artificial surfaces spread as a result of residential expansion (especially in Portugal, France and Ireland, but also in the UK, Belgium, Denmark and Sweden) and the greater need for services, recreation, coastal defences and harbours (especially in the North Sea). Other problems arise from increased demand for water resources (especially during summer in southern Europe) and over-frequentation of natural sites – a main issue in areas with high value ecosystems which are exceptionally delicate, such as wetlands, sea-cliffs, coastal dunes and beaches. Beach nourishment is one of the alternatives carried out to counteract the effects of coastal erosion and to maintain the extension of beaches. Other relevant activities can have adverse environmental impacts and effects, such as: recreational boating – probably the most widespread form of marine tourism; whale-watching – a growing industry in Europe, significantly contributing to the marine tourism sector (in 2002, 62,050 people went whale-watching in Iceland, approximately 30% of all visitors to the country); and cruise-travelling, a sector of tourism that has been increasing systematically and is expected to grow even more in the coming years, especially in northern Europe.

3.1.4 Extraction of aggregates

Each year across the OSPAR area, around 50 – 60 million cubic metres of marine mineral deposits are extracted from the seabed for the construction industry or for beach nourishment. Gravel and sand (aggregates) are the principal materials extracted, but in some countries significant volumes of non-aggregate marine mineral resources such as maerl are also exploited.

The extraction of marine mineral deposits has profound effects on the seabed. It removes the substrata and associated organisms and may disrupt ecological services. Dredging may also result in changes to the nature and stability of sediments, increased turbidity, redistribution of fine particulates and the production of plumes of suspended material.

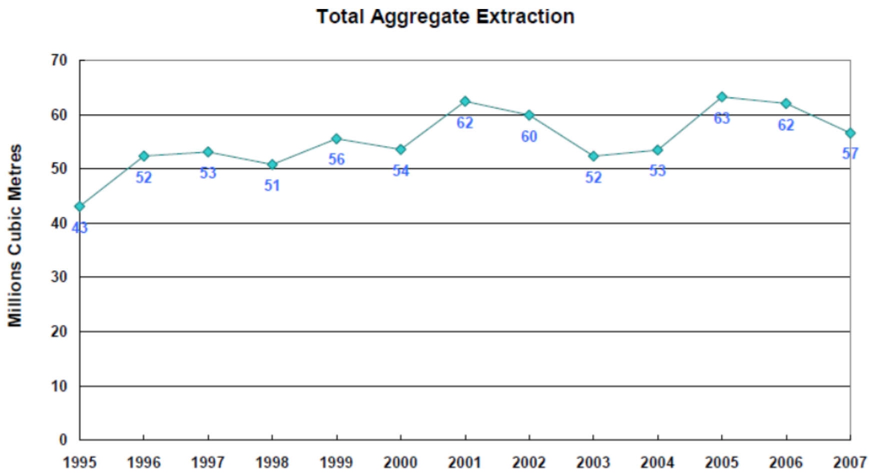


Figure 3.1.4.. Total aggregate extraction in the OSPAR Maritime Area Source: ICES, 2005, 2006, 2007, 2008, 2009. Note this only represents data reported to WGEXT and is thus an approximation.

The type and quantity of aggregate dredged in the OSPAR area varies according to location and end-use requirement (see Figure 2.2). By its very nature, dredging is a shallow water coastal activity, thus is most prevalent in Regions II, III and to a slightly lesser extent Region IV. Region II includes the Netherlands (the biggest producer by volume), and significant parts of the UK and France and Denmark (the next three biggest producers). The volume of sand and gravel extracted in Region II is estimated at approximately 80% of the overall volume extracted throughout the OSPAR area. Demand for marine sand and gravel is likely to increase as a result of sea level rise.

While the total quantity of material extracted from the seabed has risen by approximately 30% over the last decade, available data suggest that the spatial extent of sand and gravel extraction in the OSPAR area is generally stable, as new concessions are progressively offset by relinquished acreage.

3.1.5 Renewable Energy

There is an increasing trend in the number of developments (sea space) of offshore wind farms (Figure xxx).

