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

10–14 March 2014

ICES Headquarters, Copenhagen

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International Council for the Exploration of the Sea
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Contents

Executive summary

The Working Group on Integrated Assessments of the North Sea (WGINOSE) met in Copenhagen 10–13 March 2014. The meeting was chaired by Andrew Kenny (UK). There were nine participants representing six nations which were the same as the 2013 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 Scientific Steering Group on Integrated Ecosystem Assessment Programme (SSGIEA). Specifically the group aims to provide:

1) Annual status reporting, through the application of statistical analyses, of the principal activties, pressures and state indicators operating at the subregional level of the ecoregion.
2) Probability based analysis of the inateractions between 'key' components of the greater North Sea subregions using stochastic models, and;
3) an assessment of the possible outcomes of management actions at the ecosystem level through its contribution to the greater North Sea ecosystem overview.

An important output of this meeting was the continued development of a BBN model to explore the relatinships between ecosystem componets of the North Sea and to make predictions of state changes in response to different managfement scenarios. WGINOSE has agreed to prgress the model development intersessionally and a WebEx meeting has been organized for 16 May, 2014.

Working with the ICES data centre four subregionas of the ICES North Sea ecoregiona have been defined and will now be used to aggregate the data accordingly for IEA purposes. These subregions will also be used to define the spatial limits of the BBNs to be developed.

A review of the latest North Sea ecosystem overview was undertaken focusing discussions on the utility of a figure which summarizes the interactions between pressures and state changes.

The second interim meeting of the Working Group on Integrated Assessments of the North Sea (WGINOSE) will take place in Hamburg, Germany from 9–13 March 2015.

WGINOSE will continue to work in partnership with expertise from OSPAR ICG Cumulative Effects to demonstrate the modelling approach being developed to support cumulative effects assessments.

Recommendation	For follow up by:
WGINOSE recommends that the ICES data centre provide IBTS Q1 cpue data for the demersal, benthic and pelagic species already selected by the end of April, or as soon after as possible.	ICES Data Centre

1 Opening of the meeting

This year's meeting of WGINOSE was held at the ICES Headquarters, in Copenhagen from 10–13 March, 2014. Participants of the meeting (Annex 1) were welcomed by Andrew Kenny, Chair of WGINOSE.

2 Adoption of the agenda

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

3 Introduction to meeting

WGINOSE is a working group which develops the links between the science-base of Integrated Ecosystem Assessments (IEA) and ecosystem management advice in the ICES greater North Sea ecoregion. The group works towards this goal in cooperation with similar groups within the ICES SCICOM Scientific Steering Group on Integrated Ecosystem Assessment Programme (SSGIEA). Specifically the group aims to provide:

1) Annual status reporting, through the application of statistical analyses, of the principal activties, pressures and state indicators operating at the subregional level of the ecoregion.
2) Probability based analysis of the inateractions between 'key' components of the greater North Sea subregions using stochastic models, and;
3) an assessment of the possible outcomes of management actions at the ecosystem level through its contribution to the greater North Sea ecosystem overview.

This is the first year of working on a set of multi-annual ToRs (Annex 3) which essentially cover, i. updating the status and trend analysis, ii. reviewing and updating the ecosystem overview report, iii. develop and apply a dynamic BBN model to assess the cumulative effects of multiple human activities, and iv. Reviewing the data needs and gaps for IEA of the ICES greater North Sea Ecoregion.

In addition to reviewing the data needs and gaps for IEA, the group focused its efforts at this meeting on developing the subregional dynamic BBN models for the greater North Sea.

4 Develop and apply dynamic models as tools for integrated and combined effects assessments (ToR c)

4.1 Introduction

A Bayesian Belief Network (BBNs) is being developed by WGINOSE as a tool to assess both the relationships between key variables and the combined effects of their potential changes.

BBNs are multivariate statistical models, acknowledged for their unique probabilistic modelling approach and their high model transparency. BBNs are based on two structural model components: (1) a directed acyclic graph (DAG) that denotes dependencies and independencies between the model's variables or BBN nodes; and (2) conditional probability tables (CPTs) denoting the strengths of the links in the graph (Aguilera *et al.,* 2011) or between variable nodes. The DAG consists of a structured set of variable nodes which represent the modelled system. The statistical dependencies between different nodes are indicated by directed arrows which represent cause effect relations between the system's variables. Each arrow starts in a parent node and ends in a child node. The graph is acyclic and therefore there are no feedback arrows from child nodes to parent nodes. The DAG can be developed by experts based upon system understanding or can be learned by empirical observation. The resulting BBN structure forms the bases for developing an operational BBN (see Landuyt *et al.,* 2013) and references therein).

The potential use of BBNs to integrate various variables and explore combined effects has been described in detail (ICES, 2012). Following on from this conceptual work the group focused this year on the development of a BBN structure (or DAG) for the southern (SNS) and northern North Sea (NNS) based on available datasets (see ToR D). For both cases the rational of the BBN structure was that it should be both meaningful to managers (that is it deals with the ecosystem components of greatest interest or value) whilst at the same time being ecologically 'sensible' and coherent in terms of assessing different management scenarios. Hence the outcome could feed into a risk based management approaches at different management scales (see Cormier *et al.,* 2013). It was therefore not the groups intention to include all components of a subregional foodweb or a multispecies fisheries assessment, rather having access to annual average time-series data from 1983 for a range of components, we selected for the SNS and NNS a set of commercially and functionally important fish species and related to those triggering key variables with respect to physics, nutrients, plankton, landings and fishing effort.

The benefit of having such models is that they potentially provide a means of assessing the effects of cumulative or multiple pressures, as each additional pressure can be jointly assessed alongside other pressure nodes in the model. The effects on the ecosystem (state components on the model) can then be assessed at a scale appropriate to assessment and management needs. For example, the models offer the potential to answer questions like "what are the combined effects of beam trawling and the extraction of marine aggregates on the status of benthic invertebrate fauna in the southern North Sea".

4.2 Southern North Sea Model

As mentioned above we focused on the availability of good quality time-series data (1983–2012) which is also spatially representative of the SNS subregion to specify the

BBN structure (see Figure 4.1). The selected fish species of commercial and management interest were to sprat (*Sprattus sprattus*), sandeel (*Ammodytes spp*.), cod (*Gadus morhua*), turbot (*Scophthalmus maximus*) and plaice (*Pleuronectes platessa*). Other components of the ecosystem were included so as to construct a synthetic ecosystem of the SNS as a network of nodes in a BBN model.

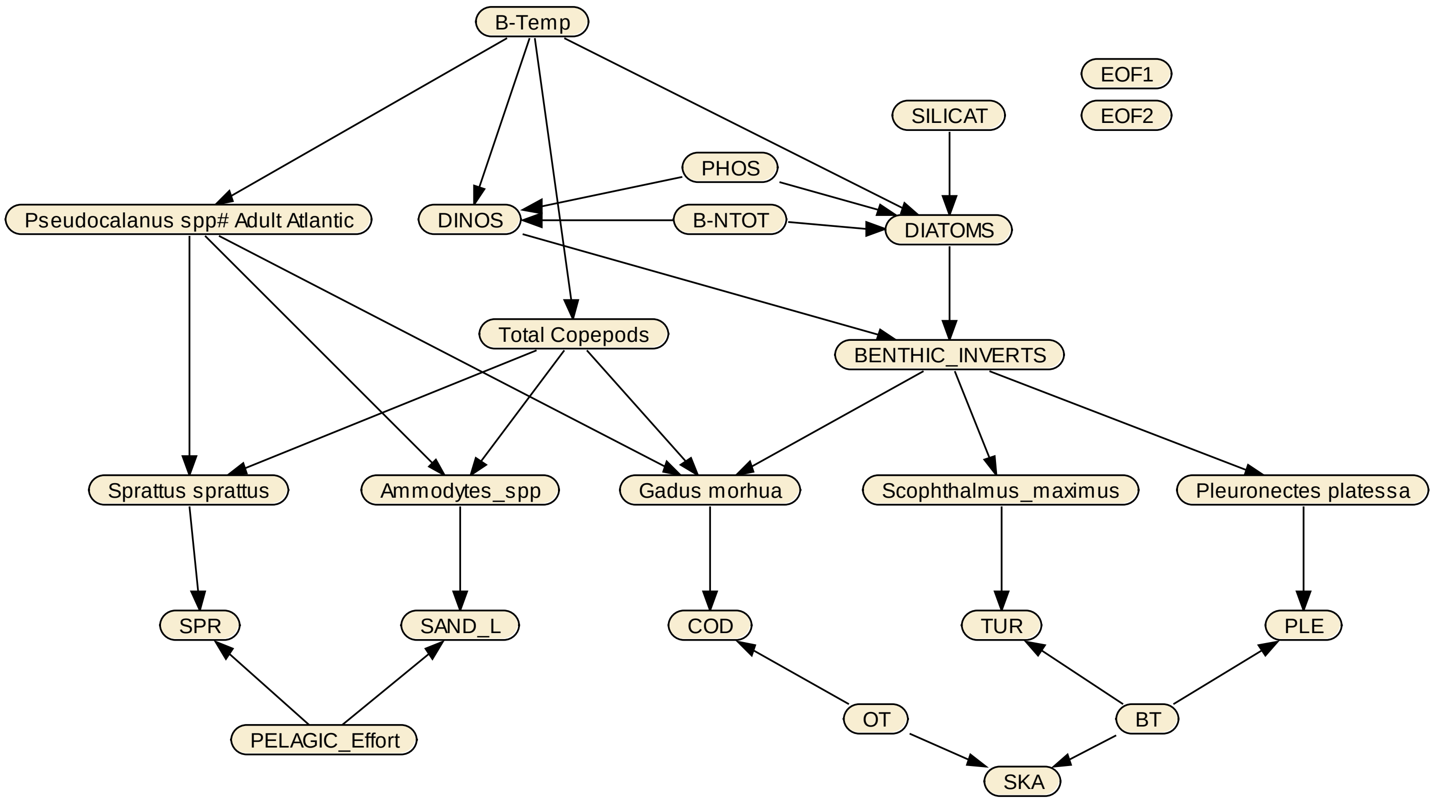

Figure 4.1. Defined SNS acyclic directed graph (BBN structure) describing the relationships between the key fish species (with respect to commercial interest and their functional role) and directly related (causative) biotic and abiotic parameters and pressures related to fishing activities. Note the EOF nodes (PCA's of current fluxes) are not yet linked to any of the model nodes.

4.3 Northern North Sea

For the Northern North Sea (NNS), again we focused on the availability of good quality time-series data (1983–2012) which is spatially representative of each subregion in question. The NNS BBN structure was built around Norway pout (*Trisopterus esmarkii*), herring (*Clupea harrengus*), haddock (*Melanogrammus aeglefinus*), cod, and Pollock (*Pollachius virens*; Figure 4.2). The corresponding BN nodes are described in table X. In contrast, to the SNS model the EOF nodes have been linked to *Calanus helgolandicus*. Note that we linked cpue of herring to cod to reflect the predation pressure that adult herring have on cod larvae (van Denderen and van Kooten, 2013)

4.4 Operationalizing the directed acyclic graph

After having defined the BBN structures for the SNS and NNS the next step is to define the conditional probabilities based on the available time series. This requires a sound explorative analysis of the correlation matrix of the respective sets of variables. It is anticipated to generate the required time-series data for both subregional models by the end of May 2014. The approach taken will as described previously by WGINOSE, that is to use Principal Component Analysis (PCA) to explore the covariance between variables (ICES, 2012).

The general idea of PCA is to identify modes of significant covariation between different variables. PCs will be used to represent the essential behavior (reaction) of groups of species, for instance, leaving out details considered irrelevant for the whole system or having no clear interrelationship with the forcing parameters represented in the BN. The use of PCs does not preclude the representation of individual species in the BN. But PCs may act as parent nodes and interactions of individual species with (e.g. abiotic) forcing variables may all be channeled through these PCs. Further PCs will be employed to aggregate detailed numerical simulations of water transports in the region of interest. Corresponding loadings are represented as vector fields of residual currents. These vector fields (technically: Empirical Orthogonal Functions (EOFs)) are readily interpretable in terms of hydrodynamic advection including the Atlantic inflow into the North Sea. Time-series of PCs analyzed from model-based multidecadal reconstructions of hydrodynamic conditions are representative for the variable abiotic environment driven by changing atmospheric conditions. Therefore, in the group the inclusion of the North Atlantic Oscillation (NAO) index as another proxy for large-scale atmospheric conditions was not considered necessary. Thus if exploratory PCA applied to a dataset including both (anticipated) predictors and response variables should reveal a leading mode that is well separated (in terms of explained variance) from all other PCs, this mode will provide a good indicator for the design of a corresponding module of the BN. Transformation of the probabilistic description of multivariate data into a causal scheme, however, still needs the additional use of external knowledge.

