Abstracts of Papers and Posters

Submitted to the 2010 Annual Science Conference prior to 15 April 2010

Theme Session A

Operational oceanography for fisheries and environmental applications

ICES CM 2010/A:01

The fate of winter flounder larvae spawned in coastal waters of the Gulf of Maine

Greg DeCelles, Steven Cadrin, and Geoff Cowles

Historically, winter flounder (*Pseudopleuronectes americanus*) in the Gulf of Maine were considered to be obligate estuarine spawners. This spawning strategy is thought to promote the formation of relatively isolated subpopulations of flounder in estuaries and bays along the coast. Recent evidence, however, has documented the presence of contingent groups of winter flounder that spawn in coastal, rather than estuarine habitats. Although it is likely that coastal spawning increases gene flow and connectivity between meta-populations, the transport of larvae originating in coastal waters has not been studied to date. To address this question, a coupled biophysical individual-based model is being used to track the transport and development of larvae spawned in three coastal regions of the Gulf of Maine. Velocity data generated by the Finite Volume Coastal Ocean Model (FVCOM) is being used to simulate the Lagrangian trajectory of each larva within the physical domain over a period of 60 days. Settlement success is calculated as the average time spent by each particle in suitable habitats (waters <20 m) over the last 18 days of its larval period, and success is averaged over all particles from each release site. Settlement areas have been delineated geographically, and connectivity matrices are being used to estimate rates of settlement success between spawning grounds and nursery areas. The results of this model will offer insight into the population structure of this species in the Gulf of Maine, and will improve the information available for spatially specific management of this species.

Keywords: FVCOM, Gulf of Maine, individual based model, winter flounder.

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ICES CM 2010/A:02

Forecasting Northeast Atlantic cod (*Gadus morhua* L.) stock recruitment based on satellite monitoring of sea surface temperature data

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The authors attempted to track down the dependence of Northeast Atlantic cod recruitment, estimated at age 3 years+, on the habitat conditions being established in the spawning areas, larval drift, and feeding of young cod. The data used were the 1997–2009 Barents Sea sea surface temperature (SST) satellite monitoring data. The annual indicators of the abundance of 3-year-old cod were plotted against the period-averaged water temperature anomalies shifted back by 3 years for the main spawning area of cod (off the Lofotens) for March–April, and for three regions of early ontogenesis of cod (West Spitsbergen, Nordcap, and Murmansk–Novaya Zemlya) for May–October. The 3+ year classes of cod (up to 400 million indindividuals) graded as "poor" fall on the years with negative (2001) or high-positive (2006, 2007) SST anomalies in the spawning zone; they are –0.3°C, +1.5°C, and, +1.6°C respectively. The SST anomalies within –0.1°C to +1.1°C provided for the medium (400–900 million individuals) or strong (900 million individuals) generations which respectively occurred in favourable (1999, 2003, 2004, 2005) and most favourable (1998, 2000, 2002) years in terms of survival. This relationship becomes even more pronounced if the SST anomaly analysis for the above three zones includes the larval and pelagic young drift for May–October, and for the same period of the previous year whose conditions are likely to affect the quality of future broodstock and their eggs. The satellite monitoring of temperature conditions in benchmark zones

that are the major factor in the formation of year classes of cod might be considered an additional fishery forecasting possibility by ensuring predictions two years in advance.

Keywords: anomalies of SST, Northeast Arctic cod, recruitment, satellite data, strength of year classes.

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ICES CM 2010/A:03 Poster

Predicting the bluefin tuna habitat from space: another tool for the future management and control of pelagic fisheries

Jean-Noël Druon

The bluefin tuna habitat in the Mediterranean Sea is mapped using daily sea surface chlorophyll and temperature from satellite remote sensors. Fish demonstrate two main behaviours—feeding and spawning—which are explored in the habitat model. The feeding habitat is associated with oceanic fronts of temperature and chlorophyll while the spawning habitat is characterized by a stable surface layer during spring (surface heating). The use of habitat mapping in fishery management could open up restricted grounds to fishing in order to preserve the resource (e.g. avoiding spawning areas). Increasing the fleet concentration would increase the efficiency with which it could be controlled by traditional means or radar imagery (vessel detection systems). While protecting the resource, the near real-time habitat maps would guide fishers to the best fishing ground in the open area, significantly reducing variable costs (fuel, man-days at sea). In addition, the model applied to a decade of satellite data provides valuable statistics for the scientific community on the preferred habitats of this highly migratory species. Although the first species to be studied is the emblematic bluefin tuna in the Mediterranean Sea, which is endangered by overfishing, the approach is transposable to most temperate and tropical pelagic species from forage fish to top predators.

Keywords: bluefin tuna, chlorophyll, control, chlorophyll, fisheries, habitat mapping, management, SST.

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ICES CM 2010/A:04

Towards operational management of pelagic ecosystems

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Satellite data and operational ocean models provide the necessary inputs for ecosystem models of the lower to mid and upper trophic levels. One key explanatory variable that is usually missing but important for an understanding of the dynamics of key exploited or protected marine species is the dynamic of the micronekton that is at the mid-trophic level (MTL) in the ecosystem. This includes both prey of large predators and predators of eggs and larvae of fish. We present the development of an operational model of mid-trophic functional groups driven by physical and biogeochemical variables. Once a reasonable prediction of MTL organisms is achieved, the number of applications for near real-time management and monitoring of marine ecosystems and resources should increase rapidly, as illustrated by the examples provided here. This includes the prediction of feeding and spawning habitats for many exploited and protected species, their movements and spatial distributions, and their population dynamics under the combined effects of natural (climate variability) and anthropogenic forcings (fishing, climate warming).Keywords: climate, ecosystem, fisheries, habitat, management, micronekton, operational model, ocean forecast, population dynamics.

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ICES CM 2010/A:05

Oceanographic modelling products as a decision support to the Irish aquaculture sector

Glenn Nolan, Kieran Lyons, Neil Ruane, David Jackson, Joe Silke, and Robin Raine

As high-resolution physical circulation models in Irish waters have improved, there is a growing demand for operational outputs and products from these models. A regional physical model (ROMS) produces a 7-day forecast for Irish waters daily. Several nested models with a horizontal resolution of several hundred metres have been developed for coastal areas such as Connemara, Bantry, and Killary Harbour. Several applications have been based on forecast and hindcast model output to date. Model flowfields that include the effects of river discharges, meteorological conditions, and wider field oceanographic conditions have been used to accurately define epidemiological units around individual finfish aquaculture sites. In the event of a fish disease outbreak, this information supports decision-making regarding movement of fish and fallowing of sites. In forecast mode, this tool will be used as a real-time decision support tool for the aquaculture industry. Similarly, models have been used in hindcast mode to examine the distribution and transport of sea lice between salmon farming sites. Varying resolution models have been compared to assess the accuracy of hindcasts and predictions under different forcing conditions. Finally, model currents are used to hindcast harmful algal bloom events off southwest Ireland in 2009 to examine transit times of harmful algae from inoculation areas in the Celtic Sea to shellfish and finfish sites in Bantry Bay. This complements a short-range model developed for Bantry based on shifts in wind direction that accurately predicts the onset of toxic algal events in several previous years.

Keywords: fish disease, forecasting, HABs, Ireland, oceanographic products, sea lice.

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ICES CM 2010/A:06

A 38 years hindcast of a coupled physical–biogeochemical model and its use for fisheries oceanography in the Bay of Biscay

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Overexploitation and climate change are increasingly causing unanticipated changes in marine ecosystems, such as higher variability in fish recruitment and shifts in species distribution, leading to a pressing need to develop fisheries oceanography. In the mean time, operational oceanography is progressing rapidly and its products are becoming easy to access for a large community, including fishery scientists. We performed a 38 years hindcast (1972–2009) run with a coupled physical–biogeochemical model (ECO-MARS3D of Ifremer) over the Bay of Biscay, using realistic meteorological and run-off forcing. We first describe the model, as well as indices that were derived as potential drivers of fish populations. These relate to mesoscale activity (eddies, plumes, fronts, stratification) or biological production (chlorophyll and zooplankton concentration, primary production), and all refer to the Bakun's triad: enrichment, concentration, retention. We then review the use of this hindcast in relation to anchovy life cycle in the Bay of Biscay. First, the environmental time-series was used to force higher trophic level models. The physical–biological environment was needed either for transport of early life stages of fish, for larval growth in individual-based model, or for adult growth and reproduction with a dynamic energy budget model. Second, the hindcast can be used to derive fish habitats from statistical regression of eggs or adult field distribution on environment covariates, and then extrapolate over simulated years. Third, we integrated the environment variables and indices over appropriate areas and periods in relation to the anchovy life cycle, and tested their ability to explain recruitment with quantile regression.

Keywords: Bay of Biscay, coupled model, *Engraulis encrasicolus*, fisheries oceanography, hindcast.

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ICES CM 2010/A:07

The ICES WGOOFE Questionnaire—defining oceanographic requirements in the fisheries and environmental communities

Bee Berx, Mark Dickey-Collas, and Morten Skogen

Although the ICES community is quite operational in how it uses fisheries data for advice, the ICES Council has realized it is much less so when it comes to the use of environmental data in its application towards achieving an "ecosystem approach" to management. The Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE) was established to address this by acting as an interface between the producers of oceanographic data products and potential users from across the ICES community. Although the providers produce many operational products, they have approached WGOOFE for guidance on the requirements of users. In order to inform its recommendations, WGOOFE launched a questionnaire for ICES scientists to complete. The survey contained questions on the desired oceanographic parameters, the ideal temporal and spatial resolution, and the delivery method, format, and time-scales. Participants were also asked a few short questions on their background and abilities. In total, 100 surveys were completed by scientists from many different disciplines. Despite this mix of backgrounds, the results demonstrate that the ICES community would prefer oceanographic data to be delivered in an easy-access format with free, quick, and reliable delivery. ICES scientists did not want formats commonly used in the meteorology or oceanography disciplines. Despite the large amount of effort being expended currently to produce real-time and forecast data products at high resolution, most interest from the ICES world is reserved for historic time-series of data at a range of resolutions. It was also clear that WGOOFE itself had not ranked the oceanographic parameters in a manner that completely reflected the needs of the ICES community. Next, the WGOOFE will communicate the results of this questionaire to the provider community, while continuing to bring exciting new and existing oceanographic data products to the attention of ICES users.

Keywords: data products, operational oceanography, user requirements.

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ICES CM 2010/A:08

Using a towed profiler to compare satellite primary productivity models with *in situ* measurements of vertical chlorophyll on the northeastern United States continental shelf

D. Christopher Melrose, Mark S. Berman, Kimberly Hyde, and John E. O'Reilly

A towed undulating sampling platform equipped with a chlorophyll fluorometer was used on three transects across the US Northeastern Shelf Large Marine Ecosystem to study the influence of variations in the vertical distribution of chlorophyll on satellite primary productivity models. The three transects were located off the coast of New Jersey, across the Nantucket Shoals, and from Georges Basin onto Georges Bank. Satellite-based productivity models provide a powerful tool for performing synoptic productivity measurements over entire ecosystems; however, satellite productivity models have greater uncertainty than *in situ* measurements. This uncertainty exists in part because satellite measurements are biased to near-surface chlorophyll and have an inability to resolve vertical structure or deep chlorophyll layers. Comparisons with *in situ* vertical profiles provide a way to test the effect of varying vertical structure on the accuracy of satellite productivity models and allow these models to be regionally and seasonally tuned for greater accuracy. The use of a towed undulating sampler can also provide more representative comparisons with satellite measurements than would be possible with point samples in regions with strong physical and biological gradients, because it can sample continuously over relatively large areas.

Keywords: *in situ*, primary productivity, satellite, towed undulating platform.

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ICES CM 2010/A:09

Use of otolith chemistry and electronic tags as fishery oceanography tools: a case study of blue marlin in the western Atlantic Ocean basin

R. J. David Wells and Jay R. Rooker

Fishery oceanography often involves linking fishery-dependent data to a suite of remotely measured oceanographic parameters, including sea surface temperature, salinity, and sea surface height. Here, we present the use of two novel environmental recorders—otolith chemistry and electronic tags—which both record the physico-chemical conditions of the surrounding water mass inhabited and therefore serve as valuable fishery management tools. Otolith chemistry is useful because chemicals incorporated into the aragonite matrix of the otolith are related to the physico-chemical conditions of the surrounding water mass, thus serving as a natural tag. Chemical signatures in the otolith can be used to determine retrospectively an individual's natal origin and migratory history, and therefore serve as useful markers for assessing population connectivity. Electronic tags, such as pop-up archival transmitting tags, measure *in situ* time-at-depth, temperature, and light levels (proxy for geolocation) and are particularly useful for fish capable of long-distance movements and behavioural migrations. In this study, we discuss the complementary results using both tools from a case study of blue marlin in the western Atlantic Ocean and adjacent seas (i.e. Gulf of Mexico, Caribbean Sea) which suggest divergent movement patterns of a highly migratory species. We conclude by putting our results in the context of how these tools can be used in the fishery management decision-making process.

Keywords: behaviour, electronic tags, otolith chemistry, population structure.

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ICES CM 2010/A:10

Towards operational biogeochemical modelling for resource management of coastal waters

Karen Wild-Allen, Jenny Skerratt, Farhan Rizwi, and John Parslow

The biogeochemistry of coastal waters can now be modelled in three dimensions with high spatial and temporal resolution to inform managers of current and possible future changes in water quality parameters. Models simulate the transformation, cycling, and dispersion of anthropogenic nutrient loads into coastal waters through phytoplankton, zooplankton, macrophytes, and detrital phases. Nutrient remineralization and dissolved oxygen dynamics are also resolved. Model resolution far exceeds the typical spatial and temporal resolution of biogeochemical observations, making model initialization, boundary forcing, and validation difficult. Novel instrumentation and sensor platforms have the potential to address some of these issues. Recent observations from a moored, continuously recording nutrient sensor and a mobile glider platform are discussed. Validated coastal ocean colour remote sensing with high spatial resolution provides synoptic data comparable with model output and the ability to achieve near real-time model validation of surface features. Simulations of anthropogenic nutrient impacts in southeast Tasmania are shown. Human pressures on local estuarine and coastal waters include river water extraction, industry and sewerage effluent discharge, and an expanding salmon farming industry. Future scenario simulations quantify likely anthropogenic impacts and communication of results to resource managers has resulted in the implementation of an environmental monitoring programme as part of an adaptive management framework.

Keywords: anthropogenic impacts, biological model, coastal-zone management, model validation.

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ICES CM 2010/A:11

Lunacy in Atlantic cod: assessing the timing of spawning in Atlantic cod using ocean models and electronic data storage tags

Timothy B. Grabowski, Bruce J. McAdam, Kai Logemann, Vilhjálmur Thorsteinsson, and Gudrún Marteinsdóttir

Understanding the environmental processes determining the timing and success of reproduction is of critical importance to developing effective management strategies for marine fish. Unfortunately, it has proven difficult to comprehensively study the reproductive behaviour of broadcast-spawning fish, such as Atlantic cod (*Gadus morhua*), in the wild. The combination of oceanographic models and electronic data storage tags (DSTs) has the potential to provide insights into the behaviour of fish, allowing for data collection over relatively large spatial and temporal scales that can be correlated to predicted environmental conditions and ultimately be used to refine predictions of year-class strength. In this paper we present data retrieved from DSTs demonstrating that Atlantic cod spawning in Iceland is tied to a lunar cycle with a pronounced semilunar cycle within it. Peak spawning activity occurs around the full and new moon with no evidence of relationship with diel tidal or day/night cycles. We then use a Cartesian coordinate ocean model with three-dimensional adaptive mesh refinement and primitive equations (CODE) to assess the changes in environmental conditions at known cod spawning grounds associated with lunar and semilunar cycles and identify oceanographic conditions that might render this spawning strategy beneficial.

Keywords: Atlantic cod, spawning behaviour, lunar cycles, oceanographic hindcasting.

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ICES CM 2010/A:12

Use of neural networks to forecast the abundance of Argentine hake in the Southwest Atlantic

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The Argentine hake (*Merluccius hubbsi*) is one of the most abundant commercial species in the Patagonian–Malvinas shelf area. In this work, we propose a predictive model of abundance for this species based on a multilayer perceptron (MLP) neural network. The network was developed using fishery data that were collected on board Spanish commercial vessels operating in the area between 1989 and 2006 and environmental data provided by the oceanographic model implemented by MERCATOR Ocean. The MLP output is the cpue (catch per unit of effort; kg h^{-1}), which is used as an abundance index. As input variables we included latitude, longitude, Julian day, temperature, and salinity at three depth levels, sea surface temperature gradient, and moon phase. The whole dataset was split into two independent sets, one to train the network and the other one to validate it. GIS techniques and statistical methods were used to analyse and visualize the data and the results. Model results demonstrate a good fitting between the observed and estimated cpue ($r = 0.74$ using the validation set). This tool might be useful to implement an operational forecasting system.

Keywords: Argentine hake, MLP, neural networks, prediction model.

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ICES CM 2010/A:13

Investigation on krill transport factors in the Scotia Sea for fisheries and management applications

Kasatkina Svetlana and Vladimir Shnar

Data from acoustic surveys and oceanographic observations were used to estimate characteristics of krill transport across different polygons in the Scotia Sea. Krill flux over the study polygons was considered to be a passive transport by water masses and assessed by the geostrophic transport. Estimates of water velocity and krill biomass transported across the boundaries (outflow and inflow) of these polygons were made. Variabilities of the spatial–temporal distributions of krill biomass and aggregations characteristics associated with multiple processes of krill inflow–outflow over the study areas were traced. It was revealed that krill transport across fishing grounds affects the operational indices of commercial vessels (mean catch per haul, mean catch per hour). The authors discuss the characteristics of krill transport as important information for krill stock management in the Scotia Sea. It was shown that the annual krill biomass transported across traditional fishing grounds could exceed the precautionary catch limit based on the results of a multi-ship acoustic survey and adopted by the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) for the Scotia Sea.

Keywords: acoustic and oceanographic observations, Antarctic krill flux, fisheries, geostrophic transport.

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ICES CM 2010/A:14

Operational data distribution at Institute of Marine Research

Sjur Ringheim Lid, Helge Sagen, and Trond Westgård

The Norwegian Marine Datacenter (NMD) started serving operational research data from vessels operated by the Institute of Marine Research in early 2000. Through the EU FP7 project MyOcean the NMD has become the thematic assembly centre for Arctic *in situ* data. As a thematic assembly centre the NMD delivers *in situ* data to the global assembly centre and to the ocean forecasting centres, where it is used for assimilation or validation of model output. The data service has been expanded to include data from other data sources, such as the Coriolis data service. Real-time quality-control procedures have been defined in the MyOcean project and all data go through these procedures and are flagged according to the SeaDataNet Quality flag scale. The Institute of Marine Research has also started work on other data types gathered on research vessels. These data types include different kinds of biological samples and chemical data that will become available to scientists in near real time.

Keywords: automatic quality control, MyOcean, operational data distribution, SeaDataNet.

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ICES CM 2010/A:15

Indices for fishery management based on larval transport model predictions

Elizabeth North, Zachary Schlag, and Wen Long

Incorporating the influence of environmental variation and recruitment variability in stock-assessment models is hampered by the complexity of interacting physical and biological processes that operate during the early life of fish and shellfish. The objective of this research is to apply a coupled hydrodynamic and larval transport model to calculate two metrics that summarize the influence of environmental variability in a format that could be used by fishery managers. The metrics that we calculate are (1) a physical baseline and (2) minimum transport-based spawning-stock biomass (SSB). We will use the blue crab, *Callinectes sapidus*, as the model organism and the

Middle Atlantic Bight as the study area. We define a physical baseline for a population as the minimum number of offspring needed to "swamp" the physical variability in a system and produce reliable transport between spawning and nursery areas. We define minimum transport-based SSB levels as the minimum biomass of adult females that can produce the offspring needed to meet the physical baseline and ensure relatively stable recruitment. Multiple techniques will be applied to account for the unknown sources of mortality along transport pathways in order to create an envelope of possible transport-based SSB estimates. The transport-based SSB levels will be compared with the target SSB levels derived from current stock assessments of the blue crab. Application of these metrics in an operational context will be discussed.

Keywords: coupled biological–physical models, fishery management, larval transport.

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ICES CM 2010/A:16

MyOcean—operational products for fisheries

Henning Wehde

The EU-supported project MyOcean is the implementation project of the GMES (Global Monitoring for Environment and Security) Marine Core Service, aiming at the deployment of the first Europe-wide concerted and integrated capacity for monitoring and forecasting of the oceans. The project objective is to analyse, forecast and observe the oceans at global and regional European scales in order to provide a monitoring service for the marine environment and security. By combining remote sensing and *in situ* observations and their assimilation into three-dimensional circulation/ecosystem models, MyOcean aims to provide a service that delivers the best information available on global and regional oceans. These data include temperature, salinity, currents, ice extent, sea level, and primary ecosystem parameters. The target applications are marine safety, marine resources, climate and seasonal forecasting, as well as marine and coastal environments. Within this study special focus is laid on the MyOcean key area of marine resources and the value of the service products will be highlighted, specifically on the fisheries within the North Atlantic.

Keywords: GMES project, operational oceanography.

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ICES CM 2010/A:17

Influence of mesoscale oceanographic structures on larval distribution and survival in jack mackerel (*Trachurus symmetricus*) off central Chile

Sebastián Vásquez, Marco Correa-Ramírez, and Aquiles Sepúlveda

The jack mackerel, *Trachurus murphy* (Nichols), is a medium-sized pelagic fish that has a wide distribution in the southeast Pacific Ocean and constitutes the most important pelagic fishery in Chile. The jack mackerel population structure includes an extensive dispersion towards the oceanic zone off Chile, where its reproduction occurs during spring. The spatial distribution of jack mackerel larvae during the main spawning season between 2003 and 2005 was addressed through several surveys at 790 plankton stations covering ca. 350 000 square nautical miles. Large numbers of larvae (individuals between 1.7 and 14.9 mm in length) were commonly found up to 1000 nautical miles off central Chile associated with the Subtropical Convergence Zone (STCZ), where strong oceanic mesoscale eddies and meandering currents are typical features during spring. The otolith microstructure shows a significant positive relationship between larval age and distance northward, as well as a relevant association between survival of larvae and mesoscale structures. The eddy definition by the Okubo–Weiss parameter shows that mesoscale oceanographic features have a strong influence on the horizontal distributions of fish larvae and could be providing

physical mechanisms that may facilitate the regional self-sustaining of the jack mackerel population off Chile.

Keywords: meandering currents, mesoscale eddies, Okubo–Weiss parameter, otolith microstructure.

