

Theme Session J

The Role of Benthic Communities as Indicators of Marine Environmental Quality and Ecosystem Change

Conveners: Heye Rumohr (Germany) and Chris Frid (UK)
Rapporteur: Eric Jagtman (the Netherlands)

Background

This Session was organized with the aim to discuss progress in the development of marine environmental quality indicators based on data of benthic communities.

Marine environmental quality indicators are in great demand following recent developments in the marine regulatory framework. At the fifth North Sea Ministers Conference it was agreed that marine quality indicators should be operational by the year 2005. Against this background speakers were invited to give up-to-date information on the development of indicators and discuss advantages and limitations in the use of these indicators.

Summary of presentations

During the Session criteria were listed that are crucial for the development of good indicators. Ideally, indicators should demonstrate the capability to measure change, they should enable us to understand cause-effect relationships, and they should support effective communication. However, there was a need for monitoring in relation to oil and gas activities, sludge and dredging disposal and dredging of marine aggregates. Consequently, indicators were developed in order to be able to properly describe the complexity of the ecosystem investigated.

A wide range of examples of indicators were given, including a marine biotic index based on five functional groups sorted by sensitivity to organic enrichment,

biodiversity and community indices as well as an index for commercial stock value. The underlying data for the marine indicators were collected by bottom sampling, scuba diving, and digital image analysis. Examples of the indicators presented can be seen at <http://www.azti.es/>

In all presentations, case studies demonstrated what use could be made of the indicators discussed. Most commonly, indicators were used to describe temporal and spatial changes in the ecosystem, and it was effectively demonstrated that indicators are suitable to differentiate between impacted and non-impacted sites under the influence of human activities. Limitations discussed related to the limited geographical range in which indicators can be safely used and the ability to distinguish between nature/climate-driven changes and human impacts. It was therefore suggested that the use of benthic indicators should be linked to rigorous quality procedures.

Conclusion

Taking into account the limited number of presentations (seven, including two posters), it was not feasible to get a full overview of developments in constructing marine environmental quality indicators. However, it is considered that, since developments in the (marine) regulatory framework are ongoing (e.g. EU Marine Strategy), there is a strong need to stimulate further work in this field. This will be necessary to enable ICES to advise OSPAR and the EU on these issues.

Theme Session L

Plankton Monitoring: Better Coverage by Ship-of-Opportunity and Remote Sensing Methods

Convener: Seppo Kaitala (Finland)

Background

Plankton monitoring at fixed stations has its obvious limitations. Phytoplankton monitoring of the Baltic Sea has for the past ten years benefited from continuous measurements by commercial vessels (Ship-of-Opportunity) on passage across the Baltic Sea. Furthermore, remote sensing is necessary in order to expand the limited information provided by ships to cover larger areas. On the other hand large sets of calibrated Ship-of-Opportunity (SOOP) data provide assured ground-truth data for remote sensing applications. At the moment these studies are approaching a stage where algal biomass and main taxonomical groups of algae (including cyanobacteria and other harmful algae) can be described and quantified using their characteristic pigment signatures. These developments will provide a new insight into spatial and temporal variations of phytoplankton

Summary of presentations

SOOP methods

The "Ferrybox" dataset (1999–present) provides a context for detailed process studies in an estuarine environment. This autonomous system records plankton blooms, with reduced aliasing of timing and peak biomass, in the hypernutrified system of Southampton Water. A ferry, making up to 16 crossings a day, records temperature, salinity, fluorescence, position, and turbidity data every second and relays 10 minute summaries of data back in near real-time.

Net heat flux, high tidal range (up to 5 m), eutrophication gradient data gave interesting observations to study in interannual variability in the timing and magnitude of spring bloom development. This study promotes the understanding of the importance of stratification for phytoplankton community succession.

Plans to establish an integrated operational system for the Baltic Sea as an operational observation system of harmful algal blooms were described. These would consist of a cyanobacteria-specific SOOP flow-through monitoring system, development of satellite image calibration for cyanobacteria-specific pigments, and a joint sample programme of harmful algae and algal specific toxicants. The information will be delivered as fast as possible through the BOOS web page.

The Alg@line system, which began in 1992 as a single monitoring route across the Baltic Sea, has now developed into a joint operational monitoring and information service in the Baltic Sea. The SOOP approach forms the backbone of Alg@line. The main objective of Alg@line is the monitoring of the phytoplankton community and harmful

algal blooms. In addition to an almost real-time reporting on algal blooms, the collected data is used for scientific research.

Temperature and salinity data collected automatically at 4 to 5-m depth along the SOOP transect Tallinn-Helsinki have been used for the identification of upwelling events near the opposite coasts of the Gulf of Finland. The upwelled water, since it originates from the deeper layers below the seasonal thermocline, is usually cold and rich in nutrients. The upwelling appears when along-shore winds are blowing: in the Gulf of Finland, the eastern winds cause upwelling near the Estonian coast and the western winds – near the Finnish coast. A method was developed to estimate the intensity of upwelling events (upwelling index) for every crossing. The integrated upwelling index (calculated as a cumulative sum of indexes starting from 1 May) can be used in a model to forecast the intensity of blue-green algae blooms in the Gulf of Finland.

An advanced SOOP monitoring system is now in operation on the route between Cuxhaven (Germany) and Harwich (UK). The FerryBox system has sensors and analysers for the parameters salinity, pH, oxygen, turbidity, fluorescence, ammonium, nitrate/nitrite, o-phosphate, and silicate. Strong gradients in both nutrients and turbidity were observed in the coastal vicinity on both sides of the transect. Data for different algae groups measured by excitation with different wavelengths are also analysed and compared with pigment analysis and cell counting.

Development of phytoplankton was strongly influenced by the physical environment. The observations in the North Sea clearly show low winter values in chlorophyll *a* over most part of the transect, nearby coastal effects of riverine loadings, and patchy distribution of algal blooms along the transect in spring and summer. The recording systems of physical and chemical parameters are highly advanced, but optical detection of phytoplankton is under development.

Remote sensing methods and data assimilation

It was demonstrated that SeaWiFS satellite measurements of ocean colour did not correlate at all well with chlorophyll *a* concentrations in the North East Atlantic waters.

The main problem is that the NASA calibration algorithms were developed for open ocean waters (Case I waters), and there are large areas of coastal and polar waters, where these algorithms do not work well. Attempts were made to avoid these problems by using three-dimensional thin plate regression splines to estimate *in situ* (bottle) measurements as a function of SeaWiFS estimates. The presentation and Figure L1 clearly demonstrate the need to develop a special calibration algorithm to estimate chlorophyll *a* concentration in the Northeast Atlantic waters.

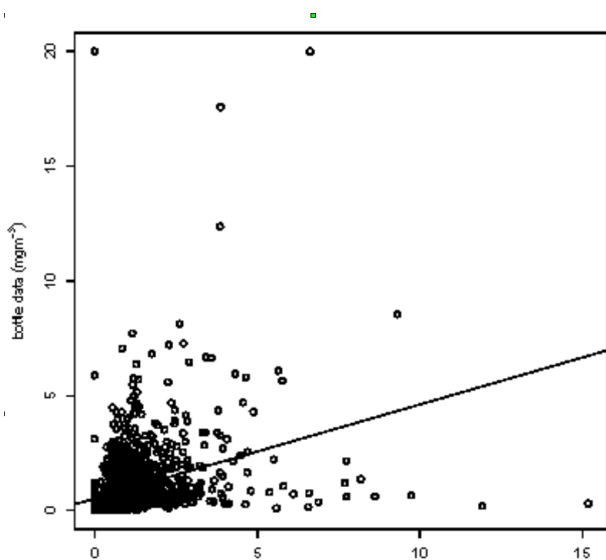


Figure L1: Chlorophyll *a* concentrations plotted against the corresponding satellite predictions, with a regression line superimposed. R^2 is only 10%, indicating a poor correlation between SeaWiFS and bottle data. From CM2003/L:04. "Prediction of the annual cycle of phytoplankton production in the North East Atlantic" by E. D. Clarke, S. N. Wood, M. R. Heath, D. C. Speirs, W. S. C. Gurney, and S. J. Holmes.

Methodology has been established to develop an empirical algorithm of chlorophyll *a* for MODIS satellite data with an automated flow through fluorometer measurements (Alg@line system). In the Baltic Sea, the concentrations of coloured dissolved organic matter (CDOM) and suspended material from allochthonous sources are high and create a need to apply locally developed band ratio algorithms. Although the available data was only for three days, the study gave promising results to develop a special algorithm for the Baltic Sea (Figures L2 and L3).

Satellite data are spatially continuous observations whereas the Alg@line data include transect observations. The data assimilation technique optimally combines these two data

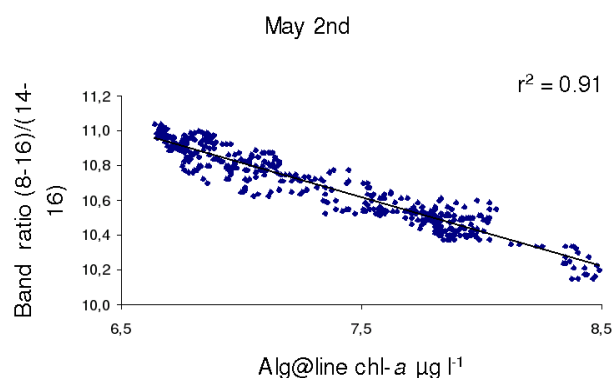


Figure L2. Scatter plots between ship-measured chlorophyll *a* and MODIS reflectance band ratios. From CM2003/L:07. "Remote sensing of chlorophyll *a* in the Baltic Sea together with automated fluorometer measurements". By T. Takio, J. Vepsäläinen, S. Kaitala, and V. Fleming.

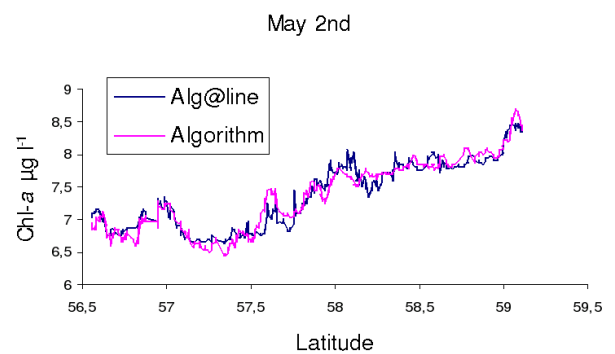


Figure L3. Alg@line measured chlorophyll concentrations vs. algorithm estimated values. From CM2003/L:07. "Remote sensing of chlorophyll *a* in the Baltic Sea together with automated fluorometer measurements". By T. Takio, J. Vepsäläinen, S. Kaitala, and V. Fleming.

sources by taking into account the spatial autocorrelation function of chlorophyll *a* concentration estimated from the transect data. Kriging interpolation is used for the extrapolation or interpolation of Alg@line observations for any location outside the employed transects. The developed method takes an advantage of the high accuracy of Alg@line transect data together with the full spatial coverage of satellite observations. It is shown that the introduced technique significantly improves the quantitative regional water quality assessment accuracy when compared with the use of only the transect data or only the space-borne data.

Unattended flow-through fluorometers are currently operationally employed in the Baltic Sea to provide information on chlorophyll *a* concentration and distribution. However, the spatial coverage of these SOOP data is restricted to transects cruised by vessels. Space-borne optical spectrometers, such as SeaWiFS and MODIS, provide daily remote sensing reflectance observations correlated to chlorophyll *a* concentration of the surface water layer. However, their accuracy is limited in the brackish waters of the Baltic Sea due to the relatively high turbidity and yellow substance (CDOM) level. The optimum method to apply satellite data is the assimilation of remote sensing observations with *in situ* data.

Phytoplankton quantification methodologies

The seasonal variability in spectral absorption and fluorescence characteristics of living phytoplankton in the northern Baltic Sea and studies on their relation to the phytoplankton community structure was reviewed. Phycoerythrin and phycocyanin fluorescence were found to be relevant indicators for picocyanobacteria and filamentous cyanobacteria. To derive algal biomass from the spectral groups using the spectral fluorescence of multicomponent natural phytoplankton samples, multivariate validation was found to be superior to univariate methods, e.g., the classical least squares regression. With experimental data, the partial least squares (PLS)-model was noted to give the best predictions for all spectral taxonomic groups. The

information needs for satellite data calibrations of specific pigments of phytoplankton groups were also addressed.

Sampling and evaluation of filamentous cyanobacteria has been considered a problem in studies of phytoplankton ecology. The influence of hose diameter was investigated when collecting surface-water integrated samples of filamentous cyanobacteria and image analysis as a tool for estimating the total length of filaments during a summer bloom in the Northern Baltic Proper. The hose diameter did not have any effect on integrated samples of filamentous cyanobacteria. Also image analysis gave the same estimates of filament length as traditional manual counts. Such results are also important for the monitoring of harmful algal blooms and as ground-truth data for satellite image validation.

Concluding remarks

SOOP systems on commercial ferries can cover larger areas than is possible by research vessels and mooring stations. These systems function also during cloudy weather, when most satellite sensors cannot “see” the sea surface. During clear days satellite sensors produce good images, but the comparison of ocean colour data produced with global calibration algorithms, with ground-truth data has given unsatisfactory results in many areas of the Northeast Atlantic, including the Baltic Sea. As shown in this Session, the development of local calibration algorithms are needed. SOOP systems produce the necessary ground truth for these calibrations. The detection of different phytoplankton groups is under development.