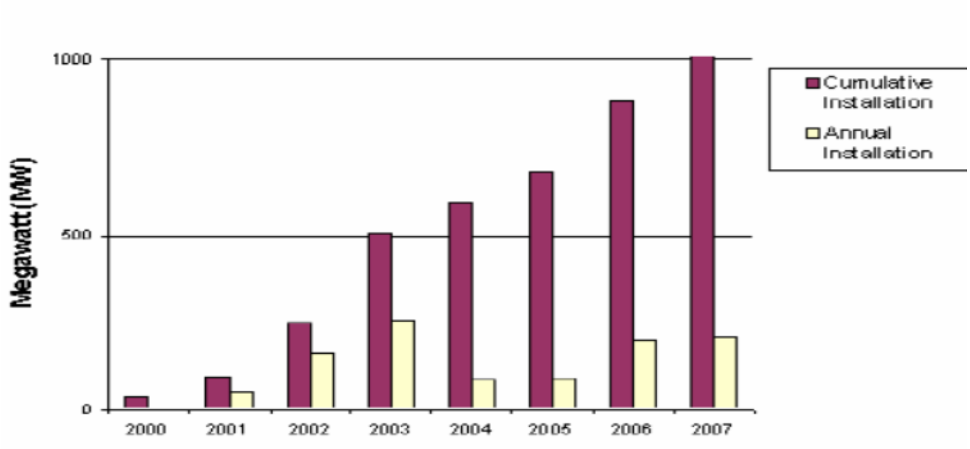


Figure 3.1.5.1 European estimates in offshore wind energy production (EWEA data on installed capacity)

It has been estimated that the UK has approximately 33% of the total EU wind resource (Troen and Petersen 1989).Thus taking the UK as an example the forecast is for continued growth in the sector (Figure xxx).

The drivers for this increasing trend in development are:

1) The European Directive 2001/77/E committed member states to set national targets for the consumption of energy from renewable sources, which resulted in the Energy Policy for Europe establishing a 20% target as mandatory.

2) The Renewable Energy Directive (2009/28/EC) requires the UK to produce 15% of all its energy from renewable sources by 2030 (approximately 30–35% of electricity from renewables). The means by which this will be achieved is set out in the UK Renewable Energy Strategy . The strategy is for over 30% of the UK's electricity to come from renewable sources by 2020 with two-thirds expected to come from wind power.

3) Other countries have similar obligations [expand?].

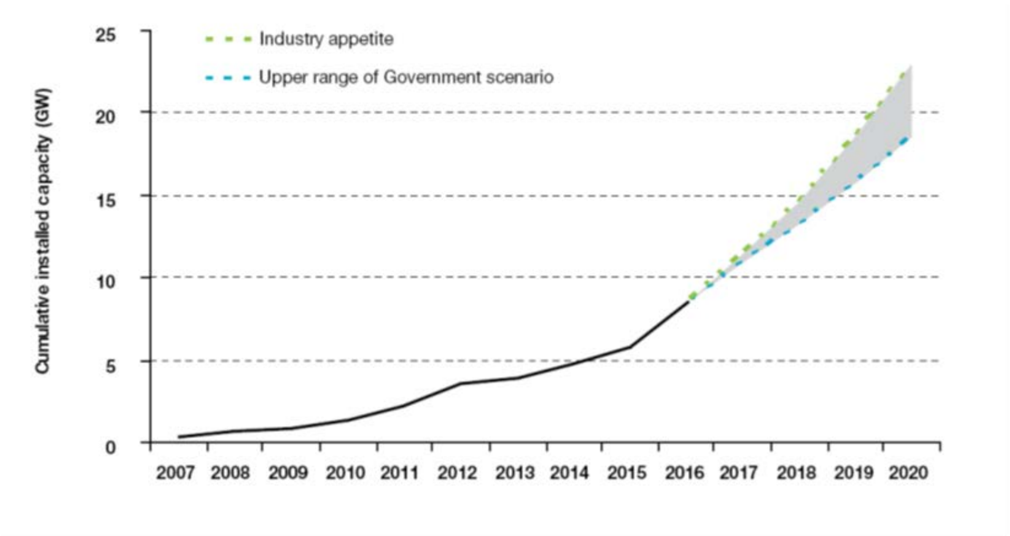


Figure 3.1.5.2. UK Offshore wind deployment forecasts for 2016-2020 (RenewableUK, 2011).

Potential impacts associated with the development of offshore wind-farms (not exhaustive) (Source: OSPAR, 2004):