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ICES CM 2010/A:18

Site selection for stock replenishment using a hydrodynamic model: example for the pacific oyster (*Crassostrea gigas*) culture in the Pertuis Charentais region

I. Bernard, O. Le Moine, J.-Y. Stanisière, S. Pouvreau, P. Goulletquer, and F. Dumas

The critical issue for oyster farmers in the Pertuis Charentais region of France is to obtain a sufficient spat supply on a yearly basis in areas dedicated to spat collecting to sustain oyster production. To address this practical question we searched for the main hydrodynamic factors driving spatfall abundance using a hydrodynamic model. Five hydrodynamic-related factors were included in the simulation: spawning time, pelagic larval durations, wind, broodstock location, and spat collecting location. The main result is that "broodstock location" is the most important factor that impacts larval abundance above spat collection areas at the end of larval life. Northern beds supply spat areas located in the southern areas. This implies that the most important spatfall area in the mouth of the Charente River may be sustained by wild oysters, for which stocks are unknown. The importance of broodstock location implies an improved coordination between policy of eradication of wild oyster beds, aiming to increase productivity, and the policy of replenishment to improve the spatfall level. Moreover, it should be of concern when considering the development of farming of triploid oysters, which do not contribute to reproductive effort. Based upon those results, wild oyster stock assessment is a necessary step for determining where the replenishment should be carried out. The large variability of the contribution of oyster beds, however, seems to indicate that replenishment in well-chosen areas may be successful in improving spat supply.

Keywords: *Crassostrea gigas*, larval dispersal, population connectivity, stock replenishment.

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ICES CM 2010/A:19 Poster

Chilean jack mackerel aggregations in the southeastern Pacific in winter–spring season 2009 revealed by seabird observations and oceanographic features

O. Krasnoborodko and F. Litvinov

The complex survey of Chilean jack mackerel habitat and distribution in the southeastern Pacific outside Chile's EEZ 25–42°S/74–126°W was carried out aboard Russian RV "Atlantida" in August–November 2009. Acoustic, ichthyological, hydrological, and ornithological surveys were undertaken. The strong differences in the density of Chilean jack mackerel were revealed, the highest density corresponded to the seasonal position of the Subtropical Southeastern Pacific Front (SSPF) between 33 and 37°S. This frontal zone was affected by the surface wind direction (mainly south–southwest) and subsurface geostrophic circulation (between 0 and 250 m from 0.2–1.0 to 7.0–9.7 cm/s). It was revealed that both the strongest gradients of sea surface temperature in the SSPF zone and the corresponding densest Chilean jack mackerel aggregations were, in turn, clearly marked by the most abundant seabird aggregations. The densest seabird aggregations in the SSPF zone were observed between 34–36°S/85–87°W, 34–38°S/90–96°W, 34–38°S/103–106°W, 34–35°S/112–114°W, and 36–38°S/114–116°W. These zones corresponded to the densest Chilean jack mackerel aggregations and sea surface temperature gradients of SSPF greater than 0.05°C per nautical mile. The information collected may serve as an additional tool for the analysis of Chilean jack mackerel spatial distribution in this region in winter–spring. Maps of the distribution of the

bird species (*Daption capense* (occurrence 72%), *Procellaria aequinoctialis* (65%), *Diomedea exulans* (45%), *Diomedea melanophis* (23%), etc.) in relation to Chilean jack mackerel aggregations and oceanographic features are presented.

Keywords: Chilean jack mackerel, seabirds aggregations, southeastern Pacific, Subtropical Southeastern Pacific Front.

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ICES CM 2010/A:20 Poster

Lagrangian tracking of *Anguilla anguilla* leptocephali in a 1/12° Mercator-Océan simulation of the North Atlantic

Bruno Blanke, Sylvain Bonhommeau, Nicolas Grima, and Yann Drillet

European eel (*Anguilla anguilla*) larvae have one of the longest larval migrations of the marine realm, swimming more than 6000 km from their spawning grounds in the Sargasso Sea to European continental shelves. The duration of this migration remains debated, being thought to be between seven months and three years long. This information is crucial, however, because it determines the period over which larvae are affected by environmental conditions and hence the subsequent recruitment success. We investigated the migration pathways and duration of eel larvae using three years of high-resolution (daily, 1/12°) velocity fields available from a Mercator-Océan model configuration without data assimilation. We specifically studied the impact of spatial and temporal resolutions on our estimates by applying various filters in time (from daily to 12-day averages) and space (from 1/12° to 1° gridcell aggregation) to the nominal model outputs. Larvae were released in the eel spawning area and considered as passive tracers at three specific depths (surface, 50 m, and 200 m). We diagnosed the intensity of water transfer between appropriate control sections that encompass the eel larva distribution. Transit ages were also investigated, with a particular focus on the pathways that minimize the connection times between the western and eastern North Atlantic. The study shows that small-scale structures (eddies, filaments) contribute to the existence of faster connections although they also correspond to additional complexity in trajectories. The shortest pathways mostly follow the Gulf Stream and the North Atlantic Drift, whereas more interior connections require time transfers less compatible with biological issues.

Keywords: European eel, operational oceanography, Lagrangian diagnoses.

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ICES ASC 2010/A:21 Poster

The climate of Icelandic waters, 1948-2009—high-resolution, adaptive grid ocean modelling

Kai Logemann, Jón Olafsson, and Guðrún Marteinsdóttir

In order to gain deeper insights into the role of physical processes in determining the variability of the Icelandic marine eco-system, the workgroup MARICE, University of Iceland, is running a numerical model of the hydrodynamics of Icelandic waters and adjacent seas. The ocean model CODE (Cartesian coordinates Ocean model with three-Dimensional adaptive mesh refinement and primitive Equations) is used which was recently developed at the University of Hamburg and the University of Iceland. A dataset was created which contains the three-dimensional fields of temperature, salinity, and flow around Iceland for the years 1948–2009 with a spatial and temporal resolution of 1 km and 3 h, respectively. With the focus on decadal variability, the simulation is presented and compared with observations. Successfully simulated structures are analysed and model errors discussed. Finally, model runs describing decadal variability in temperature and salinity are linked with temporal changes in recruitment and abundance of commercially important pelagic and groundfish species.Keywords: decadal variability, ocean modelling, Icelandic waters.

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ICES CM 2010/A:22 Poster

Improved estimates of diatom primary production for use in fishery production potential models

K. J. W. Hyde, M. J. Fogarty, J. A. Hare, and J. E. O'Reilly

Fishery production potential is a function of the amount of primary production, the fraction of this production available to higher trophic levels, the transfer efficiency between successive trophic levels, and the number of trophic levels through which energy must be transferred. Two pathways are recognized for transfer of primary production in the system—the classical grazing food chain, principally new production by diatoms and direct grazing by mesozooplankton, and nanoplankton production, which includes the microbial foodweb and involves two or more trophic transfer steps before reaching mesozooplankton. The northeast continental shelf of the United States is a highly productive ecosystem with several commercially significant fisheries. This dynamic ecosystem has experienced changes in climate and physical forcings that have contributed to large-scale alterations in ecosystem structure and function. Recent analyses suggest that phytoplankton biomass in the northeast ecosystem has increased up to 33% during the last decade compared with the late 1970s to early 1980s. Furthermore, other studies have indicated that the increase in biomass is associated with a shift from larger diatoms (>20 μm) to smaller nanoplankton and picoplankton species. Current fishery production models use estimates of diatom production (approximately 30% of total primary production) from MARMAP shipboard surveys (1977–1988), but it is unlikely that these measurements are representative of the current phytoplankton community. Thus this study will evaluate satellite remote sensing models of phytoplankton species composition and/or size fraction to estimate diatom production in order to incorporate these results into current estimates of fisheries potential production.

Keywords: chlorophyll, diatoms, fisheries production models, new production, northeast US continental shelf ecosystem, primary production,

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ICES DM 2010/A:23 Poster

Environmental preference of dolphinfish (*Coryphaena hippurus*) derived from remotely sensed data along the Pacific coast of Colombia

John J. Selvaraj, Adriana Martínez, and Angela I. Guzmán

In this study we looked at the relationship between catch data and satellite-derived oceanographic features to predict potential fishing habitats of *Coryphaena hippurus* off the Pacific coast of Colombia. Catch data were derived from logbooks of industrial longline fishing fleets and satellite data on sea surface temperature (SST) and chlorophyll *a* (Chl *a*) from a moderate-resolution imaging spectroradiometer (MODIS). Data were analysed for the years 2003–2008. Longline data included date, fishing location, number of individuals captured and number of hooks used. Catch per unit effort (cpue) expressed as numbers (fish/1100 hooks) was used as index of relative abundance. To predict the spatial patterns of potential dolphinfish fishing habitats (PDFH), we developed a model using a generalized linear model (GLM) based on the functional relationships between the environmental variables and cpue. The PDFH maps were validated against catch data from the year 2009. It was found that the preferential habitat for dolphinfish corresponded to an SST range of 25.5–27.5°C and a Chl *a* range of 0.2–0.75 mg/m^3 based on the highest cpue values during the fishing season (November–March). Persistent high cpue was observed along the northern coast, extending longitudinally during the months November–February and in deeper waters during March within the EEZ. Cross-validation of the cpue predicted by the model was reliable ($r = 0.75$) with the observed cpue. The dynamics of the thermal fronts and currents in this region may have contributed to the spatial patterns of the PDFH.

Keywords: dolphinfish, generalized linear model (GLM), MODIS.

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ICES CM 2010/A:24 Poster

Study of demersal fish distribution and environmental conditions in the Great Sole Bank using statistical and GIS techniques

E. Spyrakos, M. Darriba Estévez, Luis González Vilas, and J. Torres Palenzuela

Variations of oceanographic conditions in relation to the abundance and distribution of demersal fish in the Great Sole Bank (ICES Statistical Division VIIj) were studied during the year 2009 in the framework of the project "Study of sea bottom circulation and its environmental and fisheries impacts". In this study we focused on three different commercial species: cuckoo ray (*Raja naevus*), megrim n.e.i. (*Lepidorhombus* spp.), and anglerfish n.e.i. (*Lophiidae*), which represent the majority of the catches database. Fisheries data were collected on board three commercial vessels operating in the study area as part of the Fishing Vessel Owners' Cooperative of the Port of Vigo (ARVI). Daily recordings of sea surface temperature (SST), surface sea salinity (SSS), sea bottom temperature (SBT), sea bottom salinity (SBS), and seabed currents were obtained from the Mercator-Ocean Model. Maps were generated using geographical information systems (GIS) in order to study the spatial distribution of the species. Generalized additive models (GAMs) were developed for the three species. Catch per unit effort (cpue), used as an abundance index, was modelled as a function of bathymetry, location, SST, SSS, SBT, SBS, day, seabed currents, and moon phase. The depth of the catches varied between 100 m and approximately 600 m. The results demonstrated that the different techniques used in this study can provide useful information about demersal fish distribution in the area and their relation to environmental conditions.

Keywords: anglerfish, cuckoo ray, GAMs, GIS, megrim, seabed environmental variables.

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ICES CM 2010/A:25 Poster

Physical and biogeochemical MyOcean operational products and end-user applications

Rosa Barciela and Karen Edwards

The provision of free and open operational oceanographic services and products to the wider user community has become a reality through MyOcean, the implementation project of the GMES Marine Core Service. MyOcean strives to deliver the best available oceanographic information from models and also from observations to anyone at anytime (near real-time, short-range forecast, and hindcasts are all available), anywhere (information at global and regional scales, from the deep ocean to the shallow seas) and at any depth (from the surface to the bottom of the ocean). This presentation focuses on the physical and biogeochemical MyOcean products routinely available from the UK Met Office model for the European North Atlantic West Shelf. End-user applications already making use of those products, including a trial tool for the operational prediction of nuisance algal blooms, will also be presented.

Keywords: biogeochemical, MyOcean, North Atlantic, North West Shelf, operational products, physical.

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ICES CM 2010/A:26 Poster

Operational oceanography products and services: how can they help in setting the initial state and trends of the oceans?

Sylvie Giraud Saint-Albin, Patrick Lehodey, and Eric Greiner

Scientific understanding and knowledge of the marine environment and its state, on the one hand, and data and models to translate this into meaningful and useful information to support sustainable development and, if necessary, effective interventions, on the other hand, are both crucial for forming marine environmental policy, as carried out by the EU Marine Strategy Framework Directive. MyOcean Ocean Forecasting Systems bring a revolution to European governmental agencies. With a coupled physical–biogeochemical forecasting capacity, monitoring the ocean state and its trends is now feasible. Current state estimates can be provided in real-time as well as interannual statistics to measure variability and trends at various space- and time-scales (required by the ecological processes) against a given "reference" state (or initial state). What-if scenarios can also be performed by these systems, exploring the impact of specific conditions for the future. The use of operational oceanography products opens the way to objective and scientific analysis and quantification of climate change impacts on the targeted marine ecosystems at different time and spatial scales through model downscaling. A set of environmental indicators is presented here and taken from the halieutic domain. Some challenges are still not resolved as model uncertainties are big when you come to "underobserved" variables such as biogeochemical parameters and habitats, or low-frequency signals such as climate change (50 years). Downscaling climate scenarios to regional scale for coupled physical–biogeochemical models also raises open scientific questions and requires strong interoperability between global, regional, and coastal operational oceanography systems.

Keywords: downscaling, indicators, initial state, MSFD, MyOcean.

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Theme Session B

The risk of failing in integrated coastal-zone management

ICES CM 2010/B:01

Monitoring and evaluation of spatially managed areas: A generic framework and its application

Vanessa Stelzenmüller, Andy South, Stuart Rogers, Jan van Dalfsen, Peter Jones, Steven Degraer, Marijn Rabaut, and Magda Vincx

The application of an ecosystem approach to management of the sea requires both integrated and strategic frameworks such as integrated coastal-zone management (ICZM) and the use of marine spatial planning (MSP) to minimize spatial use conflicts and environmental degradation. Such an integrated management promotes sustainable development based on achieving a balance of environmental, social, and economic objectives. Here we introduce a first draft of a generic framework developed in the EU FP7 project MESMA that gives guidance on how to assess the effectiveness of an existing management within a spatially defined area. More precisely, we define spatially managed areas as geographical entities where a marine planning framework is or will be used to manage multiple human activities in space and time while maintaining ecosystem integrity. The framework comprises practical guidance on the following steps: (i) selection of operational objectives and related criteria; (ii) collation and integration of information; (iii) performance assessment; and (iv) feedback processes. In the course of the MESMA project this generic framework will be applied and tested in a number of case studies. Here we highlight the processes and practical tasks involved in each of the framework steps, reflect on the first attempts

to implement this framework and identify the requirements for practical tools such as standardized methods to map human activities and assess their cumulative impacts.

Keywords: management objectives, MSP, spatial management.

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ICES CM 2010/B:02

Socio-economic and cultural objective setting for supporting the effective use of indicators for integrated management of ecosystems

Amy Diedrich and J. Tintoré

The success of integrated management approaches such as marine spatial planning and integrated coastal-zonezone management (ICZM) in improving, conserving, and protecting ecosystems has been limited by the challenge associated with translating scientific information into management action. One of the reasons science can fail to provoke management responses is that research is often conducted without appropriate consideration of the socio-economic and cultural (SEC) and political contexts of the ecosystem that is being managed. Although science cannot make management decisions, which often result from a combination of objective information and value judgements, it can provide valuable data to inform and monitor the consequences of management actions. However, it is critical that this information be orientated towards addressing priority objectives from SEC and political perspectives, in addition to ecological objectives, if it is to be effective in generating appropriate actions at the governance level. Indicators have been receiving considerable attention in recent years as one potential solution to bridging the science–policy gap through the provision of viable, interpretable scientific information that responds to specific management objectives. The aim of this presentation is to emphasize the critical role of SEC objective setting and prioritization as a primary step towards the effective use of indicators for provoking management actions that support ecosystem management goals. The discussion will be contextualized using the case study of the Balearic Islands' ICZM indicators and LIMCosta projects, which are being implemented through partnerships between the scientific community, government, civil society, and the Chamber of Commerce.

Keywords: cultural objectives, ICZM, indicators, socio-economic objectives.

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ICES CM 2010/B:03

Integrating coastal-zone dialogues: can initial networking of partners reduce conflicts in marine coastal areas?

Denis Lacroix

Integrated coastal-zone management (ICZM) is a link between three fields: environment, human activities, and economics. All three are under strong and contradictory pressures, entailing various types of development with numerous factors and limited up-to-date and consistent knowledge. Nevertheless, decision-makers must find methods and means to manage the sustainable development of the coastal area, a place where different and often conflicting uses are steadily increasing, notably in the Mediterranean. Numerous guidelines are available but in practice these are often far from usual and common sense recommendations. The actor-network theory (Callon and Latour) could be a useful tool to clarify and reduce the chronic problem of the conflict of uses in coastal areas. The usefulness and efficiency of this theory was demonstrated through the example of scallop fishery management in northern Brittany in the 1980s. After scaling up, this theory demonstrates its relevance and usefulness through two modern issues dealing with coastal management *lato sensu*: networking of actors involved in aquaculture development in order to train

them to a new ecosystem approach (the IUCN initiative) and artificial reef project management (e.g. the Portuguese model of the Algarve). The advantage of this theory is the fact that it is a concrete and applied method that can be easily proposed to any set of stakeholders as soon as the challenge or project can be defined. This practical method can also be used as a simulation process incorporating foresight analysis.

Keywords: actor-network theory, ecosystem-based management, foresight analysis, ICZM.

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ICES CM 2010/B:04

Identifying cultural ecosystem services: the coastal futures approach

Kira Gee and Andreas Kannen,

Ecosystem services are variously employed to describe interactions between natural systems and human use. The research project "Coastal Futures" applied the concept to the specific case of offshore wind farm development in the German North Sea. Although the entire range of ecosystem services was assessed, our focus in this presentation is on cultural ecosystem services, an aspect often neglected because of the inherent difficulties of measuring non-market ecosystem values. Using the two districts of Dithmarschen and North Frisia on the North Sea coast of Schleswig-Holstein as a basis, we first describe the entire range of cultural ecosystem services found in the adjoining sea areas. Assuming strong development of offshore wind farming, we then describe the potential impacts of this development on the cultural ecosystem services identified. Because intangibles are difficult to quantify, we use a mixed quantitative and qualitative approach to rate these impacts both in spatial terms and in ecological terms. Some of the inherent difficulties of locating cultural ecosystems in space and time will be discussed. Although our results only represent a snapshot of the current situation, we believe that identifying and communicating non-market values can make an important contribution to integrated coastal-zonezone management (ICZM) and marine planning in that it allows values that are otherwise difficult to voice to be included in the debate.

Keywords: cultural impacts, ecosystem services, integrated coastal-zone management (ICZM), maritime spatial planning (MSP), offshore wind farms.

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ICES CM 2010/B:05

Marine Scotland Science: contribution of bathymetric surveys to marine planning for renewable energy developments

P. J. Hayes and I. M. Davies

Marine Scotland Science (MSS) has been asked to assist the emerging wave and tidal energy industries by providing regional datasets from selected areas around Scotland. One aspect of the work undertaken by MSS was to survey the bathymetry of the Pentland Firth, where tidal streams can attain 12 knots. Bathymetric data were collected using the FRV "Scotia" with a Reson Seabat 7125-B multibeam echosounder system. Transect lines were spaced ensuring 50–100% coverage for the majority of the survey area. In total, 235 km^2 were surveyed in the Pentland Firth from 18 July to 5 August 2009. The data were post-processed using industry standard software by Netsurvey Ltd. A quantitative approach was developed to make the best use of the bathymetric dataset. Within Arc GIS, the bathymetric data were used to create shape files with 10-m-depth intervals and 5-degree gradient intervals. A separate shapefile was created with buffer zones running parallel to the coastline, extending offshore at 1 km intervals. Each of the layers created was classified, clipped to the same size, and brought together into one shapefile in a geodatabase. This allows the data to be queried according to the seabed depth, seabed gradient, and distance offshore. Areas of the

seabed suitable for demonstration through to full-scale commercial deployments can be calculated, based on developers' operating tolerances for depth, gradient, and distance offshore.

Keywords: bathymetry, geodatabase, marine spatial planning, renewable energy.

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ICES CM 2010/B:06

Institutional and regulatory reform to contribute to the achievement of development objectives in the marine environment

J. C. McKie and I. M. Davies

Wave and tidal stream power generation is a high priority for the Scottish Government in meeting its target of 50% of the energy demand in Scotland to be met from renewable resources by 2020. Activities necessary to achieve this ambitious target include a spatial plan-led approach to development, and effective and efficient regulatory processes. A regulatory system review demonstrated that the consenting/licensing process has been complicated and multi-stranded, involving separate applications to several governmental regulators. Each regulator operated their own consultation processes, resulting in some consultees (statutory and other) receiving multiple approaches from regulators for comment on the same project. The Scottish Marine Act (2010) introduces a single Marine Licence to be issued by a single new body, Marine Scotland. The Marine Licence will incorporate the requirements under the various items of legislation which previously have been progressed independently. The regulatory processes therefore have been centralized within a single regulator who will establish a single point of contact ("one-stop-shop") for project developers. It will also allow an approach to regulation in which a case officer will take responsibility for the processing and progression of all elements of work leading to the granting or refusal of a Marine Licence. Further supporting activities include the preparation of a licensing and environmental impact assessment (EIA) guidance manual for developers and regulators, and environmental monitoring guidelines.

Keywords: guidance manual, institutional reform, marine licence, monitoring, regulatory reform, renewable energy, simplification.

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ICES ASC 2010/B:07

Risk-based frameworks in ICZM and MSP decision-making processes

Roland Cormier, Andreas Kannen, Beatriz Morales Nin, Ian Davies, Clare Greathead, Raphael Sarda, Amy Diedrich, Vanessa Stelzenmueller, and Erlend Moksness

The coastal zone is considered to be the point of highest interaction between land-based activities and the local marine ecosystem. In addition, the coastal zone is a significant contributor to the socio-economic prosperity of local communities, supporting a broad base of economic and cultural sectors. As a result, it is also the zone where aquatic ecosystems can be particularly vulnerable to pressures caused by human activities and where management operates within a complex jurisdictional backdrop. An integrated management approach to both terrestrial and marine spatial planning aims at reducing conflicts while maintaining the productivity (in a broad sense) of aquatic ecosystems. Although fairly straightforward in the planning process, implementation and follow-up of such plans have proven to be challenging. Given the complexity of integrating ecosystem, social, cultural, and economic demands within a defined geographical area, decision-making approaches using classical risk analysis can provide structure that facilitates and informs the planning and implementation processes. Such an approach also assists fact-based priority setting while adhering to principles of inclusiveness and transparency. This paper presents lessons learned

and best practices from integrated coastal-zone management projects and explores the use of such approaches in marine spatial planning.

Keywords: coastal zone, risk analysis, spatial planning.