Theme Session M

Biological Effects Monitoring in the Baltic Sea

Conveners: Kari K. Lehtonen (Finland) and Doris Schiedek (Germany)

Introduction

Monitoring of the state of the seas has traditionally been almost entirely based on measurements of concentrations of harmful substances in seawater, sediments, and biota. However, with the already enormous and continuously increasing number of potentially toxic substances present in and released into seas this approach alone is no longer considered meaningful, cost-effective, or even possible. During the past decades, molecular, biochemical, cytological, immunological, and physiological techniques have been under dynamic development for the detection of effects of contaminants in marine organisms. More recently a strong emphasis on their further development and application in marine monitoring programmes has emerged within the EU, resulting in research programmes such as BEEP (Biological Effects of Environmental Pollution in Marine Coastal Ecosystems).

The risk assessment approach presently taken, i.e. concluding toxicity data for safety limits in the environment obtained from laboratory experiments with one contaminant, is bound to be invalid due to the presence of a mixture of various pollutants, in addition to all the natural stress factors. Seasonal variability influences the exposure of marine organisms to contaminants and even temporary oxygen deficiency leads to the release of various sediment-bound contaminants and increases exposure. In spring, an increased riverine runoff elevates the concentrations of pesticides and herbicides used in agriculture. Furthermore, the behaviour of organisms is dependent on, e.g., seasonal variability in temperature, nutritional conditions, and reproductive cycle.

The current approach in the Baltic Sea and its limitations

In the Baltic Sea, eutrophication has been classified as the greatest threat to the marine environment. Owing to limited resources, the studies and monitoring of contaminants and, in particular, their effects have received much less attention. According to the prevailing view, the effects of contaminants are anyway masked by the effects of eutrophication. This belief may remain valid if one uses indicators that are related to changes observed at population or community levels, where they can usually be directly related to increased concentrations of nutrients and the resulting pathways of biological processes. However, there exists a large suite of methods developed to indicate biological effects of pollutants, some of which are more general stress indicators and some indicating exposure to specific groups of contaminants.

The EU Water Framework Directive requires the application of biological effects methods over chemistry-based ones in the monitoring of the state of marine coastal ecosystems. This has generally been interpreted as methods that describe changes at population or community levels, measured as changes in abundance and biomass of species, and interspecies relations. The successful application of such an approach requires (1) time-series long enough to catch the natural internal fluctuations often occurring in populations, as well as (2) “undisturbed” reference areas. Of these, the former takes a considerable period of time to be obtained, while the identification of the latter in the Baltic Sea has been proven to be a difficult, or even an unrealistic task.

Objectives

The Session aimed at gaining an overview of ongoing research activities in this respect and to draw some conclusions regarding a future implementation of biological effects monitoring in the Baltic Sea. From the 18 contributions submitted 13 papers and two poster presentations were given during the session, all being well within the focus of the Session. Of the results presented, about 50% were output from the BEEP project mentioned above. One poster dealt with the improvement of wastewater discharges using an example from the Black Sea and giving some indications on how to apply this method in the Baltic Sea.

Presentations

Keynote lecture

K. Cooreman gave an overview regarding the status and use of biological effects techniques in marine environmental areas with focus on studies performed in the North Sea. He showed that biomarkers are a useful concept to estimate environmental stress as early warning indicators for contamination and illustrated this in a graph (Figure M1). He also made clear that biomarkers are good indicators linking several levels of biological organisation in order to predict changes. At the end of his talk he pointed out that there is still a need for the evaluation of biological indicators (biomarkers) in the field.

Application of biomarkers in the field

Based on results from studies on perch, there is evidence that the inner part of the Stockholm archipelago is chronically contaminated and that apparently the perch population in this area has already adapted to this situation.

Changing availability of intracellular contaminants to biomolecules may alter adverse effects

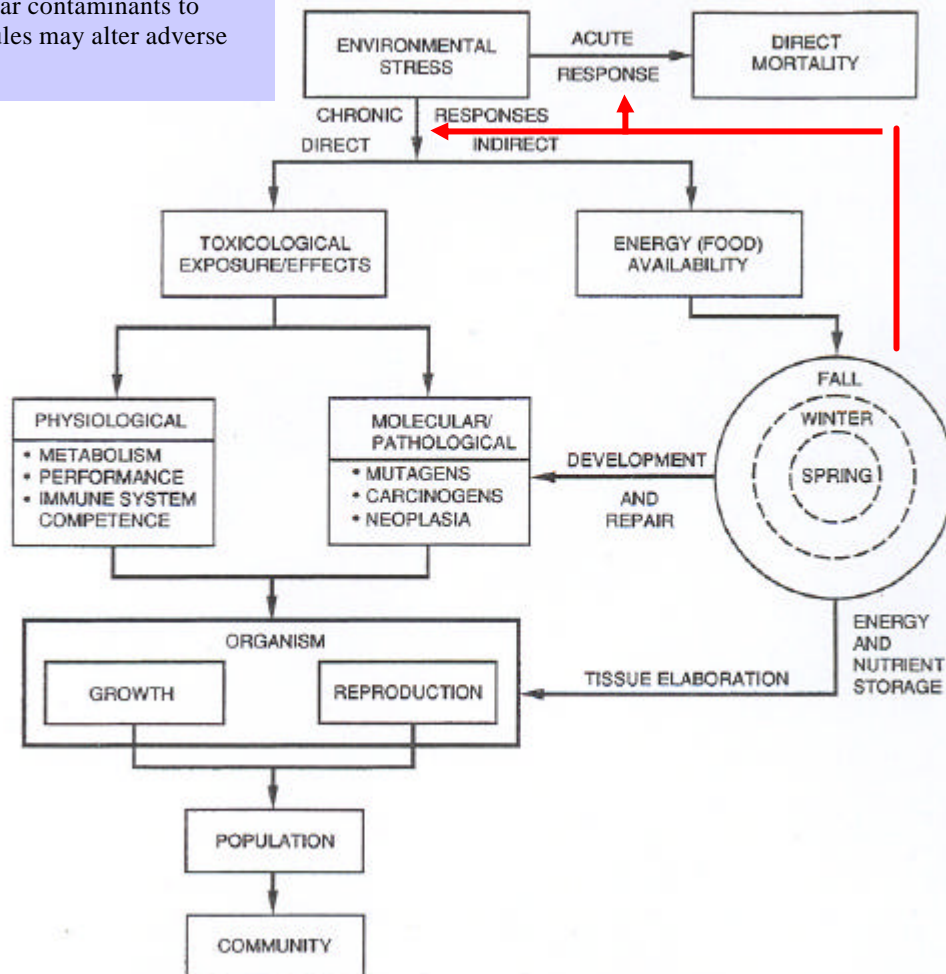


Figure M1. Response of organisms to chronic environmental stress. (From Larsson, A., Haux, C. & Sjöbeck, M. 1985. Fish physiology and metal pollution: results and experience from laboratory and field studies. *Ecotoxicology and Environmental Safety* 9, 250-281)

Clear contamination gradients and some resulting biological effects could also be shown for the Lithuanian coast. This work also demonstrated that biomarkers might be suitable to detect recent contamination events, such as a large oil spill due to a tanker accident.

It is evident that there still exists considerable contamination which affects the biota of the Gulf of Gdansk even though the concentrations have been reduced during recent years.

Biomarker responses in mussels and eelpout which appear to be related to the contaminant level were also found in the Wismar Bay, western Baltic. Some biomarkers are particularly promising (AChE, lysosomal membrane stability, micronuclei) to indicate biological effects in blue mussels.

Biological effects on single species

From data, obtained on cod at different locations in the Baltic, from the Kiel Bight up to the Lithuanian coast it is clear that cod physiology is affected by contaminants and that there are regional differences in the biological responses (more pronounced in the southern Baltic),

mainly because of differences in contamination level and patterns.

Based on liver histopathology as an indicator for biological effects, it was shown to what extent flounders in the Baltic Sea are affected. Elevated prevalences of toxicopathic lesions were recorded in an area on the Lithuanian coast contaminated with PAHs.

The usefulness of measuring bile PAH-metabolites as an indicator of PAH exposure was demonstrated by laboratory experiments on perch and salmon and field measurement in the northern Baltic Sea. At some locations in this area the fish are already chronically exposed, indicated by the fact that only 1-OH-pyrene, a persistent metabolite, was measurable in the fish bile.

From studies on perch in Estonian waters, it is obvious that life status and age of the fish has to be taken into account when studying contamination and resulting biological effects.

Findings in blue mussels from various BEEP locations in the Baltic Sea, clearly show that micronuclei frequency is a sensitive indicator for genotoxic effects. Using data

from laboratory experiments there are indications about the time period needed until mussels may recover genotoxically from contaminant exposure.

Experiments showing the impact of TBT on creatine kinase in fish spermatozoa raised the question whether the TBT concentrations, chosen in the experiment, realistically reflect the exposure situation in the field.

Environmental health indicators

Different concepts were presented in order to develop overall environmental health indicators.

Based on a comparative study on two bivalve species, *Macoma balthica* and *Mytilus edulis*, an example was given on how to use the biomarker responses obtained in applying an “Integrated Biomarker Response Index” (IBR). Integrated biomarker response indices were calculated using four different biomarkers and comparing them with chemical data of different contaminants.

The “Bioeffect Assessment Index” (BAI), offers a somewhat different approach. It has been developed for the integration of several pathological endpoints, based on investigations on flounder in the North Sea and its application for Baltic Sea specimens.

Both concepts were discussed and it was considered that such indices are needed and should be further developed when applying biomarkers in the assessment of ecosystem health.

Conclusions

The results presented in the Session clearly indicate that the present contaminant levels in different parts of the Baltic Sea are causing biological effects in various species, and in some cases leading to chronic stress. It also could be demonstrated that examining the health of organisms has many advantages. Physiological effects of environmental pollutants are often rapidly manifested, and the observations on disturbance during a health check may be used quickly to direct more detailed chemical analytical work to the potential problem area. Although many of the effects of toxicants are reversible, causing no permanent damage to the organisms or reduce their fitness or reproductive capacity, a great number of them

do have potential links to genotoxicity, disease, and reproductive disorders which are features that may strongly affect populations and communities.

The current concept for the Baltic Sea aiming at assessing environmental health in an integrative mode, lacks such an approach – looking at the health of organisms that form the ecosystem and resolving which factors are causing the problems.

Agreement on the necessity of biological effects monitoring was reached. The following issues were raised regarding the general strategy to implement biological effects monitoring in the Baltic Sea:

- Clear definition of the purpose of biomonitoring and optimising the strategy accordingly.
- The need for different sets of biomarkers for different areas (regional approach).
- The need to apply a set of biomarkers representing different levels of biological organisation.
- The need for continuous monitoring of biological effects for estimating the health status of the ecosystem.
- Implementation of an integrated chemical and biological monitoring as a meaningful tool in assessing ecosystem health.
- When developing environmental health indicators, their limitations should be taken into account to avoid oversimplification of the complex interactions within an ecosystem such as the Baltic Sea.
- Development already made in OSPAR regarding the monitoring of biological effects should be utilised when designing a similar programme for the Baltic Sea.
- Development of Ecological Quality Objectives (EcoQOs) based on knowledge of the biological effects of contaminants with the aim of reducing their concentrations to non-effective levels.
- ICES should continue to have a leading role in the further development of EcoQOs. A good opportunity is the implementation of the Baltic Sea Regional Project (BSRP) and its associated ICES Study Groups.
- ICES may act as mediator to HELCOM in regard to implementation of biological effects methods in the COMBINE programme.

Theme Session N

Size-Dependency in Marine and Freshwater Ecosystems

Conveners: Henrik Gislason (Denmark) and John Pope (Norway)

Background

Marine and freshwater ecosystems are typically organised according to size. Most species have to grow through a series of sizes and many of the processes to which aquatic organisms are subject may depend as much on their size as on their species (e.g., mortality and growth). Hence, the size of the individual may largely determine its biological characteristics.

Size dependency is seen in the processes affecting individuals. However, emergent properties of the ecosystem that are size-related (e.g. regular size spectra, distribution of life history characteristics) are apparent, but the linkages are not well understood. This suggests that renewed studies of size-dependent processes and interactions in aquatic ecosystems and the construction of size-based models would further understanding. They would further our understanding of how aquatic ecosystems are structured and how they might respond to exploitation.

In introducing the Session, John Pope outlined simple ways in which size was important and a very natural nomenclature or currency in biological processes and hence in ecosystem structuring and modelling.

Presentations

Sized-based processes

Four papers were presented that described diverse size-based biological processes relating to the migration and distribution of Norwegian spring-spawning herring, sprat eggs in the Baltic, recruitment, adult survival and spawning of anchovy in the Bay of Biscay, and the diet of stranded cetaceans in the English Channel.

Two posters were also introduced concerning size-based preference models for North Sea demersal species and feeding patterns of herring, sprat, and three-spined sticklebacks in the Gulf of Finland.

One of the main points raised from the discussion of these presentations was that size is clearly not necessarily the primary factor influencing some of the processes that were presented. In particular, interactions between age and size as well as condition (as subcomponent of size) may additionally influence spring-spawning herring migration patterns. The occurrence of apparent preferences for northern over-wintering areas but more southern spawning areas (for fish in better condition), could be the result of an energetic trade-off. The consideration of bioenergetics approaches, perhaps in combination with size-based methods could be useful.