Issue	Source of Potential Impacts	Examples of Potential Impacts
Birds	- turbines, mainly rotor blades and wakes - light emission	- bird collision - attraction of birds due to illumination by navigational lights and subsequent increase in the risk of collision
	- wind-farm as a whole	- temporary or permanent habitat loss or change, including exclusion of habitat, *e.g.* sandbanks, water surface/water body due to disturbance - fragmentation of feeding, breeding and roosting areas, as well as migratory routes due to barrier effect - change of food species availability
	- boat traffic during construction and maintenance	- stress and reduction of biological fitness - temporary or permanent exclusion from habitat
	- electric cable to shore – increase of temperature in sediments during operation	- increased risk of botulism in coastal areas (eulittoral) resulting in an increased death rate for wading birds and water birds
Bats	- turbines mainly rotor blades and wakes	- collision and barrier effects
Marine Mammals	- shadow from rotor blades - emission of sound and vibration into the water body - construction noise (including pile driving)	- habitat loss due to avoidance - fragmentation of migratory routes and of sites for foraging and reproduction - induced permanent or temporary threshold shift in hearing (PTS/TTS), reduced perception of biologically significant sounds (masking)
	- boat traffic during construction and maintenance	- changed behaviour, stress
	- electric cables (see below)	- disturbance of small- and large-scale orientation
Fish	- electric cable within the wind-farm and to shore – artificial electromagnetic fields emitted during operation, in particular from monopolar direct current cables	- disturbance of small- and large-scale orientation (especially migratory species) - impediment of foraging activity - physical barrier
	- emission of sound and vibration into the water body	- habitat loss as fish may leave area - disturbance of behaviour and stress
	- clouding and sedimentation during construction	- damage to fish eggs - damage and or disturbance to spawning grounds
	- introduction of hard substrate - construction noise (including pile driving)	- alteration of food species availability and abundance, which in turn may alter community composition and abundance of fish - induced permanent or temporary threshold shift in hearing (PTS/TTS), reduced perception of biologically significant sounds (masking)

Issue	Source of Potential Impacts	Examples of Potential Impacts
Zoobenthos	- cable laying	- disturbance of intertidal habitats
	- local destruction and sediment plumes during the construction/removal of foundations - permanent covering of the sea floor - introduction of artificial hard substrate - changes in hydrodynamics - electric cable within the wind-farm and to shore – increase of temperature in sediments during operation	- temporary and permanent habitat loss - alteration in the benthic community composition - indirect habitat loss through small-scale changes in sediment structure around the turbine and changes of large-scale sediment dynamics - alteration in the endobenthic community including colonisation by alien species - increased degradation of the organic content resulting in a release of heavy metals (depending on the total organic matter content and metal content of the sediment)
Macrophytes	- local destruction and sediment plumes during the construction of foundations - permanent covering of the seafloor	- temporary and permanent habitat loss
	- change of current dynamics and sediment conditions - introduction of artificial hard substrate	- habitat loss - alteration in the plant community composition
Hydrodynamics and Morphodynamics	- construction and presence of foundations and cables	- change of sediment dynamics, for example slowing down of natural erosion and sedimentation processes (at the site and adjacent coastlines) - reduction in wave energy (shadow effects) from different sized arrays and how/if this influences sediment inputs and exchanges - beach faces and flood defences
Landscape	- tall structures visible from afar - lighting	- intrusion on the typically flat and featureless sea and "industrialisation" of this natural landscape - alteration of the scenic landscape – especially at night
Navigation	- danger of collisions between vessels and wind turbines (including restriction/constriction of shipping routes)	- pollution through oil spills or chemical spills - impact on socio-economic operations
Emergency Operations	- obstacles due to the presence of static structures	- impact on emergency operations
Other Users	- exclusion of other users from the area - disturbance of the natural landscape	- socio-economic losses, *e.g.* for fisheries and tourism

3.2 Pressures

Corresponding to the priority activities above:

Acute

- Abrasion
- Smothering
- Substrata loss
- Death or injury by collision
- Selective extraction of living (e.g. fishing) and non-living resources (e.g. aggregates)

Chronic

- Introduction of synthetic compound
- Introduction of non-synthetic compounds
- Introduction of non-indigenous species

4 State of the System

4.1 Biodiversity

OSPAR considered six separate ecosystem components and has compiled a list of "common indicators" for each component. As a result of this OSPAR decision, most MSs who are also CPs to OSPAR compiled their own lists of indicators to comply with these Ecosystem component categories. These ecosystem components are: Pelagic habitats, Sedimentary habitats, Rock and biogenic reef, Seabirds, Marine mammals and reptiles, Fish and Cephalopods. For the North Sea ecoregion we now adopt the same approach to considering biodiversity indicators.

4.1.1 Pelagic habitats

1) Change of plankton functional types (life form) index Ratio. Targets currently not defined for this indicator.

2) Plankton biomass and/or abundance. Targets currently not defined for this indicator.