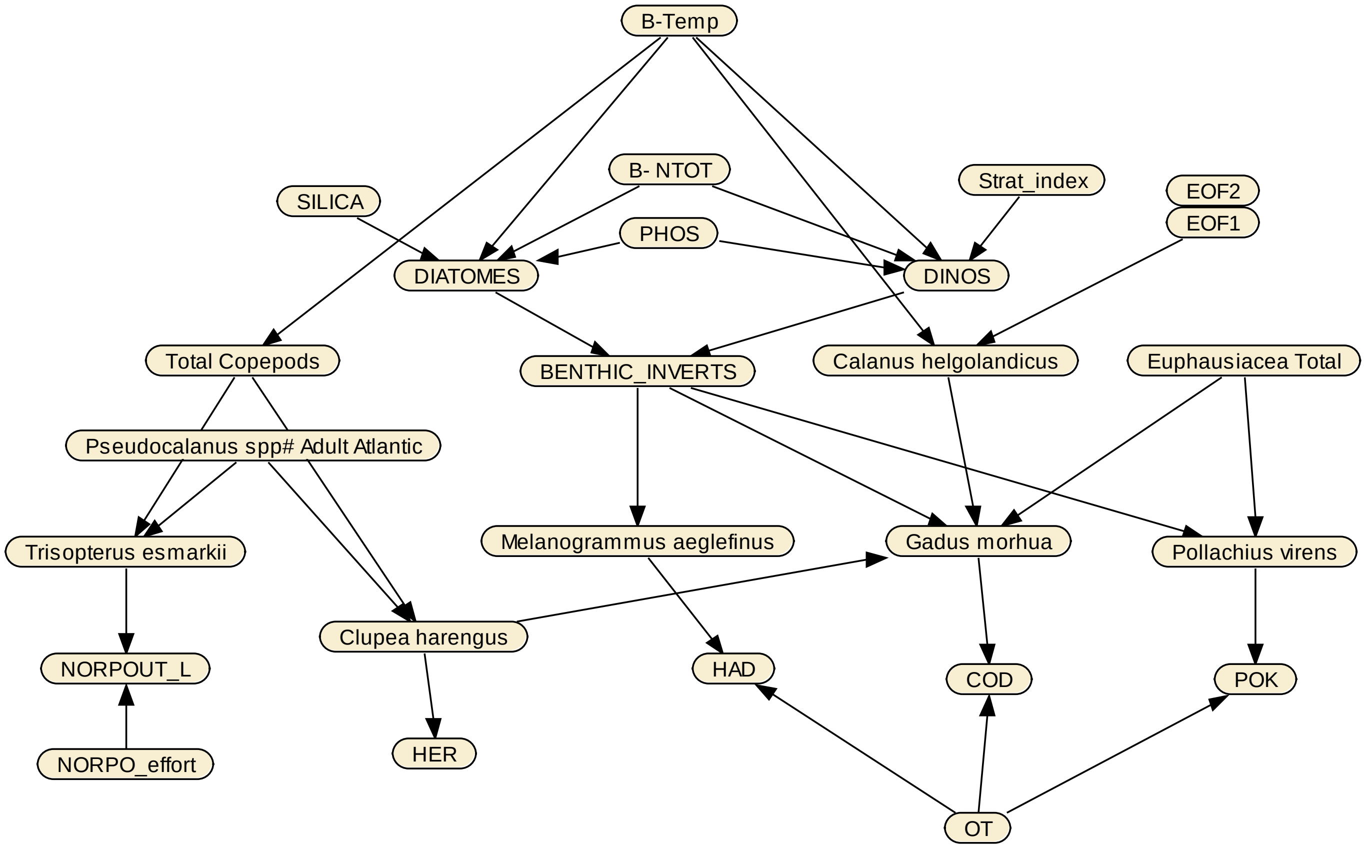

Figure 4.2. Defined NNS acyclic directed graph (BBN structure) describing the relationships between key fish species (with respect to commercial interest and their functional role) and directly related (causative) biotic and abiotic parameters and pressures related to fishing activities.

The problem of combining data-driven exploratory modelling with causal concepts was addressed in a presentation by Ulrich Callies, referring to the example of inter-annual variability of mean spring conditions at station Helgoland Roads. It was shown how interactions (also indicated by relevant principal components) can be described in terms of an undirected graph that represents a set of conditional independence constraints. The inclusion of directionality in this graph to reflect causality was discussed as a subsequent independent step based on external knowledge.

Conditional independence modelling (also called covariance selection modelling) is anticipated to provide useful information in two respects:

a) The structures of undirected graphs are brought about by underlying causal processes. Although the graphs are insufficient for a direct and unique identification of these processes, conditional independence graphs can nevertheless be regarded as important intermediate steps on the way towards the construction of a BN.

b) Imposing conditional independence constraints may stabilize multivariate regression schemes even when some of the variables that occur in the graphical model are neither explanatory nor response variables in the regression scheme of interest. The mechanism demonstrated by Ulrich Callies might be understood as being based on the identification of noise in individual time-series depending on whether or not observed changes in the time-series of interest are accompanied by consistent changes in other time-series linked to it.

4.5 Future work

WGINOSE agreed that during 2014/15 source datasets for each of the NNS and SNS nodes would be progressed so that the BBN models could be set up and provisionally evaluated in terms of their performance. A WebEx meeting was agreed to be convened, hosted by Cefas, for the 16 May 2014.

WGINOSE agreed that priority should be given to developing accurate pressure maps for the principal activities assessed to be significant pressures in the North Sea ecosystem. This should be done in collaboration with OSPAR EIHA as part of its work programme for 2014/15. This could include e.g:

1) Preparation of Northeast Atlantic activity maps for offshore renewable energy; oil and gas infrastructure and aggregate extraction. These should be relatively fine scale to show turbine locations, well heads, pipelines, cables (rather than licensed blocks).

2) Depending on the outcome of the provisional BBN being developed by WGINOSE it may be advantageous for ICES (via WGINOSE) and OSPAR to collaborate on a case study to test the cumulative effects modelling approach for potential inclusion in a future QSR.

4.6 References

Aguilera, P. A., Fernández, A., Fernández, R., Rumí, R., and Salmerón, A. 2011. Bayesian networks in environmental modelling. Environmental Modelling and Software, 26: 1376–1388.

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Landuyt, D., Broekx, S., D'Hondt, R., Engelen, G., Aertsens, J., Goethals, P. L. M. 2013. A review of Bayesian belief networks in ecosystem service modelling. Environmental Modelling and Software, 46:1–11.

van Denderen, P. D., and T. van Kooten, 2013. Size-based species interactions shape herring and cod population dynamics in the face of exploitation. Ecosphere, 4(10):130. http://dx.doi.org/10.1890/ES13-00164.1

5 Review of the data needs and approaches to support the operational implementation of IEAs (ToR d)

5.1 Definition of ICES greater North Sea ecoregion subregional areas

An important task undertaken this year was to define subregional areas of the ICES greater North Sea ecoregion. The subregional areas correspond to meaningful ecological units whose boundaries are defined by strong gradients in their physical oceanography, such as changes in depth, sediment transport, salinity, oxygen and currents. The four subregions of the ICES greater North Sea ecoregion are; i. Northern North Sea, ii. Southern North Sea, iii. Skagerrak and Kattegat, and iv. English Channel (Figures 5.1 and 5.2).

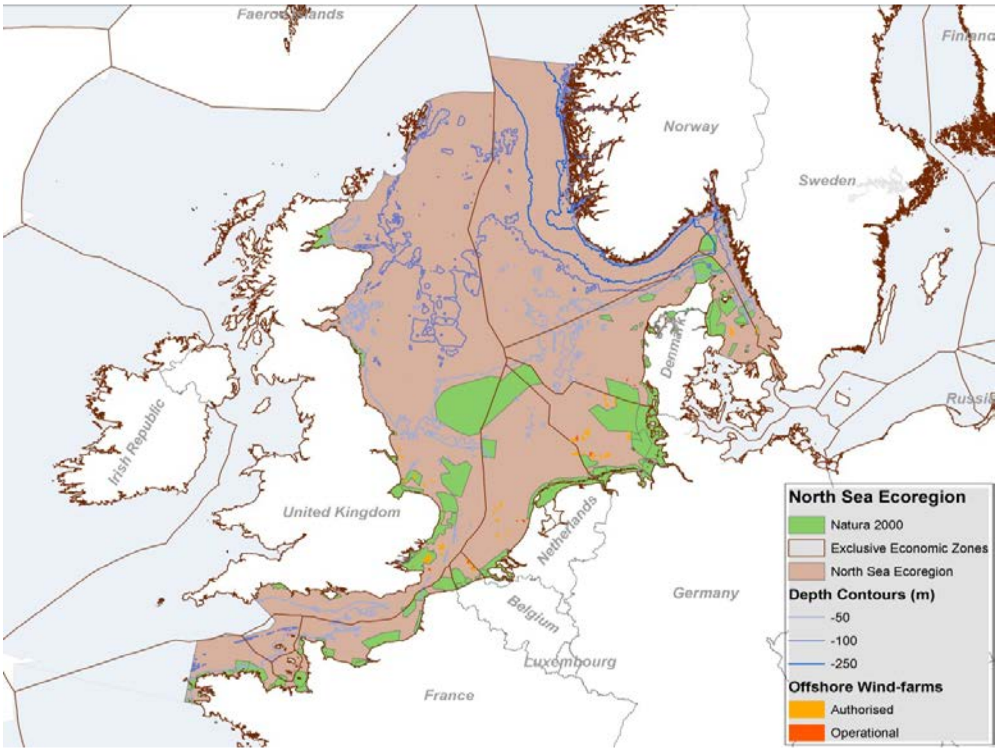


Figure 5.1. The spatial extent of the ICES greater North Sea ecoregion with selected features of interest.

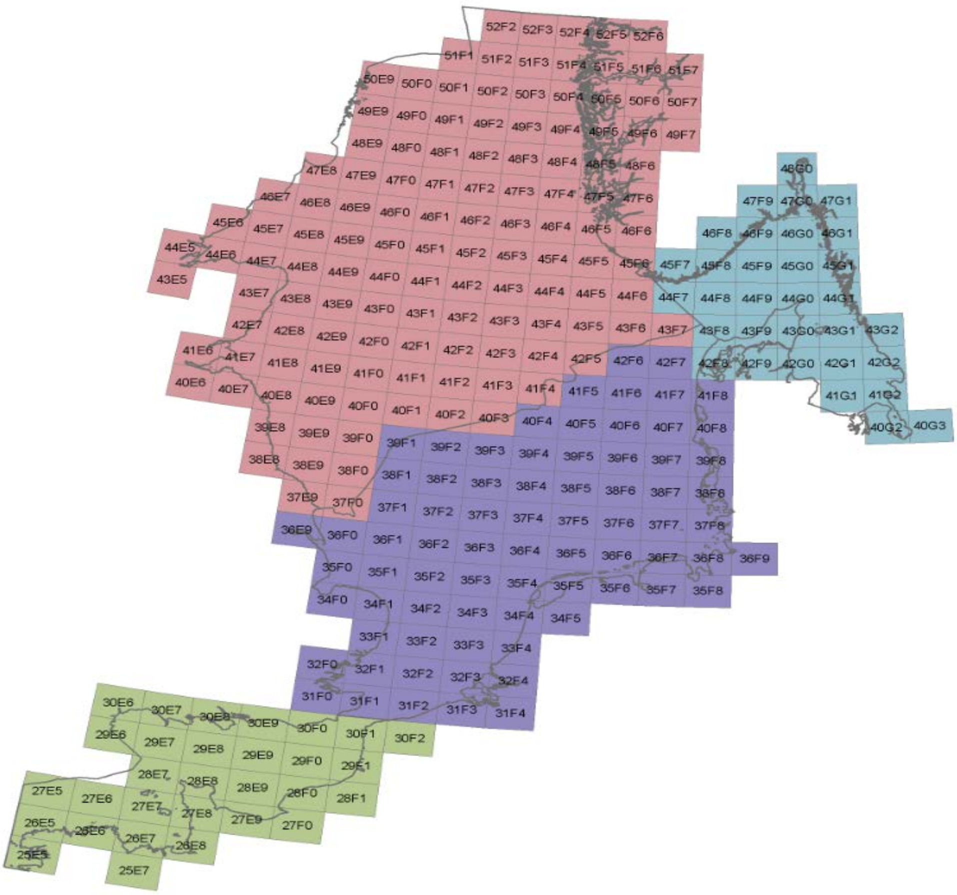


Figure 5.2. The spatial extent of the four subregional areas of the ICES greater North Sea ecoregion. These subregions are now being used to organize and collate the data needed for IEAs at the spatial scale of ICES rectangle for the period 1983 – onwards.