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ICES ASC 2010/B:08

Policy fragmentation implications in ecosystem-based management in practice

Roland Cormier, Andreas Kannen, Ian Davies, Rafael Sarda, and Amy Diedrich

Integrated assessment processes are a practical outworking of ecosystem-based management principles. In its simplest form, most assessments involve the overlaying of geospatial components highlighting susceptible ecosystems in relation to a given project or sector activity. The end product aims to minimize environmental impacts through the implementation of mitigation measures. In general, this approach is ill-equipped to deal with cumulative effects resulting from multiple sector-based activities. Although integrated assessments may adequately ascertain the impacts, the implementation of resulting management plans is hampered by the complex, potentially conflicting, jurisdictional policy objectives of various levels and arms of government in a given geographical area. In the coastal zone, this complexity is amplified when land-based interactions located in the catchment area are considered. These are typically managed by policy objectives that may not align with marine ecosystem integrity. Such management plans can also have limited effectiveness without clear established formal accountabilities. In this paper, policy fragmentation is discussed as being a key impediment to effective ecosystem-based integrated management approaches. It also presents examples of successful projects highlighting institutional and policy integration initiatives.

Keywords: ecosystem-based management, policy fragmentation.

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ICES CM 2010/B:09

Integrated assessment for use in system-based management: ecosystem health and restoration through sustainable use of resources

Josianne G. Støttrup, Grete E. Dinesen, Karen Timmermann, Stiig Markager, Eva Roth, Lars Ravn-Jonsen, Dewan A. Ahsan, Marianne Holmer, and Sten Sverdrup-Jensen

Developing human activities often conflict with nature preservation requirements and integrated assessments are necessary to build reliable scenarios for management. In a shallow estuary, the Limfjord in Denmark, reduction of nutrient loadings is necessary to fulfil criteria for European Union regulations, such as the Water Framework Directive (WFD). Cuts in nutrient loadings do not necessarily result in corresponding reductions in eutrophic impacts or in improvements in primary and higher trophic production, and the socio-economic consequences for mussel fisheries and aquaculture production are complex and hard to predict. An integrated analysis (ESE assessment) of interactions between nutrient loading and mussel production (fishery and aquaculture) was carried out, including ecological, social and economic aspects related to these issues. The model developed allows prediction of the effects of nutrient reduction on mussel growth and harvest yield from fisheries and aquaculture, and the socio-economic consequences. Furthermore, the model allows for feedback scenario prediction of production management of fishery (e.g. quota) and aquaculture (e.g. licences and labour), economic externalities (e.g. market demands and prices) and ecological externalities (e.g. oxygen-depleting events, harmful algal blooms). In the economic–social model components are embedded a ”husbandry function” for aquaculture production and an ”agent-based” production model for the mussel fishery, which are attractive features of high value and interest to the fisheries and mussel farming communities. The scenario results also

include unanticipated potential wider benefits of ecosystem health by optimizing management in relation to other EU-driven regulations, such as the Natura 2000.

Keywords: ecosystem health, integrated assessment, system-based management.

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ICES ASC 2010/B:10

Integrated coastal-zone management: bridging the land–water divide

Marc Ouellette

The coastal zone is an area of high ecological complexity and productivity given its intrinsic connectivity between habitats and processes of freshwater and marine aquatic ecosystems. It is also an area of complex anthropogenic interactions with variable social, economic, and cultural components. Furthermore, it is the zone where aquatic ecosystems are the most vulnerable to cumulative pressures caused by human activities of various types and intensity, where management lies within a complex jurisdictional backdrop. Thus, the coastal zone is a complex mosaic of variable zones of influences and ecosystem component vulnerabilities along the land–water interface. Canada is a maritime nation. It is bordered by the Pacific, Atlantic, and Arctic Oceans, it has the world's longest coastline (at ca. 244 000 km), and also borders interior freshwater "seas", the Great Lakes. Eight out of our ten provinces border oceans, as do our three Territories. Given this backdrop, integrated coastal management seems a formidable challenge, but it is possible and it is critical that we do it strategically and efficiently with the best available information at present. Under the Health of the Oceans Initiative, four Centres of Expertise have been established within the Oceans Sector of the Department of Fisheries and Oceans in order to better understand and address national integrated coastal and oceans management issues. An overview of the objectives of the CoE on Coastal Management is presented with a focused update on its efforts in the development of ecosystem-based approaches, in relation to cumulative effects, and risk analysis decision-making tools.

Keywords: adverse environmental effects, indicators characterization, integrated coastal-zone management, risk analysis.

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ICES CM 2010/B:11

From population modelling to management: integrating different risk factors affecting a seabird living in the Gulf of Finland, Baltic Sea

Inari Helle, Samu Mäntyniemi, Martti Hario, and Sakari Kuikka

The successful management of environmental risks requires that risks are considered simultaneously, rather than separately. It is also vital that uncertainty is taken into account in a coherent manner. The Gulf of Finland, the easternmost part of the Baltic Sea, is a brackish-water area facing many human-induced threats. In this paper we present a modelling approach that allows the integration of several risks and show how the results can be used to support management decisions. We use the common eider (*Somateria mollissima*) breeding in the Gulf of Finland as an example. The main threats to the species are assumed to be changes in salinity (through their main food items—blue mussels), oil spills, and hunting. First, a probabilistic age-structured Bayesian parameter simulation model describing the population dynamics is built, after which different risk factors are included in the model. Salinity changes are assumed to manifest in the survival of ducklings, whereas both hunting and oil spills remove a certain proportion of the total population. Of these risks, hunting can be estimated to some extent, but with the oil spills both the magnitude and the future frequencies of accidents are highly uncertain. Finally, the results are used as an input for an integrative decision model, a Bayesian network, in which different

management strategies regarding oils spills and hunting can be tested. The method presented here will be applied later also to the Baltic herring (*Clupea harengus membras*) living in the Gulf of Finland.

Keywords: Bayesian modelling, common eider, Gulf of Finland, hunting, oil spills, uncertainty.

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ICES CM 2010/B:12

Probabilistic assessment tool for the Water Framework Directive: application to the Gulf of Finland

Annukka Lehikoinen, Eveliina Klemola, Samu Mäntyniemi, and Sakari Kuikka

Ecological status classification (ESC) of the Water Framework Directive (WFD) aims at the harmonized evaluation and management of inland and coastal watersheds in Europe. The target state, "good ecological status" by year 2015, provides a clear minimum to be reached. WFD ESC is based on a management-oriented view. If the state of a watershed is judged to be moderate or worse, there is a need to act and improve the state. So far it seems evident that the objectives of the WFD will not be attained before the deadline. We present a prototype of a modelling tool that can be used to assess the probability of reaching WFD aims in the Finnish coastal waters of the Gulf of Finland. The model is based on a relatively simple Bayesian network structure that integrates the results obtained by applying complicated load and ecosystem models and data analyses, given alternative nutrient abatement scenarios in Finland, Estonia, and Russia. Thus, the Bayesian network is used as a meta-model that integrates knowledge from several sources. The role of future climate change, as well as uncertainties arising from it and other sources can also be analysed. We suggest that this type of decision model could be useful in international cooperation when defining the objects, areal responsibilities, and optimal use of resources available for the abatement of nutrient loads. It would also be helpful when comparing divergent national implementation approaches of the WFD ESC or evaluating the magnitude of reference values and uncertainties related to them.

Keywords: Bayesian networks, decision analysis, ecological status classification, Water Framework Directive.

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ICES CM 2010/B:13

Use of reality models (architecture) for integrated coastal-zone management

Knut Torsethaugen

Challenge: How can actors involved in coastal development digest, accumulate, and use "state-of-art" knowledge from political, social, economic, and natural science in their daily work? How can we bridge the gap between advanced science and local coastal-zone management? Coastal areas are a limited resource with dynamic physical and biological properties and varying social and economic restraints and management. Cost-efficient and sustainable use of coastal areas is therefore a complex and interwoven issue. Making decisions within such complex systems can be more difficult the more information is available and simple solutions not based on a holistic, knowledge-based view can lead to disasters.

Solution: A reality model or architecture concept is introduced. Similar concepts are used in other sectors, such as enterprise, intermodal transport, and software development. The reality model is based on a vision and is a top–down holistic description of all of the elements and relations between elements that is part of the system. The overall aim is to establish a common framework for integrated coastal management based on accepted goals, experience, existing models, and cross-disciplinary knowledge. The model identifies conditions for how new scientific knowledge can be

implemented in decision-making and is a guide for cost-efficient collection of information to fill knowledge gaps. The model includes functional and information architecture, which, combined with future ICT, can be the basis for developing decision support tools so that sustainable solutions can be found on different management levels as part of a holistic approach and thus reduce the risk of failure.

Keywords: architecture, coastal zone, reality model.

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The Gerrico project: when modelling helps the integrated management of the coastal area

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The Gerrico Project, managed jointly by Ifremer and the University of Nantes, is focused on the Bay of Bourgneuf. Located in the south of the Loire estuary on the French Atlantic coast, this bay is largely used by oyster farming (13 000 t yearly) and characterized by many interesting habitats, such as seagrass beds and honeycomb worms. In recent years the Bay of Bourgneuf has been faced with several problems affecting oyster growth, survival, and quality, the maintenance of water quality, biodiversity, and the sustainability of activities. The original feature of the Gerrico Project is the development of methods capable of taking into account the entire area from the watershed down to the marshes and the coastal sea, using a chain of coupled models to integrate the different activities by combining physical modelling (sedimentology, hydrodynamics), biological modelling (growth of the algal biomass, oyster growth), and economic modelling (management of oyster-rearing parcs on the scale of the production basin or shellfish-farming business). The common point driving this approach is water quality, on which depends the optimization of coastal activities. Some scenarios at different spatial and temporal scales (e.g. increasing nutrients; oyster growth variability between farming sites, impact of trophic competitors (slipper limpets, wild oysters), carrying capacity assessment) have been implemented in order to simulate the biological and socio-economic consequences of different types of management. The objective is to establish a dynamic tool that will provide a firm basis for integrated management of the coastal area.

Keywords: coastal area, ecological modelling, economic modelling, marshes, oyster farming, physical modelling, watersheds.

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Participatory approach to identify governance indicators for integrated coastal-zone management: the case of Marine Protected Areas

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Marine Protected Areas (MPAs) are the laboratory of integrated coastal management. Driving the MPA system requires the implementation of a battery of indicators of governance. This governance must take into account both the internal dynamics of the system and the threats coming from the system environment. As part of a research project funded by the French Ministry of Ecology, (Liteau program), four coral reef MPAs were selected as pilot studies (St Martin in the Caribbean, Reunion and Mayotte in the Indian Ocean, the South Lagoon of New Caledonia in Oceania) to develop governance indicators jointly between scientists and managers of MPAs. The approach is definitely bottom–up. It is based on the co-construction of indicators. In that way, the views of the scientists who bring their knowledge of governance and ICZM were crossed with the views of the MPA managers who bring their field knowledge and specific requests relating to the management

of their MPAs. The process was conducted in five steps which will be described. The main indicators will be presented and then discussed.

Keywords: French overseas territories, governance indicators, ICZM, marine protected areas, participatory approach.

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Some hints on the risk of failing in IZCM

G. David and A. Thomassin

The risk of failing in integrated coastal-zone management (ICZM)—is it only ascribable to increasing anthropogenic pressures in the coastal environment? Based on the example of Reunion Island and other French overseas region, the view expressed here is that the main risk results from the lack of structure in ICZM: (i) in the arena of public authorities acting on the coast; (ii) among private actors; and (iii) between public authorities and private actors. The integration between public actors is driven by coastal planning schemes but it does not work as hoped. Thus, the daily management of coastal activities remains sectoral. Local politicians are often wary of the concept of ICZM which they see as a top–down concept. The relationships between the authorities and local stakeholders dealing with coastal management are usually driven by rules. But often the enforcement is weak, owing to a poor acceptance of these rules by the local stakeholders. To improve the situation, the establishment of bodies for dialogue and consultation between the public authorities and local stakeholders is requested. In a more realistic way, collecting indicators devoted to social acceptability could be a first improvement. The establishment of a body dealing with information sharing, including indicators, among the public authorities could be a second step. Thus, integrated information management is a prerequisite to ICZM. Avoidance of this rule may risk major failure in ICZM.

Keywords: ICZM, information sharing, Reunion Island, risk of failing, social acceptability indicators.

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Using Bayesian network modelling to cope with the Marine Protected Area governance issue

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Bayesian networks are useful tools for modelling interactions and predictions in socio-ecological systems because they offer a robust theoretical framework towards risk and uncertainty management problems through the use of probabilities. Furthermore, this theory gives the possibility of combining expert knowledge and data. That is why they have been successfully used for helping resource-management decision-making process in numerous case studies. We propose application of this approach in order to deal with the Marine Protected Areas governance issue. A first model of Bayesian network has already been developed from a French Polynesia case study concerning fisheries response to regulations in Moorea Island. This step allowed us to think about a more comprehensive model, which would encompass the ecological, economic, and institutional components that underlie the understanding of the Marine Protected Areas governance issue. Therefore we derived a second model from six case studies: three in the Mediterranean and three in French overseas areas. The first objective was to draw through the structure of the Bayesian network a synthetic and comparative framework that represents the expert knowledge relative to the Marine Protected Areas implementations and their consequences on the different components of the socio-ecological system. The second objective is to simulate a governance scenario for a particular case study—as the impacts of different regulation measures on the resources and biodiversity conservation of the ecosystem or on the satisfaction of users such as fishers or tourists—once the parameters of the model have been set up by using both database and expert judgement.

Keywords: Bayesian networks, expert knowledge, fishery management and regulations, governance, indicators, integrated approach, Marine Protected Areas, probability, risk management, scenarios, simulation, social acceptability, tourism.

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ICES CM 2010/B:18

Constructing and validating indicators of Marine Protected Areas performance for decision support

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Marine Protected Areas (MPAs) are a key instrument for managing coastal ecosystems. Many international agendas foster the creation of MPA for achieving conservation of marine biodiversity, but also fishery management and more generally management of coastal uses. Scientific advice together with the provision of adequate tools is needed to assist managers in monitoring and assessing MPA performance. For this purpose, a sound collaboration between science and policy-makers is critical. A major objective of this collaboration is to define appropriate indicators in relation to detailed management objectives and actions. Indicators are intended to help in setting up appropriate conservation and regulation measures or adapting existing ones. This paper presents the approach developed in the PAMPA project for deciding, testing, and validating indicators of MPA performance. Formalizing objectives, constraints, and needs for managers is a first step in this process. The second step is to test and validate candidate indicators from real field data through application to various case studies. Indicators are related to biodiversity, resources, uses, and governance; they are obtained from several observation techniques and pertain to several case studies over the world, both in the Mediterranean and in French coral reef areas. The approach is illustrated through various examples from these case studies.

Keywords: decision-support system, indicators, Marine Protected Area, multidisciplinary, PAMPA project.

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ICES CM 2010/B:19

Economic assessment of the ecosystem services provided by freshwater in the coastal zone: an application to the Charente river catchment

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Integrated coastal-zone management is an emerging governance practice which aims at combining environmental preservation, economic development, and social concerns in the context of complex ecosystem dynamics and increasing anthropogenic pressures. Coastal managers need economic assessments in order to investigate the consequences of policy options which apply to different sectors simultaneously and pursue multiple objectives. The ecosystem services concept offers a framework for a better understanding of users' conflicts and management trade-offs regarding natural resources and the environment. This paper presents an economic assessment of the variations of the ecosystem services supplied by freshwater in the coastal zone, depending on various management options. This assessment has been carried out according to the "system approach framework" methodology developed by the European project SPICOSA (Science and Policy Integration for Coastal System Assessment). An integrated systemic model has been built following a participative approach in order to address the issue of freshwater allocation in the Pertuis Charentais region. The stakeholder forum agreed upon the assumption that freshwater scarcity affects mainly "provisioning services" used by households (drinking water) and agriculture (irrigation), "cultural services" used by recreational fishers, "support services" used by shellfish farming, and "regulation services" needed by wetlands. The economic assessment of these

ecosystem services is based on two methods: remediation costs and productivity losses. The results contribute to the deliberative process engaged with local managers in order to explore new rules and institutional arrangements for water allocation, their consequences on ecosystem services, and their meanings in terms of conflict mitigation.

Keywords: economic assessment, ecosystem services, integrated coastal-zone management, productivity losses, remediation costs, user conflicts.

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ICES CM 2010/B:20

Series of institutional and legal frames in the coastal-zone management: where are the risks of failing, where are urgencies in the field of law?

Florence Galletti

Since the mid-1980s, coastal-zone management has been affected by several tools in the law sector: protection through national or European Environmental Law, the Law of the Sea, and in particular legal constraints and permissiveness of the famous French Law called "law-coast", or one of its European counterparts. These constraints on coastal and maritime zones have been integrated with variable success in integrated coastal-zone management, although it is not a legal concept. Despite all measures of institutional and legal frameworks, coastal areas, which had been presented as dynamic zones, mainly in terms of economics and tourism, are facing many difficulties. They are linked to a complex set of factors: dependence on foreign markets, great wealth to be gained in a short time, development of the industrial sector as harbour activity, a mass of legal tools in the relations between state and private sector, legal insecurity, condemnations, trials, etc. Such difficulties have led the public policies sector to a critical situation, as exemplified in France. We discuss the risks of failing in legal coastal-zone management and its evolution. Is the collapse of this system of coastal-zone management predictable? Understanding the effects of French law of 3 January 1986, relative to the arrangement, protection, and development of the coast on public policies led by decentralized institutions. What are the contributions and limits of this law? Can we envisage other components for the coastal-zone management by the law?

Keywords: decentralization process, environmental law, French law called law-coast, law, law of the sea, legal coastal-zone management, marine and coastal public policies, Marine Protected Area, state.

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ICES CM 2010/B:21 Poster

Why and how integrated coastal-zone management should be put into the context of national maritime strategies

Yves Henocque

Over the last 30 years hundreds of integrated coastal-zonezone management (ICZM) initiatives have taken place all over the world but with very limited success for a number of reasons. For example, (i) local ICZM projects often become an end in themselves rather than a step towards a self-sustaining process, (ii) the perception of ICZM as an environmental management activity is stubbornly persistent, there is a need to embed ICZM into economic development, the very practice of environmental policy integration, and (iii) there is a lack of concrete articulation between local ICZM action and national policy. As regards the latter, things are now changing rapidly in many countries, including the European countries under the incentive of the new European maritime policy. Nowadays, ICZM initiatives are to be considered in the framework of national maritime policies and their underpinning principles, including the ecosystem-based approach.

Keywords: ecosystem-based approach, environmental policy integration, ICZM, maritime policies.

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ICES ASC 2010/B:22 Poster

Application of marine spatial planning tools to the minimization of risk to renewable energy developments

I. M. Davies, M. Harrald, and A. Donald

Wave and tidal stream power generation is a high priority for the Scottish Government in meeting its target of 50% of the electricity demand in Scotland to be met from renewable resources by 2020. Renewable energy projects have the potential to interact with the environment (e.g. conservation aims) and with other uses of the sea (e.g. shipping routes, fishing areas). A significant risk in the regulatory process is that these interactions must be formally assessed (e.g. through EIA and Appropriate Assessment under the EU Birds and Habitats Directives) and reduced to acceptable levels. Marine Scotland collaborated with The Crown Estate (owners of the UK seabed) to identify areas of wave and tidal stream resource which avoided sensitive areas and limited impacts on existing marine uses. The identification of potentially suitable development areas was addressed through the application of marine spatial planning tools to develop an information framework covering the availability of exploitable resource and a wide range of information on constraints including incompatible current uses, environmental designations, shipping, commercial fishing, recreation, biodiversity, and fish spawning and nursery grounds. The output was a series of maps identifying the relative degree of constraint on wave and tidal development areas around the Scottish coast, from which decisions could be made on areas to consider for early leasing for wave and tidal power development.

Keywords: marine spatial planning tools, renewable energy, risk management, tidal stream, wave.

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Short-term chronological visualization of post-hurricane destruction in Puerto Rico using geographic information systems

Jacob Spuck

Much of what we know about hurricane destruction today is a result of many years of post-hurricane impact assessment by various professionals across the world. Although there have been many ways in which to study post-hurricane destruction, modern technology is today allowing for more detailed analysis of impact assessment. With the use of geographic information systems (GIS) as one application of technology, we are not only able to study long-term impacts of hurricane destruction, but also short-term impacts that occur chronologically up to 72 h after the hurricane has passed. Studies such as these are critical ways in which we can help to plan for evacuation and minimize casualties from post-hurricane impacts.

Keywords: coastal-zone management, natural diasasters, remote sensing/GIS.

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Spatiotemporal variability of fish functional assemblages along a marine estuarine–coastal gradient

Dorothée Kopp and Anik Brind'Amour

The coastal areas are highly dynamic ecosystems displaying great natural variability in temperature and salinity conditions. These factors, recognized as major drivers shaping coastal

communities, are expected to change relative to global warming. Recent studies have highlighted temporal trends in the spatial distribution of warm water and marine fish species in different estuaries of the Bay of Biscay. Simulations recently realized with the model Mars3D indicated an increase in the mean bottom temperature (+1.5°C) and mean salinity (+2 psu) over the past 30 years in the Bay of Vilaine, an open shallow muddy estuarine area under the direct influence of freshwater inflows. This paper assesses the spatiotemporal patterns of marine migrant species that use the Bay of Vilaine as a coastal nursery ground. It uses a fish dataset from beam trawl nursery-dedicated surveys carried out from the end of August to the end of October between 1981 and 2009. Analyses were conducted using a functional description of the fish species categorized by species tolerance of temperature and salinity conditions. The present study is a contribution to the ecological understanding of temperature and salinity changes in coastal ecosystems.

Keywords: Bay of Vilaine, fish community, functional groups, nursery grounds, salinity, time-series.

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ICES CM 2010/B:25 Poster

Assessing potential impacts of Marine Protected Areas on various Gulf of St Lawrence stocks and fisheries using ISIS-Fish

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Canadian demersal stocks have faced a strong decline in recent decades mostly as a result of overexploitation. In 2007, various initiatives started to protect fragile marine environments, counter pollution, and strengthen preventive measures. Those included the designation by the Department of Fisheries and Oceans (DFO) of six new Marine Protected Areas (MPAs), in agreement with Canada's international and national commitments. MPAs are one among other management tools that contribute to the improved health, integrity, and productivity of marine ecosystems. Two areas of interest (AoIs) have been proposed for designation as MPAs in the southern Gulf of St Lawrence, namely the American Bank and the Shediak Valley. These AoIs are recognized as key habitats for a number of fish and invertebrate species. ISIS-Fish is a spatially and seasonally explicit simulation tool especially designed to explore management measure impacts. It is used here to evaluate possible outcomes of implementing MPAs on various stocks (Atlantic cod, snow crab, herring, and American plaice) in the southern Gulf of St Lawrence. The current low status of most stocks in the area has led to important quota reductions or moratoriums during recent years. Through ISIS-Fish we explore different management strategies applied to those AoIs such as a no-take option or partial regulation of exploitation. These simulations could help forecast potential benefits of proposed AoIs and provide the DFO with useful material for their MPAs designation process. This preliminary study permits the identification of key processes that should be described in depth to provide a more realistic estimate of impacts.