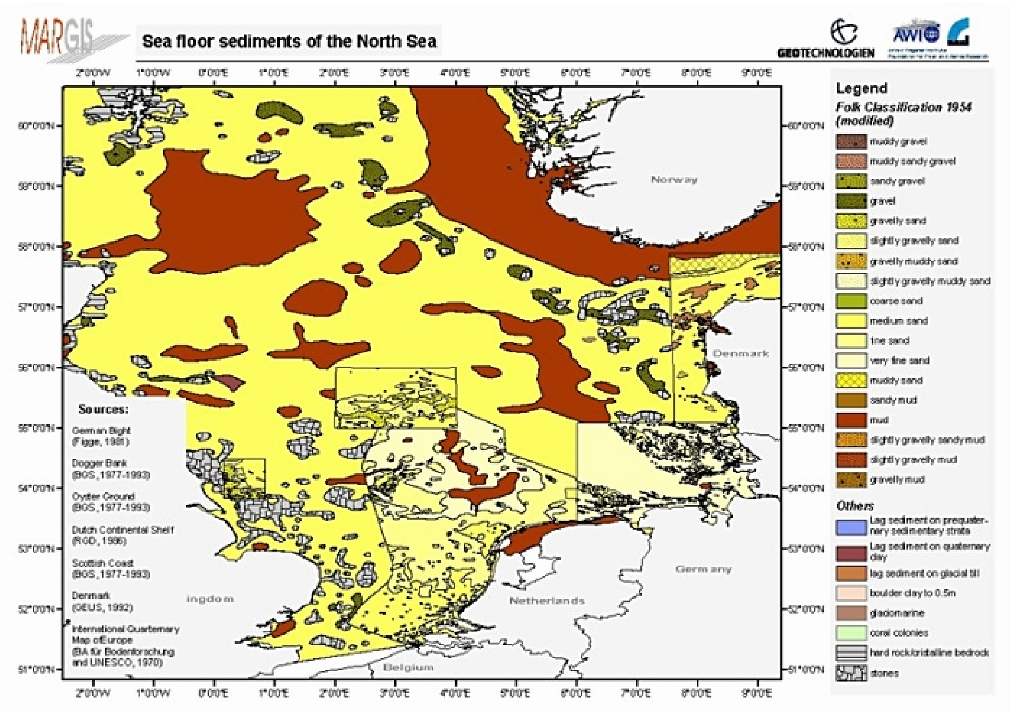
3) Changes in biodiversity index(s). Targets currently not defined for this indicator.

4.1.2 Sedimentary habitats

- It is not known whether "common indicators" for biodiversity are currently being considered by OSPAR for this ecosystem component.

Rock and biogenic reef

- It is not known whether "common indicators" for biodiversity are currently being considered by OSPAR for this ecosystem component.



Seabed sediment types of the North Sea.

4.1.3 Seabirds

1) Distributional pattern of breeding and non-breeding marine birds: No major shifts or shrinkage in the range of marine birds in 75% of species monitored.

2) Species-specific trends in relative abundance of non-breeding and breeding marine birds: 75% of species should be above their individual species-specific thresholds.

3) Annual breeding success of kittiwake: No specific target set for this, but target un-der consideration is linked changes in surface seawater temperature (Frederikson et al., 2004), so is a moving target reflecting changes in environmental conditions.

4) Breeding success/failure of marine bird species: Widespread seabird colony breeding failures should occur rarely in other species that are sensitive to changes in food availability. Based on species- specific target of - The annual percentage of colonies experiencing breeding failure does not exceed the mean percentage of colonies failing over the preceding 15 years, or 5%, whichever value is greater, in more than three years out of six.

5) Mortality of marine birds from fishing (bycatch) and aquaculture: Estimated mortality as a result of fishing bycatch and aquaculture entanglement does not exceed levels that would prevent targets for MSFD Descriptor 1 Criterion 2 (population size) from being achieved.

6) Non-native/invasive mammal presence on island seabird colonies: Minimize the risk of invasion by non-native mammals on all island seabird colonies, where this has not already occurred (including islands from where mammals have been eradicated); and eliminate detrimental impacts caused by mammals at a prioritized list of island seabird colonies.

4.1.4 Marine mammals and reptiles

1) Distributional range and pattern of grey and harbour seal haul-outs and breeding colonies: No decrease with regard to the baseline beyond natural variability.

2) Distributional range and distributional pattern within range of cetaceans: No de-crease with regard to the baseline beyond natural change OR to restore or maintain populations in a healthy state.

3) Abundance of harbour and grey seals: No statistically significant decrease with regard to the baseline beyond natural variability.

4) Abundance, at the relevant temporal scale, of cetacean species regularly present: No statistically significant decrease with regard to the baseline beyond natural variability (1): An increase in numbers in all areas where it occurs, and a recovery in areas where it was known to occur up to the 20th century (2).

5) Fecundity rate of harbour seal and grey seal (pup production): No statistically significant deviation from long-term variation / no decline of ≥10% at each management unit.

6) Mortality rate due to bycatch: The annual bycatch rate of [marine mammal species] is reduced to below [X] of the best population estimate.

4.1.5 Fish and Cephalopods

1) Population abundance/biomass of a suite of selected species, e.g. trends in the abundance of sensitive fish species: a statistically significant fraction of the sensitive species for which data meet "adequately monitored" criteria are increasing in abundance (trends-based targets for individual species abundance metrics).