Physical oceanographic differences among areas may mask size effects and this was shown in the paper on sprat eggs in the Baltic. Seasonal trends were detected for a decline in sprat egg size for all parts of the Baltic except the Bornholm Basin, where there are differences in oxygen level. It was suggested that differences in the buoyancy of smaller eggs across areas may provide some additional insight. The possibility of seasonal mixing with other populations was also suggested as a potential mechanism for this observation. The size-selective processes for anchovy were discussed and it was felt that growth of anchovy and their pattern of survival are consistent with a “live fast die young” trade-off. The discussion on the diets of stranded cetaceans concluded that the prey size of common dolphin was lower than expected and suggested that common dolphin could be a competitor with many finfish. The issue of sample size was discussed, which is very low for cetacean diet studies due to the reliance on strandings and bycatch data. Various methods apart from stomach analysis, as well as the comparison of bycatch and stranding results were suggested as possibilities for future comparison. The importance of observational data was thought to be very useful from a modelling perspective, as this helps to clarify what types of modelling assumptions may or may not be realistic, especially given that many modellers prefer to embrace more simplified views as tractability is also important.

Size-based metrics

Three presentations dealt with size-based metrics and various aspects of community size structure for the Celtic Sea and North Sea and feeding ecology of trophic guilds in the eastern Baltic. Striking similarities between the Celtic and North Seas were noted in that increases of small fishes accompanied declines in size structure.

It was discussed that the presentation of fishing mortality in these studies was useful as opposed to presuming declines in size structure definitely emerged from the direct effect of fishing, without consideration of trends in fishing mortality. Fishing mortality indices would be particularly useful if available by size and by functional groups and areas to further this type of work. The availability of discard data would also be useful for getting a better idea of fishing mortality for smaller sizes. There is clearly a need for additionally examining total production. The correspondence with literature of some of the observations presented was noted, such as predatory release. It may be that we are observing a shift in species with smaller L_{max} . Teasing apart environmental effects and fishing effects was also discussed as well as looking at data from lower trophic levels in these areas. Overall effects across the other parts of the marine ecosystem were discussed. It was thought that the

availability of comparable time-series may impede a comprehensive examination of comparing these.

Size-based models

Two very interesting modelling papers were presented, one incorporating a combination of trophic and size-based approaches, and the other a model of continuous size-spectra which involved simulation of fishing effects, and production oscillations on slopes of the overall numerical size spectra. The first demonstrated that given the assumptions of the model, the degree of predation had an effect on biomass distribution. The inclusion of ontogenetic shifts and diet shifts of species were suggested as a potential for contrasting results. The second paper on size-spectra suggested, through clearly

presented simulations, that slopes from linear size spectra may provide a weak indicator of changes in size structure and there could be departures from linearity.

Conclusion

One of the major points of this Session was the need for modellers to make simplifications to make their models tractable but that observations of processes from biologists would help to guide modellers when size effects are subtler. Bringing together researchers focussing on species-based ecosystem modelling and those that focus on size-based approaches would be useful for consideration of the difference in these approaches.

Theme Session O

Transport of Eggs and Larvae Relevant to Cod Stocks of the North Atlantic

Conveners: Joel Chassé (Canada) and Bjørn Ådlandsvik (Norway)

Background

Ocean currents transport the eggs and larvae of cod and other gadoid species. In some areas this transport is over 1000 km or more and is essential for the maintenance of certain stock components (e.g. the West Greenland offshore stock appears to be dependent upon Icelandic production of cod eggs and larvae). For other stocks, transport is important to move them into areas of high food production (e.g. the Baltic). The importance of variability in transport on recruitment has been more elusive, however. Understanding the relative importance of transport on cod recruitment was the aim of the ICES Workshop on the "Transport of Cod Larvae" (ICES CM 2002/C:13). Circulation models coupled with early life history models were used to determine the drift of cod eggs and larvae and to examine possible physical and biological processes responsible for the transport or retention of cod larvae. In addition, observational information about egg and larval transport was presented. It was also hoped to develop interannual transport indices based on physical variables that reflect the magnitude of the larvae drift or retention and attempt to incorporate these indices into the cod assessment process. Unfortunately this was not achieved. The ICES/GLOBEC Working Group on "Cod and Climate Change" meeting following the Workshop drafted a proposal to hold a Theme Session as a follow-up to the Workshop. Its objective was to improve our understanding of the role and relative importance of transport in controlling the recruitment of cod, other gadoid fishes, and prey species of cod such as capelin. The Theme Session would provide an opportunity to emphasize the major findings from the Workshop to the broader ICES community, to hear about other work on the same topic and, hopefully, present some transport indices for comparison with recruitment.

Presentations

Prior to the formal talks, J. Chassé presented a brief introduction on the connectivity of marine populations and the possible effects of transport. He stressed the non-linearity of many of the processes involved, and hence the need for models to address these issues.

There were a total of seven talks and one poster. Six of the papers considered the transport of eggs and/or larvae for five different cod stocks. The last paper considered the important problem of determining the age of fish eggs, which is needed to obtain validation data for egg transport models.

A circulation model of the Baltic was used to track the movement and drift of larvae. A coefficient of overlap between model larvae and idealized prey distributions

was determined from the probability of predator-prey overlap, which depended upon the hatching time of eggs. From model runs for 1979-1998, a relationship was found between the overlap index and the variability of recruitment success.

On Georges Bank, annual egg mortality rates of cod and haddock were found to be dependent upon the local wind stress. Model simulations of egg drift based upon climatological mean circulation flow fields plus time-dependent wind-driven flow suggest wind-driven flow off the Bank was a major factor in the interannual variability of egg mortality for both cod and haddock.

In the southern Gulf of St. Lawrence, simulations of egg and larval drift of cod also indicate the importance of the mean and wind-driven components of flow on the drift of larvae and showed large interannual variability in this drift. Survival indices for comparison with recruitment could be calculated using the number of settling larvae within an area divided by the number of eggs produced in the same area. Such survival indices will need to take into account import of larvae from other regions of the Gulf, however.

For the Northeast Arctic cod, two models were presented that tracked the eggs and/or larvae from their spawning grounds in the Lofoten area in Norway up into the Barents Sea. One showed that, in warm years, the larvae were transported to the southern Barents Sea with a high year-class survival, as compared to cold years when the survival rates were low. The other model showed how temperature along the drift paths determines growth rates and can explain the observed size difference in larvae in the Barents Sea.

Concerning the stock structure of the cod off Greenland, their relationship through migration and larval transport was described. There were several stock components, including on the shelf, around the coastal regions and in the fjords. From tagging experiments it was shown that cod from all three regions off West Greenland migrated to East Greenland and Iceland.

Discussion

John Steele provided some comments and views based on the presentations during the Session as well as from some of the presentations in Theme Session P on biophysical modelling that were directly relevant. He highlighted some characteristics related to the transport of eggs and larvae for the five cod stocks that were presented. He noted the lack of any over-riding hypothesis associated with transport, as different processes appeared important for different stocks. As proven from the dominance of cod in the ecosystem after

the last glaciation, their adaptation to environmental change was relatively fast in terms of geological time. How important was the transport of cod eggs and larvae in this colonization? He also noted that there were two conflicting hypotheses regarding the control on the recruitment of gadoids that were presented within Theme Sessions O and P. Within Theme Session O most assumed that survival during the drift of eggs and larvae determines the recruitment of young fishes, whereas in one of the papers on haddock in Theme Session P it was suggested that post-settlement processes determine recruitment. It was generally agreed that it is too early to discriminate which hypothesis is the most plausible, although both may be important and perhaps species-dependent. None of the models of cod presented included settlement, but it was noted that it is more difficult to model cod settlement than haddock. Cod appears to be more flexible than haddock in choosing bottom habitat for settlement. This might be examined through model-derived indices.

Egg and larval surveys suggest that larvae drift from Iceland to West Greenland in most years and that recruitment may depend less on the variability in larvae transported from Iceland to West Greenland, but more upon how many of those larvae make it onto the West Greenland Shelf or survive once they are there. The participants were reminded that one must not simply look at mean drift, but also at its variability when making comparisons to recruitment. The causes of recruitment variability may be frequency dependent, differing between interannual and decadal and even from one year

to the next. For example, one year it might be egg and larvae mortality that determines recruitment and the next year it might be post settlement mechanisms. A promising approach might be to study the life history of the survivors. Identifying when and where the survivors are from and the route they followed would be helpful.

It was agreed that more information on zooplankton is likely needed in order to better understand the mechanisms leading to recruitment. Processes controlling the over-wintering population of *Calanus finmarchicus*, an important food for cod, are important and that there is a large variability in these populations. Some efforts are being directed towards the modelling of zooplankton with cod larvae on Georges Bank, in Norway and elsewhere.

In conclusion, the study of transport processes for fish larvae is progressing rapidly. The combination of physical circulation modelling with particle tracking and individual-based temperature-dependent growth is becoming a mature and standard tool for handling such problems. Further work on developing transport indices for comparison with recruitment indices is needed. From the models presented, it appeared that different processes were important for different stocks. However, further comparisons between stocks is needed and encouraged, especially using similar models. Models require more realism (i.e. food availability and predation) to better account for egg and larval mortality. Future model developments must be extensively validated against field observations.

Theme Session P

Physical-Biological Interactions in Marginal and Shelf Seas

Conveners: Wolfgang Fennel (Germany), Henn Ojaveer (Estonia), and Charles Hannah (Canada)

Introduction

Ecosystems of marginal and shelf seas, among them the Baltic Sea, are characterized by pronounced gradients and high spatio-temporal variability of both oceanographic (salinity, temperature, oxygen) and biotic (e.g. food-web structure, productivity, taxonomic composition) characteristics. In addition, the structure and extent of human impacts (eutrophication/pollution, fisheries bio-invasions) differs between and within the seas. Better understanding of the physical-biological interactions which control the dynamics of the systems and the responses of the systems to natural and anthropogenic forcing is of essential importance for proper management of natural resources ranging from environmental quality to commercial fish stocks.

Presentations

At the meeting 34 papers were presented, 20 talks, and 14 posters. The papers covered the globe from the Baltic to Australia and the topics ranged from a laboratory study of sardine eggs to a comparison of fishing and climate effects on biomass yields across a large marine ecosystem. The sessions were very well attended and both the speakers and the audience were lively and enthusiastic.

Several themes emerged from the presentations:

- Comprehensive coupled circulation and ecosystem models have become useful for addressing complex ecosystem level issues.
- Many questions related to a single species can be addressed using a circulation model without explicitly addressing predator-prey interactions.
- A large amount of observational work is still required to provide the basic biological and life history information for all species of interest and to quantify the basic physical-biological interactions (e.g. what controls the vertical distribution of a particular species?).
- The importance of the deep-water renewal to the Baltic Sea ecosystem.

The Session opened with a presentation from the ICES Study Group on “Modelling Physical-Biological Interactions” on their strategy for future developments in modelling physical/biological interactions. Many of the ideas presented, in particular the need for more basic biological information and the need for focussed data sets to rigorously validate the models, were reflected in papers presented during the Session. The strategy paper also identified a need to develop a common notation and conceptual framework for assessing the similarities and differences between any two models. This was addressed in the second paper which developed a common mathematical framework for both continuous models and particle models.

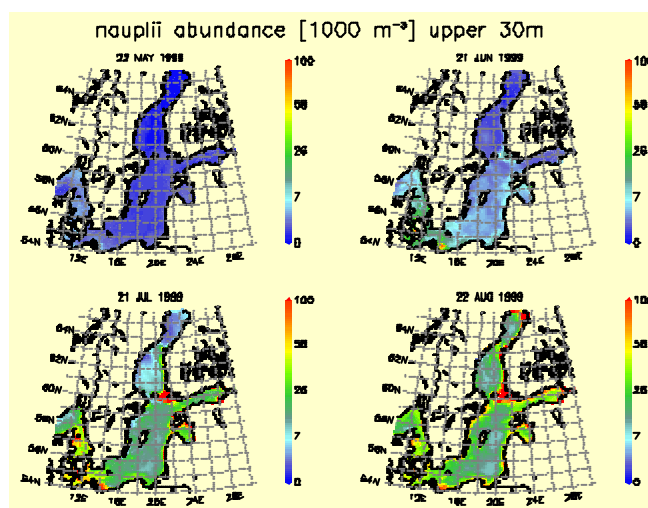


Figure 1. Modelled abundance of copepod nauplii in spring-summer 1999. (From: *Thomas Neumann, Wolfgang Fennel, and Christine Kremp: A stage resolving model of copepods coupled with a 3-dimensional biogeochemical model of the Baltic Sea CM2003/P:20*)

Coupled circulation and ecosystem models

The coupled circulation and ecosystem models came of age at this meeting. These models provide spatially and temporally resolved simulations of the hydrodynamics, nutrients, and lower trophic levels. Generally the surface fluxes are obtained from numerical weather prediction models and the river inputs include nutrients from land-based sources. The development of such models is well advanced in the Baltic. In one study, a model was used to simulate the algal succession in cyanobacteria blooms in the Baltic and it showed how different species can dominate the bloom in different years depending on whether upwelling or downwelling dominates during the summer. Another paper showed how deep winter mixing provides the excess phosphorous required to support large cyanobacteria blooms and that the summer weather controls the details of the summer bloom. The importance of the winter mixing provides the mechanism to explain the observed correlation between the NAO and cyanobacteria blooms. In other Baltic applications the models provided the circulation and phytoplankton biomass required to support a stage resolving model of copepods (Figure P1) and to simulate interannual variability in the drift of cod larvae. In the North Sea such a model was used to provide an estimate of the 'state of the ecosystem' for 2000 and 2001. The state included estimates of the annual primary production,