Keywords: Gulf of St Lawrence, ISIS-Fish, Marine Protected Areas, simulation.

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ICES CM 2010/B:26 Poster

Ecological and fisheries consequences of a mismatch between biological population structure and management units of Atlantic cod in US waters

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A mismatch between biological population structure of a species and spatial management units of the fishery can present problems, because the scale of management action should match the scale of biological processes. We hypothesized that recognition of fine-scale population structuring of Atlantic cod in US waters will redefine our perceptions of the productivity, stability, and sustainable yield of the regional population. The goal of our study was to use simulation modelling

as a tool to examine the ecological and fisheries consequences of a mismatch between management unit and biological population structure, as defined by genetic analysis, of Atlantic cod. Two age-structured simulation models were compared to test our hypothesis: (i) the management unit model, wherein fish were grouped based on the current spatially defined US management areas (Gulf of Maine and Georges Bank), and (ii) the biological structure model, which consisted of three genetically defined population components (northern spring-spawning, southern winter/spring-spawning, and Georges Bank spring-spawning groups), with some mixing of early life stages. Productivity and yield of the biological structure model was lower than that of the management unit model because of consideration of the unique vital rates and dynamics of, and connectivity between, spawning groups. Stability of the system, however, was enhanced through these same attributes. Consideration of biological structure of cod changed our perception of the magnitude and distribution of productivity in the region, suggesting that expectations of productivity of Georges Bank cod should be reconsidered.

Keywords: management area, population structure, productivity, simulation model, stability, sustainability.

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ICES CM 2010/B:27 Poster

An indicators system to assess recreational fishery management goals linked to Marine Protected Areas: example of its implementation in three Mediterranean pilot sites

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In the French project "PAMPA" dealing with indicators of MPA performance, managers and researchers from eight French overseas and Mediterranean pilot sites are building an approach in order to assess the biodiversity conservation and the sustainability of uses in coastal marine areas regulated by a management plan. A standardized framework is developed from the identification of management objectives to the validation of an indicators dashboard for the decision-making process linked to the MPAs. Several components of the coastal marine ecosystems and their uses are taken into account, with a focus on recreational activities because of their development related to the success of the MPAs and their impacts on the natural, social, and economic systems of the concerned areas. From three Mediterranean examples (Côte Bleue, Banyuls/Mer, and Cap Roux), we show different steps of the implementation of this framework for the purpose of underlying the statistical aspects linked to the definition of good indicators in order to answer management needs: collecting data with standardized surveys, exploratory data analysis using few metrics related to management measures, and selection of indicators on the basis of their statistical properties depending of the variability of the system analysed. Five categories of indicators (pressure, impact, fishing practice, social acceptance, and socio-economy) are defined to assess and to monitor recreational fisheries. They will be involved in an indicators set concerning the other uses (commercial fisheries and non-extractive uses), the species and habitats in and outside the protected coastal areas, and the governance of the MPA.

Keywords: Marine Protected Areas, metrics and indicators, recreational fisheries, standardized approach, statistical analysis, sustainable management, users' typology.

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ICES CM 2010/B:28 Poster

Recreational fishing around the Cap Roux MPA (northwestern Mediterranean Sea): evaluation, impacts, and consequences for the future of the marine reserve

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The Cap Roux Marine Reserve was created in 2003. It is situated close to the coastline of the department of Var, and covers an area of around 480 ha. All types of fishing are prohibited inside the MPA: professional or recreational fishing, spearfishing, and collecting. A monitoring of the leisure fishing was conducted inside and around the MPA from April 2009 to October 2009 in the "PAMPA" project. Based on initial results, a decreasing gradient of the fishing pressure was observed from the north to the south of the MPA. The easy access to the northern part of the MPA could explain the higher pressure in this area. In contrast, the southern part is more isolated and exposed to wind. Despite the mandated protection, several fishers were still observed inside the MPA, mainly as a consequence of lack of information and insufficient markers around the MPA. In these cases, the sizes of the fish caught were greater than those that were caught outside the MPA. Recreational fishing constitutes the most important pressure on fish assemblages in the Cap Roux MPA although its effect is not as extensive here as in other Mediterranean MPAs. For example, compared with the MPA of Cerbère-Banyuls (northeast French Mediterranean), the Cap Roux MPA appears to be less affected by fishing activities. It is thus important to include this activity in the future management plan of the Cap Roux MPA. Regular monitoring of recreational fishing is advised.

Keywords: leisure fishing, management plan, Mediterranean Sea, monitoring, MPA.

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ICES CM 2010/B:29

Marine Protected Areas for coastal fishery management: confronting artisanal fishers' perceptions and fisheries data

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Marine Protected Areas (MPAs) are increasingly advocated for the sustainable management of coastal resources and associated fisheries. The Côte Bleue Marine Park (CBMP), on the French Mediterranean coast, was established in 1983 as a tool for fishery management. It comprises two no-take reserves (NTAs; 290 ha) and ca. 5000 m^3 of artificial reefs. The aim of this study is to characterize the artisanal fishery in the CBMP and to develop indicators of the effects of the MPA on fishers' activity based on their attitudes and motivations. Surveys were conducted in 2009–2010 with the fishers (80%) willing to participate in this study to investigate the artisanal fishing activities. After landing, information was collected on gear, target species, and fishing areas, both for the present trip and for the past week. When possible, catches were weighed and identified to species level. Boat characteristics were obtained from administrative data. Independent individual interviews were also carried out to determine fishers' perceptions and motivations. These data were first analysed to come up with a synthetic description of the fishery that includes precise maps of the spatiotemporal distribution of fishing effort, especially around the NTAs and the artificial reefs. In a second step, we investigated the relationships between observed fishing activities and fishers' perceptions. If most fishers think that NTAs and artificial reefs have positive impacts on the artisanal fishery in general, perception of positive effects on the individual activity seems to depend of the métiers used and the distance of the fishing grounds to NTAs and artificial reefs.

Keywords: artisanal fishery, distribution, fishers' perception, fishing effort, MPA.

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ICES ASC 2010/B:30 Poster

Recreational fishing: a key issue for resources management in the southwest lagoon of New Caledonia

B. Preuss, D. Pelletier, and E. Gamp

Recreational fishing represents a large proportion of the total catch in many countries. This informal fishery is difficult to study and often overlooked, yet the characterization and estimation of catches of this activity is essential with regard to management plan building. Moreover, decision-makers need spatiotemporal information to implement adequate management tools, such as MPAs, TACs, or minimum size restrictions. The southwest lagoon of New Caledonia is a fragmented coral reef area facing the increasing population of Nouméa. It is a city of ca. 163 700 inhabitants, where recreational fishing is a widespread activity. This situation makes the management of informal fisheries a key issue for resources sustainability. An MPA network composed of seven reserves is the aim of the actual management plan, but recreational fishing effort and catches remain poorly known. In this study we address the question of recreational fishing management by a spatiotemporal modelling of fishing effort and catches. We used a roving survey, with attendance counts, and interviews with anglers. As expected, day types, weather conditions, and season, were the main factors explaining the attendance of recreational fishers. Furthermore, the lagoon could be divided in several areas corresponding to different types of fishing techniques and target species. Thus, in order to manage properly reef fish diversity, managers have to account for the spatiotemporal distribution of fishing effort, and for the life cycle and life-history traits of the most targeted species. In this respect, the applicability of a management plan to recreational fishing will be a key issue for the implementation of efficient resources management.

Keywords: fishery management, fishing effort distribution, MPA, recreational fishing, roving survey.

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ICES CM 2010/B:31 Poster

Coastal fishing management complexities

Beatriz Morales-Nin, Miquel Palmer, and Antonio María Grau

Human activities are often concentrated in coastal regions, resulting in multiple uses of natural resources for human needs, with fisheries as a significant part. Fisheries are complex ecological and social systems, evolving in time with a shift from a subsistence activity to commercial and towards recreational activity. The management policies have different jurisdictions at regional, national, and transnational level and must council the different management tools used to conserve the biodiversity and the social fabric in the coastal zone. We use as an example the Mediterranean coastal fisheries, which are basically traditional small-scale activities of low investment. The entire fleet comprises 42 000 small boats playing an important socioeconomic role in the European fishing industry, representing 42% of the employment in the EU catching sector and contributing 12% of EU catches, which, because of the narrow Mediterranean shelf, mostly correspond to coastal waters. Overlapping with the small-scale fishery in space and resource use, is a very important and increasingly popular recreational fishery, with over 2106 anglers and 3105 recreational fishing boats in the Mediterranean. The main management actions in the Mediterranean comprise limiting effort, gear selectivity, and closed areas and periods, as well as regulations for the commercialization and traceability of the fishing products. Our example provides evidence of the complexity of fishing rights and how they can be adapted into practical fishery management. combining fishing rights, open access recreational fishery, community-based management, and biodiversity conservation.

Keywords: coastal fishery, management.

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ICES CM 2010/B:32 Poster

Management plan as tool for sustainable use of marine resources: lessons from Latvia

Solvita Strake

Over last four years Latvia has put in considerable effort to implement the EU Birds and Habitats Directives and within the framework of the LIFE project "Marine Protected Areas in the eastern Baltic Sea" has established seven Marine Protected Areas (MPAs). At present there is only experience with terrestrial protected areas in Latvia. Therefore, the fears of different stakeholders about how MPAs will influence the economy and coastal development are understandable as together with designation of MPA two management plans for two territories have been elaborated. The management plan areas represent all most significant sea and coastal uses and socioeconomic interests. Especially diverse is the "Western Coast of the Gulf of Riga" with sea ports, shipping routes, fishery, tourism, and recreation. Near "Nida–Pērkone" there is potential interest in building wind farms and extracting oil. To support communication with stakeholders and to enhance acceptance of the management measures a full-scale socioeconomic analysis was carried out for the both sites, including explanation of the costs and benefits related to establishment of the MPAs. This work has been performed for the first time in Latvia and significantly contributed to the success of the stakeholder acceptance. In comparison with terrestrial areas, for marine sites there is very little opportunity to apply active management measures. Therefore, the proposed measures mainly concern regulation of economic use (e.g. fishery, tourism, port development and maintenance, extraction of mineral resources, offshore wind farm development, etc.), administrative measures, monitoring, scientific research, as well as rising of public awareness.

Keywords: management plan, Marine Protected Area, stakeholders, use of marine resources.

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ICES CM 2010/B:33 Poster

Marine Scotland Science: Contribution of seabed habitat surveys to marine planning for renewable energy developments.

M. R. Robertson and I. M. Davies

Sustainable development of marine renewable energy (wave and tidal stream power) in coastal waters requires that due account is taken of the biodiversity and conservation value of the seabed habitats in development areas. Areas of high tidal streams may contain reef habitat, an Annex 1 habitat in the EU Habitats and Species Directive. As part of Marine Scotland Science (MSS) assistance to the emerging wave and tidal energy industries, regional seabed survey datasets are being collected from selected areas around Scotland. Survey work in the Pentland Firth and Orkney waters, which have significant potential for both wave and tidal power, has included acoustic surveys using the FRV *Scotia* with a Reson Seabat 7125-B multibeam echosounder system. The backscatter data have been processed using QTC Multiview software to develop acoustic classifications of seabed sediment type. In addition, seabed video and still imagery has been used to develop biotope classifications (EUNIS assessment system) of the areas surveyed. The biotope classification has been used to ground-truth the acoustic data and to create biotope maps.

Keywords: Renewable energy, marine spatial planning, seabed habitat, acoustic survey, biotope classification, Pentland Firth, Orkney

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ICES CM 2010/B:34 Poster

Interaction in coastal waters: a roadmap to sustainable integration of aquaculture and fisheries — the COEXIST project

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Coastal areas are subject to an increase in competing activities and protection and are a source of potential conflict for space allocation. The maintenance and/or development of small-scale coastal fisheries and aquaculture are highly dependent on the availability and accessibility of appropriate sites. Activities include not only fisheries and aquaculture, but also tourism, wind farms, Marine Protected Areas, etc. There is good reason to believe that the competition for such sites will increase, emphasizing the need for improved management tools supporting policies for space allocation along the entire European coastline. COEXIST is a broad, multidisciplinary approach with 13 European partners to evaluate these interactions with the ultimate goal of providing a roadmap to better integration, sustainability, and synergies among different activities in the coastal zone. The project will study the interactions between capture fisheries and aquaculture and evaluate mutual benefits and possible bottlenecks for concomitant development of these activities in the coastal zone within the context of the ecosystem approach to management. It will propose, develop, and evaluate the efficiency of spatial management tools (zoning, closed areas, etc.) to promote different forms of coastal aquaculture and fisheries at different scales (e.g. local, regional) and it will exploit mutual opportunities (e.g. artificial reefs, protected areas, wind farms, tourism etc.) within a context of competition for space by multiple users. The project will address differences in acceptance of activities (fisheries, aquaculture, and other use of the coastal zone) by the public.

Keywords: aquaculture, coastal zone, fisheries, interaction, legislation, marine spatial planning.

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ICES ASC 2010/B:35 Poster

The development of a novel regulatory and planning tool to guide the sustainable development of oyster aquaculture in New Brunswick, Canada

Sophie Bastien-Daigle and Matthew Hardy

Conservation and protection of fish habitat in coastal zones is proving to be inherently challenging because of the myriad regulators and stakeholders interacting there in a complex web of legitimate uses and conflicts. Innovative management regimes are required in that zone in order to protect fish habitat and other ecological resources while allowing for its sustainable development. Emergence of the aquaculture industry in the coastal zone has sparked calls at the global level for integrated regulatory frameworks to guide its development. The federal and provincial governments of Canada agreed, in 2002, to develop a comprehensive framework covering environmental review and management, site selection, design criteria, and operating conditions to guide oyster culture. The main objective of this framework was to streamline and bring a greater measure of predictability, consistency, and timeliness to the environmental review process of oyster aquaculture projects within the context of sustainable development. Key elements: This class screening relied on geospatial analysis to reduce spatio-temporal interactions between the activity and valued ecosystem components such as locations of bird colonies, species at risk, waterfowl and fish habitat, wetlands, dunes, and saltmarshes. In addition to these safeguards, possible use scenarios with various management options were evaluated. Zones were subsequently defined where shellfish leases could be best located to protect the environment, to reduce conflict with

other users and to meet regulatory requirements. The Replacement Class Screening Report will continue to be updated via an Adaptive Management Process that will provide continuous feedback as to its effectiveness.

Keywords: aquaculture, environmental assessment, oyster, regulatory framework.

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ICES ASC 2010/B:36 Poster

Environmental vulnerability profiles: characterization of pressures in the southern Gulf of St Lawrence, Canada

Matthew Hardy, Marc Ouellette, and Roland Cormier

The worldwide realignment of research and management objectives in recent years to respond to implementation of the "ecosystem approach" represents a departure from past practices where emphasis was mainly on a single-species fisheries or single-activity basis. Although there is a broad consensus on the purpose of this realignment, its practical application continues to be a significant challenge given the complexities of attempting to develop multispecies/activity integrated management plans, frameworks, and approaches for all factors affecting the aquatic environment. The management of human activities, both aquatic and land-based, that contribute to adverse environmental impacts on aquatic ecosystems is one of the major challenges associated with integrated coastal and ocean management. There is recognition that effective integrated management will require new pragmatic approaches, in addition to current practices. It is also particularly important to develop approaches that build greater credibility with the public with regard to integrated planning initiatives and that are based on clear, factual, and interpretable information. The Gulf of St Lawrence Regional Vulnerability profile is being developed by the Department of Fisheries and Oceans Canada with contributions from a number of federal and provincial departments. The purpose of this atlas is to identify and scope the environmental pressures associated with a number of human activities from a geospatial perspective and to illustrate their respective and relative intensity. This is not an assessment, but may serve to identify research or assessment needs. It can also be the basis for engaging relevant federal and provincial partners as well as for communicating with the public in a structured and factual manner.

Keywords: atlas, coastal management, geospatial, vulnerability.

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ICES ASC 2010/B:37 Poster

The adaptation of a risk-based approach for integrated coastal management

Matthew Hardy and Ray MacIsaac

In Canada, the development of risk-based approaches to support decision-making continues to be a priority for integrated coastal-zone management. The development of a conceptual framework for risk-based integrated management is considered as a means to more effectively use existing information and ensure the efficient deployment of resources as well as renewing the focus on priority setting. Strengthening the initial phases of this process is key to building a credible and pragmatic management process that has the potential to be successful at achieving realistic goals within a well-defined scope and scale of issues. The retooling of the best available information is being considered with regard to the development of environmental vulnerability profiles in order to incorporate: (i) ecologically significant areas, (ii) social-cultural and economically significant areas, (iii) human use activities and their zone of influence, and (iv) characterizing the potential conflicts and compatibilities. The intent is to provide the context to frame preliminary decisions with regard to the appropriate approach and level of response required to lead to more focused assessments relating to ecology, sociocultural and economic, and governance issues. The elements

being considered are founded on the recognition of jurisdictional authorities and their respective accountabilities for the management of issues that cannot be resolved unilaterally by any organization or entity alone. Moreover, a risk-based framework is being examined as a means to provide an objective, rigorous, and iterative approach that may serve to validate facts and perceptions around public concerns while enhancing communication and engagement.

Keywords: coastal, integrated management, risk analysis, vulnerability.

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Theme Session C

Natural mortality variation in populations and communities

ICES CM 2010/C:01

An investigation of the biological basis of variation in age-specific survival rates of adult Pacific herring (*Clupea pallasi*) from British Columbia

Ronald W. Tanasichuk

Data for over 430 000 fish sampled between 1991 and 2006 were used to investigate the biological basis of adult natural survival rate (S) variability in British Columbian stocks of Pacific herring (*Clupea pallasi*). Sampling programmes provided an opportunity to estimate adult age-specific survival empirically. The effect of age on adult survival rates for southern British Columbian (West Coast Vancouver Island, Strait of Georgia) herring populations was retested; results of earlier work demonstrated that M, the instantaneous natural mortality rate (where $M = -\ln(S)$) increased with age. The analysis was extended to include the northern (central coast, north coast, Queen Charlotte Islands) populations, and to evaluate the effects of fish size, stock density, prey biomass, competitive fish biomass, and predator biomass or abundance on survival rate variability. Survival rate was found to decrease with age for all populations, but there were additional population-specific responses to variations in prey (the euphausiid *Thysanoessa spinifera*) biomass and/or marine mammal abundance. A re-analysis of fecundity data demonstrated that relative fecundity did not decrease with age. This suggests that the effect of age on survival does not operate through senescence. This supports an hypothesis that fecundity determines lifespan rather than the converse. Empirical estimates of S were different from those calculated using conventional methods for estimating M from life-history parameters.

Keywords: biotic effects, herring, natural mortality, variability.

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ICES CM 2010/C:02

Climate- and fishery-induced changes in predator distribution trigger a spatial reallocation of its prey: the Baltic Sea case study

Michele Casini, Ulf Bergström, Martin Lindegren, and Philip Axe

Understanding the processes regulating a population's spatial distribution is crucial in ecology in general and management of exploited resources in particular. Here we use spatially explicit fishery-independent (acoustic and bottom-trawl surveys) and hydrological databases covering a 30-year period to explore the factors affecting Baltic sprat distribution. Previous studies have demonstrated that overall the sprat population drastically increased in the Baltic Sea from the early 1990s. However, our data indicated that the sprat density has increased mainly in the northern areas, whereas the increase in the southern areas has been minor. Generalized regression analysis and spatial prediction GRASP models identified a tight negative spatial linkage between the prey

sprat and its predator cod. In fact, from the mid-1980s the overfished cod, in correspondence with a reduction in its population size, contracted its distribution to the southern areas probably as a result of hydroclimate changes (decrease in salinity). This suggests the appearance of a spatial pattern in the top–down control of cod on sprat, which was unveiled by a climate-induced spatial reallocation of the predator. The increase in temperature over the Baltic Sea, however, could have also contributed to the northward expansion of the thermophilic sprat. The stronger increase of the sprat density in the northern areas was also accompanied by a more severe drop in sprat body condition in these areas, probably as a result of density-dependent effects. Overall, this study elucidates the occurrence of a spatially explicit predator–prey trophodynamic control, and stresses the importance of including spatial aspects in management decisions of both species.

Keywords: cod, GRASP, hydro-climate impact, spatial distribution, sprat, top–down control.

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ICES CM 2010/C:03

Is predation by grey seals a major component of *M* among large 4T cod in the Gulf of St Lawrence?

M. O. Hammill, D. Swain, G. B. Stenson, V. Harvey, and H. Benoit

The southern Gulf of St Lawrence Atlantic cod fishery collapsed as a result of overfishing and a moratorium was declared in 1992. In spite of limited fishing, this stock has demonstrated no sign of recovery because of high *M* for large cod. Various hypotheses for the high *M* include dumping at sea, poor condition, fisheries-induced life-history changes, parasite infections, and predation by seals. Examination of the various hypotheses indicate that seal predation is the most likely source of high *M* because of the strong correlation between *M* and changes in the grey seal population size. Diet data suggest a strong cod component, but primarily of smaller fish, invoking the need for significant belly biting to account for consumption of sufficient numbers of large cod, but there are significant gaps in the spatial/temporal coverage of grey seal diet composition. A spatial analyses of the overlap between grey seals equipped with satellite transmitters and overwintering fish demonstrates positive selection by large males for overwintering concentrations of small 4T cod in Cabot Strait. The distribution of abundant small cod, however, is highly correlated with that of less abundant large cod, possibly overwhelming the signal. Diet sampling in the area demonstrated that cod contributed over 50% of the energy to the grey seal diet in the area, and the mean length of cod consumed was 42 cm compared with an average length of 28 cm from summer diet samples. Estimating consumption indicates that grey seal predation could form a significant component of *M*, but rather than a large-scale removal of animals a targeted reduction in areas of seal–cod overlap may be more effective.

Keywords: Atlantic cod, grey seal, *M*, seal predation.