5.2 Evaluation of 'core' variable availability in relation to the new subregional areas

The table of 'core' variables produced at last year's meeting was updated to include variables relevant to each of the other subregions, notably; Skagerrak and Kattegat, and the English Channel (Table 5.2)

In all cases, it is noteworthy that of the 10 principal trophic levels (or ecosystem components) judged to be dominating the North Sea ecosystem only 4 are routinely assessed and included in the North Sea IEA, namely; component i. abiotic climate variables, component ii. plankton variables, component iii. fish stock variables, and component iv. fishing pressure variables (Table 5.1).

Table 5.1. The number of variables representing each of the 10 trophic components assessed to be important in the function of the North Sea ecosystem. The list of 'core variables' from WGINOSE report in 2013 compared to the number of variables collated and assessed in the present study for the Northern North Sea (NNS) and Southern North Sea (SNS) respectively. Numbers in parentheses correspond to SNS only.

	Abiotic Climate	Plankton	Benthic Inverts	Fish (CPUE)	Seabirds	Mammals	Fishing	Renew-ables	Minerals	Oil & Gas
Identified as 'core' from WGINOSE 2013 report	18	17	?	25	?	?	5	?	?	?
Collated and assessed in present report	11	45	-	19 (14)	-	-	5(15)	-	-	-

It was noted that benthic invertebrates, seabirds and to some extent marine mammal and mineral extraction data are potentially readily available from relevant ICES expert groups for the North Sea as spatially resolved time-series. It was therefore decided to focus on sourcing data for each of these additional components. However, time prevented this task being completed equally for each component and therefore a decision was taken to concentrate on the benthic invertebrates' component as this is also an important node within the proposed development of both the NNS and SNS BBN models.

5.3 Benthic invertebrate 'source' data

The essential requirement for benthic invertebrate data are a dataset which has is both a long time-series and is spatially representative of the subregional ecosystems in question. This is a demanding requirement typical of 'data hungry' stochastic modelling techniques, but such a dataset does exist for the NNS and SNS subregions as a result of the Dutch beam trawl survey.

5.3.1 Survey history

The Dutch beam trawl survey (BTS) was originally set up to create a fishery-independent time-series of plaice and sole. The survey information is used in the ICES North Sea Demersal Fish Assessment Group (WGNSSK). The Dutch BTS is funded under the data collection framework (DCF) of the EU and internationally coordinated by the ICES Working Group on Beam Trawl surveys (WGBEAM).

5.3.2 Time-series

From 1985 onwards, data on fish and macro-zoobenthos have been collected in the southeastern North Sea by RV Isis. From 1998 onwards RV Tridens II has conducted a beam trawl survey in the western and central North Sea. The spatial coverage of the survey including the frequency of sampling between 1985–2012 and 1999–2012 for the RV Isis and RV Tridens areas respectively are shown in Figure 5.3 and Figure 5.4

Table 5.2. List of variables and components routinely included in North Sea IEAs by WGINOSE highlighted in green. The table also highlights (in orange) important component variables which are known to be operationally collected but are not routinely included in the assessments by WGINOSE, but should be. Only one component/variable identified as important but not operationally collected which was *benthic mieofauna*.

Components/ variables	NNS	SNS	SK	EC		Source/ 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 Y	x	X		1st Q	Model	IBTS/CTD	Yes	Yes	
Surface Salinity	X	x	X		1st Q	Model	IBTS/CTD	Yes	Yes	
Bottom Salinity	X Y	x	X		1st Q	Model	IBTS/CTD	Yes	Yes	
Temperature Index of Stratification	X Y	x			2nd Q	Model	IBTS/CTD	Yes	Yes	
Nutrient Concentrations (NO3, PO4, Si; empirical/model)	BN-Tot, BP-Tot BS-Tot	BN-Tot, BP-Tot BS-Tot	SN-Tot, SP-Tot SS-Tot			Model/EMECO		No yet	No	Gaps in nutrients data and associated monitoring programmes at the scale of the NS.
Current fluxes (PCA loadings – EOF)	Y		X?							
Water transport on fixed sections (NOOS)	X	x			Monthly	NORWECOM		Not yet	yes	
Oxygen Concentration	X	X	X			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 Y	X	x		Monthly	Satellite/MUMM		Not yet	Yes	

Components/ variables	NNS	SNS	SK	EC		Source/ Group	Other Sources	Routinely Included	Repre-sentative	Notes
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			Monthly	GETM/Model		Not yet	Yes	
Wave Generated Bottom Stress	X	x			Monthly	WaveNet (UK)		Not yet	Yes	
Freshwater Flows (river run-off, Scottish Coastal Current etc)	X	x	Y		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			2nd Q	SAHFOS/CPR		Yes	Yes	
Temora longicornis	X	x			2nd Q	SAHFOS		Yes	Yes	
Oithonia spp.	X	x			2nd Q	SAHFOS		Yes	Yes	
Arcatia spp.	X	x			2nd Q	SAHFOS		Yes	Yes	
Cladocera	X	x			2nd Q	SAHFOS		Yes	Yes	
Limacina spp.	X	x			2nd Q	SAHFOS		Yes	Yes	
Echinodermata larvae	X	x			2nd Q	SAHFOS		Yes	Yes	
Calanus helgolandicus	X Y	x			2nd Q	SAHFOS		Yes	Yes	
Calanus finmarchicus	X	x			2nd Q	SAHFOS		Yes	Yes	
Metridia lucens	X				2nd Q	SAHFOS		Yes	Yes	
Decapoda larvae	X	x			2nd Q	SAHFOS		Yes	Yes	
Euphausiaceae	X Y				2nd Q	SAHFOS		Yes	Yes	
Tot Copepods	Y	Y								
Psuedo-calanus adult	Y	Y								

Components/ variables	NNS	SNS	SK	EC		Source/ Group	Other Sources	Routinely Included	Repre-sentative	Notes
Ichthyoplankton (mackerel, eel, plaice etc)	X	x			Variable	SGSIPS/ICES Data Centre		Not yet	Yes	(Herring, cod, mackerel, eel, plaice)
Zooplankton surveys			X			SMHI – SHARK				
Phytoplankton										
Dinoflagellata	X Y	X Y			2nd Q	SAHFOS		Yes	Yes	
Diatomeae	X Y	X Y			2nd Q	SAHFOS		Yes	Yes	
Phytoplankton Colour Index	x	X			2nd Q	SAHFOS		Yes	Yes	
HAB	x	x				PML/EA/Met. Office (AlgaRisk)		Not yet	Yes	To check if this is an operational product/programme
Phytoplankton surveys			X							
Benthic Invertebrates										
Benthic Macrofauna	Y	Y	?			Netherlands BTS data		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)										
Ammodytes sp.		Y								
Clupea harengus	X Y	X	X		1st Q	IBTS/WGIPS		Yes	Yes	
Dicentrarchys labrax		X	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 Y	X Y	X		1st Q	IBTS		Yes	Yes	

Components/ variables	NNS	SNS	SK	EC		Source/ Group	Other Sources	Routinely Included	Repre-sentative	Notes
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 Y	X	X		1st Q	IBTS		Yes	Yes	
Merlangius merlangus	X	X	X		1st Q	IBTS		Yes	Yes	
Platichtyes flesus		X	X		1st Q	IBTS		Yes	Yes	
Pleuronectes platessa	X	X Y	X		1st Q	IBTS		Yes	Yes	
Pollachius virens	X Y		X		1st Q	IBTS		Yes	Yes	
Solea vulgaris		X	X		1st Q	IBTS		Yes	Yes	
Sprattus sprattus	X	X Y	X		1st Q	IBTS/WGIPS		Yes	Yes	
Trisopterus esmarkii	X Y	x	X		1st Q	IBTS		Yes	Yes	
Trigla lucerna	x	x	X		1st Q	IBTS		Yes	Yes	
Scophthalmus maximus	x	X Y	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					Annual every 3 years	WGSAM		Not yet		12 species of fish and top-predators (from 1970, F, R, SSB, T B)
Top predators										

Components/ variables	NNS	SNS	SK	EC		Source/ Group	Other Sources	Routinely Included	Repre-sentative	Notes
Breeding seabird populations					Annual	WGSE/ESAS		Not yet	Yes	Single Index - 7 gulls, 4 terns, 2 cormorant, etc.
Grey Seals Pup Prediction NS UK colonies					Annual	WGMME		Not yet	yes	
Harbour porpoise					Annual	WGMME/SCANS		Not yet	yes	
Sectors/Activities/Pressures										
ICES Fish Landings (Iva,b,c)	X	x			Annual	ICES data centre also RDCs	Other MS	Yes	Yes	
HER	Y									
HAD	Y									
NOP	Y									
POK	Y									
SPR		Y								
Sand-L		Y								
COD	Y	Y								
TUR		Y								
PLE		Y								
SKA		Y								
Pelagic Effort		Y								
OT – combined	Y	Y								
BT		Y								
NOP-Effort	Y									
VMS	x	x			Annual	National datasets, future ICES?	MS, data centres	Not yet	Yes	
Fishing Mortality					Annual	ACOM		Not yet	Yes	

Components/ variables	NNS	SNS	SK	EC		Source/ Group	Other Sources	Routinely Included	Repre-sentative	Notes
Catch	x	x			Annual	ACOM		Not yet	for some spp, but not all, likely to change because of discard ban	
Discards	x	x			Annual	ACOM		Not yet		for some spp, but not all, likely to change because of discard ban
Sea Mammal and Reptile Bycatch					Annual	WGBYC		Not yet		No database as yet
Tourism/Recreational Pressures	?	?			Annual	WGRFS		Not yet		recreational fisheries group in ICES
Aggregate Pressures	x	x			Annual	WGEXT		Not yet	No database as yet	
Oil/Gas Pressures	x	x			Annual	OIC (OSPAR)		Not yet	Yes	OSPAR Offshore Industries Committee. Production by country
Renewable Energy Pressures	x	x			Annual	EIHA (OSPAR)		Not yet	Yes	OSPAR Environmental Impacts of Human Activities Committee. Annual database of windfarm areas

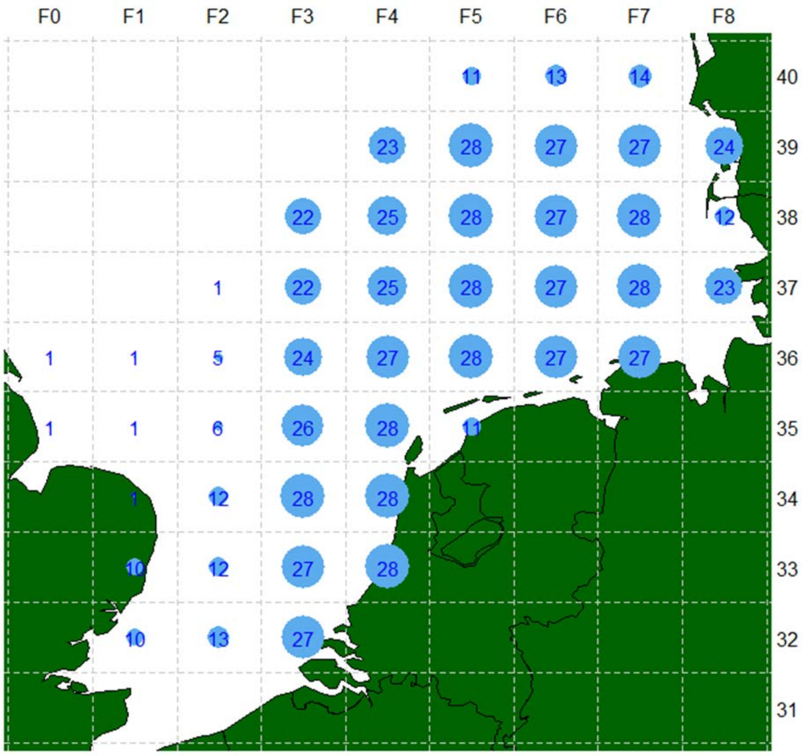


Figure 5.3. Sampling frequency of the Isis area from 1985–2012.