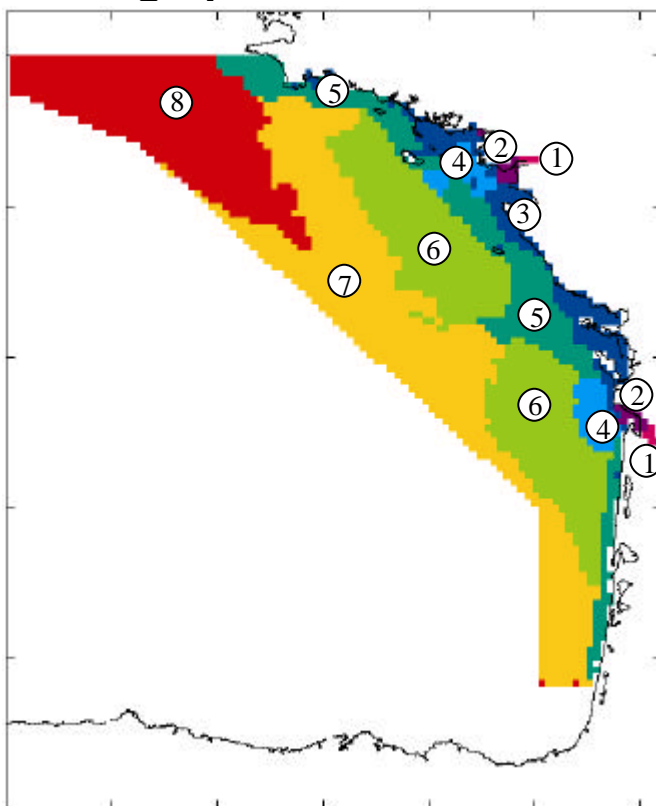
phytoplankton biomass, oxygen levels, and the state of eutrophication. The model was also used to estimate the impact of a 30% reduction in nitrate input from land-based sources.

Single-species models and other models

The quest for simple models that capture the essential dynamics and provide explanatory power was well represented in the Session. In the Bay of Biscay, circulation model output is being analysed using statistical techniques in a search for characteristic patterns in the physical environment (Figure P2). If the patterns can be simply related to the physical forcing (e.g. winds, river runoff) then this can be used in the interpretation of biological data and to hindcast the physical environment in times when sufficient information is not available for numerical model simulation. On the Scotian Shelf, a simple model was able to capture the qualitative features of the spatial structure of the plankton community and recent changes in the plankton community structure.

Substantial progress in modelling a single species can be made using detailed circulation models without explicitly modelling the rest of the ecosystem. Biological processes such as growth, mortality, and predator-prey interactions can be parameterised. A biophysical model of anchovy

Geographical entities



1. high estuary,
2. low estuary,
3. coastal,
4. river plume,
5. near coastal,
6. central shelf,
7. open shelf,
8. north-western shelf

Each region (group) is related to a specific type of hydrological succession during the period March-June.

Figure P2. Zonation of the continental shelf of the Bay of Biscay. (From: *Benjamin Planque, Pascal Lazare, and Anne-Marie Jégou: Interannual variability in spring hydrological changes. A method for typological classification and an application to the Bay of Biscay continental shelf. CM2003/P:30.*)

recruitment in the Bay of Biscay has provided simulated recruitment indices in reasonable agreement with the ICES assessments for 1997/1998/1999. Simulated stock-recruitment relationships for haddock in the North Sea were shown to be very sensitive to the assumed settlement dynamics, highlighting the need for improved understanding of this life stage. In the Baltic, simulated drift and temperature-dependent growth of *Pseudocalanus* shows increased advection out of the Bornholm Basin in the 1990s relative to the 1980s, consistent with the observed decrease in *Pseudocalanus* population in the 1990s.

The use of individual-based models for simulation of zooplankton and larval fish continues to be widespread. There is active research in the techniques for simulating the interaction of spatially variable turbulence with particles and for efficient ways to incorporate the interaction of the individual with its environment. The models of physical-biological interactions are being very successful and are widely used. However, some caution is called for when one considers the massive differences in scale between the environment perceived by a larval fish (or a zooplankton) and that explored by our sampling (and modelling) techniques. The resulting uncertainties need to be carefully considered when using simulations to search for relationships between the environment and larval fish growth and mortality.

Basic biology and physical-biological interactions

Marine ecosystems are complex entities and the field of physical-biological interactions is still an emerging field. As such observations are an important source of new ideas and fundamental information. The studies ranged in scale from single eggs to entire ecosystems.

At the scale of individual organisms, it was shown that sardine eggs readily adapt to the local fluid density, whereas anchovy eggs do not (this affects the vertical distribution of the eggs). The difference is the volume of the perivitelline space. Mackerel larvae in the Bay of Biscay show increased growth and condition with increases in wind speed for low wind speed; consistent with the theory on turbulence mediation of prey encounter rates.

The U.S. GLOBEC program on Georges Bank continues to provide interesting information on physical-biological interactions. In the Gulf of Maine, there are two sibling species of *Pseudocalanus* that are practically identical morphologically, but distinct genetically. They have different but occasionally overlapping patterns of seasonal abundance. Here it was shown that one species prefers the upper water column and one the lower; this probably leads to the different patterns of abundance. New sampling techniques allow an assessment of both the total zooplankton biomass and the copepod abundance. The comprehensive data set collected in the Gulf of Maine may force a reassessment of the roles of large scale physical forcing and local plankton dynamics on the plankton community.

At the population level in the eastern Baltic, it was shown that phytoplankton population strength was more related to nutrient dynamics whereas zooplankton dynamics is more related to hydrological conditions, and that sprat spawning and recruitment success is mainly governed by climate variability such as winter severity and wind direction.

Frontal zones are widely accepted as areas of persistent accumulation of organisms at all trophic levels. It is widely assumed that planktivorous fish aggregate near fronts to take advantage of the high levels of plankton. However, the hypothesis is difficult to prove. A combination of observed hydrographic parameters and model output was able to explain up to 50% of the variance in the clupeoid data from North Sea survey cruises in the 1990s. The importance of various types of frontal zones was supported by observations in the Gulf of Riga (Baltic), and it was argued that the high density of organisms at intermediate and higher trophic levels in frontal zones should be taken into account when designing monitoring programmes which are expected to track ecosystem productivity.

At the level of entire ecosystems there were two interesting results. Off the coast of Western Australia, the apparent biological desert of the warm Leeuwin Current was shown to be moderated by high productivity along the coast during the summer upwelling season and by high productivity at the base of the Current. On the Faroe shelf, the cod stocks appear to be limited by the carrying capacity of the shelf, as the cod recruitment is tightly coupled with the phytoplankton production.

The renewal of the deep waters of the Baltic

The renewal of the deep waters of the Baltic with inflows from the North Sea is important for the Baltic Sea ecosystem as the inflows provide high salinity and oxygen levels which are important for many species. The 1993 renewal event (the first after 17 years of stagnation) was simulated with a 3D circulation model to investigate the spatial extent of the spreading.

In the Bornholm Basin, the spreading patterns of a series of renewal events in 2002/2003 were described, based on monthly cruises. These renewal events provided the background for observations using a Video Plankton Recorder of how the differing hydrographic and oxygen levels play an important role in controlling the volume of water accessible to reproducing female *Pseudocalanus* spp. Oxygen levels were also shown to be important to the vertical distribution of sprat and herring. The vertical temperature gradient (rather than absolute temperature) may also be important.

Anthropogenic influences on the environment

In a global study of the forces driving changes in biomass yields in 29 Large Marine Ecosystems (LMEs) it was shown that fishing effort was the principal forcing mechanism in fourteen cases, eutrophication in one, and climate in thirteen. In the cases where climate was the

primary mechanism, fishing effort was a secondary driver.

Based on the results of the comprehensive coupled circulation and ecosystem models, the expected response to reduced nutrient loadings from the rivers will be different in the North Sea and Baltic Sea because of differences in the physical/chemical/biological environment. On a much smaller scale, a study of the

Vistula Lagoon in the Baltic showed that the recent changes in land use patterns have improved metrics such as biological oxygen demand but have not had a major impact on the plankton community. The introduction of the North-American polychaete *Marenzelleria* into the Baltic is a reminder that shipping-induced bioinvasions are an important source of anthropogenic forcing on the environment.

Theme Session Q

Regional Long-Term Changes in the Spatial Distribution, Abundance and Migration of Pelagic and Demersal Resources

Conveners: Carmela Porteiro (Spain), Colin Bannister (UK), and Dave Reid (UK)

Background

As stocks of key commercial species decline and fisheries are subjected to strong management measures, including closed spawning and juvenile areas, assessments are deteriorating, due to the declining quality of fisheries data and the reduced availability of samples from the closed areas. Assessments and the monitoring of recovery plans will therefore be increasingly dependent on the results of survey series. Also, as stock abundance declines, spatial patchiness, and the likelihood of changes in the distribution of species due to species interactions and climate change, become increasingly important.

In order to address these issues, contributions were invited on:

- The spatial distribution and heterogeneity of abundance of individual species among areas, using survey data and fisheries logbook data.
- How the spatial distribution and heterogeneity of abundance of individual species change through time.
- Evidence for the occurrence of environmental shifts by comparing changes in relative abundance across species within regions, and within species across regions.
- The implications for assessments and for the monitoring of a recovery plan.

Presentations

The Session covered a wide range of types of research within the broad theme of long-term distribution and migration change. In general terms presentations were divided as follows:

Spatial distributions and change

A global overview of the changes in wild fish stocks and the broad pattern of decline and area reduction, as well as some controversial solutions, was presented. Changes and stability in the spatial distribution of stocks and, of particular sections of a stock e.g., juvenile vs. adult fish, were also demonstrated.

An important conclusion was that analysis of long-term distributions can reveal changes that fail to be emphasised when looking in short temporal windows (e.g. < 10 years). It also showed that, while abundance distribution may not change, there can be substantial changes in the population make-up and biology within those areas.

Migration changes

Changes in recent years in relation to changes in current path, and a dramatic change in mackerel migration in the NE Atlantic based on commercial data, were demonstrated.

Vertical distributions

Changes in vertical fish distribution and particularly their impact on survey analysis were presented. This emphasises the fact that distribution change is generally seen in a geographical sense, but that vertical distribution changes can have profound impact.

Small spatial scale studies

Presentations emphasised the need to observe fine-scale distributions of fish in enclosed waters (fjords). The main observation tool was acoustics. Fjords can represent major refuges or nursery areas and should be emphasised in the future.

Methods for studying distributions

The value of resource mapping was emphasised, both GIS-based analysis and mapping with variography. The need to map the biological variability in a stock and to understand the variability between years was emphasised. Both methods have broad relevance to many distribution studies.

Population dynamics

Presentations on population dynamics in relation to spatial distributions demonstrated the importance of considering changes in the basic population dynamics underlying the observed changes in distribution. This raises the question of whether the changes in distribution or the changes in dynamics are the primary factor.

Biodiversity issues

These studies shifted the focus from the generally monospecific distributions presented in the earlier papers to the issue of changes in distribution of many species in the same observation window. The major point was that similar or complementary changes in many stocks can emphasise a functional trend. The importance of non-commercial species was also emphasised. Many of the routine surveys are able to deliver data on these species, and the value of these data should be emphasised.

Posters

The seven posters addressed most of the topics described above and confirmed many of the conclusions described.

Conclusions

The Session showed that there was considerable interest in long-term changes in distribution and migration. This should be seen, particularly in the context of climate change. Implicit in many of the stock assessment surveys and methods is the assumption that there are no major changes in distribution or migration. This Session has emphasised the need to consider both distribution and migration changes in this context. An important conclusion was the need to look over as long a time period as possible. There is a tendency in the community to perceive the last decade as being the “norm”, notwithstanding our awareness of climate change. Studies over a multi-decadal time span show that such perceptions can be seriously flawed or at least

misleading. The need to consider changes in components of the stock was also clear, e.g. juveniles *vs.* adults, and also to consider vertical as well as horizontal distribution changes. Both of these emphasise the observation that long-term changes are comprised of more than just abundance decline (generally) and distribution change in time and space.

Finally, the impression gained was that there was a good body of work in this area currently being carried out. However, the approaches were diverse, and no obvious standard tools were yet available. One result of this was that direct comparison between different pieces of work would be difficult, and application directly to management decisions would tend to be *ad hoc*. A coherence of approach and output would be a clear advantage and should be encouraged. Much of the work was of direct relevance to subject area, and the strong interest in this Session reflected the importance of the field.

Theme Session R

Freshwater and Diadromous Fishes in the Baltic Sea

Conveners: Toomas Saat (Estonia) and Erkki Ikonen (Finland)

Background

The Baltic Sea is one of the largest brackish water basins in the world. Due to its very low salinity, freshwater species can survive there. However, this low salinity, even in the Baltic Proper, decreases the survivability of marine species. In addition to diadromous species, many freshwater species are common and abundant in the brackish water of the Baltic Sea. They constitute a permanent and important component of the coastal ecosystems of the Baltic Sea. Some of these species (pikeperch, pike, perch, several cyprinids) are important for the commercial and recreational fishery. Some have been recently included among the species for which populations have to be monitored in the sea by the EU member countries. Traditional stock assessment methods are often not applicable for freshwater species, especially as they will be too expensive in comparison with the value of catch due to complex stock structures.