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ICES CM 2010/C:04

Abundance and mortality of northeast Arctic cod and haddock during their first three years of life

Bjarte Bogstad, Odd Nakken, Elena Eriksen, and C. Tara Marshall

For northeast Arctic cod and haddock, long time-series of year-class abundance are available at several stages before they recruit to the fishery (i.e. before they reach age 3). Several studies have already been made of the influence of various factors on the abundance and survival of these stocks during the first three years of life, in particular for cod. Revision of dataseries, however, as well as availability of longer dataseries makes a new analysis worthwhile. The analysis includes both virtual population analysis (VPA) estimates of abundance of spawning stock and recruitment,

as well as estimates of total egg production and survey estimates from pelagic and bottom-trawl surveys. Information on cod predation on cod and haddock is also used. The mortality at various life stages is found to vary considerably between cohorts for both stocks. Although the mortality is highest during the first months of life, the year-class strength can be affected considerably by processes taking place between the 0-group stage (ca. six months) and age 3. The variation in mortality is related to density dependence, temperature, predator abundance, and other factors.

Keywords: abundance, Barents Sea, cod, haddock, mortality.

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ICES CM 2010/C:05

Understanding the fishing to natural mortality ratio for management purposes

Niels T. Hintzen, Tobias van Kooten, and Reinier Hille Ris Lambers

It is essential to understand natural mortality (*M*) in fish if we are to plan appropriate measures to conserve and restore stocks. For many marine fish (both demersal and pelagic) changes in natural mortality were hypothesized to play a relatively minor role compared with fishing mortality (*F*) in determining their population dynamics. Within many stock assessments *M* has therefore always been assumed constant. With recent reduced fishing pressures, however, natural mortality may have become a far more important factor in regulating the development of commercially exploited populations. In order to assess the consequences of natural mortality for population size and stability we developed a size-structured population model of herring and its main food source, zooplankton. We consider a situation where natural mortality comes, in part, from a second species which feeds on early life stages of herring. By varying the strength of the interaction between herring and the predator, we can directly assess the consequences of relaxing the assumption of constant natural mortality, as well as quantifying the importance in estimating natural mortality at different life stages for our knowledge of the stock characteristics. Quantitative model results suggest that population survival is sensitive at a low level to mortality in the early life stages of herring.

Keywords: fishing mortality, natural mortality, management, size-structured model.

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ICES CM 2010/C:06

Predation impact on juvenile plaice (*Pleuronectes platessa*) in its nursery ground (Tralee Beach, Scotland); field application of a TaqMan real-time PCR-based assay targeting plaice DNA

Aitor Albaina, Martin I. Taylor, and Clive J. Fox.

Natural mortality of juvenile plaice (*Pleuronectes platessa*) through predation was estimated in a Scottish nursery ground (Tralee Beach) in spring 2009 by means of a DNA-based method (TaqMan real-time PCR-based assay), targeting a plaice-specific cytochrome-*b* sequence in the DNA extracted from potential predators' stomach contents. The assay was run in more than 1100 stomachs from a set of predators thought to be important sources of mortality of small juvenile plaice on inshore nursery grounds (including the brown shrimp, *Crangon crangon*, the shore crab, *Carcinus maenas*, and several fish species). Previous studies of predation on juvenile plaice have used visual examination of stomach contents but this is time-consuming and may underestimate true predation levels as remains become unidentifiable as a result of maceration and digestion. Molecular-based tools for detecting the presence of prey tissue in predator stomachs and scat are increasingly used in marine ecology and provide an alternative approach to visual identification. In this sense, while 44.8% of the brown shrimp's stomachs tested positive for plaice DNA after running the assay, only 5.7% and 10.2% did for, respectively, the shore crab and gobies. Results are

discussed in relation to different biological (nursery ground community composition, prey and predator size, etc.) and environmental (temperature, light, depth, tide, etc.) variables; the fate of juvenile mortality by predation in plaice recruitment is also discussed.

Keywords: *Carcinus maenas*, *Crangon crangon*, natural mortality, nursery ground, *Pleuronectes platessa*, predation, stomach contents, TaqMan real-time PCR assay.

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ICES CM 2010/C:07

Modelling approach for evaluating of natural mortality variation caused by cannibalism in the Barents Sea cod

Anatoly Filin

Cannibalism is an important population mechanism to control cod abundance in response to environment variations. The estimates of the Barents Sea cod cannibalism calculated on the basis of the quantitative analysis of stomach content have been available since 1984. Based on these estimates the quantity of juveniles consumed by cod significantly varies from year to year and depends on abundance and age composition of adult cod, juvenile abundance, as well as the stock size of capelin as a main food item. Using a multispecies STOCOBAR model, an attempt to extend the time-series of data on cod cannibalism on the basis of the accessible historical data on capelin abundance, cod commercial stock, and water temperature since 1972 has been made. The dependence of rate of cod natural mortality through cannibalism on capelin stock size in the Barents Sea under different temperature and cod stock was analysed, applying scenario modelling. The aspect of improvement of cod harvest control rule based on obtained findings is considered.

Keywords: Barents Sea, cod, cannibalism, ecosystem approach, model, natural mortality.

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ICES CM 2010/C:08

Baltic cod cannibalism: differing consequences at stock recovery vs. decline?

Stefan Neuenfeldt, Eero Aro, and Fritz Köster

Cod cannibalism in the Eastern Baltic Sea was most intensive in 1978–1984, a period with high juvenile abundance and large adult stock size. Approximately 60% of the 0-group and 30% of the 1-group cod were consumed by conspecifics. Subsequently, cod recruitment and adult stock decreased, whereas sprat, the main fish prey for cod, became significantly more abundant. Predation rates on 0-group and 1-group cod decreased to 23% and 9%. Since 2003 cod stock size has increased again, and predation on the 0-group has also increased. Predation on the 1-group, however, has not increased as yet. Analysing trawl survey data and cod stomach content data in connection with a multispecies model, we show that the stagnant predation on age group 1 is a product of size structure at increasing adult cod biomass during recovery, and spatial overlap between small and large cod. We also address whether the changes in spatial overlap are a result of density-dependent habitat selection, environmental forcing, or a combination of both.

Keywords: cod predation mortality, cannibalism, density-dependent predation, recovery.

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ICES CM 2010/C:09

Trends in mortality of young herring larvae—evidence of a link to recruiting year-class strength

Sascha M. M. Fässler, Mark Dickey-Collas, Mark R. Payne, and Thomas Brunel

Since 2002 the recruitment of North Sea herring has been below average and the signal can be easily seen in surveys of metamorphic larvae. From the 1970s onwards the recruitment strength of North Sea herring has been determined somewhere between the hatch and metamorphosis of the larvae. Larval abundance (1972–2008) was coupled to a spatial hydrodynamic model to investigate whether the mean daily mortality rates have increased since 2002. Tracked cohort mortality rates (horizontal life table approach) were compared with "snapshot" estimates (vertical life table approach, i.e. decline across ages at one point in time). Distinct trends in the mortality rates were evident using dynamic factor analysis: the Downs component (southern) exhibited a constant rise in mortality, whereas the other three components (northern) demonstrated a shared distinct increase after 2002. The use of this long time-series of field surveys has provided valuable information on the trends in mortality rates and highlights that the signal of poor recruitment from 2002 onwards coincides with an increase in mortality in larvae younger than 30 days post-hatch (<16 mm). This suggests that year-class strength is determined very early in the development of North Sea herring perhaps associated with a critical period in the first 30 days.

Keywords: *Clupea harengus*, herring, larvae, mortality, North Sea.

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ICES 2010 CM/C:10

The role of haddock egg predation in the collapse of an Atlantic herring population

David E. Richardson, Jonathan A. Hare, Michael J. Fogarty, and Jason S. Link

Predation on the early life-stages of marine fish may be a source of interannual and multidecadal variability in recruitment. Quantifying predation-related mortality of eggs and larvae, however, has proven difficult, hampering attempts to incorporate predation into population models. We developed an egg predation model to estimate the survival rate of Atlantic herring (*Clupea harengus*) eggs on Georges Bank from haddock (*Melanogrammus aeglefinus*) predation. This model assumed that larval herring abundance was a function of herring spawning-stock biomass and egg survival from haddock predation, and that haddock exhibit a type III functional feeding response. Estimated herring egg survival rates from haddock predation ranged from <2 to 70% between 1971 and 2005. Egg predation was then incorporated into a herring population model that included a Beverton–Holt model describing the relationship between larval abundance and recruitment at age 2. The population model indicates that Georges Bank Atlantic herring has multiple equilibrium population levels, and predicts that when the haddock population is high, seemingly conservative levels of fishing can precipitate a collapse of the herring population. This model explains the herring population collapse in the mid-1970s. The model also predicts that the herring population may collapse because of the recent recovery of haddock on Georges Bank, a prediction that is supported by the declining abundance of herring since 2006 in a compilation of 17 fishery-independent time-series. These findings illustrate the difficulty in rebuilding fisheries when ecological interactions are not incorporated into fishery models and management plans.

Keywords: depensation, haddock, herring, larval fish, predation mortality.

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ICES CM 2010/C:11

The importance of overlap—predicting North Sea cod recovery with a multispecies fishery assessment model

Alexander Kempf, Gjert Endre Dingsør, Geir Huse, Morten Vinther, Jens Floeter, and Axel Temming

The overlap between predator and prey is known as a sensitive parameter in multispecies assessment models for fish, and its parameterization is notoriously difficult. Overlap indices were derived from the North Sea IBTS survey and used to parameterize the North Sea Stochastic Multi Species Model (SMS). The impact of different levels of detail in the overlap implementation (constant or year and quarter specific) on the historic (1991–2007) and predicted trophic interactions as well as the development of predator and prey stocks was investigated. The focus was on a general comparison between single-species and multispecies forecasts and the sensitivity of the predicted North Sea cod recovery towards different overlap implementations. The spatiotemporal overlap between cod and its predators was found to increase with increasing temperature, indicating that foodweb processes will potentially reduce the recovery potential of cod, especially in warm periods. Multispecies scenarios were highly influenced by assumptions on future spatial overlap and predicted a considerably lower recovery potential than single-species predictions. In addition, a negative impact of a North Sea cod recovery on its prey stocks was found in the multispecies forecasts. The consequences of these findings for management concepts were discussed.

Keywords: North Sea cod, recovery, spatial overlap, trophic interactions.

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ICES CM 2010/C:12

Assessing natural mortality of anchovy from surveys' population and biomass estimates

A. Uriarte and P. L. Ibaibarriaga *et al.*

In ordinary catch-at-age models, natural mortality conditions and determines the catchabilities at age obtained in the surveys that tune the assessments. For the same reason, inferring the natural mortality of a fish stock from survey estimates requires some assumption of the survey catchabilities at age. The anchovy fishery in the Bay of Biscay has been closed since 2005 (to date) because of low biomass levels. At the time, since 1989 the population has been directly monitored by two independent surveys—an acoustic survey and an egg (DEPM) survey—which have supplied basic information for the assessment of this stock by ICES. The closure of the fishery supposes a major change in total mortality levels affecting the population compared with the former period of exploitation, allowing estimates of natural and fishing mortalities, assuming that no major changes in *M* occur between both periods. A seasonal integrated catch-at-age analysis was tuned to the fishery and two series of surveys under the assumption of constant catchabilities across age for the two surveys' population estimates. An analysis of the period 1987–2009, searching for a single and constant natural mortality-at-age, results in minimum residual SSQ for an *M* around 0.8. But a better result is obtained when a pattern of increasing natural mortality-at-age is allowed, a possibility suggested a long time ago for this type of short-living species.

Keywords: anchovy, integrate assessment, natural mortality, *M* at age.

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ICES CM 2010/C:13

Optimal fishery management accounting for variation in natural mortality: the Baltic sprat and herring case

Rudi Voss, Stefan Neuenfeldt, Martin F. Quaas, and Jörn O. Schmidt

Economic–ecological modelling has received increasing attention in the effort to achieve sustainable fisheries. So far, mainly single-species models have been used, which do not account for species interaction and/or climate change. However, both of these processes alter the associated natural mortality rates (M) and have the potential to strongly influence stock dynamics. Many traditional economic fishery models have been criticized by biologists, especially if results were gained by rather simple biomass models. Biological assessment models, on the other hand, rarely explicitly take into account economic considerations. To overcome these shortcomings, we have developed an age-structured, economic–ecological model that accounts for the dominant processes affecting natural mortality. With the goal of ultimately providing the most appropriate management advice for the operating fishery possible, we adopt an economic objective function (present value of resource rents) and determine optimal management. In the Baltic Sea, mortality rates of sprat and young herring are strongly influenced by adult cod stock dynamics via predation. Furthermore, both clupeid stocks show temperature-dependant stock–recruitment relationships. We simulated stock trajectories for a period of 30 years for two different natural mortality scenarios: (i) high vs. low cod abundance and associated changes in predation mortality $M2$ and (ii) high vs. low temperature scenarios and associated changes in the stock–recruitment function. By applying the age-structured ecological–economic model, we derive the optimal management strategy in terms of net present value of resource rents. We compare the relative importance of both processes (i.e. temperature increase via global change and variation in predation pressure via management of the cod stock) on optimal management.

Keywords: age-structured model, bioeconomic modelling, fishery management, global change, species interaction.

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ICES CM 2010/C:14

Finite-state continuous time models to infer regional and ontogenic changes in mortality and migration rates from tag-recovery data for migratory species

Timothy J. Miller

Finite-state continuous-time models provide a framework for simultaneous inference of various population dynamics parameters such as mortality and migration rates. These models are particularly useful for analysing data arising from tagging studies such as tag-recovery experiments because of the ability to simultaneous account for nuisance parameters associated with these data. These nuisance parameters account for aspects such as tag-reporting behaviour, tag shedding, and temporary tag-induced changes in behaviour. It is important to account for these parameters for the scale of estimated fishing and natural mortality to be correct. Migration and mortality rates can also be modelled as functions of environmental covariates. The analytical approach is illustrated with an application to an Atlantic cod tagging experiment in the Northwest Atlantic Ocean. For Atlantic cod we consider models that allow ontogenic changes in migration between three adjacent regions as well as fishing and natural mortality rates that may be region-specific.

Keywords: finite-state continuous-time, migration, mortality, tag-recovery.

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ICES CM 2010/C:15

Integrated assessment model of Peruvian anchovy: interdecadal variation of natural mortality

Ricardo Oliveros-Ramos, Renato Guevara-Carrasco, John Simmonds, Francois Gerlotto, Jorge Csirke, Ramiro Castillo, Andrés Chipollini, Arnaud Bertrand, and Jorge Tam

The objective of this work is to present a new integrated assessment model for Peruvian anchovy (*Engraulis ringens*) northern-central stock. The model considered variable length and dispersion at recruitment, allowing the length structure of the stock to be represented in an age-based model. Natural mortality is modelled with a flexible function of length, allowing very different behaviours. Interdecadal variability in natural mortality was also considered, trying to represent the effect of regime shifts in the Humboldt Current Ecosystem. The model was calibrated using acoustic estimates of biomass, length structures from scientific surveys, landings, and catch-at-age data from the fishery. An evolutionary algorithm with different fitness functions for each variable was used for the calibration. Variations of natural mortality with modelled values of biomass, recruitment, and fishing mortality for the period 1985–2005 are presented.

Keywords: anchovy, evolutionary algorithms, integrated stock assessment, regime shifts.

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ICES CM 2010/C:16

Spatially explicit foodweb models and implications on natural mortality

Ivonne Ortiz and Kerim Aydin

Ecosystem models in Alaska are used to provide estimates of natural mortality in various stock assessments. These stock assessment and ecosystem models are not spatially explicit, however, and assume that natural mortality operates homogeneously across space. Such an assumption leaves out important processes such as local depletion or geographic gradients in mortality driven by environmental variables and/or the centre of distribution of predator species. We now have a suite of four spatially explicit foodweb models for the Aleutian Islands and the Eastern Bering Sea at various scales and levels of species resolution and model detail. These models include: for the Aleutian Islands: (i) a series of 2-longitudinal-degrees foodweb models along the entire American portion of the archipelago; (ii) five site-specific foodweb models inside Trawl Exclusion Zones established around Steller sea lion haulouts and rookeries; (iii) for the Bering Sea, a composite of four regional foodweb models centred on the Pribilof Islands with regions based on northern fur seal foraging destinations; and (iv) FEAST (Forage/Euphausiid Abundance in Space and Time), a highly detailed end-to-end model fully coupled with a regional oceanographical model, an NPZ (nutrient–phytoplankton–zooplankton) model, and an economics model, with a spatial resolution of 10 km. The estimated predation and consumption patterns provide insight on the spatial distribution of the main sources of natural mortality, how these overlap with fisheries, and the implications for local communities or species of particular concern.

Keywords: foodweb models, natural mortality, predation, spatial patterns.

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ICES CM 2010/C:17

Analytic theory of size-spectrum dynamics

Axel G. Rossberg, Keith F. Farnsworth, and David Reid

Building on work by Andersen and Beyer, Pedersen and co-workers recently developed a numerical model for community size spectra that resolves both species, characterized by maturation body size, and the individual size distributions within species. Empirical values for all model parameters are known. Here, an analytic characterization of static and dynamic model states

is presented. The combined equilibrium conditions for (i) population structure, (ii) population size, and (iii) size-spectrum slope imply that predation mortality (M) must generally equal the mass-specific individual growth rate (specific physiological mortality = 1), but is lower for the smallest individuals—confirming and explaining simulation results by Pedersen *et al*. This, in turn, implies an equilibrium condition for (iv) the size-spectrum offset (i.e. absolute biomass density). However, the dependence of specific physiological mortality on biomass density, and hence the density dependence of size-spectrum dynamics, can be weak, and then external effects control community structure. The theory predicts that and how perturbations of the size spectrum (e.g. by fishing) propagate to larger species (at a rate that generally differs from individual growth rates), and the time-scale of recovery to the unperturbed spectrum. Concerns that community perturbations by fishing may cascade to lower trophic levels are not supported by this theory.

Keywords: analytical tractability, physiologically structured populations, size spectrum, specific physiological mortality.

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ICES CM 2010/C:18

Spatial differences in natural mortality of North Sea gadoids

A. Rindorf, N. G. Andersen, and M. Vinther

The natural mortality of fish in the North Sea is often assumed to be higher in northern areas where the abundance of predatory fish is largest. Investigations based directly on observed stomach contents, however, have not been performed and it remains unknown whether the effect of higher density of predators in northern areas is at least partly abated by higher autumn temperatures in southern areas, leading to higher consumption rates of individual predators. To investigate the spatial differences in natural mortality caused by the combined effect of differences in consumption of individual predators and predator density, we investigated the consumption of cod, whiting, and saithe in different areas of the North Sea. We used the stomach data sampled in the years 1981–1991 under the coordination of ICES, accounting for the effects on estimated consumption of temperature, energy content of the prey, the presence of other prey, and size of the predator. The consumptions by predator length group and area was raised to an index of total consumption in the area using survey catch rates, and this index was compared with the IBTS catch rates of gadoid prey species. This resulted in an area-specific index of mortality. Maps of predation mortality indices were compared with estimates derived assuming consumption and food composition to be constant for all predators. The results demonstrate the importance of accounting for changes in temperature as well as for changes in predator–prey overlap when attempting to predict the effects of a warming climate on natural mortality.

Keywords: natural mortality, North Sea gadoids, spatial pattern, temperature effects.

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ICES CM 2010/C:19 Poster

Life history strategies of *Oithona brevicornis* from Muttukadu backwaters of Chennai, Tamilnadu

R. Ramanibai and N. S. Bharathi Devi

Laboratory experiments were conducted to determine the effect of salinity, temperature, pH, and light exposure on the survival, development, and reproduction of *Oithona brevicornis*. Seven different temperatures (5, 10, 15, 20, 25, 30, 35, 40°C), five pH ranges (5, 6, 7, 8, and 9), five salinity variations (0, 2, 4, 6, and 8 ppt), and four different photoperiods (8L:8D; 12L:12D; 16L:16D; 0L:24D) were employed to study the responses of *O. brevicornis*. The copepods were subjected to varying food concentrations (70×10^4 cells/ml, 50×10^4 cells/ml, 35×10^4 cells/ml) at two constant

temperatures of 25 and 30°C. Survival rate and morphometric measurements of naupliar, copepodite, adult stages, clutch size, and egg diameter were calculated. *O. brevicornis* demonstrated highest life expectancy of 100% under 25–30 ppt salinity. Maximum reproduction occurred at a temperature of 30°C (84.61%), pH 8.0 (90.90%), and photoperiod exposure of 8L:8D (76.66%). In 50 ml medium of 70×10^4 cells/ml algal concentration, the survival of *O. brevicornis* was 90.7% and they attained their maximum length (prosome + urosome) of 0.71 mm in males and 0.87 mm in females, and produced clutch sizes of 0.58 mm (in diameter). The main aim of our paper was to describe the reproductive characteristics of *O. brevicornis* in Muttukadu backwater. There is little information, however, concerning the life cycles and reproductive dynamics of other copepods, especially those with small body sizes.

Keywords: *Chlorella vulgaris*, environmental factors, *Oithona brevicornis*, reproductive parameters.

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ICES CM 2010/C:20 Poster

On the increase in natural mortality (*M*) of the Iceland scallop (*Chlamys islandica*) in Breidafjordur, western Iceland, and the succeeding collapse of the fishery in the early 2000s

Hrafnkell Eiríksson, Gudrun G. Thorarinsdottir, and Árni Kristmundsson

The Iceland scallop (*Chlamys islandica*) fishery started in Breidafjordur, western Iceland, in 1970 and was conducted until 2003 when a fishery closure was recommended by the Marine Research Institute, Reykjavík. The annual landings totalled ca. 9000 t from 1993 to 2000. Survey indices declined drastically between 2001 and 2008, resulting in indices in 2008 amounting to only 13% of the average for 1993–2000. The downward trend in the stock abundance is considered to be mainly owing to mass mortality, caused by an unknown apicomplexan parasite in adult scallops, with nearly 100% prevalence observed in larger shells (>60 mm shell height). The adductor muscles were most heavily infected and gonad development was hampered in infected individuals. The Iceland scallop is distributed within the subarctic transitional zone where maximum sea temperatures of 12–15°C have been recorded. In Iceland, the annual bottom sea temperature during the period 1970–1995 ranged from 0 to 10°C on the various scallop grounds. The period from 1993 to 2003, however, is characterized by a steady increase in summer sea surface temperature, reaching the highest estimated level of the previous century in Iceland in 2003. More recent temperature data from the Breidafjordur scallop grounds have shown recordings from 11 to 12+°C at 15–25-m depths in August–September for most of the last decade. An experimental study demonstrated that scallops collected during late summer can tolerate temperatures up to 13°C, at least for up to 21 days, but there is considerable mortality at 14°C. The rising temperature in Breidafjordur in recent years has therefore brought the summer maximum temperature close to the apparent temperature tolerance of the stock (e.g. the 12.2°C measured in August 2003). It does not appear, however, that the direct effects of temperature are the sole factor responsible for the dramatic decline in Iceland scallop stocks in recent years. Other factors that are often temperature-dependent, such as disease, may be equally or even more responsible. Thus, the increased temperature since around the mid-1990s may have made the scallops more susceptible to infection. Furthermore, it could have created more favourable conditions for the apicomplexan parasite to proliferate inside the shells, resulting in the observed mass mortality and recruitment failure in the Iceland scallop stock.