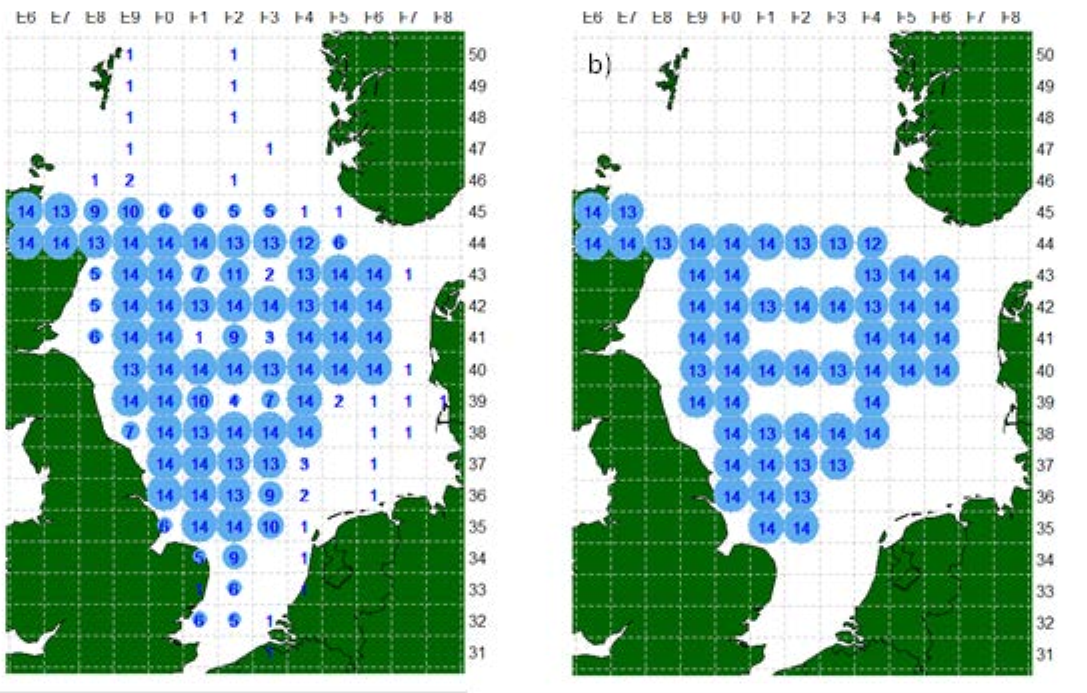


Figure 5.4. a) Sampling frequency of the Tridens area from 1999-2012, and b) the 54 sampling areas with a sampling frequency ≥12 years.

5.3.3 Gear

The BTS is carried out with two eight meter beam trawls, one on each side of the vessel. The beam trawls are rigged with 4 tickler chains attached to the beam and 4 tickler chains attached to the net. The difference in rigging between the gear used by RV Isis and RV Tridens II is the flip-up rope, which is used in the western and central North Sea to prevent net damage by boulders. The flip-up rope affects the catchability of at least some flatfish species (Groeneveld and Rijnsdorp, 1990). Mesh-size of the codend is 40 mm.

5.3.4 Sampling method

The sampling is semi-random; the statistical rectangles to sample are defined before the survey, as is the number of hauls in a statistical rectangle. Within the rectangle, positions might vary yearly, although it is recommended to fish more or less in the centre of the rectangle when conducting one haul, and in case of more hauls in a rectangle, it is recommended to keep a distance of about 10 nautical miles between the hauls. Standard haul duration is 30 minutes, considered as the time between fully lowering the gear and starting to bring it up again.

5.3.5 Catch handling

The catch of the starboard net is sorted completely. For finfish at least 50 specimens per species are measured to the centimetre below (10.9 cm=10). Elasmobranchs are measured by sex to the centimetre below. The shellfish *Cancer pagurus* and *Nephrops norvegicus* are measured by sex to the millimetre below. Freeliving macro-zoobenthos is also identified to species level and counted. For attached species only presence is recorded. Of the free-living macro-zoobenthos, the minimum and maximum lengths are recorded as well as the total weight from the sample.

5.3.6 Data storage/accessibility

Data are imported into the IMARES database. From there, an extraction of the trawl information, the length and age information of fish species and the WGBEAM defined macro-zoobenthos species is made for the ICES database DATRAS. All other macro-zoobenthos data are available via IMARES on request.

5.3.7 Species sampled

The top-22 of species sampled with the Isis over the time period from 1999-2012 and their average density in number per hectare (nha) per year are given in Table 5.2. Over this time period 86 species are found in the Isis dataset.

Based on the selection of stations shown in Figure 5.4b, a total of 190 species (categorized by genus-level) were sampled with the Tridens surveys from 1999 to 2012. The top-23 of these species and their average density in number per hectare (nha) per year are given in Table 5.3.

Table 5.2. ISIS: The average density in number per hectare (nha) per species (top 22) per year. Species are listed in decreasing order of the summation (total_nha) over the years.

species		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	total_nha
Liocarcinus	Crustacea	672.8	313.1	5.5	285.9	1232.6	1457.9	2495.6	555.7	871.8	652.4	677.5	3368.1	499.6	295.7	13384.1
Asterias	Echinodermata	1845	793.3	1071.6	777.4	610.3	783.2	464.7	377.8	545.7	725.8	547.8	1020	1311.5	456.5	11330.5
Astropecten	Echinodermata	365.4	269	702.3	860.7	895.8	786.4	791.9	589.1	616.8	778.5	932.5	752.1	783.6	782.3	9906.2
Ophiura	Echinodermata	750.2	406.3	499.2	676.9	74.2	91	68.6	86.3	161.3	310.8	215.4	414.1	421.6	192	4367.8
Macropipus	Crustacea	0	0	3455.1	472.8	0	0	0	0	0	0	0	0	0	0	3927.9
Crangon	Crustacea	4.3	0	169	422.3	219.6	358.6	173.9	89.1	82.8	268.4	161.9	999.7	130.7	115.3	3195.7
Echinocardium	Echinodermata	816.1	27.3	248.8	61.3	170.1	143.4	37.6	44.8	34.6	18.1	170.6	74.4	32.5	400.1	2279.6
Bivalvia	Mollusca	0	0	636.8	0	0	0	0	0	0	0	0	0	0	0	636.8
Corystes	Crustacea	16.9	12.3	33	13.4	37	41.6	34.7	31	12.5	24.9	23.1	259.8	20.5	13.6	574.4
Pagurus	Crustacea	40.5	38.2	28.6	23.1	30.8	16.9	11.8	13	32.9	42.2	37.5	38.3	41.9	41.7	437.4
Aphrodita	Annelida	13.1	16.8	23.2	18.5	19.6	19.2	17.5	26.1	2.6	5.5	13	5.2	4.4	6.7	191.6
Buccinum	Mollusca	8.5	10.9	2.7	2.9	3.8	3	1	1.6	2.4	17.1	13.2	2.1	32	12.6	113.9
Echinidae	Echinodermata	2.5	57.8	2.1	16.4	1	0	0	0	0	0	0	0	0	0	79.7
Psammechinus	Echinodermata	13	0	4.7	11.7	1.9	1.7	2.4	0.7	22.4	1.5	0.9	0.5	0.6	7	69
Fabulina	Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	64.7	64.7
Carcinus	Crustacea	3	4.1	8.9	5.4	3.2	5.6	5.4	4.4	3.6	3.7	0.5	4.2	2.6	7.9	62.4
Luidia	Echinodermata	0	0	0.8	0	0.4	3.3	11.3	8.6	4.6	6.7	15.2	3.8	2.4	2.4	59.6
Anthozoa	Cnidaria	0.1	3	33.4	1	7.3	2.2	0.4	0	0	0	0.4	3.6	1.1	0.9	53.4
Ascidiacea	Chordata	0	0	4.2	0.5	3	1.3	16.1	5.5	0.1	0	0.3	0	0	12	43
Nephrops	Crustacea	0.5	7.4	0.1	4	1.4	3.3	2.1	10.9	6.1	0.8	2.8	0.1	0.5	1.6	41.7
Halichondria	Porifera	0	0	0	0	0	2.1	1.3	1.7	0.6	0.3	2.6	0.2	12.3	19.4	40.5
Ophiothrix	Echinodermata	2.9	0.9	1.8	1.9	0.1	2.1	1.4	2.3	0.4	0.2	2.8	0	7.8	8.1	32.7

Table 5.3. TRIDENS: The average density in number per hectare (nha) per species (top 23) per year. Species are listed in decreasing order of the summation (total_nha) over the years.

species		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	total_nha
Astropecten	Echinodermata	111.8	132.3	120.1	142.7	184.1	198.2	235	317.2	466.1	768.4	703.4	473.4	480.7	379.4	4712.9
Ophiothrix	Echinodermata	16.4	73.3	1.3	19.8	2079.8	0.8	2.5	2.1	1.6	3.3	0.5	0.6	2.3	1	2205.2
Liocarcinus	Crustacea	41.3	26.3	40.7	38	56.5	85	371.6	112.5	96.1	55.5	94.1	453.9	63.4	140.5	1675.5
Gracilechinus	Echinodermata	0.5	0.8	25.7	710.3	573.2	0	0	0.1	64.8	0	0	0	0	0	1375.4
Hyalinoecia	Annelida	41.3	312.7	29.6	65.6	229.8	23	24.3	30	59.7	88.6	89.5	99.1	121.5	53.3	1267.9
Asterias	Echinodermata	53.3	52	53	85.6	83.9	55.5	82.1	46.6	81.9	79.5	102.1	187.9	96.2	161.9	1221.4
Pandalus	Crustacea	100.8	754.4	2.9	45	68.1	79.3	0.9	1.3	0.5	0	0	0.2	0.1	0.2	1053.8
Mytilus	Mollusca	973.6	0	0	0.1	0	0.3	0	0	0	0	0	0	0	0.1	974.2
Pagurus	Crustacea	25	7.2	7.9	38.3	42.9	29.1	44.9	38.5	79	84.6	65.9	65.1	79.2	68.5	676.2
Ophiura	Echinodermata	18.5	9.1	6.8	22.9	4	7.5	14.7	309.3	12.4	11.2	19.2	84.8	21.2	75.4	616.8
Luidia	Echinodermata	19.8	21.1	7.5	20.9	59.1	69.9	84.9	38.1	35.4	36	38.2	10.1	15.7	21.1	477.7
Psammechinus	Echinodermata	13.9	23	2.5	6.5	23.7	51.9	76.1	26.2	96.7	14	7	55.2	2.3	71.8	470.8
Echinus	Echinodermata	37.6	62.2	14.5	1	19.9	39.9	57.2	7.4	9.5	16.7	8.2	67.8	9.7	11.6	363.3
Bolocera	Cnidaria	0	15.3	14.2	28.5	30.2	23.1	52.7	21.8	28.6	51	19.3	9.6	7.9	1.6	303.9
Adamsia	Cnidaria	7.2	2.9	4.5	20.7	20	5	11.7	8.1	31.4	31.8	19.4	21	15	18.4	217.2
Buccinum	Mollusca	5.6	6.7	6.2	10.1	9.3	12.5	22	13.9	18.7	15.7	20.7	25.6	15.4	18.7	201.1
Ascidiella	Tunicata	20.7	8.5	3.2	14.8	28.4	11.6	3.4	1.6	0.6	35.2	1.4	5.1	16.9	6	157.3
Aphrodita	Annelida	6	6.5	13.7	15.1	10.5	15.5	20	11.5	8.5	7.7	5.2	9.2	12.5	8.8	150.7
Pennatula	Cnidaria	2.2	2.8	5.1	9.4	42.2	9.1	20.1	6.4	9	9	3.5	6.1	5.5	19.2	149.7
Echinocardium	Echinodermata	10.2	3.6	7.8	7.2	7.9	37.7	20.9	10.3	3.1	3.4	19.8	9.3	1.2	1.7	144.2
Euspira	Mollusca	0	0	0	0	0	0	0	131.2	0	0	0	0	0	0	131.2
Spatangus	Echinodermata	12.2	6.2	5.8	8.8	1.5	3.6	8.9	9.6	24.7	6.1	11.8	8.4	4.4	16.7	128.7
Neptunea	Mollusca	2.4	3.4	3.2	7.2	8.1	7.7	9.6	6.4	12.7	10.5	10.8	6.4	11.4	9.6	109.5

6 Update the integrated ecosystem trend analysis for the North Sea (ToR a)

6.1 North Sea IEA trend analysis

Datasets for the available core variables (see table 5.1) were collated, formatted and transformed according to methods previously described by WGINOSE and its predecessor groups (see Kenny *et al.*, 2009). The analysis was conducted on each component separately, in addition to integrating all the data into a single analysis. To facilitate an operational and standardized analysis of data an R script was developed to generate the required IEA outputs for this section (see Annex 4).