Presentations

Diadromous species

Hatchery-reared salmon, a strain originating from the Neva River, were studied by smolt tagging in the Estonian rivers in the Gulf of Finland. Tag recapture rate was found to be very low, varying between 0 and 5%. The main reason for the weak result was estimated to be high post-smolt mortality. Short feeding migration, mainly restricted to the Gulf of Finland, has been typical for this salmon strain. However, in this experiment a significant part (45%) of feeding salmon were caught in the Baltic Proper during the second year after release. This suggests that feeding grounds in the Gulf of Finland have deteriorated so much that the major part of Neva salmon post-smolts meet with high mortality, and only migration out from the Gulf to the Baltic Proper offers enough food for survival.

Tagged Neva salmon smolt were also compared to the widely-migrating salmon strain originating from the River Tornionjoki, which discharges into the northernmost part of the Gulf of Bothnia (Subdivision 31). Two-year-old Tornionjoki salmon and Neva salmon smolts were reared, tagged, transported, and released in the Kymijoki mouth in 1998 and 1999. Their life history before entering the sea was similar within both strains. Tag recovery percentages of Neva salmon varied between 1 and 3%, while tag recoveries from the Tornionjoki salmon releases were 9-12%. The yield given by 1 000 released Neva salmon smolts varied between 50 and 200 kg, while in Tornionjoki salmon the yield varied between 500 and 700 kg. Also in this

experiment feeding fish of both strains were mainly caught in the Baltic Proper.

This suggests that Neva salmon, which has been shown to be a genetically short migrating strain feeding mainly in the Gulf of Finland area has lost the good survival rate observed from the 1980s to the mid-1990s. The wide-migrating salmon strain (Tornionjoki) has typical feeding grounds in the Baltic Proper and when released in the Gulf of Finland, these post-smolts migrated to the Baltic Main Basin and did therefore not suffer from high post-smolt mortality.

The reason for the changed nature of salmon feeding grounds in the Gulf of Finland is not clear but the evidence suggest that it is a question of changed ecosystem and especially the food web of salmon post-smolts. Large-size marine plankton species are less common nowadays in the Gulf of Finland and abundance of 0+ herring and sprat in the Gulf is poor compared to the Baltic Proper, where abundance of marine plankton and young herring and sprat is much greater.

It was shown that both sea temperature and river temperature affected salmon spawning migration time in the River Dalälven in the period 1960-2002. The river mouth opens into the Bothnian Sea (Subdivision 30). It was shown that the timing of the spawning migration highly correlates with sea temperature, in the southern Main Basin. Depending on seawater temperature in April, May, and June, the timing of the spawning migration may vary 18-20 days. Higher seawater temperature induces an earlier run. It was also seen that seawater and river temperatures were highly correlated and therefore large-scale climatic processes determine the temperature regime in the Baltic Sea region. Female salmon migration time showed stronger correlation to temperature compared to males. It was shown that females enter the river 14 to 18 days earlier than males. The discharge of the River Dalälven had no effects on the timing of migration, and the entering time was not correlated with the ovulation dates of females.

This suggests that seawater temperature and the timing of the salmon run could be used in predicting the size of the salmon run. This kind of tool might be very useful for salmon fishing management purposes.

A tagging experiment using the delayed release technique, in which salmon smolt were kept in net pens for three months before releasing, was carried out on the Danish islands of Bornholm and Møn in 1995-1999. A total of 600 000 salmon smolt were released of which about 2% were Carlin-tagged. The aim of this experiment was to study possibilities to increase the harvesting potential of reared salmon near release sites and at the same time decreasing the fishing pressure on wild

salmon. The tag recovery percentages for the Bornholm experiment was 15.8%, and for the Møn experiment 9%.

Tag recoveries were obtained from the Baltic Sea (97.5%), the rest were caught in Kattegatt and the Atlantic Ocean and, in part, in freshwater. Straying to the Swedish west coast rivers was studied and results show that seven tagged salmon were caught in these rivers. When scaling these findings according to the total number of releases a rough estimate suggests that less than 800 salmon entered these rivers, mainly the river Göta. A clear increase was detected in the proportion of catches being made near Bornholm. This delayed release technique resulted in a higher post-smolt survival compared to traditional releasing techniques, thus resulting in more harvestable fish. However, homing of salmon released by this technique is weaker compared to traditional releasing techniques. Therefore, strayers that enter rivers with a weak salmon population may cause genetic changes in these salmon populations.

In a study of the likely origin of ascending salmon with a malformed dorsal fin in the River Umeälven it was demonstrated that dorsal fin damage is very common during smolt rearing. Salmon smolts released in the River Umeälven have always been adipose fin-cut, but the salmon with malformed dorsal fins had normal adipose fins. The likely origin of these strayers was studied using mtDNA and six microsatellite loci. The results indicated that a considerable part of these fish originated from the releases in River Ångermanälven and River Luleälven. It was estimated that 10-12 strayers from these two rivers annually enter the River Umeälven. Releases in the rivers Ångermanälven and Luleälven were made 10-15 km upstream of the mouth. However, these fish suggest quite a high straying behaviour. This amount of straying might change the genetic structure salmon in the case of a very weak salmon population.

In the Kymijoki River, in 1980, the salmon run was estimated at 100 000 individuals and the present run is probably a bit greater due to improved water quality in the river. However, catches have been quite small. Low catches are most probably related to the difficult fishing conditions in the strong currents. The low appreciation of the value of lamprey in the region may have decreased the fisheries for this species. Nevertheless, during the most recent years marketing of lampreys has not met with difficulties.

Monitoring of coastal fish and fisheries

Freshwater fishes represent an important component of fish assemblages in many coastal areas of the Baltic Sea, and in several countries they are intensively exploited both by the commercial and the recreational fishery.

In an overview on monitoring of the coastal fishery in Sweden specific attention was paid to stock identification. Data on fisheries yield are gathered from logbooks, an enlarged EU sampling programme, and fishermen's reports. As in other Nordic countries, recreational fishery is of great importance, and a new programme to gather data on the recreational fishery was

initiated in 2003. The importance of fisheries independent data for management was stressed. For example, mark-recapture data was used to validate inquiry data from a pikeperch fisheries.

Fisheries-independent data (monitoring with gill nets) and improvements of the existing system, elaborated in Sweden and adopted by HELCOM (and widely used in Sweden, Finland, and Estonia) showed that stratified random sampling with Nordic multi-mesh size gill nets better reflects the true species composition of coastal assemblages and size spectrum of fish than the existing system. An overview on coastal gill net monitoring in Estonia, which is conducted yearly in seven permanent research areas, and improvements to the existing system applied here (random sampling, enlargement of the mesh size spectrum, etc.) was presented. In conclusion, it was stressed that any modifications to the existing system must be undertaken with care so as not to lose the existing long-term data series. Due to high selectivity of gill nets, additional sampling methods (seining, etc.) seem valuable.

Analysis of long-term changes in coastal fish assemblages and populations, and spatial distribution of fish showed that long-term changes in freshwater fish assemblages and populations in the Baltic Sea are induced by different factors, both anthropogenic (fishery, eutrophication, pollution, uncontrolled stocking, introduction of alien species) and natural (temperature changes, abundance of predators).

Freshwater species

Data from laboratory experiments have revealed that growth of pikeperch and perch in brackish water is better than in freshwater at higher summer temperatures (~20°C), which is probably related to seasonal migrations of these species between the freshwater Curonian lagoon and brackish water. It was also shown that the embryonic development of gibel carp is enhanced in brackish water, and salinities along the Estonian coast do not limit the reproduction of this alien freshwater species. Explosive distribution of gibel carp in coastal waters of Estonia in recent years is probably due to high water temperature in recent summers and low abundance of predators.

Conclusion

It is clear that the importance of freshwater and diadromous species in the Baltic Sea is very high. Due to low salinity, marine species are scarce and therefore, diadromous and freshwater species play a remarkable role in the Baltic Sea fishery. The decreasing status of some marine species increases the importance of freshwater species. Also, the development of market prices suggests that the value of these species is increasing. These species play an important role in the ecosystems of the Baltic Sea and therefore they are good indicators of changes in the Baltic ecosystem.

Theme Session S

Ecosystem Consequences of Cyanobacteria in the Baltic Sea

Convener: Markku Viitasalo (Finland)

Background

Cyanobacteria blooms belong to the most alarming signals of the changing status of the Baltic Sea. While the cyanobacteria have occurred in the Baltic during its present brackish-water stage (ca. 7000 years), it is assumed that their frequency, duration, and spatial coverage have increased along with eutrophication. Global warming and its potential consequences – increases of water temperature, precipitation, and freshwater runoff – may also make conditions more favourable for the cyanobacteria. However, relatively little is known at present about the impact of cyanobacteria blooms on the ecosystem as a whole, especially about their effects on the highest trophic levels, i.e. the fish. In addition to reports on case studies, the Session welcomed modelling and theoretical studies from the Baltic as well as other marine ecosystems.

Presentations

During the phenomenal cyanobacteria bloom 2002 on the Estonian flounder stocks, flounder catches were small, but after the bloom the adult flounder catches increased again, suggesting that these had migrated into deeper water during the bloom. In contrast, one-year-old flounder practically disappeared that year. This suggests that, since the young flounder mainly feed in shallow waters, they may be more strongly affected than the older ones. This is in keeping with the fact that the highest nodularin concentrations found in Baltic fish are found in flounder (Kankaanpää, Sipiä et al.). This is probably due to flounders feeding on blue mussels, which accumulate cyanobacteria toxins through their filtering activity.

An evaluation of the effects of the cyanobacteria-exposed food web on two planktivorous animals, a fish larva (pike, *Esox lucius*), and a mysid shrimp (*Neomysis integer*) showed contrasting results. The growth of pike larvae was slower when larvae were fed with zooplankton exposed to cyanobacterial filtrates, despite the fact that the fish had no direct contact with cyanobacteria. Parallel results have recently been found for herring larvae. In contrast, no effect on mysid growth was observed. This shows that the cyanobacteria effects found in one species cannot be directly generalised to others, even though they would be utilizing the same resources.

Allelopathic effects of Baltic cyanobacteria on other phytoplankton species demonstrated that the Baltic cyanobacteria have negative effects on certain phytoplankters, and that allelopathy may affect phytoplankton succession. The known hepatotoxins are probably not involved in the allelopathic effect, since the non-hepatotoxic *Aphanizomenon flos-aquae* had a stronger effect than the toxic *Nodularia* strains.

Conclusion

The Session gave interesting new information on cyanobacteria effects in the Baltic. The scarcity of submissions dealing with ecosystem effects of cyanobacteria can be taken as an indication of the paucity of information on their effects on a system level. In this sense the marine research lies behind that done in the limnetic ecosystems. The indirect and sub-lethal effects of harmful algae remain to be more thoroughly studied.

Session T

On the State and Stability of the northern North Atlantic: Patterns and Trends

Conveners: Alicia Lavin (Spain), Harald Loeng (Norway), and Tom Rossby (USA)

Background

The objective of this Session was to provide a forum for a survey and discussion of our knowledge of the northern North Atlantic, including the Nordic Seas.

Presentations

The ten papers scheduled for presentation spanned a wide variety of topics: environmental factors that affect recruitment of gadoids, long-term variability of water mass characteristics and water mass transport, connections between wind-stress curl variations and transport, and the possibility of lunar forcing of high latitude climate.

While the Session was shorter than hoped for, there was broad agreement that the papers were of high quality and relevant to the ICES community. There certainly exist other forums where physical oceanographers can present and discuss their research, but only the ASC provides an opportunity for a direct dialogue between physicists and the ICES community, a dialogue that will surely continue to strengthen given the growing interdisciplinary character of marine research.

Environmental factors that affect recruitment of gadoids

In this spirit a couple of papers addressed physical conditions that may affect spawning and recruitment of gadoid species on the North Atlantic. While these two extensive studies noted that certain areas (the North Sea and the Grand Banks) exhibited greater levels of recruitment success than others, they noted that other factors such as water temperature and winds can also influence the level of recruitment success. Often, the correlation with physical parameters could be expressed in terms of the NAO index. Interestingly, not only temperature but also temperature variability could influence growth rate and recruitment success pointing to more complex or subtle physical mechanisms at play in controlling the reproductive lifecycle of gadoid species. We can anticipate the further development of interdisciplinary studies of this type.

Long-term variability of water mass characteristics and water mass transport

Two presentations addressed the hydrographic state of the North Atlantic in two areas, the northern North Atlantic and the southern Bay of Biscay. Both studies examined the long-term variability of water mass characteristics, from a general climate point of view as well as with respect to how these may impact fish stocks. Significantly, both studies brought out the enormous value of tracking environmental conditions on inter-annual, decadal, and longer time scales. Every effort should be made to continue these. Increasingly, we are seeing greater attention given not only to the state of the ocean and changes over time, but also to the circulation of the ocean, i.e. fluxes and their variability. Knowledge of transports can help shed light on why changes in the hydrographic state take place. Not always or necessarily directly, but as constraints that need to be understood and included in numerical syntheses of ocean circulation. For example, to what extent do changes in hydrographic conditions result from advective versus diffusive processes? – an old and continuing ambiguity that direct measurement of currents can help to resolve. One study, of the Gulf Stream, noted that variations in Gulf Stream transport were significantly smaller than what has been reported in the past, perhaps due to inadequate sampling (Figure T1). Another study focused on the leakage of freshwater transport from the East Greenland Current into the Greenland and Norwegian Seas. Quantification of these fluxes is extremely important for a proper understanding of the mechanisms and rates at which dense waters are produced in the Nordic Seas. If fresh waters can suppress the production of dense waters, the supply of salty waters from the south can enhance deep-water production.