Keywords: apicomplexan parasite, *Chlamys islandica*, fishery collapse, mortality, recruitment failure.

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ICES CM 2010/C:22 Poster

Updated information on impacts of temperature, species, and body size on RNA–DNA ratios of starving marine fish larvae

Stefan Meyer, Catriona Clemmesen, Arne Malzahn, Josianne G. Støttrup, and Myron A. Peck

This study combines the most recent information on starvation-induced changes in biochemical condition (RNA–DNA ratio) in marine fish larvae and represents an ongoing effort to provide a comprehensive conceptual and quantitative model for biochemical-based mortality estimates in early life stages of fish. The current state of this study expands the previously presented work to a total of six marine finfish species (*Clupea harengus*, *Coregonus oxyrhynchus*, *Gadus morhua*, *Gobius* sp., *Melanogrammus aeglefinus*, and *Sprattus sprattus*) spanning 3.5 orders of magnitude in body size from 20 μg dry mass larvae to 90 mg dry mass post-larvae. Bulk nucleic acid content was analysed in individual fish and muscle tissue after exposure to known periods of food deprivation under controlled laboratory conditions. Decrease rates of ln-transformed, standardized RNA–DNA ratios (sRD) vs. time of starvation (degree-days) and 5% threshold values of sRD are provided for species, life stages, ambient temperatures, and initial body sizes. Sufficiently large datasets are decomposed for trends in discrete percentiles of observed variability, reflecting individual starvation trajectories over time and therefore providing realistic parameters for subsequent individual-based estimates (such as time to death). Further efforts were undertaken to relate biochemical condition to survival probability under recurring food availability by analysing data from refeeding trials around the point of no return and assessing otolith increment widths obtained from larval Baltic cod and post-larval Baltic sprat.

Keywords: Baltic cod, Baltic sprat, condition, herring, haddock, gobies, larvae and juveniles, otolith increments, RNA–DNA ratio, starvation, whiting.

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ICES CM 2010/C:23 Poster

The impact of fishing pressure on natural mortality and underlying ecosystem structure

Jennifer E. Houle

This research uses a model based on the multispecies size-spectrum theory of Andersen and Beyer to address how a temperate marine community responds to changes in fishing pressure in terms of natural mortality, underlying ecosystem structure, and possibilities for recovery. This model is used rather than other models, such as Ecopath with Ecosim, because it is built from individual-level, mechanistic processes that combine to form a community of individuals of different functional species defined by a single parameter—maturation size. Ecosystem and population level properties, such as size-spectrum community structure, production, and biomass, are emergent properties rather than explicit inputs. The model represents the primary aspects of marine ecosystems: that natural mortality is mostly from predation, that individuals grow over many orders of magnitude during their lifetimes, and that predation is size-based. From these, individual body size rather than species identity defines an individual's trophic position, and the maturation size of a species rather than its name becomes more important. The model includes density-dependent recruitment and has been extended to include additional scaling of predation mortality and reproduction/recruitment with maturation size. Fishing pressure is added to an undisturbed ecosystem in the form of size-specific mortality mimicking those size classes caught in fishing gears. The results of changing fishing pressure on natural mortality and underlying ecosystem structure are analysed, along with the possibility for a disturbed ecosystem to recover its original structure. This research contributes to the understanding of the mechanisms behind the alterations of ecosystems by fisheries.

Keywords: ecosystem model, fishing, mortality, size spectrum.

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ICES CM 2010/C:24 Poster

Survival rate of brown crab (*Cancer pagurus*) discarded from the pot fishery on the west coast of Scotland

Matthew W. Dawson and Simon Northridge

A robust knowledge of the causes and rates of mortality is essential to providing sound management advice for a population. In the realm of commercially harvested marine species it is often relatively straightforward to find an accurate value for the direct fishing mortality (*F*) inflicted on a population. Indirect effects that contribute to the natural mortality of a population are harder to provide, however. Discard mortality is an anthropogenic factor that contributes to natural mortality (*M*) in many species, including the brown crab (*Cancer pagurus*). This study identifies the proportion of target species bycatch in the Scottish west coast brown crab fishery (28% of total catch) and quantifies the rate of anthropogenically induced mortality (24% of discarded crabs). To investigate, samples of the discarded crabs were kept in keep pots in the vessels vivier tank and checked daily for 7 days to remove and record any dead. The mortality rate was considered to be the percentage of the sample that had died during the week. Sampling focused on random samples made up of all discard groups, and then split samples which contained only one of three discard groups: undersized, sick, and soft-shelled individuals. Control samples of healthy marketable crabs were used to identify the experimentally induced mortality. This could then be subtracted to give a more realistic figure for discards returned to the sea under normal fishing operations. The figure obtained is then used to calculate the discard mortality of 639 tonnes for the Scottish fleet in 2008.

Keywords: *Cancer pagurus* (brown crab), discard mortality, pot fishery, Scotland.

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ICES CM 2010/C:25 Poster

Size-based assessment of ecosystem effects of fishery management decisions

Ken H. Andersen and Casper Berg

Within an ecosystem approach to fishery management, development of management plans should include consideration of the expected consequences of the management action of the target species on the rest of the marine community. Using a size- and trait-based community model, we make general assessments of the direct and indirect ecological consequences of management plans based on a changes in fishing mortality on industrial, pelagic, and/or demersal fisheries. The assessment covers the temporal development of the fish and zooplankton community and the effects on the target groups of species as well as on other species in the ecosystem. The model quantifies how management actions targeted on one group of species propagates to the rest of the community. The model is simple and fast, and is implemented with a web-based interface.

Keywords: ecosystem approach to fishery management, impact assessment, size spectrum.

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ICES CM 2010/C:26 Poster

The forgotten sex: paternal effects on embryonic and larval mortality of Atlantic cod (*Gadus morhua* L.)

Muriel-Marie Kroll, Myron A. Peck, and Edward A. Trippel

In marine fish, rates of natural mortality (*M*) are highest during early life and are negatively correlated with rates of growth and body size. In these early life stages (eggs, larvae, juveniles) subtle differences in *M* can cause large differences in recruitment and year-class success. Therefore, it is particularly critical to understand factors that contribute to variability in *M* during early life.

The present study tested the hypothesis of paternal influence on rates of mortality and development in eggs and early larvae of Atlantic cod (*Gadus morhua* L.). Eggs from one female (which equalized maternal effects in the study design) were separately fertilized by the milt from twelve males. Embryos from each unique pair were maintained in replicated ($n = 6$) incubators at 6.3°C. Daily mortalities of embryos until hatch and unfed larvae until death were enumerated. Hatching success and larval characteristics were compared among the 12 half-sib families (e.g. yolk-sac size, lipid content, RNA–DNA ratio). Fertilization success of ~320 eggs per incubator ranged from 70 to 90%. Among males, the mean (±SE) egg mortality until hatch ranged from 1.8 (±0.9) to 10.3 (±2.3)% d^{-1}. Hatching success of fertilized eggs among families ranged from 10.2 (±3.0) to 63.0 (±5.1)%. Our results indicate that the genetic contribution from males (paternal heritage) can have a marked affect on early life mortality. Results are discussed in light of the potential and often unrecognized importance of males relative to females in shaping natural mortality and recruitment variability in marine fish stocks.

Keywords: egg, family effects, hatching, larvae, mortality, paternity, RNA–DNA ratio.

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Theme Session D

Fisheries certification—is it working and what are the implications for ICES?

ICES CM 2010/D:02

Eco-certification, assessments, and advice: implications of market measures for traditional practices

Jake Rice

The eco-certification standards necessary to be consistent with international guidelines from the FAO greatly expand the factors to be considered in "assessing" a stock and fishery. The actual assessments are done by small panels of selected experts, and it is fisheries and not States that formally request certification (and the assessments required to be certified). Nonetheless, the panel assessments are in large part critical reviews of work submitted by the applicant(s) for certification. The analytical work traditionally associated with a "fishery assessment" will usually have been done by agencies or under contract. To the extent that States in support of their fisheries or the fisheries themselves want to use traditional sources of science advice as the basis for their submissions of "assessments" to the expert panels doing the certification evaluations, the eco-certification standards require the traditional contents of an "assessment" to be reviewed. In this paper, experience with both the ICES and Canadian fisheries and ecosystem assessment processes and with several eco-certification evaluation panels is applied as a basis for such a review. The P1 Marine Stewardship Council (MSC) certification standards deal with the status of the target species of the fishery and the direct impacts of the fishery on the target species. The P2 standards deal with the impact of the fishery on the ecosystem in general. For P1 the degree to which "standard assessment practice" produces results that are sufficient for an eco-certification assessment against P1 is considered. For P2, what an "ecosystem assessment" would have to address in order to be sufficient to inform a certification panel regarding the sustainability of impacts of a fishery relative to the ecosystem is outlined.

Keywords: biodiversity conservation, eco-certification, fisheries, stock assessment.

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ICES CM 2010/D:03

The Marine Stewardship Council (MSC): measuring fishery sustainability and the implications for ICES

Daniel D Hoggarth, Oluyemisi Oloruntuyi, and Amanda Stern-Pirlot

The Marine Stewardship Council (MSC) has pioneered the development of fishery certification and achieved rapid growth in its first 10 years. In North Atlantic (ICES) waters and around the world, more and more industry clients are entering assessment against the MSC programme, with the aim of demonstrating their green credentials and to gain access to the MSC eco-label. This paper emphasizes the need for information to be available for these fisheries, relating to the status of target stocks, and on bycatch species, habitats, and the wider ecosystem. The paper describes how the MSC has evolved since it was established 10 years ago, and outlines the MSC fisheries and supply chain standards and methodologies. The scope of the programme now includes "enhanced fisheries" usually involving some combination of wild harvest and culture. MSC's new risk-based framework has also improved accessibility of the programme to small-scale and data-limited fisheries in the developing world and elsewhere. The experiences of scientists working as assessment team members and peer reviewers within the assessment process are described, as is the way in which scientific data are used in MSC assessments. Against this background information, the paper confirms the consistency of the MSC scheme with international guidelines, including the FAO 2005 Guidelines on eco-labelling and the ISEAL Code of Good Practice on Standard Setting. MSC's work on monitoring and evaluating the impacts of the programme is covered in a companion paper.

Keywords: assessment standards and methodologies, certification, FAO eco-labelling guidelines, ISEAL, MSC.

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ICES CM 2010/D:04

The Marine Stewardship Council (MSC) approach to low trophic level fisheries

Tony Smith and Mat Bartholomew

The Marine Stewardship Council (MSC) released a new Fishery Assessment Methodology (FAM) in 2009. Several low trophic level (LTL) fisheries have already been certified within the MSC programme, and several more are under assessment, including Gulf of California sardine and an Antarctic krill fishery. Although the FAM makes special reference to requirements for assessing the sustainability of LTL fisheries, some stakeholders questioned whether further guidance or modification to requirements were required. In response, the MSC established a Low Trophic Level Fisheries Working Group in July 2009 to address this issue. The Working Group has held two workshops of stakeholders to discuss issues concerning certification of LTL fisheries, including selection of appropriate reference points and harvest strategies, appropriate spatial management strategies for central place foragers, and considering the impacts of environmental forcing. As part of the review process, the Working Group commissioned a scientific study to evaluate the impacts of fishing LTL species on other parts of the ecosystem. The scientific study used existing ecosystem models for a range of fishery ecosystems to evaluate the impacts of fishing LTL species on their predators and prey, and on other parts of the ecosystem. Although the results of this scientific study are aligned with the review process, the approach and outcomes are very relevant to the management of LTL fisheries in the absence of MSC assessment and certification. The outcomes of the public consultation and the scientific study will be presented and their implications discussed.

Keywords: ecosystem effects of fishing, harvest strategies, low trophic level.

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ICES CM 2010/D:05

Seafood Environmental Management System (SEMS)—a tool for understanding why fishers do what they do

C. Barrett, D. Rihan, and F. Fleming

The fishing industry globally is facing increasing pressure to demonstrate sustainable and responsible practices in order to maintain market and resource access. In this context Bord Iascaigh Mhara (BIM), in Ireland, in close collaboration with the fishing industry, has developed a Seafood Environmental Management System (SEMS) tailored specifically for Irish fishing vessels to help demonstrate their responsible practices. This is an applied model of a more traditional environmental management system. The SEMS is designed to drive continual improvement in environmental and responsible fishing practices and can be adapted to fit the priorities and characteristics of a specific vessel operating in any fishery or fisheries. Such an operator-based approach to environmental performance with commercial certification applications can be seen as a complementary tool to the traditional fishery management framework. The system is based around three pillars of responsible practices, quality, and provenance, with a code of conduct incorporating technical annexes on the three principles. Currently, 80 Irish vessels have engaged in the SEMS process and it has displayed a number of positive benefits including providing an incentive for fishers to collect fishery information at an individual vessel level, instilled a culture of compliance among participating fishers, and also been used as a positive communication tool for fishers. It has been used successfully as a stepping stone for certification and accreditation including the Marine Stewardship Council (MSC). This paper outlines the development of the system, the documentary support, and also gives examples of the types of information fishers are recording and how this could be useful for scientists, economists, and managers in providing a better understanding of how fishers operate and why they do what they do.

Keywords: environmental management system, fishery information, responsible, sustainability.

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ICES CM 2010/D:06

Assessing the impact of the Marine Stewardship Council (MSC) programme: can certification and eco-labelling change the fisheries world?

Maylynn Nunn, Oluyemisi Oloruntuyi, and Chris Grieve

The impact of a fishery eco-labelling system is linked to its standards: their scientific basis and rigorous application; the robustness of the system's assessment procedures and mechanisms ensuring transparency and participatory engagement. Other contributors to impact include number and volume of certified fisheries and labelled products, and extent of market support. Studies demonstrate the Marine Stewardship Council (MSC) performs well against measures of effectiveness. Following ten years of implementation there is interest in demonstrating the MSC's impact on fisheries and associated ecosystems through objective, science-based analysis. Evaluating the impact of certification can be complex because of the range of factors that combine to influence fishery operations. Nonetheless, two main studies using different methodological approaches have already provided early insights into how the MSC programme leads to "change". The studies demonstrate benefits that can be linked to certification, including specific environmental improvements, instances of progress in policy and operations and economic and social benefits. The MSC is currently developing a framework to formalize the way impacts are assessed. It is being designed to be an objective, cost-effective process that allows monitoring and evaluating trends over time. It involves selecting and testing indicators and data-monitoring tools and will incorporate significant stakeholder input to ensure credibility and relevance. In addition to ensuring accountability, an improved and more consistently applied impact assessment procedure will provide a valuable learning mechanism for continuous refinement of the MSC.

Keywords: certification, eco-labelling, evaluation, impacts, monitoring, MSC.

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ICES CM 2010/D:07

Eco-certification of unsustainable fisheries

Peter A. Shelton

Eco-certification and eco-labelling hold the promise of augmenting traditional fishery management approaches carried out by governments and regional fishery management organizations (RFMOs) for sustainable fishery. A number of Marine Stewardship Council (MSC)-certified fisheries, however, are not in fact sustainable using commonly accepted maximum sustainable yield (MSY)-based criteria and in these cases the eco-label may be misleading the public. Eco-certification of depleted fisheries or fisheries with insufficient data to determine a sustainable fishing strategy are contributing to a weakening of the impact of the MSC brand and could diminish a valuable societal feedback mechanism to achieve truly sustainable fisheries where government and RFMO legislation and conventions have largely failed. Further complications arise because MSC certifies fisheries targeting more than one species (e.g. South African hake) or more than one stock (e.g. New Zealand hoki) where one component may be severely depleted, yet the fishery as a whole is deemed "sustainable". Aspects of MSC governance are also of concern in democratic society in which wild marine fish populations are viewed as a public asset. A secret preassessment selection process for candidate fisheries before public disclosure that a full assessment has commenced (and non-disclosure of unsuccessful preassessments), profit-maximizing strategies of a near-monopoly of consulting companies hired to do the assessment, the down-weighting of negative independent review of assessments, the costly objection process, and the legal rather than scientific objection-resolution process should all be of public concern. Rather than being universally supported by environmental groups, the MSC has been accused of lowering the bar on a number of controversial sustainability assessments in order to increase its market share and feed its expansionist aspirations, and of fostering a competitive-exclusion approach to existing credible regional or national sustainable seafood endeavours such as the Monterey Bay Aquarium Seafood Watch programme, which not only identifies the best seafood choices but also highlights those to avoid. A number of these shortcomings can be addressed, and should be, if public support for the MSC eco-label is to grow at the same rate as the number of fisheries being certified.

Keywords: eco-certification, eco-label, precautionary approach, fishery governance, fishery management strategies, Marine Stewardship Council, sustainability.

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ICES CM 2010/D:08

Fishing impacts during spawning: a forgotten element in certification of sustainable fisheries?

Harriet van Overzee and Adriaan D. Rijnsdorp

Avoidance of fishing during the spawning season has been proposed as a contribution to achieving sustainable exploitation. Although applied in freshwater ecosystems, and generally perceived by the public as an appealing strategy, spawning closures have been largely ignored in marine fishery management. Here we review the biological effects of fishing during the spawning period and explore their implications on sustainable management. Because fishing effects will differ across species, a classification scheme is developed based on biological characteristics such as the spawning strategy and reproductive mode that allow a broad application of the results. Effects are reviewed on the level of the reproductive physiology, spawning behaviour, population dynamics, population genetics, and the fisheries. Implications for sustainable management and certification are discussed and illustrated for a selection of North Sea flatfish, roundfish, and pelagic stocks.

Keywords: reproductive potential, seasonal management, spawning behaviour, spawning fisheries.

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ICES CM 2010/D:09 Poster

Reduce, reuse, recycle: applying the principles of industrial/organizational psychology to the workload created by eco-certifications

Tatiana Tunon and Gottfried Pestal

Certification programmes such as the Marine Stewardship Council (MSC) are continuously refining their evaluation processes, but substantial challenges remain for fishery agencies faced with the practical aspects of compiling submissions for eco-certification (fragmented information, workload, transparency). These challenges are magnified when an agency has to deal with dozens of concurrent certifications and regular recertifications in addition to the regular suite of status assessments, performance evaluations, and communication materials—all of them drawing on a lot of the same information and involving the same agency staff. Principles of industrial/organizational psychology can be applied to the task of compiling information for sustainability audits, improving both the efficiency of the process and the institutional value of the resulting documentation beyond the immediate certification requirements. We illustrate the approach with the certification of fisheries harvesting pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*) in British Columbia. This process had the potential for ballooning submissions with 47 criteria evaluated for each of seven distinct certification units, for a total 329 written responses drawing from all branches of the management agency. We improved the process by redesigning the task attributes for individual contributors and reorganizing the supporting information to match the scope of related criteria clusters. For example, criteria that evaluate the regional management system rather than individual fisheries are addressed in a single regional response, which doubles as a communication resource (e.g. habitat protection measures, fleet characteristics, ecosystem research).

Keywords: chum salmon, Marine Stewardship Council, organizational challenges, pink salmon.

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Theme Session E

Elasmobranch fisheries: developments in stock assessment, technical mitigation, and management measures

ICES CM 2010/E:01

Haematological stress parameters in longline captured pelagic sharks

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Assessments of worldwide longline fisheries reveal that sharks constitute a large portion of bycatch for this gear type. Recently enacted fishing regulations in many countries, along with the low economic value of these catches, has resulted in a large percentage of incidentally captured sharks being released. To date, little information exists on the rates of post-release survival for many shark species, and thus the impact of longline fisheries on shark populations cannot be fully estimated. Recent studies have addressed the possibility of using biochemical profiles of secondary haematological stress parameters to predict post-release survivorship, yet little is known about interspecific differences in these indicators. This study sought to compare electrolytes (sodium, chloride, magnesium, calcium, and potassium), metabolites (glucose and lactate), haematocrit, and heat shock protein 70 levels between eight species of longline captured sharks ($n = 151$). Stress parameters were compared according to species, family, and ecological classification. Data reveal species-specific parameter differences in response to longline capture, as well as differences by

family (i.e. Lamnidae vs. Carcharhinidae) and ecological (i.e. oceanic vs. coastal) classification. Taken together, results suggest that differences in locomotive and respiratory adaptations between study species bring about differences in stress response by these sharks to longline capture. This study is the first to report a haematological secondary stress response assessment for such a large number of pelagic shark species, and lays the groundwork for developing species-specific indices for predicting post-release survivorship of longline-caught sharks.

Keywords: biochemistry, elasmobranch, fishery, molecular.

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ICES CM 2010/E:02

The performance of US fishery management—a case study: the northeast skate complex

Emily F. Keiley, Fiona Hogan, Azure Westwood, Dan Georgianna, and Steve Cadrin

The New England Fishery Management Council manages seven skate species in the northeast US region under a single fishery management plan. Performance of the most recent skate plan was assessed relative to mandated objectives, or "national standards". Other objectives, identified from public comments, council deliberations, and advisory meetings are compared with those stated in law. The objective to minimize the effect of skate management measures on traditionally higher valued fisheries, such as groundfish and scallops, led to a management strategy that controls landings in the directed skate fisheries but includes no incentive to reduce skate discards in other fisheries. The incentives created by the skate plan appear to be inconsistent with the objectives outlined in the national standards. New legal requirements for annual catch limits for all managed species impose further inefficiencies. Compounding the problem are uncertainties in the species composition of the fishery. Of the seven skate species, two are overfished, and one is rebuilding. Several steps can be taken to improve the management of the northeast skate complex, including more species-specific information, improved communication of bycatch information, and implementation of management measures that create incentives to reduce discarding. Area-based management measures (e.g. disaggregation of the regional complex and associated catch limits), coupled with targeted closures may simultaneously promote increased conservation and efficiency in the US skate fisheries.

Keywords: fishery management, incentives, national standards, northeast skate complex, objectives, performance.

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ICES CM 2010/E:03

The Barents Sea skates: using the fishery-independent surveys for estimation of long-term trends in relative abundance and possible considerations to reduce their bycatch

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PINRO (Murmansk, Russia) has conducted an ecosystem survey together with IMR (Bergen, Norway) since 2004. Unlike all of the other surveys, this covers the whole Barents Sea. Information on many fish species, including skates, has been collected. These data allowed the estimation of long-term trends in abundance and biomass of three abundant skate species (*Amblyraja radiata, A. hyperboreus*, and *Rajella fyllae*). Analysis of the influence of the skate fishery on their stock dynamics was made. Data from three research bottom surveys that are conducted annually from August to March in the Barents Sea were used. Areas with the densest concentrations of different skate species were discovered in this region. Measures for reduction of skate bycatch in the bottom-trawl fishery in the Barents Sea were developed according to new findings on skate biology and distribution.