6.1.1 North Sea

The integration of all data consisting of over 100 state/pressure variables describing the North Sea ecosystem between 1983 and 201 was undertaken. The data were subjected to an analysis performed by an R script (Annex 4) to generate the results shown in Figure 6.1. These results are consistent with known trends in significant ecosystem components of the North Sea during this period, namely: PC1 accounts for 38% of the variability and is characterized by a continuous decreasing trend in cod landings and heavy Otter trawl fishing effort, whereas *Calanus helgolandicus* and the haddock cpue are increasing. By contrast PC2 is characterized by an initial increasing trend in beam trawling effort and landings of turbot between 1983 and 1995, but then these show a decreasing trend from 1995 onwards, whilst the SSB of haddock and plaice increase from 1995 onwards. What is apparent is that since 1995 there has been a shift back towards the 1983 state along PC2 and the increasing trend associated with PC2 started to reverse from about 2008.

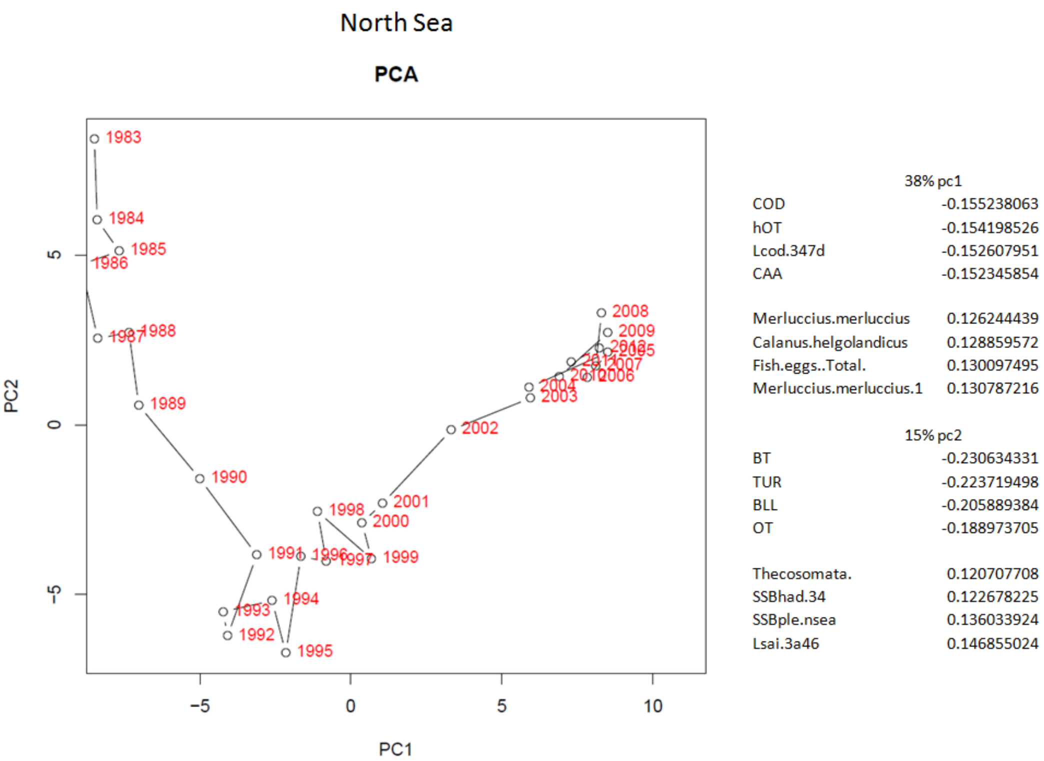


Figure 6.1. PCA of all state/pressure variables for the North Sea (NNS and SNS).

A representation of all variable anomalies described by Figure 6.1 is shown in Figure 6.2. This reveals that an apparent step change in state which occurred around 1989/90, but this result is influenced by a bias in the IBTS data used in this analysis which included all 4 quarters pre-1990 whereas it should only have included Q1 data.

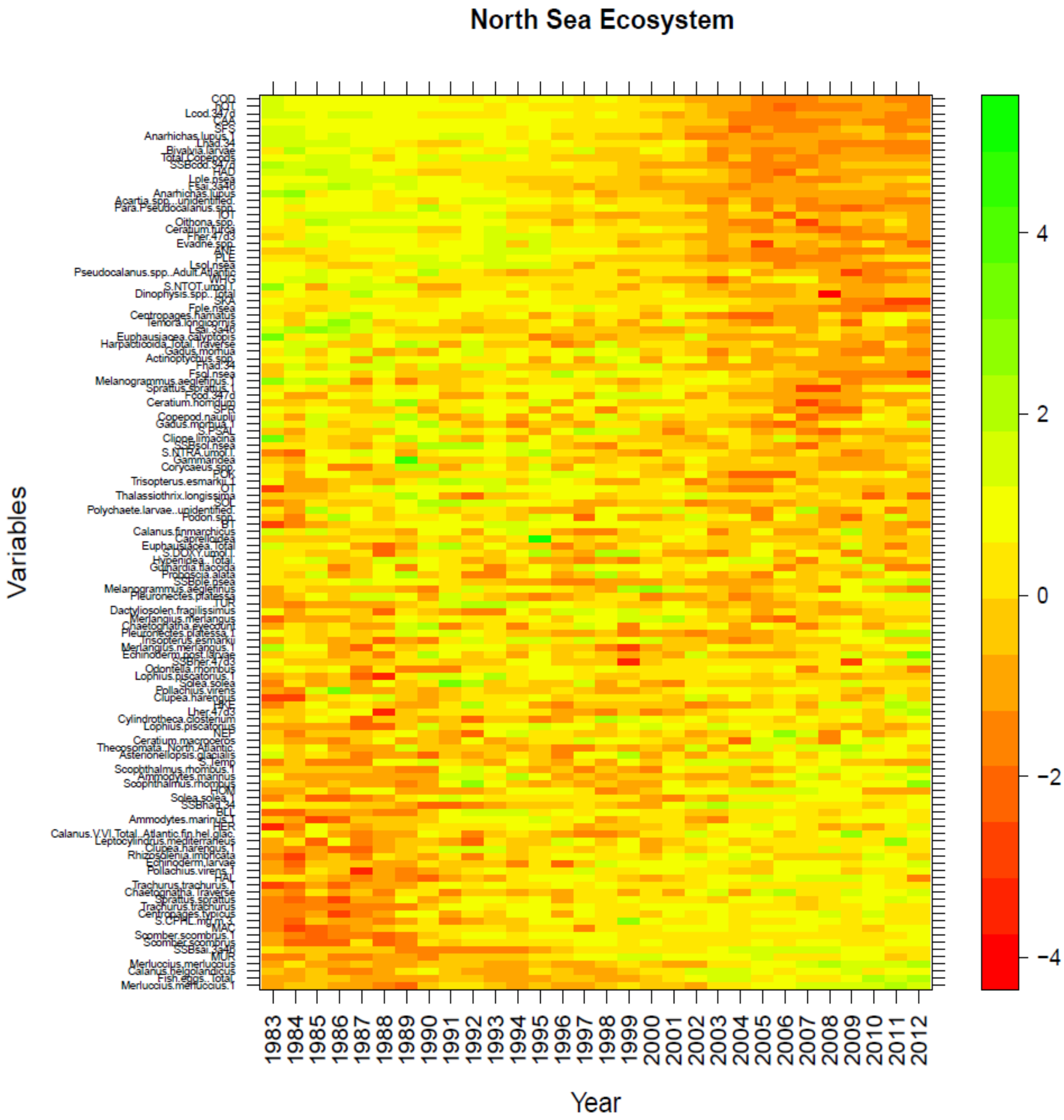


Figure 6.2. 'Shade' plot of North Sea variable anomalies.

6.2 Northern North Sea

A principal component analysis was performed on data specifically related to the Northern North Sea subregion. The analysis included data between 1983 and 2012 and used the same analytical approach as applied to the North Sea as a whole. The results of the PCA are shown in Figure 6.3. PC1 accounts for 29% of the variation over this period and is dominated by the same trends in similar variables as the North Sea, with the exception of herring which is identified as a characteristic variable with an increasing trend over the same period.

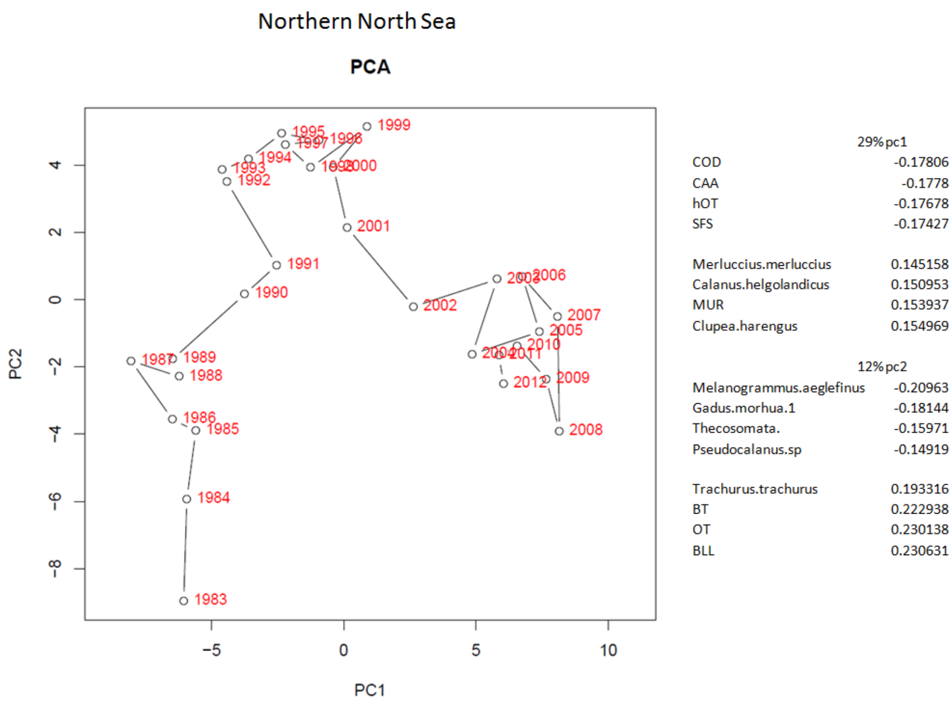
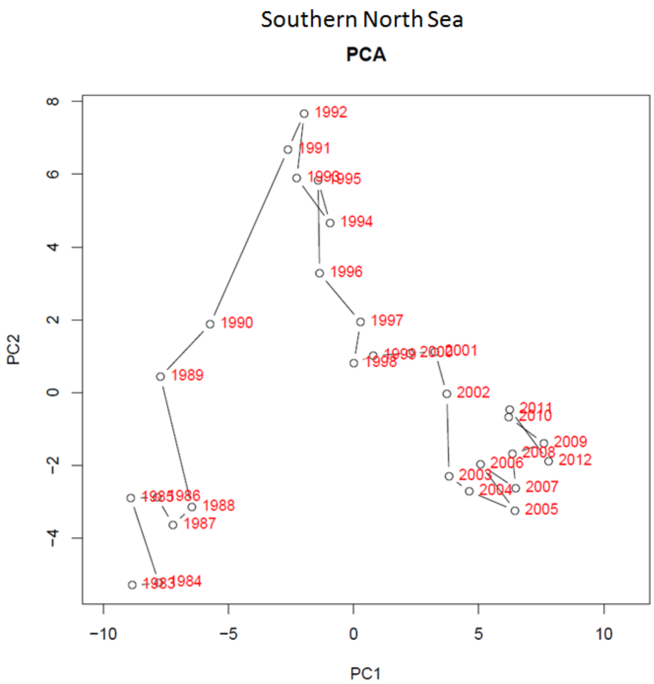


Figure 6.3. PCA of state/pressure variables specifically located in the Northern North Sea – the pattern of variation is very similar to that shown by the North Sea as a whole.