2) OSPAR EcoQO for proportion of large fish; for all species from the IBTS. [It may be that this is an error in the document. The ICG-COBAM technical lead on fish still believes that this indicator relates primarily to demersal fish]. A target of 0.3 has been proposed for the North Sea demersal fish community (Heslenfeld and En-serink 2008).

3) Mean maximum length of demersal fish and elasmobranchs. Targets currently not defined for this indicator.

4) Conservation status of elasmobranch and demersal bony fish species (IUCN). Targets currently not defined for this indicator.

5) Proportion of mature fish in the populations of all species sampled adequately in international and national fish surveys. Targets currently not defined for this indicator.

6) Bycatch rates of Chondrichthyes. Targets currently not defined for this indicator. In the North Sea about 10 skate and ray species occur as well as seven demersal shark species. Thornback ray *R. clavata* is probably the most important ray for the commercial fisheries.

7) Distributional range of a suite of selected species, e.g. trends in range extent of sensitive fish species: a statistically significant fraction of the sensitive species for which data meet "adequately monitored" criteria are increasing the extent of their range (trends-based targets for individual species range extent metrics).

8) Distributional pattern within range of a suite of selected species. Targets currently not defined for this indicator.

References

Greenstreet, S. P. R., Rogers, S. I., Rice, J. C., Piet, G. J., Guirey, E. J., Fraser, H. M., and Fryer, R. J. 2011. Development of the EcoQO for the North Sea fish community. – ICES Journal of Marine Science, 68: 1–11.

Greenstreet, S. P. R., Rossberg, A. G., Fox, C. J., Le Quesne, W. J. F., Blasdale, T., Boulcott, P., Mitchell, I., Millar, C., and Moffat, C. F. 2012. Demersal fish biodiversity: species-level indicators and trends-based targets for the Marine Strategy Framework Directive. – ICES Journal of Marine Science, 69: 1789–1801.

Shephard, S., Reid, D. G., and Greenstreet, S. P. R. 2011. Interpreting the large fish indicator for the Celtic Sea. – ICES Journal of Marine Science, 68: 1963–1972.

4.2 Non-indigenous species

Description of figure/ table or other element:

1) Rate of new introductions of NIS (per defined period).

2) Pathways management measures: Monitoring at key high risk/hot spot areas of introduction/potential spread.

The data and contents of this subsection should be drawn to the attention of WGITMO

Add short text describing main trends in the variables

4.3 Commercially exploited fish and shellfish

The recent 2012 summaries of commercially exploited fish in the North Sea are given below.

	State of the stock			
Stock	Fishing mortality relation to FMSY	Fishing mortality relation to precaution limits (FPA/Flim)	SSBrelation to MSY Btrigger	Spawning biomass relation to precaution limits (BPA/Blim)
Cod - Kattegat	Unknown	Unknown	Undefined	Reduced reproductive capacity
Cod -North Sea, Eastern Channel	Above target	Harvested sustainably	Below trigger	Reduced reproductive capacity
Haddock - North Sea and Division IIIaN	Appropriate	Harvested sustainably	Above trigger	Full reproductive capacity
Whiting - North Sea and Eastern Channel	Undefined	Undefined	Qualitative evaluation: At recent average	
Plaice -Skagerrak	Unknown	Unknown	Qualitative evaluation: West: Increasing East: Decreasing at historical low	
Plaice- North Sea	Appropriate	Harvested sustainably	Above trigger	Full reproductive capacity
Plaice - Eastern Channel	Qualitative evaluation: Lowest in time-series		Qualitative evaluation: Increasing	
Sole - IIIa	Below target	Increased risk	Below trigger	Undefined
Sole - North Sea	Above target	Harvested sustainably	Above trigger	Full reproductive capacity
Sole - Eastern Channel	Above target	Increased risk	Above trigger	Full reproductive capacity
Saithe -North Sea,	Above target	Harvested sustainably	Below trigger	Increased risk
Nephrops - IIIa (FUs 3 and 4)	Appropriate	Undefined	Undefined	Undefined