Keywords: abundance, Barents Sea, biomass, bycatch, skates, survey.

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ICES CM 2010/E:04

Management measures in elasmobranch fisheries: crucial points in the life history of pelagic and demersal species

Feodor Litvinov

It is generally accepted that one of the main problems in the conservation and management of sharks is limited understanding of their biology and thus crucial points in life history. This paper summarizes some findings in this area since 1976 in western Africa, open Atlantic, and eastern Pacific. It was found that oceanic sharks (blue, mako, hammerhead, etc.) have, like sea turtles, critical points of vulnerability in their life histories. Young sharks spend the first years of their life in coastal shallow waters where they are easily fished by gillnets of artisanal fleet, which are poorly controlled. Adult pelagic sharks meet the next crucial event: they form quasi-stationary aggregations of adult males (male clubs) and females of very high density. Any fishery of such aggregations will result in rapid overfishing and collapse of resources. Calculation of the demographic parameters of many oceanic species often assumes the existence of a single pan-mixed population, at least inside the Atlantic. According to our findings, for many pelagic species there are no less then two groups of populations—oceanic and coastal—which differ in teeth, vertebrae density, liver size, and general morphology. The idea of pan-mixed population leads to incorrect perception of rational parameters in their commercial use. The coastal demersal species like *Scyliorhinus canicula* or *Mustelus mustelus* demonstrate stable gaps in distribution range: 19–20°N and 24–27°N, being accompanied by certain morphological difference. Such gaps suggest the need for stock units of intraspecific level and so adequate protective measures for them.

Keywords: demersal sharks, infraspecific units, management measures, pelagic sharks, populations.

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ICES CM 2010/E:05

Mitigating impacts of tropical tuna purse-seine fisheries on elasmobranchs

Laurent Dagorn, François Poisson, Bernard Seret, Justin Amandé, John Filmalter, Gala Moreno, Nicolas Bez, Pierre Chavance, Paul Cowley, and Victor Restrepo

Tropical tuna purse-seiners catch tunas through two main strategies: they fish on free-swimming tuna schools or on fish-aggregating devices (FADs). Fishing on FADs generates some bycatch (3–5% of the tunas they land), mainly undersized tunas, other finfish (dolphinfish, triggerfish, etc.), sharks, and some rays. Both the silky (*Carcharhinus falciformis*) and the oceanic white tip shark (*C. longimanus*) are at risk from purse-seine fishing gear. Two main international research projects, collaborating together, are investigating new mitigation techniques to reduce the impact of tuna fishing on elasmobranchs: the EU FP7 MADE project (Mitigating Adverse Ecological Impacts of Open Ocean Fisheries, www.made-project.eu) and the ISSF (International Seafood Sustainability Foundation, www.iss-foundation.org) mitigation project. The general philosophy of both projects is to involve fishers in all stages of the research. We present the different research actions and present the first results of these projects. Three categories of mitigation techniques are currently investigated: (i) before fishers reach the fishing zone (identify areas with high rates of catches of sharks from observers data, design and test ecological FADs that do not cause entanglement of sharks), (ii) before or during fishing (to avoid catching elasmobranchs), and (iii) after fishing (optimizing the survival of released animals). In addition to mitigating bycatch, we also investigate whether the release of thousands of artificial FADs on the ocean affects the behaviour of sharks through electronic tagging. We discuss the pros and cons of the different approaches to mitigation of the impact of this fishery on elasmobranchs.

Keywords: elasmobranchs, oceanic white tip shark, purse-seiners, silky shark.

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ICES CM 2010/E:06

Lumping New England skate species into a "stock complex": does the approach meet our management objectives?

Fiona Hogan and Steve Cadrin

The northeast US skate complex consists of seven species, with distributions extending along the US Atlantic coast. Management of the skate fishery began in 2003 with the implementation of the Skate Fishery Management Plan (FMP), which incorporated all seven species into one complex. The objective of the plan is to ensure the long-term sustainability of each species, implemented via a trip limit management strategy. The recent amendment to the FMP accounted for discards in the total allowable catch, resulting in substantially reduced trip limits. Two of the seven species are targeted commercially, with the remaining five species either discarded or outside the range of the fishery. The status of the multispecies resource varies latitudinally, with northern species designated as overfished. The management plan is intended to conform to mandated national standards. National standard guidelines define a complex as "a group of stocks in an FMP that are sufficiently similar in geographic distribution, life history, and vulnerability to the fishery that the impacts of management actions on the stocks in the complex is similar." Each species differs in vital life history traits (e.g. age at maturity, longevity, maximum size), in addition to geographic range, thermal preferences, and commercial value. These differences violate the guidelines for managing skate species as a complex. A management strategy focused on individual species may allow for a more efficient harvest of targeted species while allowing for the rebuilding of overfished species.

Keywords: complex, distribution, life history, management strategies, skate.

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ICES CM 2010/E:07

The spatial distribution of spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska: the use of fishery-dependent data, fishery-independent data, and generalized modelling for the spatial management of catch and bycatch

Jason R. Gasper and Gordon H. Kruse

The spiny dogfish (*Squalus acanthias*) is a common bycatch species in commercial longline fisheries in the Gulf of Alaska. This small shark is widely considered as a nuisance and most dogfish bycatch is discarded. Their spatial distribution in the Gulf of Alaska is poorly understood. A better understanding of areas of high bycatch would provide critical information to fishery managers, whether they seek to convert discards into valuable fishery landings or whether they seek to reduce fishing mortality on this long-lived species. We analysed the spatial distribution of spiny dogfish from fishery and survey data collected between 1996 and 2008 using generalized additive and generalized linear modelling techniques. Poisson, negative binomial, and quasi-Poisson error structures were investigated using goodness-of-fit statistics. The quasi-Poisson generalized additive model provided the best fit for predicting counts of dogfish and accommodating overdispersion caused by areas with low dogfish counts. The results revealed catches of spiny dogfish were concentrated east of Kodiak Island, Alaska, with a general shift in the distribution of dogfish to the west of Kodiak Island between 1996 and 2008. Greater bottom depth and fishing effort led to a non-linear decrease in dogfish catch over the period examined. In contrast to common perception among the Alaskan fishing industry, results do not suggest a large increase in the dogfish population in the Gulf of Alaska in recent years. Furthermore, modelling results reveal areas of high dogfish density that indicate core areas that are important to future stock assessments and management of harvest and bycatch.

Keywords: Alaska, GAM, spiny dogfish, *Squalus acanthias*.

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ICES CM 2010/E:08

The effects of electropositive metals on shark catch rates

M. R. Hutchinson, J. H. Wang, Y. Swimmer, K. Holland, S. Kohin, H. Dewar, R. Vetter, and J. Wraith

Bycatch of sharks in longline fisheries has contributed to the decline of shark populations. As such, strategies to mitigate the accidental capture of sharks are needed. One strategy that is being tested is to exploit the unique electrosensory system of sharks. Sharks and other elasmobranchs use their electrosensory system to detect changes in electric fields. In this paper the hypothesis that electropositive metals from the lanthanide series—neodymium (Nd) and praseodymium (Pr)—may affect shark feeding behaviours and thereby possibly reduce catch rates was tested. Longline catch rates when these metals were placed near baited hooks were compared with catch rates using inert lead weights (control). In the southern California Bight, pelagic longline fishing gear was deployed targeting juvenile shortfin mako sharks (*Isurus oxyrhincus*) and juvenile blue sharks (*Prionace glauca*). Offshore of Kaneohe Bay, Hawaii, coastal carcharhinid species, including juvenile scalloped hammerheads sharks (*Sphyrna lewini*), sandbar sharks (*Carcharhinus plumbeus*), and tiger sharks (*Galeocerdo cuvier*), were targetted. No difference was found in the catch rates for sharks caught in the California Bight but in Hawaii significantly fewer hammerhead sharks were caught on hooks with electropositive metal pieces than were caught on the controls hooks. It was concluded that the interspecific differences in effectiveness of the electropositive metals on catch rates may be a result of different feeding strategies among species and the way in which they use different sensory modalities for detecting and attacking prey.

Keywords: electropositive metals, shark bycatch, shark sensory biology.

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ICES CM 2010/E:09

Trends in abundance and distribution of deep-water sharks to the west of the British Isles from trawl survey data

Helen Dobby, Maurice Clarke, Graham Johnston, Leonie Dransfeld, Francis Neat, and Emma Jones

Landings of deep-water sharks from the Northeast Atlantic were first recorded in the late 1980s. The rapid expansion of the fishery during the 1990s has been followed by an equally rapid decline in landings of the two most commercially important species (Portuguese dogfish and leafscale gulper shark). Recent ICES advice for these species has been for a zero catch based on an analysis of commercial catch-rate data which indicate that both species are severely depleted. The assessments for these and other deep-water shark species, however, are hampered by a lack of species-specific landings data. Fishery independent surveys provide species-specific data that can be used to monitor trends in stock abundance. Two trawl surveys are currently carried out in the deep water to the west of the British Isles by Marine Scotland Marine Laboratory (1998 onwards) and the Marine Institute, Ireland (1993–2000; 2006 onwards). In this paper, spatiotemporal trends in survey abundance and size composition for a range of deep-water shark species based on the combined survey dataset are presented. The observed trends are then considered in relation to commercial fishery data over the past 15 years.

Keywords: deep water, Northeast Atlantic, shark, survey data.

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ICES CM 2010/E:10

UK fisheries for skates and rays (Rajidae): history and development, recent management actions and survivorship of discards

J. R. Ellis, J. F. Silva, S. R. McCully, and T. Catchpole

Skates and rays (Rajidae) are vulnerable to overfishing because they are long-lived, slow-growing, late to mature, have protracted breeding cycles, and produce few young. Their large size, morphology, and aggregating behaviour also make them susceptible to capture in mixed demersal fisheries, and several species are also taken in targeted fisheries (using longline, gillnet, or trawl). The abundance and diversity of the skate community around the British Isles has changed over the course of the last 100 years. Some of the larger bodied species (e.g. white skate) have disappeared, while the smaller bodied species (e.g. spotted and thornback rays) have healthier populations. Research has also demonstrated that some species have very patchy distributions, and locally abundant species may be prone to depletion. Current management regulations for skates include a minimum landing size (in some inshore waters of England and Wales) and quotas, and some species are currently designated as prohibited species that cannot be retained. The efficacy of these and other potential measures is highly dependent on discard survival. Here we review the evolution of skate fisheries around the British Isles, discard and retention patterns of skates in selected UK fisheries, the recent introduction of management actions and discuss the merits of these and other potential measures in light of our current knowledge of discard survival.

Keywords: bycatch, fisheries, Rajidae, Rajiformes, survivorship.

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ICES CM 2010/E:11

The utility of fishery-independent trawl surveys for evaluating spatial and temporal trends in the relative abundance of Northeast Atlantic spurdog (*Squalus acanthias*)

S. R. McCully, J. De Oliveira, H. Dobby, S. Beggs, and J. R. Ellis

Spurdog is a frequently captured shark in various otter trawl surveys in the ICES area. Here we examine the size frequencies and sex ratios of spurdog taken in Scottish surveys in the North Sea and off northwest Scotland, English surveys in the North, Celtic, and Irish Seas, and Northern Irish surveys in the Irish Sea. The spatial and temporal distributions of spurdog landings in commercial landings were examined to appraise the suitability of the timing of the surveys in each area. Surveys in northwest Scotland and the northern parts of the Irish Sea captured smaller sized spurdog, and mature female spurdog were often captured in the Irish Sea. Spatial and temporal patterns in the relative abundance of spurdog are discussed. Given the implementations of a zero TAC for Northeast Atlantic spurdog (with some allowance for bycatch) in 2010, fishery-independent surveys will be of increasing importance if stock recovery is to be assessed.

Keywords: fishery management, spiny dogfish, spurdog, Squalidae, trawl surveys.

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ICES CM 2010/E:12

Winter migration and diving behaviour of porbeagle shark (*Lamna nasus*) in the Northeast Atlantic

Ryan A. Saunders, François Royer, and Maurice W. Clarke

Porbeagle shark is one of the top marine predators in the North Atlantic. Little is known about its biology, abundance, or spatial ecology in this region, however. Here we present results on the migration and behaviour of three porbeagles tagged with archival pop-up tags off the northwest coast of Ireland that reveal important information on winter diving and migratory behaviour. One

shark migrated over 2400 km to the northwest of Morocco, residing around the Bay of Biscay for approximately 30 days. The other two sharks remained more localized in offshelf regions around the Celtic Sea/Bay of Biscay and off western Ireland. The sharks occupied a broad vertical depth range (0–700 m) and temperature range (c. 9–17°C), with notable variations in diving behaviour between individuals. There were distinct day–night differences in depth distribution with each shark positioned predominantly higher in the water column during the night-time than during the day. Night-time depth distribution also appeared to be driven by the lunar cycle during broad-scale migration through oceanic waters. A 29.7-day cycle (a lunar "month") in night-time depth distribution was observed for one shark, and moon phase and night-time depth distribution was negatively correlated. Our results demonstrate that porbeagle sharks occupy and traverse regions of high fishing activity where they are potentially vulnerable to population depletion. Such large-scale movement outside the ICES area underlines the need for international coordination in assessment and management.

Keywords: diving behaviour, lunar cycle, migration, porbeagle shark, satellite tag.

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ICES CM 2010/E:15

The complexities of managing a complex: the case of assessing data-limited sharks in the Gulf of Alaska

Cindy Tribuzio, Gordon Kruse, and Jon Heifetz

In US Federal waters of the Gulf of Alaska, catch limits are not specific to a shark group or shark species within a group; instead a single catch limit is set for a complex of species that includes sharks and other non-target species (e.g. octopus). Management agencies have discussed limiting Federal catch to a cap set specific to a shark complex including salmon shark (*Lamna ditropis*), spiny dogfish (*Squalus acanthias*), and Pacific sleeper shark (*Somniosus pacificus*). A sustainable fishing mortality (*F*) based on species- or group-specific biological characteristics has not been established for these species. This study used demographic modelling techniques to determine a sustainable fishing mortality rate for spiny dogfish and to examine the risk of abundance declining below threshold levels with regards to varying harvest strategies. Results suggest that harvest rates of $F = 0.03$ are sustainable for the spiny dogfish population in the Gulf of Alaska. For management purposes, spiny dogfish are considered the representative species in the shark complex because the species is relatively well studied and the more commonly caught of the shark species. Using these results as a proxy for Pacific sleeper and salmon sharks, however, is not recommended. Demographic models are based on birth and death rates, but there are almost no data for Pacific sleeper shark and these assumptions may over- or underestimate the productivity of the species. Salmon shark are relatively well studied, but catches are quite low compared with the other species and thus using spiny dogfish as a proxy may be overly conservative.

Keywords: demographic, elasmobranch, fishing mortality, spiny dogfish.

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ICES CM 2010/E:16

Dismissing dogma? What do we really know about the spiny dogfish (*Squalus acanthias*) population in the US western North Atlantic Ocean

James Sulikowski, Ben Galuardi, Walter Bubley, William Driggers III, Eric Hoffmayer, Angela Cicia, and Paul Tsang

The status of the spiny dogfish (*Squalus acanthias*) stock in the US portion of the Northwest Atlantic has become a contentious issue. Distributed from Maine to Florida, this species was once considered to be the most abundant shark throughout its US range. As a result of reported declines below biomass threshold levels, in early 2000 the Mid-Atlantic, New England Fishery Management Councils, and Atlantic States Marine Fisheries Commission implemented a management plan which imposed annual quotas and possession limits for vessels fishing in both Federal and State waters. Because of characteristics such as slow growth, extended gestation period, small litter size, and a spawning-stock biomass (SSB) below threshold levels as recent as 2005, the spiny dogfish population was not anticipated to rebound for more than a decade. Recent Northeast Fishery Science Center (NEFSC) survey data, however, suggest a fourfold increase in SSB has occurred between 2005 and 2009. Based on the aforementioned life-history characteristics, this substantial increase in biomass is considered to be biologically unrealistic. Preliminary data are presented to support hypotheses that are divergent to common paradigms it is hypothesized that: (i) the biologically unrealistic increases in SSB may be caused, in part, by a substantially more active vertical movement pattern that prevents this species from being effectively captured by NEFSC otter trawl surveys, and (ii) the gestation period of spiny dogfish may be less than the proposed 22 months and that there may also be regionally different reproductive cycles across this species' US range.

Keywords: movement, reproduction, shark, stock assessment.

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ICES CM 2010/E:17

Application of an ecological risk assessment (ERA) to data-deficient species: elasmobranchs of the British Isles

S. R. McCully, J. R. Ellis, J. De Oliveira, F. Scott, S. P. Northridge, and G. M. Pilling

Ecological risk assessments (ERAs) can provide a relatively quick way of identifying which species are most at risk in a fishery, even in data-deficient situations. This approach has been developed and applied to a number of elasmobranch complexes in Australia and also to some high-seas fisheries. In UK fisheries, elasmobranchs generally comprise the incidental catch, and consequently data are limited and quantitative assessments problematic for even the better-studied species. ERA methodology was therefore appropriate to application to both demersal and pelagic UK fisheries operating around the British Isles. We assumed a species' vulnerability to be related to their biological sensitivity and fisheries susceptibility. We identified four key biological, and six key fishery parameters that informed on the potential sensitivity and susceptibility of the species. In both pelagic longline and trawl fisheries, porbeagle and shortfin mako sharks ranked as the most vulnerable species. In demersal otter trawl fisheries, blonde, small-eyed, and thornback rays were identified as most vulnerable, whereas in demersal gillnet fisheries spurdog was considered to be the most at risk. This approach thus identifies the species and fisheries that should be subject to more detailed assessment and/or to underpin the need for precautionary management.

Keywords: bycatch, data deficient, data poor, dogfish, ecological risk assessment, productivity susceptibility analysis, ray, shark, skate.

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ICES CM 2010/E:18

Levels of capture stress in tail-hooked common thresher sharks (*Alopias vulpinus*)

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The common thresher shark (*Alopias vulpinus*) is routinely targeted by recreational fisheries around the world. Unlike most sharks, however, that are intentionally hooked in the mouth, anglers typically target the common thresher by hooking it in the caudal fin. This capture technique reduces the capacity for forward locomotion and impairs adequate gill ventilation. This study examined the levels of several physiological indicators of capture stress arising from the caudal-based hooking technique and quantified the post-release mortality using pop-off satellite archival tags (PSATs). Among the nine physiological indicators (i.e. Na^+, Cl^-, K^+, Ca^{2+}, Mg^{2+}, glucose, lactate, haematocrit, and heat shock protein 70 (hsp70)) assessed in nine tail-hooked threshers, only plasma lactate (as high as 27 mmol/l), haematocrit (as high as 47%), and hsp70 (51% relative increase) were significantly elevated when compared with non-tail-hooked specimens, and the level of stress indicator correlated with increasing fight time. PSAT deployments on 19 common thresher sharks revealed a 26% post-release mortality, with all individuals with fight times >85 min not surviving. Taken together, this study demonstrates that the current techniques used to target tail-hooked thresher sharks, which routinely prolong fight times in excess of 85 min, result in a significant stress response and have increased post-release mortality rates. These results suggest that the current caudal-based methods used in recreational anglers may not be suitable for an effective catch-and-release-based conservation strategy.

Keywords: blood, physiology, shark, sportfishing, stress, survival.

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ICES CM2010/E:19

Importance of collaborative research programmes to implement appropriate management measures for elasmobranch fisheries

Cédric Hennache and Caroline Gamblin

In 2008, a two-year collaborative research programme called EPPARTIY (Etude de la Pêcherie Palangrière de l'Ile d'Yeu) was initiated by the CNPMEM, the APECS, and the fishers of the Island of Yeu. The objectives of the project were to monitor the local porbeagle longline fishery, to improve biological knowledge of the species, and to propose management measures for the fishery. Observation on board and sampling at landing sites were conducted. Length, weight, sex maturation, composition, and geographical distribution of catches, and biological samples (stomach contents, gonads, and vertebrae, liver) were collected. The main results of the study, discussed with fishers, allowed the proposal of management measures adapted to the fishing practice and to the stock. A fishing licence was introduced in 2009. Estimation of age conducted on vertebrae demonstrates that NorthEast Atlantic porbeagle grows more slowly than that of the Northwest Atlantic. Thus management measures have to be adapted to this stock and not generalized. Given that 71% of sharks are captured alive, it is appropriate to fix a minimum and maximum landing size (MLS). For practical reason, fishers consider that a minimum weight of 20 kg and a maximum of 100 kg will be easier to assess and to implement on board (instead of an MLS) . Finally, the information on the spatial length distribution of catches emphasizes areas where it would have been interesting to set up seasonal closure to protect juveniles or gravid females.

Keywords: biological sample, fishers, growth rate, longline fishery, management measures, porbeagle, survival rate.

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ICES CM 2010/E:20

Exploratory assessment model for Northeast Atlantic spurdog

José A. A. De Oliveira, James R. Ellis, and Helen Dobby

An exploratory assessment model for Northeast Atlantic spurdog (*Squalus acanthias*) is presented. The model is based on an approach developed for school shark (*Galeorhinus galeus*) off southern Australia. It is essentially age- and sex-structured, but is based on processes that are length-based, such as maturity, pup production, growth (in terms of weight) and gear selectivity, with a length–age relationship to define the conversion from length to age. Pup production (recruitment) is closely linked to the numbers of mature females, but the model allows deviations from this relationship to be estimated (subject to a constraint on the amount of deviation), and parameter estimates to be based on fitting fecundity data. The model fits to a combined Scottish groundfish survey index of abundance, and to proportion-by-category data from both the survey and commercial catches (aggregated across gears). The only estimable parameters considered are total virgin biomass (B0), Scottish survey selectivity-by-category (three parameters), commercial selectivity-by-category for two fleets (four parameters, two reflecting Scottish selectivity, and two from English and Welsh fisheries), pup-production parameters (up to three) and constrained recruitment deviations (1905–2005). The model assumes two commercial catch exploitation patterns that have remained constant since 1905, which is an oversimplification given the number of gears that take spurdog, and the change in the relative contribution of these gears in directed and mixed fisheries over time. This simplifying assumption allows stock dynamics to be taken back to near-virgin levels. The model estimates current depletion levels of around 5% relative to 1905, and 7% relative to 1955.

Keywords: age–length model, spurdog, stock assessment.