A re-examination of the overflow of dense water from the Faroe-Shetland Channel into the Rockall Trough established much larger rates of overflow across the Wyville-Thomson Ridge than previously estimated. This study, which is preparatory to a longer programme to monitor overflows directly, highlights several important points: first, that assumptions about what we think we know about the ocean are always subject to review and revision; second, that direct and continuing measurements can help remove uncertainties (and biases) due to inadequate sampling; and finally, and more specifically, that the overflow of dense waters may have a significant influence on the remarkably deep mixed layer structure of the Rockall Trough region.

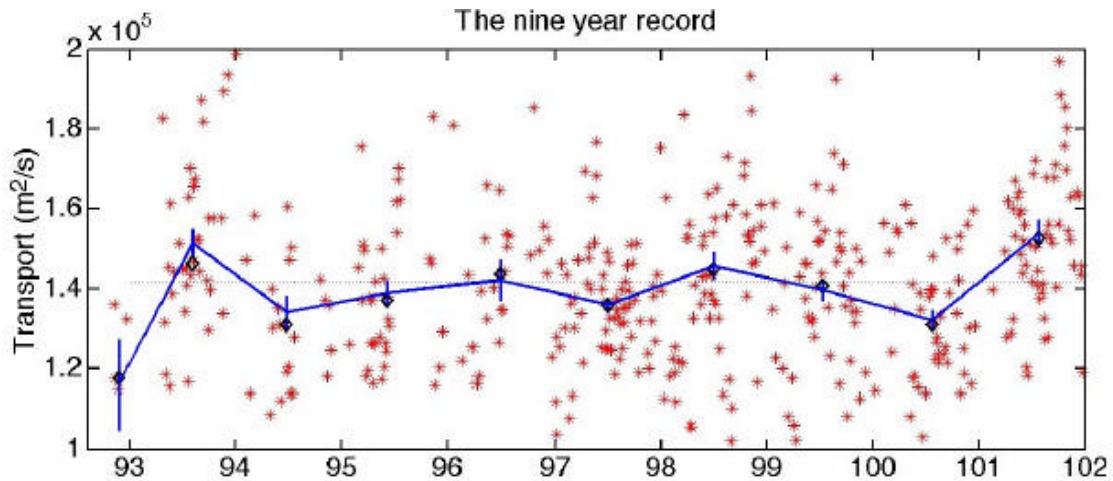


Figure T1. Measurements of Gulf Stream transport at 52-m depth from 1993 to 2002 (93 to 102). The solid line shows annual averages. (From “Spatial and Temporal Modes of Variability of the Gulf Stream in the NW Atlantic” by Tom Rossby. CM 2003/T:06).

Connections between wind-stress curl variations and transport

A very interesting presentation showed a tight correlation between wind stress curl in the North Atlantic and mass transport at the Svinøy section in the Norwegian Sea (with a 15-month lag). Even if, at this point, the mechanism needs to be better understood, the finding points to the possibility of forecasting transport variations in the Norwegian Atlantic Slope Current, one of the two major inflows into the Norwegian and Nordic Seas. Another paper focused on the transport of warm water flowing into the Norwegian Sea between Iceland and the Faroes (this is the other major branch of warm waters flowing into the Norwegian Sea). Whereas the previous presentation noted significant variations in transport related to wind stress curl, this presentation emphasized the remarkable stability of the transport with little or no seasonal variation. The differences in their variability may in part be attributed to their very different properties; the first one is significantly barotropic whereas the latter one is highly baroclinic, but these are questions worthy of further study.

Conclusions

The presentations addressed a number of topics of interest to the ICES community. Interestingly, not only hydrographic conditions were discussed, but also fluxes and processes that can help condition or alter the state of the ocean. In the past, we have per force focused on the state of the ocean and as it shifts, gradually or suddenly, attempted to back out what processes might have been responsible for the observed changes. In more recent years there has been an expanding effort to measure transports directly. This expansion is likely to continue, particularly at high latitudes in the North Atlantic where the dynamic method by itself fails to capture the substantially barotropic and topographically steered flow patterns. This is essential for a quantitative description and understanding of mass, heat and freshwater fluxes, all of which play an important role in defining the state and stability of the ocean.

Theme Session U

The Scope and Effectiveness of Stock Recovery Plans in Fishery Management

Conveners : Paul Connolly (Ireland), Colin Bannister (UK), and Jean-Jacques Maguire (Canada)

Background

This Theme Session reviewed the origin, structure, and implementation of recovery plans for a wide range of stocks and locations in order to provide the opportunity to identify their common features and the factors relevant to success. The ultimate aim was to provide a historic record, and to develop the basis for guidelines on recovery planning.

Invited Lecture

The Session was linked to the Plenary Invited Lecture by John F. Caddy, titled "Recovery Plans for Depleted Fish Stocks: an Overview of Global Experience". The invited lecture and the two sessions, comprising a total of 12 presentations and two posters, were extremely well attended, and provoked substantial discussion which later feedback suggested was widely appreciated by participants, including non-specialists.

The Plenary Invited Lecture was based on a search of the primary literature, the grey literature, and the world wide web, and covers mainly the period since the 1990s. In many cases the literature is incomplete, especially on management issues that tend not to be in the public domain. It was noted that recovery plans started with rare terrestrial organisms, but are now dominated by marine fish stocks. Early examples were pelagic fisheries, which were closed and which tended to recovery quickly, whereas most of the recent examples refer to a range of groundfish fisheries where success has generally been very poor. The examples included in the Session presentations ranged across herring in the Celtic Sea and the Norwegian sea, cod in the Northwest Atlantic and in the North Sea and Irish Sea, groundfish in New England and other areas of the United States, and North Atlantic salmon.

Presentations

There was considerable similarity between the relevant factors identified by Caddy and those identified in the Session presentations. The early pelagic stock recovery programmes appear to have been successful because it was easier to close and divert fishing effort from single-species fisheries, and because recovery was aided by rapid increases in recruitment, possibly aided in some cases by favourable environmental conditions. The failure in the demersal stocks is partly because the initial measures were inadequate, or were taken too late, or have been undermined by mixed fishery issues, the failure of output controls and technical measures due to compliance issues, or by environmental variation and ecological changes. Predicted recovery times for severely depleted

demersal stocks tend to be prolonged, on the order of a decade or more, perhaps because long-lived slow-growing demersal species require a significant age structure to bridge across periods that are unfavourable for recruitment. Thus, the cod stocks in Canada show little or no signs of recovery despite a ten-year moratorium. Demersal stock recovery plans based on retrospective analysis invariably suffer from problems of overestimation, which together with the combination of misreporting and estimation uncertainty in the most recent year of an assessment, make it difficult to monitor recovery effectively in the short term. This emphasises the need for credible fishery-independent monitoring methods.

Failure appears to be particularly likely in the case of straddling stocks, where the effectiveness of implementation depends heavily on achieving consensus across divergent national and gear/fleet segments. Discussions indicated that in this context the themes of distrust and criticism of the science by stakeholders were remarkably similar on both sides of the Atlantic and Pacific oceans. Caddy suggested that from the scientific viewpoint it was essential to change human behaviour towards a culture of sustainability, rather than a culture of harvest, and that this was most likely to be achieved when the criteria for action, and the recovery plan objectives, are pre-agreed in the legislation. Further, he suggested that the present problems would be reduced if action was taken much earlier, and that implementation was made more secure by using robust non-discretionary harvest control rules that achieve a significant immediate reduction in catches rather than by a gradualist approach to protect short-term economic interests, which simply prolongs the recovery time. It could also be suggested that since there is no absolute certainty that recovery will occur, it might be better to use the term 'emergency plan' rather than the term 'recovery plan' (which implies that recovery will occur).

Conclusion

As ever in fisheries management, the overarching causes of failure seem to be a combination of management implementation, coupled with scientific issues such as concern about the precision of many age-structured stock assessment procedures, and the frequent difficulty of distinguishing between fishing, environment, multispecies interactions, and non-fishery factors (e.g., seal predation, seismic surveys, gravel extraction) as causes, which can be used by stakeholders as reasons to impede implementation that is truly precautionary.

Theme Session V

Mixed and Multi-Stock Fisheries – Challenges and Tools for Assessments, Prediction, and Management

Conveners: Laurie Kell (United Kingdom), Walter Crozier (United Kingdom), and Christopher Legault (USA)

Background

Fleets and fisheries that harvest multiple stocks, and stocks harvested by multiple fisheries, face a number of complexities. Less productive stocks in a mix of stocks may suffer unsustainable mortality, while more productive stocks continue to support sustainable catches. Stocks harvested together may be at a very different status relative to safe biological limits, which would make different harvest strategies necessary in the same fisheries. Where fisheries take multiple stocks of the same species, uncertainties about allocating catches to stocks present special assessment problems. Projections to guide advice on effort levels appropriate for different stocks in the harvested complex can also thwart traditional approaches, management strategies produce results that are either incompatible across stocks or not straightforward to apply. Therefore, the objectives for this Theme Session were to describe developments in assessment, and projection methods for multi-stock and multi-fleet fisheries, and to discuss opportunities for applying new concepts more widely.

Invited Plenary Lecture

The Session was prefaced by a plenary lecture given by Randall Peterman (Canada), entitled “Possible solutions to some challenges facing fisheries scientists and managers”, in which he posed six challenges that we had to face when dealing with fisheries in general and mixed fisheries in particular. These were:

- Pervasive uncertainties
- Probabilities for uncertain quantities
- Time-varying parameters
- Evaluating management options
- Communication Management
- Objectives and tradeoffs

Peterman pointed out the benefits of using simulation to evaluate the robustness of management to the wide range of uncertainties encountered. He also emphasised the importance of providing scientific advice in a way that can be correctly interpreted by stakeholders.

Summary of presentations

A total of 23 papers were presented at the meeting. These dealt with mixed and multi-stock fisheries including those for whales, bluefin tuna, Baltic and Atlantic salmon, while assessment and management of mixed species fisheries were also addressed in a number of presentations.

A number of case studies were presented where management organizations have been formed explicitly to deal with mixed-stock fisheries and multiple fleets and were using the simulation approach. The International Whaling Commission (IWC) has developed the Revised Management Procedure (RMP) through simulation to ensure that management is robust to uncertainty regarding the population dynamics. The management options that perform “best” over all hypothesized population dynamic scenarios were then selected. The International Commission for the Conservation of Atlantic Tunas (ICCAT) manages bluefin tuna in the North Atlantic Ocean. This species has two known spawning areas and some intermixing of the stocks, but the level of mixing is unknown. An approach, allowing assessments of the two stocks independently but then manages assuming some mixing of the stocks, is proposed. There is currently a movement towards using operational management plans for this species. This approach is already in use in South Africa where management procedures explicitly take into account the by-catch of one species in the fishery for a second species. This allows the incorporation of conflicting rights-holder preferences into the management scheme.

Challenges posed by mixed and multi-stock fisheries and some potential approaches to overcome these challenges were proposed. North Sea fisheries have been examined in terms of combining single species advice into mixed-species management. Tradeoffs among species were examined explicitly as a function of changes in effort levels of multiple fleets under explicitly stated management priorities. The approach illustrated the challenges of managing multiple fleets that catch multiple species as both directed landings and discarded bycatch. The economic tradeoffs that occur when trying to manage multiple fleets have also been examined. Additionally fisheries have also been defined as operational units based on trends in catches over time to forecast and manage mixed-fisheries. The complexity of all these situations is enormous, but relatively simple management advice approaches were recommended for each.

In another case a different approach was taken to examine the effect of fishing on multiple species through fishery-independent data. The ability to detect the effects of fishing on both targeted species and non-commercially important species was demonstrated through the use of time-series analysis. Care must be taken with this approach that an adequate baseline is available, the survey methodology is consistent over time, and the interpretation of trends is correct. A presentation on modelling fisher’s behaviour looked at implementation

error with a view to including it in the type of simulation framework that is starting to be used in ICES.

The particular problems with providing assessment information for wild salmon stocks in the Baltic Sea, where the majority of captured salmon are of hatchery origin were addressed. Assessing the status of the wild stock is therefore difficult and information is often patchy and partial. In the PROMOS project, Bayesian methodology has been developed in order to combine and synthesise information from a variety of sources, including mark-recapture data of wild and hatchery salmon, stock-recruitment data, data on catches and effort in the fisheries and smolt abundance data. The output of the mark-recapture analysis and a hierarchical meta-analysis of stock/recruitment data provides information on fishing mortality rates and the stock/recruit function, which are used as informative priors in an age-structured life history model (Figure V1) fitted to catch and smolt abundance data, to estimate the status of wild salmon in the Baltic Sea. A particular challenge remains for the estimation and prediction of the sizes of wild smolt runs, with actual smolt census taking place on only two rivers. A combination of three models utilising data on parr (survey) abundance, smolt mark-recapture data, and life history parameters (parr to smolt relationships) improves the precision of smolt run estimates and should enable probabilistic forecast of upcoming smolt runs.