Stock	State of the stock Fishing mortality relation to FMSY	Fishing mortality relation to precaution limits (FPA/Flim)	SSBrelation to MSY Btrigger	Spawning biomass relation to precaution limits (BPA/Blim)
Nephrops - Subarea IV, FU6	Appropriate	Undefined	Above trigger	Undefined
Nephrops - Subarea IV, FU7	Below target	Undefined	Above trigger	Undefined
Nephrops - Subarea IV, FU8	Above target	Undefined	Above trigger	Undefined
Nephrops - Subarea IV, FU9	Below target	Undefined	Above trigger	Undefined
Herring in IIIa , 22-24	Above target	Undefined	Below trigger	Undefined
Herring - North Sea, VIId, III	Below target	Harvested sustainably	Undefined	Full reproductive capacity
Sprat -IIIa	Insufficient information	Insufficient information	Insufficient information	Insufficient information
Sprat - North Sea	Insufficient information	Insufficient information	Insufficient information	Insufficient information
Norway pout - North Sea	Undefined	Undefined	Above trigger	Full reproductive capacity
Sandeel - Dogger Bank area (SA1)	Undefined	Undefined	Above trigger	Full reproductive capacity
Sandeel - Southeast North Sea (SA 2)	Undefined	Undefined	Above trigger	Full reproductive capacity
Sandeel - Central Eastern North Sea (SA 3)	Undefined	Undefined	Above trigger	Full reproductive capacity
Sandeel - Central Western North Sea (SA 4)	Unknown	Unknown	Unknown	Unknown
Sandeel - Viking and Bergen Bank area (SA 5)	Unknown	Unknown	Unknown	Unknown
Sandeel - Division IIIa East (Kattegat, SA 6)	Unknown	Unknown	Unknown	Unknown
Sandeel - Shetland area (SA 7)	Unknown	Unknown	Unknown	Unknown

Stock	State of the stock			
	Fishing mortality relation to FMSY	Fishing mortality relation to precaution limits (FPA/Flim)	SSBrelation to MSY Btrigger	Spawning biomass relation to precaution limits (BPA/Blim)
Pandalus - Fladen Ground	Insufficient information	Insufficient information	Insufficient information	Insufficient information
Pandalus – Skagerrak, Norwegian Deep	Insufficient information	Insufficient information	Insufficient information	Insufficient information
Mackerel in the North Sea	Above target	Increased risk	Above trigger	Full reproductive capacity
Horse mackerel - North Sea	Insufficient information	Insufficient information	Insufficient information	Insufficient information
Pollack - North Sea	Insufficient information	Insufficient information	Insufficient information	Insufficient information

Annex 5:WGINOSE Meeting Resolution 2014

The **Working Group on Integrated Assessments of the North Sea** [WGINOSE] (Co-Chairs: Andy Kenny, UK and Christian Möllmann, Germany) will meet in Copenhagen, Denmark from 10th – 14th March 2014 to:

a) Update the integrated ecosystem trend analysis for the North Sea using as many of the 'core' variables as identified in the present report.
b) Update the 2014 North Sea ecosystem overview report using findings from ToR a above;
c) Further develop and apply a Bayesian belief network model as a tool for integrated and cumulative effects assessments to support both ICES and OSPAR needs for management advice.
d) Review the data needs and approaches to support the operational implementation of ToRs a and b above.

WGINOSE will report by DATE to the attention of SCICOM.

Supporting Information

Priority	WGINOSE aims to conduct and further develop Integrated Ecosystem Assessments for the North Sea, as a step towards implementing the ecosystem approach.
Scientific justification	Key to the implementation of an ecosystem approach to the management of marine resources and environmental quality is the development of an Integrated Ecosystem Assessment (IEA). An IEA considers the physical, chemical and biological environment, including all trophic levels and biological diversity as well as socio-economic factors and treats fish and fisheries as an integral part of the environment. The work of the group will have to goal to develop the scientific basis and the tools for implementing a full IEA. It will built on the results of REGNS and WGHAME and will to conduct (i) further analyses of ecosystem structure and function, if possible also spatially disaggregated for different subsystems of the North Sea, (ii) implement ecosystem modelling in IEA, and (iii) coordinate its work with other groups and organizations involved in developing IEA in the North Sea and other areas. WGINOSE will contribute to the ICES Science Plan to the High Piority Research Topics "Understanding Ecosystem Functioning", specifically the research topics *Climate change processes and predictions of impacts*; *Biodiversity and the health of marine ecosystems*; *Top predators in marine ecosystems*; *Integration of surveys in support of EAM*, "Understanding Interactions of Human Activities", specifically the research topics *Impacts of fishing on marine ecosystems*, *Population and community level impacts of contaminants, eutrophicationand habitat changes in the coastal zone*, *Introduced and invasive species, their impacts on ecosystems and interactions with climate change processes*; and "Development of options for sustainable use of ecosystems", specifically the research topics *Marine living resource management tools, Operational modelling combining oceanographic, ecosystem, and population processes, Marine spatial planning, including the effectiveness of management practises and its role in the conservation of biodiversity, and Contributions to socio - economic understanding of ecosystem goods and services, and forecasting of the impact of human activities.*
Resource requirements	Assistance of the Secretariat in maintaining and exchanging information and data to potential participants. Assistance of especially the ICES DATA CENTER to collect and store relevant dataseries
Participants	The Group will be attended by 20–30 members and guests.
Secretariat facilities	None.