A shade plot showing all northern North Sea variable anomalies sorted by PC1 eigenvalues is shown in Figure 6.5.

6.3 Southern North Sea

A principal component analysis was performed on data specifically related to the Southern North Sea subregion. The analysis included data between 1983 and 2012 and used the same analytical approach as applied to the North Sea as a whole. The results of the PCA are shown in Figure 6.4.



	30% pc1
WHG	-0.17583
COD	-0.16905
HAD	-0.16525
CAA	-0.16134
Pseudocalanus.spp	-0.15095
Scomber.scombrus	0.138401
Ammodytes.marinus	0.141859
Merluccius.merluccius	0.156753
NEP	0.171031
	12% pc2
Hyperiidea..Total.	-0.14863
lOT	-0.10444
Asterionellopsis.glacialis	-0.0902
Fish.eggs..Total.	-0.08773
Cylindrotheca.closterium	-0.08372
ANF	0.200562
PLE	0.206885
TUR	0.228491
BT	0.228626

Figure 6.4. PCA of state/pressure variables specifically located in the southern North Sea.

PC1 accounts for 30% of the variation over this period and is dominated by the same trends in similar variables as the North Sea as a whole, with the exception of mackerel which is identified as a characteristic variable with an increasing trend over the same period.

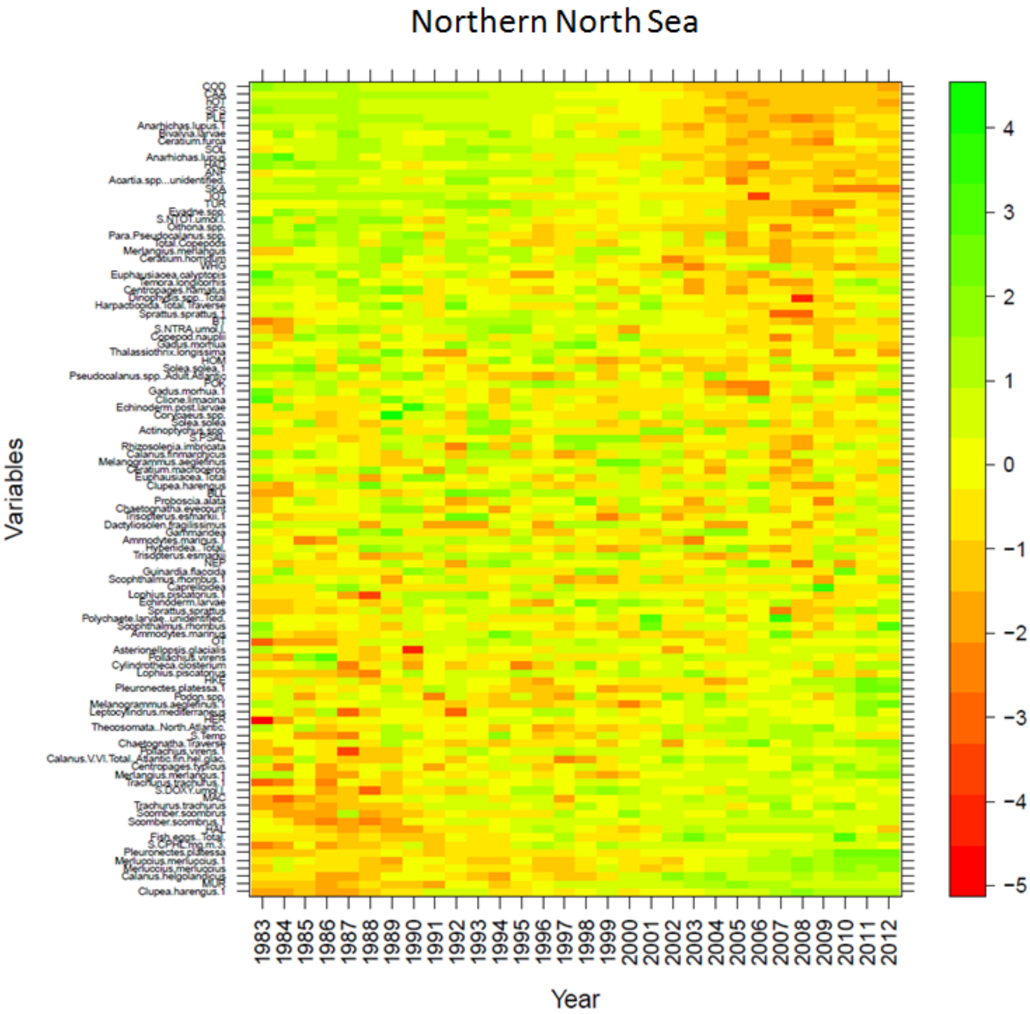


Figure 6.5. 'Shade' plot of state/pressure variables specifically located in the Northern North Sea. The plot suggests a change in state around 1989/90, but is subject to bias in the IBTS data as described in the North Sea as a whole analysis.

A shade diagram of the all the variable anomalies sorted by their eigenvalues on PC1 specific to the southern North Sea is shown in Figure 6.6. What is apparent is that the step change in the state of the southern North Sea ecosystem is seemingly greater than that associated with the northern North Sea. However, as has been previously reported, the change in state (around 1989/90) may be an artefact of the bias introduced in the IBTS data. Nevertheless, the difference in the strength of the response (change) at this time is probably significant in one of two respects; i. the cpue bias is more prevalent in the southern North Sea or ii. there is a real difference in the cpue trends between the NNS and SNS – correcting the data to use Q1 data only will resolve this issue.

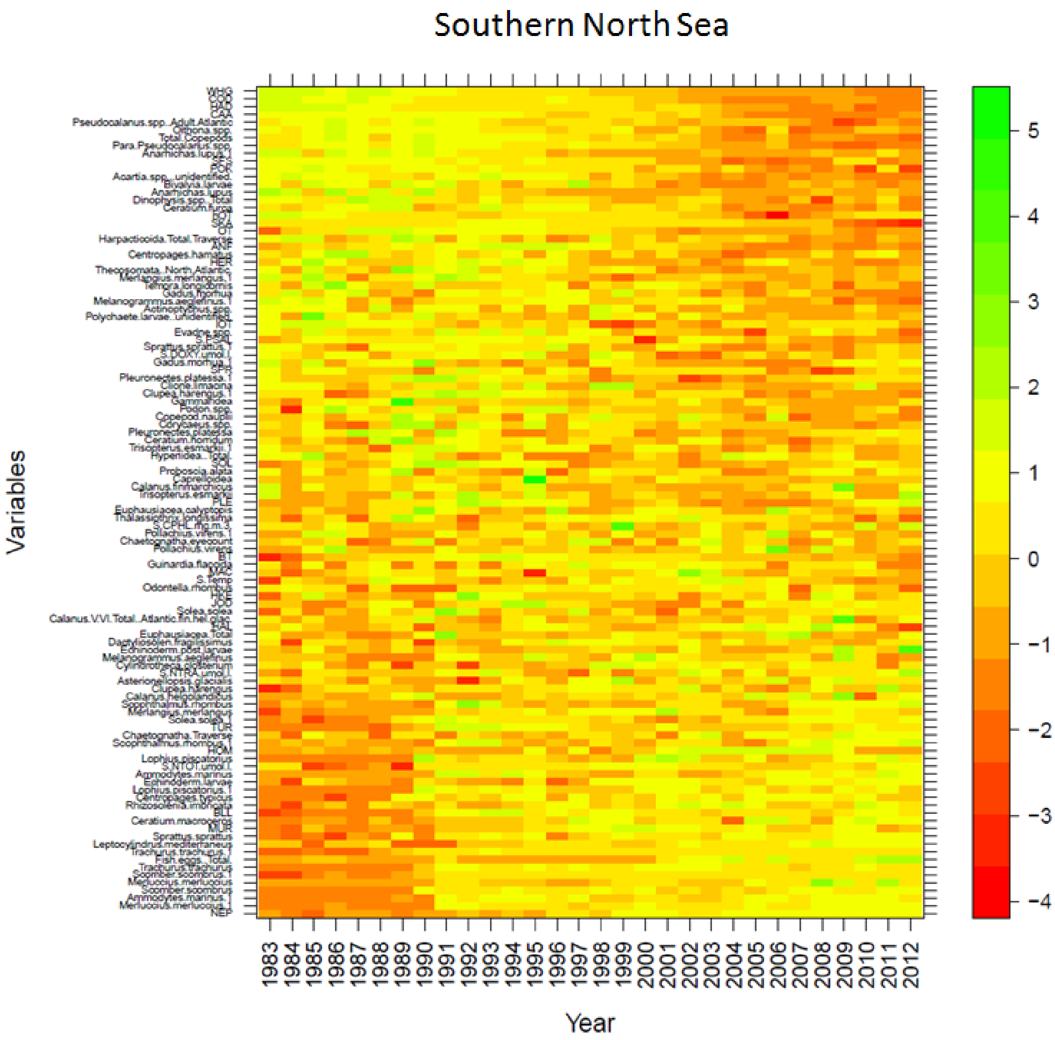


Figure 6.6. 'Shade' plot of state/pressure variables specific to the southern North Sea subregion. The plot suggests a change in state around 1989/1990, but is subject to bias in the IBTS data as described in the North Sea as a whole analysis, but note how much more strong this step change is compared to the northern North Sea shade plot.

6.4 North Sea specific ecosystem component responses

6.4.1 Environment

Trends in the environmental variable anomalies for the NNS and SNS are shown in Figure 6.7. It is apparent that there is no clear environmental signal in these data suggesting that there are issues with the spatial/temporal coverage year on year for the empirical data associated with these two regions. This in part, contributed to the decision to utilize modelled data associated with the environmental drivers.

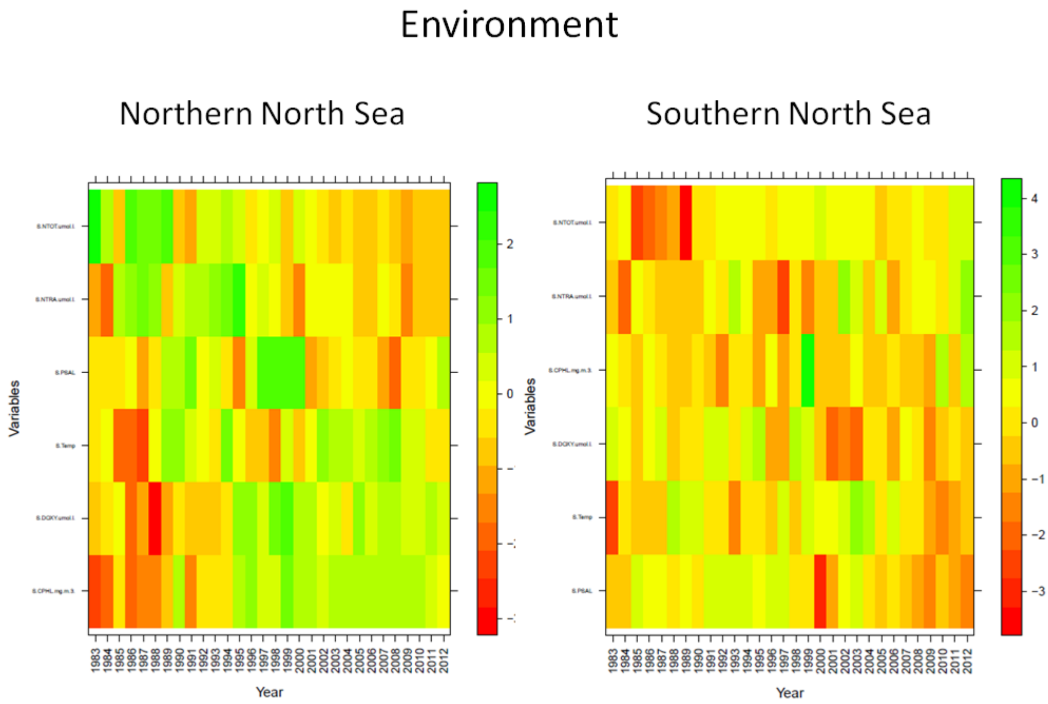


Figure 6.7. Trends in 6 environmental variables for the NNS and SNS, respectively. Possible trend in chlorophyll and oxygen concentration for the NNS (bottom two variables).