An overview of the mixed-stock fisheries for Atlantic salmon included a case study of the assessment and catch advice procedure for the West Greenland mixed stock fishery. The challenges of providing catch advice for this

fishery (which potentially exploits stocks from many hundreds of rivers in N. America and southern Europe) were outlined and the risk framework used to develop the catch advice was explained. Several developments likely to improve the assessment and management of mixed-stock fisheries for Atlantic salmon were outlined. These included development of a decision structure for fisheries management by NASCO, application of genetic analysis techniques to identify stock composition in distant water and coastal mixed-stock fisheries, and modelling of recovery trajectories in salmon stocks of different productivity under different exploitation scenarios.

In the SALMODEL project Bayesian hierarchical modelling has been adopted to develop conservation limits for Irish fishery districts, as an alternative to the present method, which utilises a catch-based pseudo stock-recruitment technique at district level and which is subject to bias because of portions of the district catch originating in other districts. Management of the distant water mixed-stock fisheries at West Greenland and Faroes requires forecast of the pre-fishery abundance (PFA) of the stock complexes contributing to these fisheries and progress with developing PFA forecast models for European stocks was described. The difficulties of developing PFA forecasts for these stock complexes lie in obtaining satisfactory indices of either parental stock of juvenile production, and in identifying environmental or other factors that influence cohort survival up to the PFA stage.

A Monte-Carlo approach has been used to derive probabilities of achieving spawning requirements in

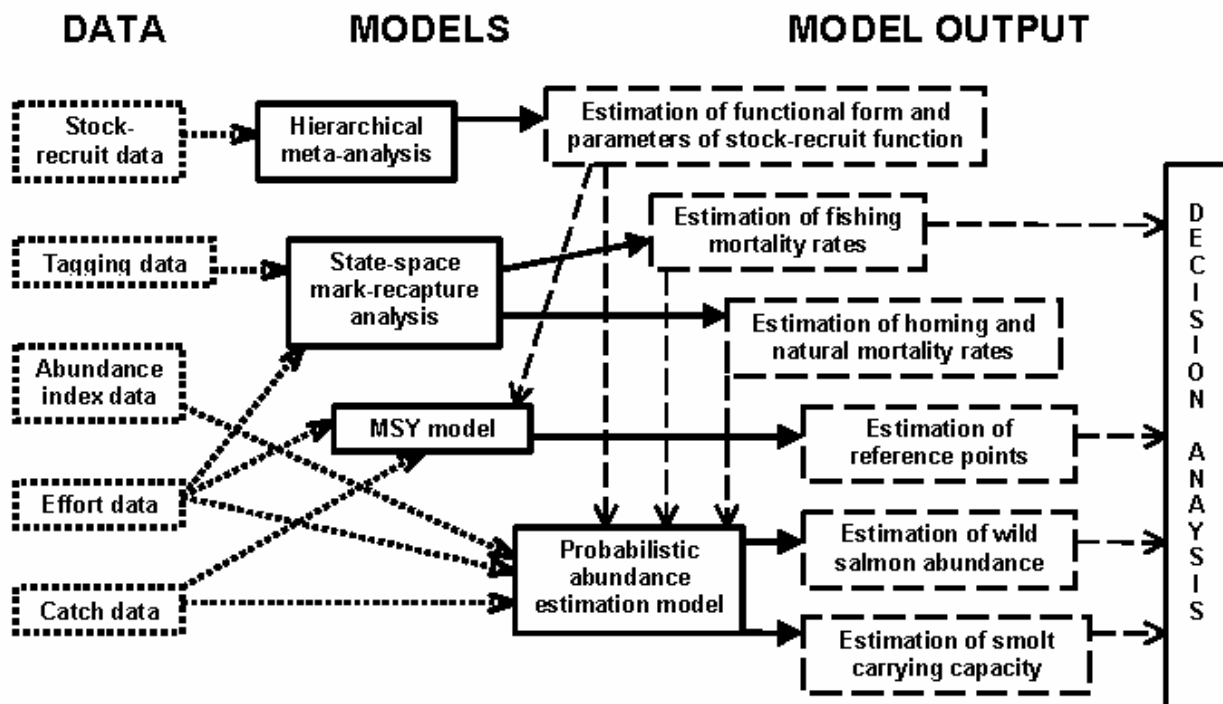


Figure V1. Overview of the current assessment methodology for Baltic salmon. (From “Assessment of Wild Baltic Salmon Stocks: How To Combine Different Sources Of Information” by Catherine G.J. Michielsens, Murdoch McAllister, Sakari Kuikka, Tapani Pakarinen, Lars Karlsson, Atso Romakkaniemi, Ingemar Perä & Samu Mäntyniemi. CM2003/V:12).

Atlantic salmon stocks of differing size and biological characteristics that are harvested together. The uncertainty of achieving spawner requirements is greater for small stocks, such that measures of performance are more variable for small stocks. Summing individual river spawner requirements into a regional requirement reduces the probability of meeting the conservation objectives simultaneously in all rivers. In particular, low productivity stocks are likely to suffer under-escapement. Case studies were developed which, in one case, modelled the degree to which regional spawner requirements for Wales should be increased to achieve spawner requirements of all 17 rivers in this region. This technique can be used to evaluate mixed-stock fisheries on a case-by-case basis.

The SALMODEL project also examined conservation of genetic variation in harvested populations of Atlantic salmon. A deterministic population dynamic model was used to examine the combined goals of maximising harvest yield and conserving effective population size in a group of populations interconnected by migration. This indicated that considerable gains could be made in effective population size in a group of populations through strategic harvesting, based on knowledge about genetic structure. However, the optimal harvest strategy varied according to relative size of populations and inter-population migration rates and directionality. This was demonstrated by a case study based on a group of populations in Western Norway, where the total effective size of a set of ten populations was dependent largely on

the effective size of one large river, which was a strong source of migrants to the surrounding rivers.

Software tools that allowed the consequences of management options to be explored are now becoming available. These include “FiSHU@LiS”, a game that could be used by stakeholders to understand the dynamics of exploited fish stocks, and tools in Excel and Visual Basic that allow fleet dynamics to be modelled.

Evaluation and discussion

The importance of communication with stakeholders was emphasised. This communication ranges from the development of specially-tailored software to explain fishery dynamics, use of cognitive psychology to explain uncertainty and risk, through to incorporation of individual stakeholder preferences in allocation of quotas for pilchard and anchovy in South African pelagic fisheries. It was agreed that it was important to ensure that the developments in science and their implications for management were explained and understood.

The management of complex systems is not necessarily going to be achieved by making the stock assessment and management more complex. Ideally, simple rules should be devised that are robust to the pervasive uncertainties in such systems. However, it was recognised that the process by which these rules could be found would in itself be complex and ideally would take the form pioneered by the IWC.

Theme Session W

Decision Systems for Eutrophication

Conveners: Markku Viitasalo (Finland) and Fredrik Wulff (Sweden)

Background

In this theme session, arranged jointly with the Session S on “Ecosystem Consequences of Cyanobacteria in the Baltic Sea”, presentations dealing with decision support systems were welcomed. Only one presentation was provided. However, the Open Lecture, given by Fredrik Wulff, was an excellent introduction to the theme.

Presentation

Simulations of the effects of reduction of river nutrient loads to the North Sea, undertaken with the biophysical model NORWECOM, demonstrate that a 50% reduction in the loads of nitrogen and phosphorous reduces the primary production by 10–30% in the southern North Sea, and by 5–10% in the Skagerrak and along the Norwegian west coast. Scandinavian rivers only contribute to 1–2% of these reductions. Also, it was noted that this reduction is less than the natural variability of the production of phytoplankton, and that the production in the southern North Sea is phosphorus

limited, while nitrogen is the limiting nutrient in the northern North Sea.

Conclusions

Modelling may be used as a tool for acquiring an early warning signal of environmental deterioration. Also, as shown by the Swedish MARE Programme, it may provide cost-effective calculations for decision-making. In the discussion it was noted that one of the most challenging tasks for the present-day ecosystem models is the description of the communities as a group of species with different – often opposite – responses to various environmental factors (such as changes in N:P-ratio). Furthermore, although the ideal would be a model applicable for as many areas and situations as possible, local environmental conditions always need to be taken into account. This is highlighted by comparing the results of the recent modelling activities that describe ecosystem responses to nutrient reduction scenarios in the North Sea and the Baltic Sea. In the Baltic Sea, for instance, the simulation of the internal loading during anoxic periods will remain an important major task.

Theme Session X

Evaluation of Fisheries Management Scenarios and the Supporting Data through Simulation

Conveners: John Simmonds (UK) and Martin Pastoors (the Netherlands)

Background

There have been a number of proposed stock recovery plans or major restrictions on fisheries implemented over the last decade (eg. Canadian cod, North Sea and Irish Sea cod, Northern hake, North Sea herring). It is essential to provide the tools to evaluate the potential benefits of a recovery plan and to understand their sensitivity to the input parameters. It is also important subsequently to evaluate whether these tools give valid projections where recovery plans have been implemented. There have also been a number of studies aimed at the evaluation of multi-annual harvesting strategies (eg. MATES and MATACs) and the influence of underlying data (eg. FIEFA, EMAS, SAMFISH and EVARES). These studies have examined a number of simulation methods and have already produced results. The Session brings together the information on both methods and results that have been produced to date.

The Session was aimed at work related to the evaluation of harvest control strategies and recovery plans. In addition to the strategies themselves, the Session served to provide a forum for discussing the influence of the data underlying the assessment models and prediction models and their influence on the main management parameters. This includes evaluation of research vessel surveys, CPUE series, landings data, and their combined influence on the evaluation of the state of the stock and setting of TACs. Investigation of the influence of different assessment and prediction models was considered.

Presentations

Evaluation and comparison between the use of different assessment models

A statistical catch-at-age model incorporating predation and or multispecies interactions was described. The method provides estimates of uncertainty in some of the parameters. Considerations regarding the plus group and evaluation of residual patterns were also provided.

Simulation methods and results for evaluating the influence of basic data in assessment models and predictions

Analysis of egg-survey data and simulation of the effects of stock distribution on catchability were presented, as was an evaluation of the contribution of different sources of information to the assessment uncertainty. The impact of error in the different sources depends on the choice of assessment model. Though a substantial part of the error in assessments is explained by sampling error in the input data, there are also other important sources of error. Where research vessel survey indices are used alone as tuning indices these tend to dominate the uncertainty in the management parameters. An evaluation of discards in the assessment of North Sea plaice provided a method for incorporating data even when only a partial time-series is available.

Simulation methods and results for harvest control strategies

Simulations on the performance of multi-annual harvest control rules were presented for roundfish and flatfish. A toolbox for examining the influence of control parameters on stock development was also described. This tool can provide good illustrations of the impact of different types of control. The suitability of the F_{pa} reference point for NEA cod and a theoretical consideration of the harvest control rules of different complexity comparing their performance against three criteria; average yield, variation in yield, and risk, was also presented.

Theme Session Y

Reference Point Approaches to Management within the Precautionary Approach

Conveners: Per Sandberg (Norway), Frans van Beek (The Netherlands), and Carmela Porteiro (Spain)

Background

ICES has implemented the Precautionary Approach (PA) in its management advice for fish stocks since 1998. The implementation of the PA by ICES has been restricted to maintain or restore the historically observed productivity of the stocks by attempting to prevent recruitment over-fishing. To achieve this, PA reference points have been defined to classify the status of the stocks and for formulating advice, for the time being on a single-species basis. The motivation for the Session was to discuss current experience with reference points, how advice based on reference points has been received by ICES clients, and in which direction the PA framework should be further developed.

Presentations

Models

Presentations on models dealt with definitions of the reference points. Some of these addressed the question of whether environmental factors should be explicitly reflected in the reference points. There were different opinions whether reference points should be modified when there are indications of change in the environmental data. It was stated that reference points based on fishing mortality probably were more robust in this sense than biomass reference points. However, biomass reference points and indicators of diversity of biomass may still be required when specific aspects of the ecosystem are addressed in the advice. It was considered that harvest control rules should be evaluated by modelling before they are implemented in management.

Communication of advice to clients and stakeholders

It was considered that the format of advice should, in a better way, address uncertainty of the consequences of various management actions. Concern was expressed on terminology like “outside safe biological limits” because it has been interpreted in different ways by different users in the absence of a definition to these users.

Stakeholders’ opinions of fishery regulations

It was noted that measures like closed areas and gear regulations were giving an assessment of stakeholders’ opinions on management preferences on habitat and the functioning of the North Sea ecosystem.

From the performance of the management advice of the North Sea fish stocks using the PA it was argued that both spawning stock biomass and fishing mortality

should be used as Ecological Quality Objectives (EcoQOs). The evaluation identified that on many occasions the direction of the advice has been wrong. The consistency of the existing reference points between stocks was also discussed.

Ecosystem considerations

It was suggested that the breeding success of sensitive predator species could be used as an indicator of a healthy ecosystem (Figure Y1). It was also suggested that more conservative reference points would result if they were based on multispecies models rather than on single-species models.