Financial	No financial implications.
Linkages to advisory committees	Relevant to the work of ACOM and SCICOM.
Linkages to other committees or groups	SSGSRP, WGNARS, WGEAWESS, WGIAB, WGOOFE, SGIMM
Linkages to other organizations	OSPAR, EU, NAFO

Annex 6: Abstracts of presentations

Long-term trends in the North Sea plankton.

Santiago Alvarez-Fernandez

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Three phytoplankton variables (Phytoplankton Colour index, Diatom and Dinoflagellate abundances) and 4 zooplankton indicators (Total number of copepods, abundance of warm-affinity, cold-affinity and small copepods) were collated from the Continuous plankton recorder dataset. Averaged monthly values for the Northern North Sea and the Southern North Sea were included in a principal components analysis in order to detect the main temporal patterns in these dataset.

After extracting the PCs, these were subjected to a suite of abrupt change detection methods (i.e. Chronological clustering, Split moving window boundary analyses, and a change point detection method). As a result three different shift points were found

- Summary of findings:
  - **1978**: A cold episodic event decreased the abundance of copepods - particularly warm-affinity copepods – and shortened the phytoplankton growing season.
  - **1989**: A warm regime started which shifted the copepod community to a warm-affinity community. The phytoplankton biomass increased considerably.
  - **1998**: There was an increase of Diatom biomass paired with a decrease of Dinoflagellate biomass. The neritic copepods halved their numbers.

After the 1998 shift there was an increase in diatom biomass, particularly during the spring peak, and a decrease in dinoflagellate biomass. Total copepod biomass decreased, and this was a result of a big drop in the smaller copepods abundance (i.e. *Paracalanus, Pseudocalanus, Temora spp.*). Warm and cold copepod abundances remained at the abundance levels before the shift.

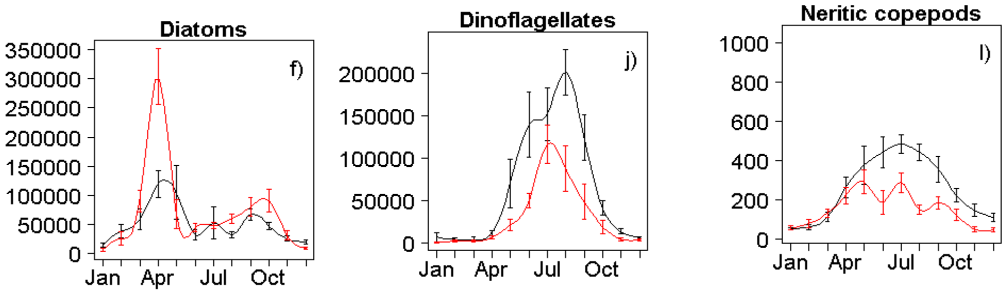

Figure 8 Monthly averaged abundances of selected groups for two different regime periods. Black line: 1989-1998, red line: 1999-2008

Although a clear link to temperature was detected with GAMs of the PCs, no clear link to temperature was found for this last shift. The only environmental variables that showed some relation to the PC containing this shift were nutrient related variables (i.e. NH4 and Total Nitrogen concentrations)

The copepod species that form the neritic assemblage (i.e; *Pseudo* and *Paracalanus* spp., *Temora longicornis*) are main prey items for larvae of several important fish species in the North Sea: herring and sprat (Last 1989, Arrhenius 1996), cod and whiting (Shaw et al. 2008).

The lack of enough prey items could lead to more competition for prey, less larval success and therefore lower recruitment for these species.

For herring this has already been shown (Payne et al. 2009), and the timing of the North Sea herring recruitment failure, the year 2000, coincides with the shift detected in plankton community structure.