6.4.2 Plankton

A total of 43 plankton variables were included in the analysis. Shade plots of the variable anomalies sorted by the eigenvalues of the first PC reveal the trends in the dominant plankton species (Figure 6.8).

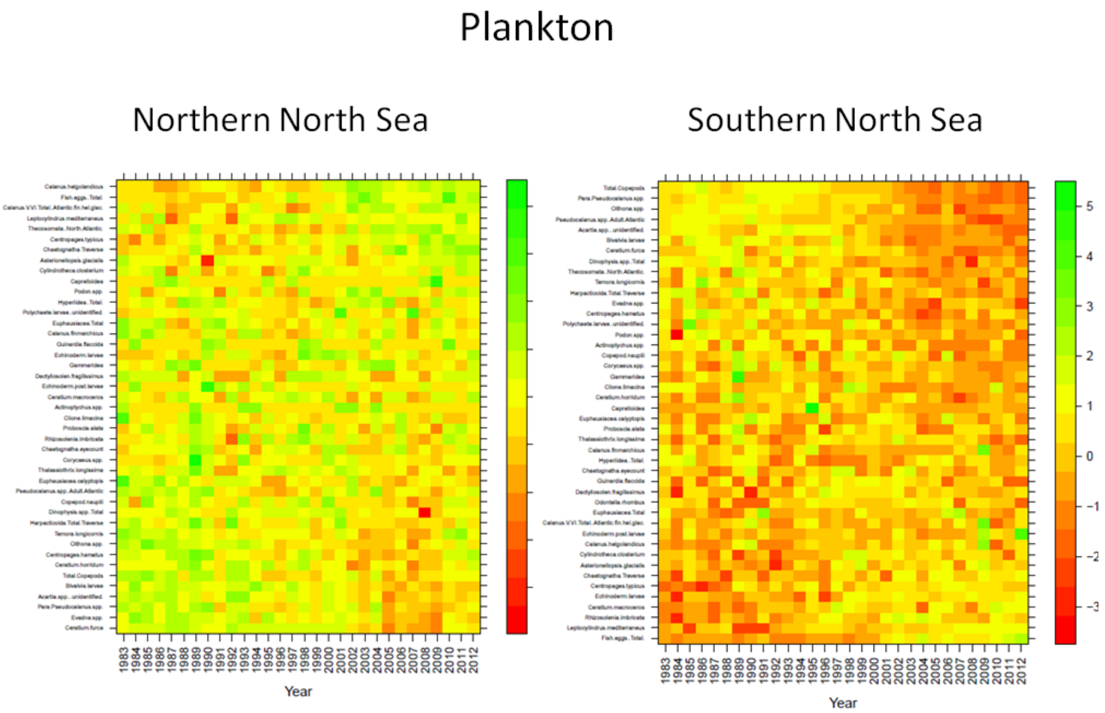


Figure 6.8. Shade plot of plankton variable anomalies for the NNS and SNS, respectively. Note there is no clear shift in ecosystem state as described the plankton component

6.4.3 Fish stocks

A total of 32 variables describing the status of demersal, benthic and pelagic fish stocks were assessed using PCA and the results are presented as a set of variable anomalies ordered by their eigenvalues from PC1 for the NNS and SNS respectively in Figure 6.9. The variables include the cpue from the IBTS surveys from 1983 and accordingly pre-1991 they include Q1-4 data whereas post 1991 they show Q1 data only – this bias in the data most likely accounts for the large change in status observed for the SNS in 1990. However, it is interesting to that there is a relative difference in the strength of the shift between the NNS and SNS which may be explained by either; i. the cpue bias is more prevalent in the southern North Sea or ii. there is a real difference in the cpue trends between the NNS and SNS – correcting the data to use Q1 data only for the full time-series will resolve this issue.

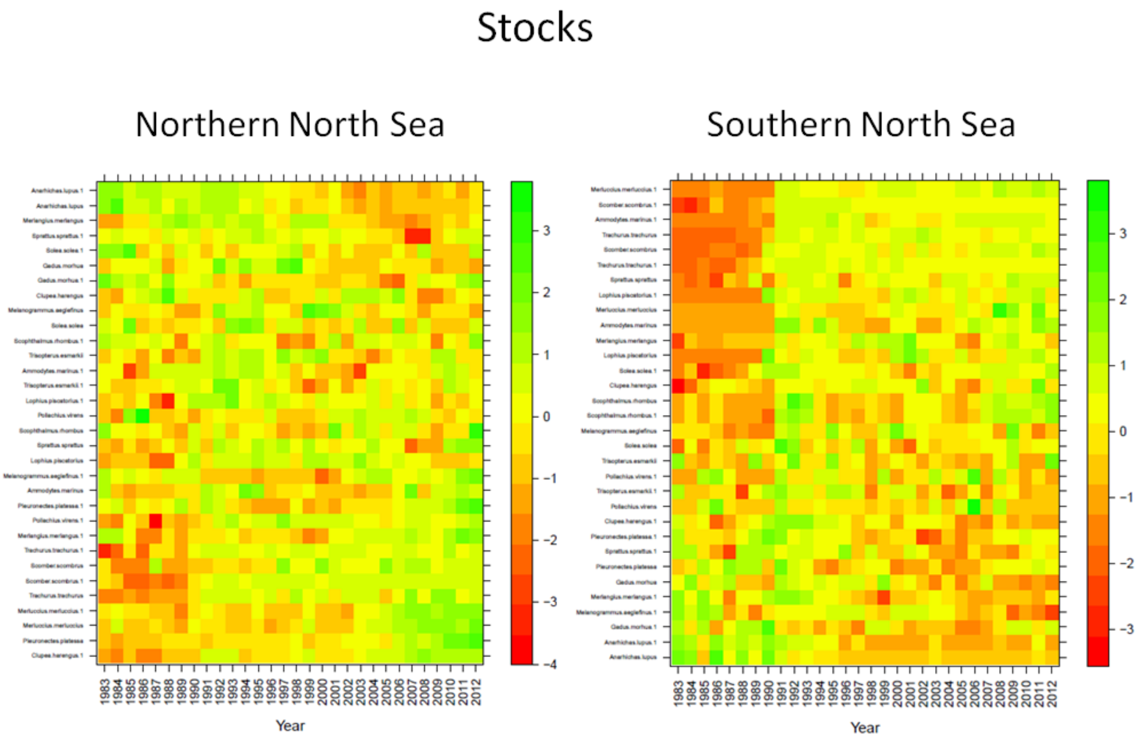


Figure 6.9. 'Shade' plot of fish stock variable anomalies for the NNS and SNS respectively. Note the apparent abrupt shift in state for the SNS which is mainly attributed to bias in the cpue data used.

6.4.4 Fisheries pressure

A total of 23 fishery pressure variables were assessed using PCA. The variables included the landings for a number of pelagic, benthic and demersal fish species and the effort for a number of different gear types such as otter and beam trawls. The trends of the variable anomalies ordered by their eigenvalues from the 1st PC is shown in Figure 6.10. It is noteworthy that there is more evidence of change in pressure around 2000 with a decrease in the landings and effort data mainly associated with the demersal fishery. There is little evidence of a large change in the fishery in 1989/90 to explain the apparent change in the status of the fish stocks at this time. However, there is possibly a stronger environmental signal associated with an increase in chlorophyll and dissolved oxygen at this time, but this is only a tentative observation as we prefer to utilize modelled environmental data to explore the temporal trends more thoroughly

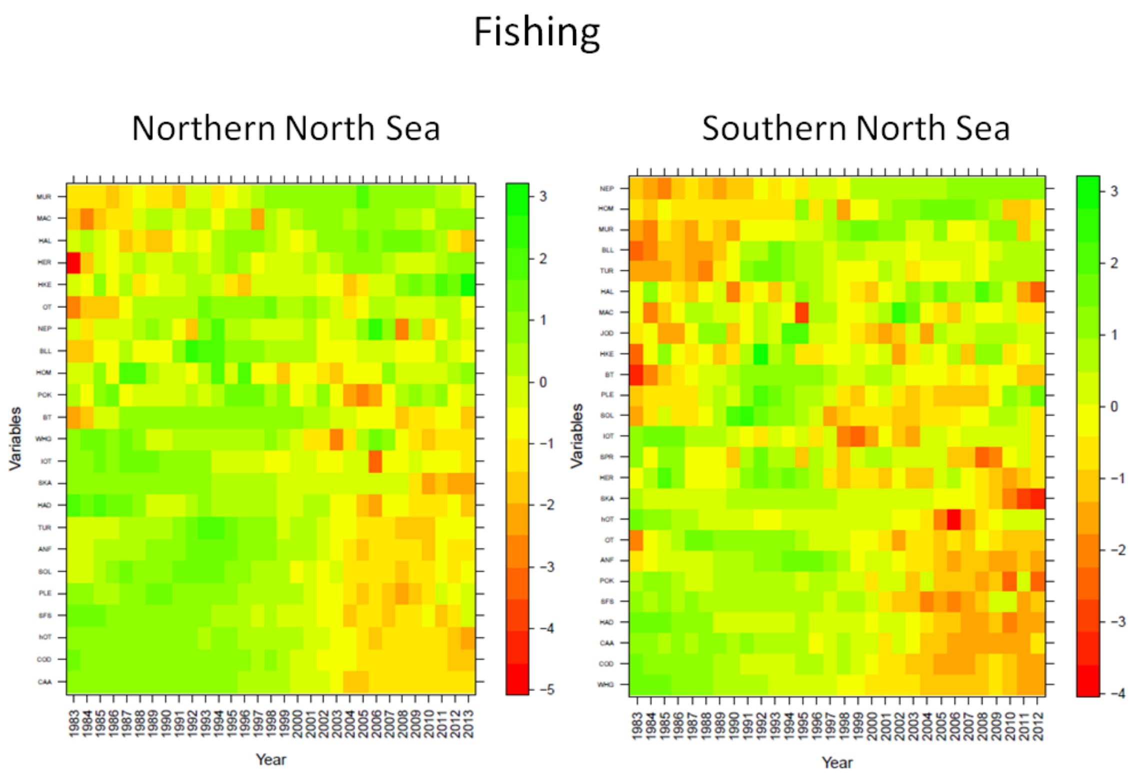


Figure 6.10. 'Shade' plot of fishing pressure variable anomalies for the NNS and SNS respectively.

6.5 Joint session with WGOOFE

On Thursday 13th March WGINOSE held a joint session with WGOOFE to discuss two items; i. a specific request from WKSPRAT and, ii. the provision of modelled environmental data to support the operational IEA of the North Sea ecoregion.

6.5.1 Request from WKSPRAT

WGINOSE received a request from WKSPRAT to provide advice on "data on environmental variables and ecosystem drivers to investigate trends in North Sea sprat productivity". This information would be used to support future benchmarks of sprat. This follows a similar request from the herring assessment working group (HAWG) in 2013 for which WGOOFE produced a briefing sheet (WGOOFE, 2013). Given sprat and herring are likely to respond (albeit in different ways) to the same environmental variables it was the conclusion of WGINOSE and WGOOFE that the advice given in support of the HAWG is also applicable for the assessment of sprat. However, there are notable spatial differences in the fisheries for these two species in the North Sea and therefore there is a need to generate a set of common environmental variables for the North Sea at spatial scales which correspond to specific areas and time-scales of interest.

It was agreed that the spatial resolution should be ICES rectangle covering the period 1983 onwards calculated as monthly averages. This would allow different users to aggregate the data spatially and temporally to meet their own specific needs.

6.5.2 Modelled data for IEA

In discussions with WGOOFE it was agreed to use modelled environmental data rather than empirical data from the ICES data centre as the temporal and spatial coverage of values from the modelled data are more representative of the subregional ecosystems under consideration. The advantages of using modelled data in this respect were considered to outweigh the disadvantages of not using direct empirical data. The environmental variables identified are those indicated in the model descriptions for the NNS and SNS, namely surface and bottom values of; oxygen, temperature, chlorophyll, nutrients (phosphorus, nitrogen, silicate), index of thermal stratification.

It was agreed that a data request for these variables as monthly averages for ICES rectangles for each of the ICES North Sea ecoregion subregions would be issued to the WGOOFE operational modelling community for a response by end of April 2014.

6.6 References

WGOOFE. 2013. ICES HAWG Environmental Briefing Sheet. Working Group on Operational Oceanographic Products for Fisheries and the Environment (WGOOFE), 13 March 2013. pp5.