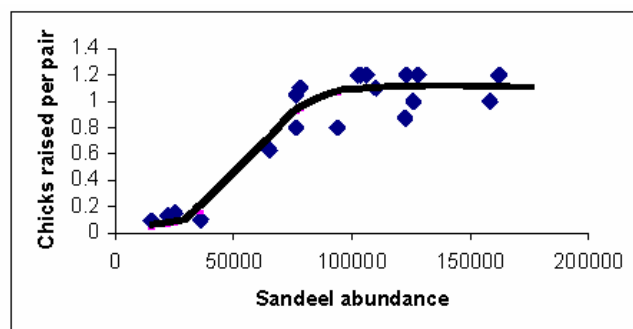


Figure Y1. Breeding success of Arctic skuas in Shetland (data from JNCC Annual Reports on ‘Seabird numbers and breeding success in Britain and Ireland’), in relation to the estimated abundance of sandeels at Shetland (VPA estimate of total stock biomass in tonnes; data from ICES). From: “Reference point approaches for precautionary management of fishing to avoid impacts on top predators” by Robert W Furness. CM2003/Y:01).

Conclusion

It was recognized that the present implementation of the PA in ICES advice is a first step and needs to be developed further. Presently, the reference points are all based on single-species models, which may be incompatible if species interactions are taken into account. The Session indicated that a dialogue between scientists and the clients/stakeholders is useful. With respect to further development of the PA there are a lot of different opinions, which have to be discussed further. It also identified that the ICES implementation of the PA is not unique. It was considered that harvest control rules could also be suitable tools to be used in a PA framework.

Theme Session Z

The Historical and Current use of Technical Conservation Measures and the Evaluation of their Effectiveness, with Special Emphasis on North Atlantic Demersal Fisheries

Conveners: Andy Revill (UK), Bob van Marlen (The Netherlands), and Phil A. Kunzlik (UK)

Background

The recent fishery crises in the North Atlantic have emphasised the importance of technical measures in the conservation of resources. Major changes are occurring in European, Canadian, and American legislation on technical conservation measures. In particular measures are being introduced to control gear design, to reduce fishing effort, or to apply area or seasonal restrictions on fishing. Their aim is to help recovery plans for stocks in waters controlled by the European Union, the Baltic States, Norway, Canada, and the United States.

Objectives

The objectives of the Session were to:

- examine the use of technical conservation measures as a tool to improve the exploitation pattern and management of fisheries;
- develop a framework for the evaluation of any technical measure prior to its introduction into legislation.

Topics addressed were:

- the degree of acceptability of technical measures by the industry, including incentives and obstacles to their introduction, and the degree of enforcement required to ensure effective implementation;
- the effectiveness of analytical models and data to predict the biological and economic effects of technical measures prior to their introduction;
- methods to monitor and evaluate the effects of technical measures after their introduction.

Contributions were invited on:

- Case studies describing technical measures and their implementation, acceptance by the fishing industry, costs including enforcement, and biological or economic benefit to a fishery.
- Pre-implementation models to predict the biological and economic benefits of a measure, including analyses showing sensitivity to input parameters.
- Comparisons of the predicted effects of different types of technical measure.
- Post-implementation monitoring schemes and analytical approaches to evaluate the effects of measures, again with sensitivity analyses.

The central question was whether technical conservation measures do work, with emphasis on gear modifications.

A possible achievement of the Session was the development of a protocol of evaluating the efficacy of technical measures. This Theme Session was considered as a first step in that direction.

Presentations

The BACOMA-project clearly showed the sensitivity of fishermen to short-term losses that might result from implementation of selection windows. Fishermen are entrepreneurs that try to make a living from their activity. Losses of some 50% in income will not be tolerated by any person, and will probably lead to compensating actions such as circumvention of the regulation and/or an increase in effort. Another important finding was that the deck lay-out of fishing vessels and gear handling operations affect the selection characteristics.

Theoretical models are continuously developed and improved to predict the potential merit of introducing technical measures. Such models, if validated thoroughly, can avoid expensive trials at sea on devices that are marginally effective.

Trawling has an effect on the abundance and the size of demersal fish, as might be expected. A study comparing a trawled area (Kattegat) with an area where all towed gears are banned (Sound) revealed that large fish can be removed from the ecosystem.

It appears that the very old problem of measuring mesh sizes is still relevant. An early reference dates back to the year 1291, indicating 712 years of effort on this topic! The methodology of measuring this key variable in fisheries management, with differing instruments in use at present for scientists (the ICES-gauge) and fisheries inspectors (the wedge gauge), is enhanced considerably. A prototype of an objective mesh gauge, based on measuring a longitudinal force that can be pre-set according to the thickness of twines, has been developed. Flaws in the existing legislation were explained, and suggestions for an improved methodology presented. The new gauge, called the OMEGA mesh gauge (Figure Z1) will become available from 2005 (EC-project OMEGA).

The experimental basis of an inclined separation panel in *Nephrops* trawl gears that was designed to reduce the associated bycatch of cod in Irish Sea *Nephrops* fisheries was discussed. This is an example of a gear designed to select on the basis of species rather than length. In both its experimental trials and through subsequent monitoring, it performed well. Nevertheless, one downside to the technical evaluation of the measure was



Figure Z1. The OMEGA Mesh Gauge. (From: “Review and evaluation of current mesh measurement methodologies and future perspectives” by Ronald Fonteyne. CM2003/Z:03)

that, although when monitored it worked well, it also proved possible to circumvent its intended effect, and this may be an issue in cases where the associated cod by-catch would previously have held significant economic value. Nevertheless, in view of the current ICES stringency of advice for cod stocks, it is likely to be methods such as this that provide scope for the continuation of *Nephrops* fisheries in areas where a cod bycatch is considered to be problematic. The challenge is to ensure its effective implementation.

One theme that runs through most discussions of conservation measures is that a pre-requisite for success is the acceptance of the need and utility of the measure(s) by stakeholders. To progress with such measures therefore, there is a need to communicate effectively and agree the need for the measure, to communicate its likely scope and effect, and to ensure that all stakeholders are made fully aware of its outcome.

The successful application of technical conservation measures in the UK sea bass fishery was seen as an example in which such pre-requisites were fully accommodated. A broad recognition of the fact that the fishery was in trouble, as indicated by the targeting of young fish and poor recruitment, was coupled to a clear management aim (to increase the age of first capture by up to two years), and this was achieved by stakeholder consultations that were not only widespread, but effective in their purpose. A range of technical conservation measures were introduced to increase the minimum landings size, to close nursery areas on a seasonal basis, and to increase the minimum mesh size in gillnets. The subsequent evaluation of effects has demonstrated an increase in the age at first capture and yield-per-recruit and of recruitment and spawning stock biomass, although causation of the two latter effects is confounded by the potential benefit of increased sea temperatures to sea bass stocks in UK waters.

Experience is being gained of developing more selective fishing gears in diverse regions such as the New England coastal and offshore mixed demersal fisheries and the Baltic cod fishery. There is a need to accommodate a mixed species fishery in which certain species components had recovered from an earlier depleted state while others had not. A composite mesh cod-end with

escape windows has been shown to work well in trials, and has some degree of industry acceptance, although delays in implementation has meant that the necessary post-introduction monitoring or validation of the measure has yet to be undertaken. Importantly, such monitoring forms an integral part of the scheme. There has also been a range of trials covering a number of technical design configurations. Clearly there is a lot that can be done to enhance the selection characteristics of fishing gears, a potential that for a number of reasons remains unrealised.

The recent introduction of the BACOMA panel into the Baltic cod fishery illustrated a number of reasons why the measure failed in that particular case. As the story unfolded it demonstrated a clear failure of implementation despite the obvious incentive on the part of all players to improve gear selectivity and to reduce discarding. Reasons behind the failure were considered to be the failure to involve all the relevant coastal states in the development of the gear itself, a permitted derogation to use an alternative, less selective gear, and the very large step change in selectivity that the particular specification of the BACOMA panel implied. A lack of compliance coupled to a failure in control and enforcement resulted in an emergency measure on behalf of the EC to close its part of the fishery. New legislation is suggested allowing a smaller mesh size in the BACOMA-window (i.e., 110 mm; the present legal mesh size is 120 mm), thus improving the selectivity characteristics of the gear less drastically, with expected higher acceptance by the industry.

A series of forecasts to demonstrate the potential of recent UK and EC gear regulations under differing assumptions of recruitment and implementation was provided. This was set against the pressing need to reduce fishing mortality on North Sea cod, and the requirement to nurture a single year class in the haddock stock. The resultant prognosis was that the gear-based measures could in principle lead to benefits to both yield and spawning stock biomass, but that this depended very much upon species and the degree of uptake of the measures. However, a brief evaluation of earlier changes to North Sea technical gear regulations from 1987-1992 showed little, if any evidence in the data of any improvement in exploitation pattern despite rather large changes in theoretical selectivity.

Conclusion

The problem of enforcement and the fact that legislation should be controlled often leads to court cases. There seems to be a lack of integrated biological-technical-economic studies. A plea for studies on the behaviour of fishermen and fleet dynamics was given. Also the problem of communication with the stakeholders was emphasised. The Theme Session was recognised as a first step in developing a ‘protocol’ for the evaluation of technical measures both before and after implementation.

Closing Session

Saturday 27 September 2003 (16:30-17:00)

Elections

The General Secretary announced the results of the elections of Science Committee chairs that were made during the course of this Conference and Statutory Meeting:

Einar Svendsen (Norway) – Oceanography Committee
Heye Rumohr (Germany) – Marine Habitat Committee
Dave Reid (UK) – Living Resources Committee

The outgoing Chairs (Franciscus Colijn, Paul Keizer, and Henk Heessen) were warmly thanked for their contributions so far to the work of ICES, including their contributions to the Consultative Committee.

Overview

The General Secretary congratulated the Estonian hosts for providing such excellent facilities which had been thoroughly enjoyed by the 450 or so registered participants. He asked the audience to note the 2004 Conference which would be held in Vigo, Spain, and the 2005 Conference scheduled for Aberdeen, UK. The Aberdeen Conference would be the first Conference to be held separately from the Statutory Meeting, which would be held later in the year at ICES Headquarters.

Awards

The Chair of the Consultative Committee introduced the winners of the best paper, best newcomer, and best poster awards who, in addition to a certificate also received a voucher for free admission to next year's ASC.

Best Paper

This award was won by Eric Benoît and Marie-Joëlle Rochet on "The Meaning of Fish-size Spectra, the Effects of Fishing on them and the Usefulness of their Slope as Indicator of Fishing Impacts" (Doc. N:05). This paper suggested, through clearly presented simulations, that slopes from linear size-spectra may provide a weak indicator of changes in size structure and there could be departures from linearity.

Best Paper Presented by a Newcomer

This award was won by Christine Hanson of the University of Western Australia. She presented Doc. P:16, co-authored by C. B. Pattiaratchi and A. M. Waite, on the "The Unique Continental Shelf Dynamics off Western Australia: Physical Controls on Phytoplankton Productivity".

Best Poster

This award was won by Sanna Suikkanen, Giovana O. Fistarol, and Edna Granéli for Doc. S:03 – "Allelopathic effects of Baltic cyanobacteria". The award panel's criteria for the selection of this poster was that it was "visually striking and a good story told simply".

The President

The President addressed the Session and commended all those who had contributed to the success of the Conference. He concluded by introducing the incoming President, Mike Sissenwine, who made a statement in which he briefly highlighted a few of his priorities for ICES in the future, as follows:

Expanding the size and diversity of the ICES scientific community

The ICES Strategic Plan vision is for an:

"international scientific community that is relevant, responsive, sound and credible, concerning marine ecosystems and their relationship to humanity." This is the scientific community that is needed so that ICES can fulfil its mission "to advance the scientific capacity to give advice on human activities affecting, and affected by, marine ecosystems".

ICES needs to continue its efforts to make its scientific activities attractive to scientists from government laboratories, universities, non-governmental organizations, and the private sector, from ICES member countries and worldwide, from a broad range of scientific disciplines, of both genders, and that are diverse in race and culture.

The quality of ICES publications is an important factor in making ICES attractive to scientists. ICES also needs effectively to use the power of modern information technology to make itself better known, and to provide access to its many valuable products.

Modernising the ICES advisory processes to fulfil today's societal needs

ICES has a long and successful history as a premier provider of scientific advice to underpin societal decisions that affect marine ecosystems. However, societal needs are changing and expanding. Increasingly, advice is needed on more complex issues, and sometimes it is needed sooner than can be accommodated by the typical annual cycle that ICES uses. Also, some advice has tremendous social implications which means that the credibility of the advice is more important than ever before.

ICES advisory processes have been evolving for several years. ICES needs to continue the evolution through routine two-way communications with advice users and stakeholders, by implementing quality assurance protocols including more independent peer review, by becoming more transparent without exposing scientists to political or advocacy group pressure, and by recognising that some degree of flexibility is necessary.

ICES must form a coalition with advice users and stakeholders to achieve a better balance between expectations for advice and support for the science that is necessary to meet expectations.

Providing the Secretariat with the tools and work environment it needs to effectively serve the ICES community

ICES is fortunate to have a dedicated and capable Secretariat staff. Those of us who spend considerable

time at the Secretariat facility in Copenhagen consider the staff to be both valuable colleagues and important friends. However, we also recognize that we are demanding more from them than ever before. It is our responsibility to provide the tools they need (e.g., modern IT support, training, and a physical facility that suits the demands being placed on it) so that they can rise to an even higher standard of support for the ICES community. It is also our responsibility to set priorities when we cannot afford to provide the support necessary to fulfil all our desires.

Closure

The President then passed the symbolic “torch”, a vase, to the Delegate of Spain who would be hosting the 2004 ASC in Vigo.

The President then declared the 2003 ASC closed.