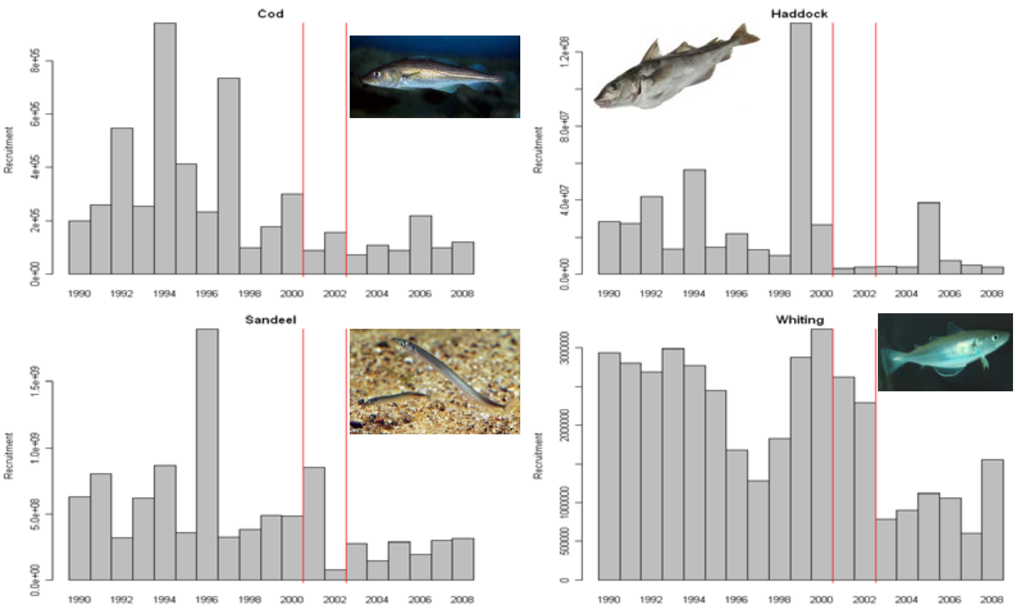

Figure 9 Recruitment for different fish species since 1990. Vertical lines represent confidence intervals of regime limit detected in preliminary analyses. Note different scales of y-axes

A preliminary analysis of recruitment figures for five North Sea fish species; cod, whiting, herring, sandeel and haddock, between 1990-2008 showed a coinciding shift around 2000, after which recruitment values were much lower.

The plankton changes shown in this summary would not have been detected if only yearly averages were considered. This highlights the importance of considering seasonality when analysing fast developing parts of the ecosystem, such as plankton. Changes at particular times in the year of these could have knock-on effects on slower developing parts of the system.

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Annex 7: North Sea subregion: Skagerrak and the Kattegat

The Skagerrak and the Kattegat (ICES area IIIa) are parts of the Greater North Sea and Ecoregion North Sea. The areas are connected to the eastern North Sea, but have a number of physical and bathymetric properties that are likely to create foodwebs and drivers differing from those in the central North Sea. The net outflow of brackish water from the Baltic Sea creates a low saline surface layer in the Kattegat and the eastern Skagerrak above the saline North Seabed water. The resulting halocline at approximately 15 m depth is most pronounced and stable in the Kattegat and the Eastern Skagerrak, making these areas highly stratified. The microtidal regime (10-30 cm) adds to the limited mixing and the restricted exchange of water between the coast and the open sea. The thermocline builds up rapidly in spring and gradually converges with the halocline.

The Kattegat is a shallow area (average depth 23 m) surrounded by densely populated catchment areas and significant agricultural and industrial activity. The halocline at approximately 15 m depth creates limited volumes of rather stagnant bottom water where the oxygen is gradually used up during summer through respiration and decomposition of organic material from spring bloom. The extent and severity of hypoxia varies among year, and has recently decreased with decreasing nitrogen and phosphorus discharges from the catchment area (Carstensen et al 2006 Limnol. Oceanogr.).

The Skagerrak includes the eastern part of the Norwegian trench which makes it comparatively deep also by North Sea standards (average depth 220 m). The eastern Skagerrak resembles the Kattegat in terms of the halocline and tidal regime, whereas the western part shares the attributes of the Southern North Sea. The archipelago along the eastern and northern shoreline is complex, including deep fjords with stagnant bottom water. Together, the physical and bathymetric properties create gradients in biodiversity and ecosystem structure from the Baltic to the central North Sea (Havs och Vattenmyndigheten 2012).

The Swedish Meteorological and Hydrological Institute (SMHI) regularly collects data and holds open access databases with physical, chemical and biological (phyto- and zooplankton) data for the Skagerrak and Kattegat area (http://www.smhi.se/k-data/marine_environmental_data.html).

For some fish species (e.g. cod and plaice) North Sea stocks extend into the Skagerrak, which seems to provide important nursery and feeding areas, but where adults migrate back to the North Sea to spawn. For cod and plaice there are local stocks in the Kattegat and local coastal populations in the Skagerrak archipelago. These local stocks do not show the recovery reported for their North Sea counterparts (ICES 2012), and may even have been lost in some coastal areas (Cardinale et al 2009, Bartolino et al 2012).

For the Kattegat, a recent paper (Lindegren et al 2012) suggests that there has been a shift from predominantly pelagic to benthic pathways in the ecosystem. Nutrients and temperature seem to be the main drivers behind the change. The simultaneous decline in zooplankton, pelagic fish, piscivorus fish (cod) and pelagic fishery would not be expected under top–down regulation.

The complicated stock structure of exploited species in the area, the differences in physical properties and ecosystem structure and the initial analyses of ecosystem dynamics and trophic pathways all point to the need for area specific integrated assessments in the Skagerrak and the Kattegat.

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