7 Update the North Sea ecosystem overview report using findings from ToR a) and ToR c) and where possible (ToR b)

As a result of the bias in the assessment of cpue data included in the IEA trend analyses (Section 6) it was decided not to update the 'key' signals section of the ecosystem overview, but rather effort should be directed to reviewing Figure 6.1.3 of the current North Sea overview report.

7.1 Comments on Figure 6.1.3

Figure 6.1.3 in the North Sea ecosystem overview aims to summarize the dominant interactions between human activities, natural drivers of change, major pressures and state. The figure from the Ecosystem Overview is a tool to help managers and policymakers to inform decision-making and is based on qualitative expert judgment. The title of the figure should change to '*Ecosystem Overview for the management of human activities and pressures in the North Sea'* to reflect the fact that it refers to activities and pressures on the ecosystem susceptible of being managed. It is also noted that the figure refers to the Greater North Sea MFSD Ecorregion (including the Chanel and Kattegat areas) and that not all locally important pressures are included.

Natural drivers should consequently not be part of the figure since they are not directly manageable although they contribute to the natural variation of the ecosystem status. CO_2 is a global issue with broader implications that are related to human activities and linked with climate change dynamics. The Ecosystem Overviews scope is regional and are designed to inform regional management. CO_2 emissions are beyond the scope at which the regional Overviews are intended and should therefore not be directly included in the figure. It must be acknowledge however, that the *status* of the North Sea is determined by a combination of naturally driven processes and pressures from human activities. It is therefore important that the extent to which state change can be managed through human activities will ultimately be determined by the relative influence of the natural drivers of change and as such a clear statement reflecting this assertion should be included in the overview text.

Annex 1: List of WGINOSE participants

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Annex 2: Agenda

Monday 10 March

Time	Task	Suggested Contributors
10:00	Welcome, ICES HQ Rules etc.	Andy Kenny, ICES Secretariat
10:15	WGINOSE Multiannualy ToRs and Agenda	Andy Kenny
10:45	ICES Science Plan and role of regional IEA WGs (The role of WGINOSE)	Mark Dickey Collas, Dave Reid, Andy Kenny
11:15	BREAK	
11:45	ToR C - Develop and apply dynamic models as tools for integrated and combined effects assessments. What it is we need to model/predict? Modelling approaches to explore (presentation of examples) – 'quick wins' Data requirements for 'proof of concept' Agree workplan for development & application of dynamic ecosystem North Sea model	Ulrich Callies, Venessa , Vanessa Stelzenmüller, Corinna Schrum, Rabea Diekmann
12:30	LUNCH	
13:30	Continue ToR C	
15:30	BREAK	
16:00	Continue ToR C	
17:00	End of Day 1	

Tuesday 11 March

Time	Task	Suggested Contributors
09:00	Agenda for the Day	Andy Kenny
09:15	ToR D - Review the data needs and approaches to support the operational implementation of IEAs Review of proposed new subregional areas for the North Sea assessment (presentation). Evaluate 'core' variables from 2013 in relation to the new North Sea sub regional areas. Undertake 'gap' analysis and prioritize actions. Develop formal links with other expert groups both within and outside ICES (progress)	Andy Kenny, Neil Holdsworth (ICES data centre), Mark Dickey Collas, Lorna Teal
11:00	BREAK	
11:30	Continue ToR D	
12:30	LUNCH	
13:30	Continue ToR D	
15:30	BREAK	
16:00	Continue ToR D	
17:00	End of Day 2	

Wednesday 12 March

Time	Task	Contributors
09:00	Agenda for the day	Andy Kenny
09:15	Plenary summary presentations ToR C and ToR D	
11:00	BREAK	
11:30	ToR A - Update the integrated ecosystem trend analysis for the North Sea using as many of the 'core'variables as identified by WGINOSE in 2013. Overview and update on data collated by subregion (1983–2013). Development of 'core' IEA numerical tools in R (proposed IEATools - initiative) Application of IEATools to subregional and regional North Sea data Interpretation and assessment of results	Andy Kenny, Rabea Diekmann, Mark Dickey Collas
	ICES Science Plan and role of regional IEA WGs (The role of WGINOSE)	Mark Dickey Collas/Dave Reid/Andy Kenny
12:30	LUNCH	
13:30	Continue ToR A	
15:30	BREAK	
16:00	Continue ToR A	
17:00	Summary of IEA Results be subregion – 'key indicators'	
18:00	End of Day 3	

Thursday 13 March

Time	Task	Contributors
09:00	Agenda for the day	Andy Kenny
09:15	Joint session with WGOOFE Defining operational links with WGOOFE Responding to WKSPART request for North Sea oceanographic drivers – 'key' signals	Barbara Berx, Andy Kenny (and others)
11:15	BREAK	
11:45	(possible) Joint session with WGMME Defining operational links with WGMME	
12:30	LUNCH	
13:30	ToR B – Update the North Sea ecosystem overview report using latest findings Purpose of the overview and links with the advisory process (presentation) Review latest overview Identification/selection of key signals based upon recent subregional analysis	Andy Kenny, Mark Dickey Collas (and others)
15:30	BREAK	
16:00	Continue ToR B	
17:00	End of Day 4	

Friday 14 March

Time	Task	Contributors
09:00	Agenda for the day	Andy Kenny
09:15	Report conclusions/recommendations and section drafting	
11:15	BREAK	
11:45	Report section drafting	
12:30	End of meeting	

Annex 3: Multi-annual ToRs

The **Working Group on Integrated Assessments of the North Sea** (WGINOSE), chaired by Andy Kenny, UK, will meet at ICES Headquarters, Copenhagen, Denmark, from 10–14 March 2014, to work on their ToRs and generate deliverables as listed in the Table below.

The **second interim meeting of the Working Group on Integrated Assessments of the North Sea** (WGINOSE) will take place in Hamburg, Germany from 9–13 March 2015.

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Update the integrated ecosystem trend analysis for the North Sea using as many of the ‘core’variables as identified by WGINOSE in 2013	a) Science Requirements b) Advisory Requirements c) Requiyrements from other EGs	1.1, 2.1 Input from relevant EWG as highlighted WGINOSE in 2013	Years 1, 2 & 3	Regional sea state trend analysis for inclusion in ecoregion overviews annually.
b	Update the North Sea ecosystem overview report using findings from ToR a and ToRc where possible	a) Science Requirements b) Advisory Requirements	1.1, 2.1 To facilitate the provision of IEA advice	Years 1, 2 & 3	North Sea ecosystem overview updated annually
c	Develop and apply a dynamic Bayesian Belief Network model as a tool for integrated and combined effects assessments.	a) Science Requirements	2.2, 2.3, 3.2, 3.3	Years 1, 2 & 3	Results which explore the balance of trade-offs between ecosystem protection and sustainable resource use
d	Review the data needs and approaches to support the operational implementation of ToRa and ToRb (above)	a) Science Requirements	4.1	Years 1, 2 & 3	Recommedations and actions giving rise to the ongoing improvement to flow of data between EWG, the data centre and WGINOSE

Summary of the Work Plan

Year 1.	In terms of delivery, the first year will focus on developing links between relevant expert groups (ICES and others external to ICES) and the ICES data centre to compile a core set of IEA variables for the North Sea. An update of the North Sea trends analysis will be performed and the results will be used to update the North Sea ecosystem overview.
Year 2.	In addition to the annual update of the trend analysis and ecosystem overview, the focus for the second year delivery will be to demonstrate the utility of the developed dBBN North Sea model, espceially in answering the 'key' questions around the balance of trade-offs between ecosystem protection and sustainable resource use for a range of human activities.
Year 3.	In addition to the annual update of the trend analyses and ecosystem overview, the focus for the 3rd year will be a review of comparative performance of WGINOSE, especially in relation to the uptake and use of model results and trend analyses in the advisory and management processes.

'Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the development of Integrated Ecosystem Assessments for the North Sea (a data rich ecosystem) as a step towards implementing the ICES Science Plan and the ecosystem approach, these activities are considered to have a very high priority.
Resource requirements	Assistance of the Secretariat in maintaining and exchanging information and data to potential partcipants, especially the services of the ICES data centre to generate data tables for analysis from selected variables held in the database.
Participants	The Group is normally attended by some 10–20 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Relevant to the work of ACOM and SCICOM
Linkages to other committees or groups	There is a very close working relationship with all the groups of SSGSRP. It is also very relevant to the EWG identified in WGHAME 2013 report..
Linkages to other organizations	OSPAR, EU, NAFO, NEAFC

Annex 4: 'R' script for IEA trend analysis

```
# Perform a PCA using singular value decomposition
# and produce a 'shade' plot  of the original data matrix (sorted against PC1)
    library (lattice)
#read in data file as a matrix
    setwd("/R")
    data = as.matrix(read.csv ("c:WGINOSE\\INT_SK.csv", row.names=1, header=TRUE))
#transform and standardize the data
    trans = log10(data+1)
    trans.std = as.data.frame(scale(trans))
#single plot of all the transformed variable anomalies to visually check for consistency
    years = row.names(trans.std)
    nvar = dim(trans.std)[2]
    plot (years, trans.std[,1], type = 'l', col = 1, ylim = c(-4,4), ylab = 'Variable Anomalies', xlab = 'Years', main = 'SK Ecosystem')
    for (i in 2:nvar)
    {
        par(new = TRUE)
        plot (years, trans.std[,i], type = 'l', col = i, ylim = c(-4,4), axes = FALSE, xlab = NA, ylab = NA)
    }
#perform PCA
    data.pca = prcomp(trans.std)
    summary(data.pca)
#scree plot
    screeplot(data.pca, type="lines", main = "Scree Plot")
#loadings (eigenvalues) for PC1 & PC2 vectors
    pc1 = data.pca$rotation[,1]
    pc2 = data.pca$rotation[,2]
    loadings = data.frame(pc1,pc2)
    pc1.order = order(pc1, na.last = TRUE, decreasing = TRUE)
    loadings.order = loadings[pc1.order,]
    loadings.order
    write.csv(loadings.order, file = "c:WGINOSE\\INT_SK_Varloadings")
```

```
#ordination using PC1 & PC2 scores
    plot(data.pca$x[,1],data.pca$x[,2], xlab = "PC1", xlim = c(-8,11), ylab = "PC2", type = "both", main ="PCA")
    text(data.pca$x[,1], data.pca$x[,2], row.names(data), cex=0.9, pos=4, col="red") # add labels
    pdf("C:WGINOSE\\INT_SK_PCA.pdf")
    plot(data.pca$x[,1],data.pca$x[,2], xlab = "PC1", xlim = c(-10,11), ylab = "PC2", type = "both", main ="PCA")
    text(data.pca$x[,1], data.pca$x[,2], row.names(data), cex=0.9, pos=4, col="red") # add labels
    dev.off()
#plot of PC1 & PC2 scores, and write file
    plot(data.pca$x[,1], main = "PC Scores", xlab = "Years", ylab = "PC1",type = "lines", col = "red")
    text(data.pca$x[,1], row.names(data), cex=0.7, col="black") # add labels
    plot(data.pca$x[,2], main = "PC Scores", xlab = "years", ylab = "PC2",type = "lines", col = "blue")
    text(data.pca$x[,2], row.names(data), cex=0.7, col="black") # add labels
    pc.scores = data.frame(data.pca$x[,1], data.pca$x[,2])
    pc.scores
    write.csv(pc.scores, file = "c:WGINOSE\\INT_SK_PCscores")
#reorder the data matrix stnddata using the ranked order of PC1 loadings pc1.order
#pc1.order10yr = as.vector(read.csv("c:data\\WGINOSE\\PC1_10YR_Order.csv"))
#trans.std.order = as.matrix(trans.std[, pc1.order10yr[,1]])
    trans.std.order = as.matrix(trans.std[, pc1.order])
#plot shade plot
    levelplot(trans.std.order, col.regions = rainbow(100, start = 0, end = 0.325), scales = list(x=list(cex=1, rot = 90), y=list(cex = 0.5)), main=list(label="    SK", cex = 2), xlab=list(label="Year",cex=2), ylab=list(label="Variables",cex=2), aspect = 1.25)
#save the file as a PDF
    pdf("C:WGINOSE\\INT_SK.pdf")
    levelplot(trans.std.order, col.regions = rainbow(100, start = 0, end = 0.325), scales = list(x=list(cex=0.8, rot = 90), y=list(cex = 0.4)), main=list(label=" North Sea Ecosystem", cex = 1), xlab=list(label="Year",cex=1), ylab=list(label="Variables",cex=1), aspect = 1.25)
    dev.off()
```