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ICES CM 2010/E:21

Investigating the acute physiological effects of air exposure and the implications on discard survival in skates from the western Gulf of Maine

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Skates are routinely discarded as bycatch during commercial fishing operations in the Northwest Atlantic. These capture events create a variety of physiological stresses that may impact survivability. As part of a larger bycatch mortality study, venous whole-blood samples have been obtained from *Leucoraja erinacea* ($n = 32$) subjected to three different air-exposure durations (0, 15, and 50 min) in a laboratory setting. Additional samples were collected 5 days later to evaluate recovery. In preliminary trials, ventilation rates decreased in each group exposed to air. Blood acid–base status (declines in blood pH and pO_2; and HCO^{3-} concentrations; elevations in pCO_2) became progressively more disturbed the longer skates were subjected to air. The drop in blood pH was probably the result of hypercapnia and respiratory acidosis because of the compromised ability to offload CO_2 at the gills while air-exposed. Despite these marked physiological perturbations, blood acid–base status resolved to presumed baseline in all experimental groups during the 5-day recovery period, although skates in the 50-min group experienced moderate (28%) mortality. It is clear from these data that *Leucoraja erinacea* has a high threshold for coping with exposure to air, and can resolve seemingly large physiological disturbances from prolonged exposure. Data will also be presented on additional rajids from the western North Atlantic Ocean that are currently being assessed according to the same treatment. Data on the nature and threshold for coping with air exposure by species can have considerable influence on regulatory fishing measures.

Keywords: acid–base balance, bycatch, mortality, Rajidae.

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Correspondence between the distribution of some shark species and primary productivity in the Gulf of Mexico across multiple scales

J. Marcus Drymon and Sean P. Powers

Successful management of marine populations requires an alignment between ecological and managerial scales. This is particularly true, yet difficult, for large, highly migratory fish such as sharks. Catch data from two fishery-independent bottom longline surveys, as well as multiple ancillary datasets representing primary and secondary productivity, physiochemical parameters, and forage fish abundance were examined to better understand the mechanisms driving the distribution of sharks in the Gulf of Mexico. For this analysis, we considered regional (tens of kilometers) as well as basin-wide (hundreds of kilometers) scales, centred on the 88th W parallel of the Gulf of Mexico. Regionally, shark community structure varied significantly as a function of longitude with Atlantic sharpnose (*Rhizoprionodon terraenovae*), blacktip (*Carcharhinus limbatus*), and spinner (*Carcharhinus brevipinna*) shark populations higher in the western region, potentially reflecting a gradient in primary productivity and forage species. On a basin-wide scale, the distributions of several species were also associated with areas of high primary productivity. In contrast, the distributions of some larger, more mobile sharks, such as tiger (*Galeocerdo cuvier*) and ridgeback (dusky *Carcharhinus obscurus*, sandbar *C. plumbeus*, and silky *C. falciformis*) sharks, did not appear to be associated with areas of high primary productivity. These findings have implications for the scales upon which future elasmobranch foodweb models should be constructed.

Keywords: east, ecosystem management, foodwebs, scale, west.

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ICES CM 2010/E:23

Video observation and testing of a grate to reduce bycatch of spiny dogfish (*Squalus acanthias*) in a silver hake (*Merluccius bilinearis*) trawl fishery

David Chosid, Michael Pol, Frank Mirarchi, Mark Szymanski, and Andrew Mirarchi

The northern whiting *Merluccius bilinearis* (silver hake) stock in the Gulf of Maine generally exceeds its biomass targets and landings have been at a historical low. This fishery has traditionally been an important source of income for small trawlers in ports from Maine to Massachusetts, USA. Spiny dogfish (*Squalus acanthias*), an abundant bycatch, can prevent or hinder exploitation of this healthy stock. This species needs to be kept out of silver hake trawlnets to reduce bycatch mortality and to prevent damage to the catch caused by the abrasive skin of dogfish. In addition, bycatch levels of spiny dogfish may become especially critical once output control measures are put into place in 2010; high discards of dogfish could close groundfish fisheries if bycatch allowances are exceeded. Furthermore, discarding of spiny dogfish is a time-consuming process. Our collaboration between fishers and biologists tested excluder grates with 50-mm (~2-in) spacing to eliminate spiny dogfish in a raised-footrope whiting trawlnet. Designs were varied by colour (black or white), and upward or downward exclusion (through a top or bottom escape vent). Videos demonstrating the behaviours of whiting, dogfish, and other species' interacting with and around the grate were reviewed. Results based on observations and catch quantities indicate an overall excellent reduction of dogfish while allowing for commercial harvests of whiting and Atlantic herring (*Clupea harengus*). Industry acceptance of a grate can provide cost benefits for fishers and protection for managed bycatch.

Keywords: behaviour, bycatch, dogfish, grate, silver hake, trawl.

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ICES CM 2010/E:24

Vulnerability in chondrichthyans: how important is uncertainty?

Sebastian Pardo and Nick Dulvy

The relationship between life-history parameters and relative vulnerability to exploitation in sharks, rays, and chimaeras has been recently investigated in several studies. Further exploration of vulnerability needs to account for all sources of variability in estimates as typically conclusions are drawn from point values rather than the likely probability distributions of traits. We examine how describing and propagating parameter uncertainty affects estimates of vulnerability. Specifically we use Monte-Carlo simulation to propagate uncertainty in natural mortality estimates through an unstructured life-history model to look at the variability in the fishing mortality required to drive a species to extinction ($F_{extinct}$). Propagation of error profoundly influences the range of $F_{extinct}$ estimates and influences the rank order of species vulnerability. This suggests accounting for uncertainties in model input can contribute to improving species prioritization for conservation or management action.

Keywords: elasmobranchs, extinction risk, rate of increase, stochasticity.

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ICES CM 2010/E:25 Poster

Age, growth, reproduction, and feeding of bottlenosed skate (*Rostroraja alba* Lacépède, 1803) in Saros Bay, the north Aegean Sea

Cigdem Yıgın and Ali Ismen

The age, growth, reproduction, and feeding of bottlenosed skate (*Rostroraja alba* Lacépède, 1803) was studied using 126 specimens from the Saros Bay (north Aegean Sea) between March 2005 and December 2007. Females made up 53.2% and males 46.8% of the individuals. The total length of females ranged from 18.1 to 159.0 cm (disc width 12.4–122.5 cm) and of males from 14.0 to 135.0 cm (disc width 9.5–93.0 cm). The total length–weight and disc width–weight relationships were described by the equations $W = 0.0019$*TL3.27 and $W = 0.0063$*DW3.22, respectively. The age data, derived from vertebrae readings, were used to estimate the growth parameters of the von Bertalanffy equation: $L\infty = 254.83$ cm, $K = 0.05$ y^{-1}, $t0 = -0.21$ y. The maximum age was 10 years. Males matured at 78 cm TL (disc width 58 cm) and females at 88 cm TL (disc width 65 cm). The stomach contained mainly fish, IRI 75.20%.

Keywords: age, bottlenosed skate, feeding, growth, reproduction, *Rostroraja alba*, saros bay.

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ICES CM 2010/E:26 Poster

Greenland shark in the Barents Sea: biology, distribution, and bycatch

S. M. Rusyaev, K. M. Sokolov, and K. V. Drevetnyak

This paper was based on data on bycatch of Greenland shark (*Somniosus microcephalus*) by bottom and midwater trawling gear in the Barents Sea obtained on research and fishing vessels (1197 catches of fish since 1968 up to the present). Information on Greenland shark biology in the Barents Sea and adjacent waters is presented in the paper. According to the Russian trawl surveys in the Barents Sea conducted annually in August–September and November–December, Greenland shark mostly occurred in the central and eastern parts of the sea. Large and small fish are more common in the western Barents Sea, which apparently points to reproductive habitat availability in deep-water areas of the northeastern Atlantic. At current intensity of Russian trawl fishery, annual Greenland shark catch taken by Russian vessels in the Barents Sea presumably amounted to 1.2

thousand sharks with total weight up to 150–200 tonnes when average weight of one fish was ca. 140 kg.

Keywords: Barents Sea, biology, bycatch, Greenland shark.

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ICES CM 2010/E:27 Poster

Stable isotope analysis of a coastal predator and available prey reveal trophic plasticity in the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)

J. Marcus Drymon and Sean P. Powers

Quantifying the trophic role of sharks in coastal ecosystems is imperative, particularly for wide-ranging species, such as the Atlantic sharpnose shark. Two years of monthly longline sampling in the coastal waters of the northern Gulf of Mexico revealed a regional gradient in the distribution of this species. The aims of this study were to use stable isotopes to determine if differences in distribution for the Atlantic sharpnose shark and its prey translated into regional and seasonal variation in trophic position and carbon source for the Atlantic sharpnose shark. Across regions, results indicated that Atlantic sharpnose sharks occupy a trophic position intermediate to secondary and tertiary consumers. A significant interaction effect was demonstrated between season and region for both isotopes, in liver and muscle tissue. Eastern region nitrogen isotope trends were characterized by high levels in spring and low levels in the fall, concordant with seasonal variation in available prey as indicated by trawl survey data. Western region nitrogen isotope data demonstrated no seasonal variation, a pattern explained by the relatively high and consistent availability of forage fish. The trophic plasticity exhibited by the Atlantic sharpnose shark in this coastal system underscores the need to choose appropriate spatial scales when examining the feeding ecology of highly mobile marine predators.

Keywords: ecosystem management, foodweb dynamics, trophic plasticity.

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ICES CM 2010/E:29 Poster

Spiny dogfish (*Squalus acanthias*) caught as bycatch in salmon driftnet fishery in the Pacific off the Kuril Islands and Kamchatka

A. M. Orlov, A. O. Shubin, E. F. Kulish, I. N. Mukhametov, and A. V. Vinnikov

Data on spiny dogfish caught by salmon driftnets in the Pacific off the Kuril Islands and Kamchatka are summarized. The highest occurrence of this shark was observed off the southeastern Kamchatkan coast and opposite the First Kuril Strait where it occurred in July–November but most frequently in October–November during northward feeding migrations. Largest specimens (over 90 cm) occurred within the upper 100-m layer only. Catches were represented by individuals of 54–121 cm total length with mean 81.79 cm. Sharks 76–90 cm long were most numerous (62.3%). Latitudinal changes of spiny dogfish length were detected. In southernmost area (44°–45°N), total length varied from 75 to 112 cm (mean 83.8 cm) while in the northernmost one (52°–53°N) it was 91–63 cm with mean 71.7 cm. Catches were represented mostly by immature individuals (97.6% of females and 83.7% of males). Maximum total length of immature females was 109 cm, whereas minimum mature female length was 91 cm. Respective values for males were 82 and 80 cm. There were almost no significant differences in male and female average sizes: mean total length and body weight were 82.7 and 82.2 cm and 1758 and 1820 g, respectively. No relationships between total length and maximum egg diameter and between total length and number of eggs were found. Relationships between total, fork, and standard lengths, body and eviscerated weights are presented. Data on gonado-somatic and

hepato-somatic indices, indices of heart and spleen, and condition factor are presented. Diet composition is described.

Keywords: salmon driftnets, spiny dogfish, *Squalus acanthias*.

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ICES CM 2010/E:30 Poster

Age and growth of the bigeye thresher shark (*Alopias superciliosus*) in the eastern Atlantic Ocean

Joana Fernandez-Carvalho, Rui Coelho, and Miguel Neves Santos

The bigeye thresher (*Alopias superciliosus*) is commonly bycatch in pelagic longline fisheries targeting tunas and swordfish. Nevertheless, very little information is available on this species' life history in the Atlantic Ocean. As part of the EU Data Collection Regulation, Portuguese fishery observers have been placed aboard fishing vessels collecting information on captures, catch sizes, and biological samples such as vertebrae. Vertebrae collection on this species started in September 2008 and is currently ongoing, with a total of 252 bigeye threshers sampled so far (through October 2009). Samples have been collected along a wide geographical range (between 18°N and 28°S), mostly along the eastern Atlantic, with some samples collected in the southwest region. Size of specimens ranged from 101 to 265 cm FL, and whereas in the northern and tropical regions most size classes were observed, in the South Atlantic only larger and mainly adult specimens were found. A linear relationship between specimen size and vertebrae diameter was found and observed vertebrae demonstrated 1 to 25 pairs of opaque and hyaline bands. A preliminary growth model based on the von Bertalanffy growth function and assuming that each pair of bands corresponds to one year of age, produced growth rates (k) of 0.068 and maximum asymptotic sizes (Linf) of 266 cm FL. These data seem to indicate a species with a slow growth rate and high longevity. As this is an ongoing project, further samples will be collected, processed and added to the growth model during 2010.

Keywords: age and growth, *Alopias superciliosus*, bigeye thresher shark, bycatch, pelagic longline fisheries.

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ICES CM 2010/E:31 Poster

Transatlantic pelagic sharks research initiative

Rui Coelho, Miguel Neves Santos, Fábio Hazin, Felipe Carvalho, Joana Fernandez-Carvalho, and George Burgess

Oceanic pelagic sharks are particularly difficult to study and manage as they migrate between international and territorial waters of different countries. This research initiative was created as an international cooperative effort between research Institutes from three countries (Brazil, Portugal, and the USA), aiming at improving the knowledge of the biology of oceanic pelagic sharks from an ocean-wide perspective. All ocean migratory species are of interest, but so far we have been focusing on the reproductive biology of the crocodile shark (*Pseudocarcharias kamoharai*, $n = 490$) and the oceanic whitetip (*Carcharhinus longimanus*, $n = 222$) in the southwestern Atlantic, and have started studying the age and growth of the bigeye thresher (*Alopias superciliosus*, $n = 252$) and the smooth hammerhead, (*Sphyrna zygaena*, $n = 180$) in the eastern-central Atlantic. Size-at-maturity (L_{50}) of *P. kamoharai* was estimated at 80.0 cm TL for males and 91.6 cm TL for females, with adult females giving birth throughout most of the year. In the same region, *C. longimanus* appears to be mating in March, with parturition occurring 10 to 12 months later, during January. This species appears to have a biennial reproductive cycle, with the ovarian and the uterine cycles taking each one full year to complete. Preliminary age and growth data for *A. superciliosus* suggests that this species grows very slowly ($k = 0.068$) with the oldest specimen sampled so far being a 25-year-old

female. Future objectives of this project include the integration of these biological aspects with population genetics and satellite telemetry.

Keywords: conservation, life history, management, pelagic sharks.

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ICES CM 2010/E:32 Poster

Conversion factors for commercial shark and skate species of French fisheries

Bernard Séret and Antonin Blaison

In stock assessment and fishery management, catches are expressed in live (whole) weights, but many fish species are processed before landing; sharks are often landed eviscerated, some species are headed and skinned, and skates are landed as wings. Consequently, dressed weights measured at landing sites should be multiplied by a conversion factor in order to calculate the corresponding live weights. For the sharks and skates of the French fisheries, only two conversion factors have been in used to estimate the live weights from eviscerated fish. These are 1.33 for the sharks and 1.21 for the skates, whatever the species concerned. Here we present the results of a study on the conversion factors of the main commercial shark and skate species of the French fisheries.

Keywords: conversion factors, elasmobranch fisheries, France, sharks, skates.

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ICES CM 2010/E:33 Poster

Azores submarine mounts as complicated habitats: management measures in the case of multi-gear fishery

S. A. Gulugin and F. F. Litvinov

Data on elasmobranchs north and south of the Azores from the 1970s to 2004 were analysed. The elasmobranch community includes 21 species, from purely pelagic (*Prionace glauca*), to purely demersal (*Raja clavata*). Historical evidence reveals various types of fishery in the region: pelagic trawl, bottom trawl, pelagic longline, bottom longline, and bottom traps. Elasmobranch species are taken as bycatch in all of the fisheries and may be targeted in pelagic longlining. Pelagic longlining demands special measures, most probably closed areas in the vicinity of the mount peaks, because species such as *P. glauca* and *Alopias superciliosus* form very dense aggregations there, and the species may be quickly overfished. On the other hand, all of the species are vulnerable to any fishery impact, as some species form tiny separate stocks on single mounts. It was demonstrated that when the water layer over mounts was 200–400 m, species of various ecological groups penetrate other niches: for example, pelagic *P. glauca* may be caught by bottom trawl and vice versa. It is clear that in such a situation management measures for seamount species should consider all of the possible implications (i.e. species may be fished by different gear type during the whole life cycle or at the successive stages). Management measures might include, for certain or all gear types, closed areas, closed periods, closed depths, gear parameters, etc. Schemes of vertical distribution for different species along seamount peaks and slopes are presented.

Keywords: elasmobranch species, management measures, multi-gear fishery, submarine mounts.

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ICES CM 2010/E:34 Poster

Going Dutch? The European Shark Action Plan in the Netherlands

Paddy Walker, Irene Kingma, and Monique van de Water

In 2009 the Dutch government strongly supported the ratification of the EU Community Plan of Action for Sharks (CPOA), following an intensive lobby from nature conservation organizations. Concurrently the organizations set out a framework for a Dutch Shark Action Plan. Recent years have seen an improvement in the level of research and knowledge of shark species and their fisheries. ICES has played a leading role in this and is supported by many EU countries, including the Netherlands. The Dutch nature conservation organizations are also prepared to help implement a strong action plan. They propose to work together with government and research institutes to: (i) initiate a regional discussion forum with other North Sea countries over responsible management of shark populations—link in to the North Sea Regional Advisory Council; (ii) organize expert meetings to aid the implementation of the CPOA in national policy; (iii) provide education and species identification guides for those working with sharks, including fisheries scientists, and controllers; (iv) cooperate with recreational anglers in tag-and-release programmes; (v) initiate a research project to identify how skate and ray populations could be restored along the Dutch coast and the Wadden Sea area. These proposals are not typical for the Dutch situation and can be applied in all countries. With good cooperation and coordination across Europe we can ensure that sharks get the protection they so urgently need. This paper presents the key issues and progress made both within the Netherlands and in a European context.

Keywords: shark action plan, shark conservation.

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ICES CM 2010/E:35 Poster

Chondrichthyan catch composition of the bottom-trawl fishery in northeastern Mediterranean waters

Dimitios Damalas and Vassiliki Vassilopoulou

Otter bottom trawling is responsible for the majority (60%) of the chondrichthyans landed in Greece. A ten-year study, in the central Aegean Sea, monitoring on-board the activities of the fishery, identified 30 species (1 chimaera, 13 sharks, and 16 skates and rays) comprising 14.3% of the total catch in weight and 2.2% in number. Chondrichthyans were present in 95% of the hauls examined. Ninety per cent of specimens caught were discarded; 17 species were almost totally discarded (>97%), whereas only four exceeded 50% in their marketed percentage in numbers. Based on length frequencies, discard ogives were constructed for six species that had uninterrupted presence and an adequate sample size. Comparisons with lengths at maturity (LM_{50}) revealed that the marketed lengths of *Raja asterias*, *Raja clavata*, and *Squalus blainvillei* were significantly below the size at which they reach maturity. In contrast, the majority of *Dipturus oxyrinchus*, *Raja miraletus*, and *Scyliorhinus canicula* specimens landed consisted of adult individuals. Taking into consideration that more than half of the species identified in this fishery are classified as threatened, vulnerable, endangered, or critically endangered, it is surprising that no conservation measures have been put in action to date in the Mediterranean. Prohibition of landing the endangered species, as well as establishment of a series of minimum landing sizes for the vulnerable/threatened ones, along with the development and adoption of gears that meet discard-reduction objectives will promote the sustainable management of chondrichthyan populations.

Keywords: Aegean, demersal trawl, discards, elasmobranchs, rays, sharks, skates.

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ICES CM 2010/E:36 Poster

Elasmobranch species of the Adriatic Sea: raw assessment of the abundance of five species through bycatch data obtained from the monitoring of pelagic pair trawl fishery

Umberto Scacco, Elio Jr. Filidei, Ivan Consalvo, Marco Ruffino, Carola Vallini, Antonio Mazzola, Massimiliano Bottaro, Otello Giovanardi, and Caterina Fortuna

Taking advantage of the on-board monitoring programme on the Italian pelagic/midwater pair trawl fishery, set up to respond to requirements of Regulation (EC) 812/2004, data on incidental catches of protected species other than cetaceans and bycatch of elasmobranch species were collected in the Adriatic Sea. A total of 3330 hauls were monitored by on-board independent observers between 2006 and 2009, in a 10–170-m depth range. Data collected demonstrated that bycatch consists of a large number of specimens of elasmobranchs, ranging from benthopelagic (e.g. *Myliobatis aquila, Pteromylaeus bovinus, Pteroplatytrygon violacea*, and *Dasyatis pastinaca*) to demersal (e.g. *Squalus acanthias* and *Mustelus mustelus*) and to more pelagic forms (e.g. *Mobula mobular*, *Alopias vulpinus*, and *Carcharhinus plumbeus*). Based on elasmobranch fishery data, stratified both by depth and area of fishing grounds, the depletion DeLury method was used to provide a raw indication of the abundance of five species (*M. aquila, P. bovinus, P. violacea, S. acanthias*, and *M. mustelus*) fished in the monitored area through this fishing gear. Results for the benthopelagic and demersal selected species, the most targeted among those recorded, seemed to indicate some decline in catch abundance, mostly in the northern Adriatic Sea, for most of the considered bathymetrical strata. Despite the fact that this analysis is only preliminary and rather basic, our data could point out that these species of elasmobranch are potentially also impacted by the pelagic/midwater pair trawl fishery. Further analyses are necessary to assess the real nature and status of these species' populations.

Keywords: Adriatic Sea, bycatch, elasmobranch, pelagic/midwater pair trawl.

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ICES CM 2010/E:37 Poster

Elasmobranch catches and discards in the pelagic longline fishery in Brazilian fishing grounds in the Southwest Atlantic Ocean: an overview of the last 32 years

F. Carvalho, D. Murie, F. H. V. Hazin, R. Coelho, H. Hazin, and G. Burgess

In this study we present an overview of the elasmobranch bycatch in the pelagic longline fishery in the Southwest Atlantic Ocean, with the specific objectives of: (i) characterizing the effort that have taken place in that region over the last 32 years; (ii) analysing elasmobranch bycatch data collected with logbooks; (iii) analysing elasmobranch bycatch data collected by fishery observers aboard commercial fishing vessels; and (iv) comparing logbook and fishery observer data. For this analysis two different datasets were used: (a) logbook data from fishing vessels operating in the area between 1978 and 2009; and (b) fishery observer data collected aboard foreign chartered vessels fishing in the region between 2004 and 2009. The results of this study will contribute to a better understanding of the impacts of the fishery in the elasmobranchs populations in the Southwest Atlantic Ocean.

Keywords: bycatch, discards, longline fishery, pelagic elasmobranchs.

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ICES CM 2010/E:38 Poster

Demographic analysis for two species of commercial skates from the northern Tyrrhenian and Ligurian Seas

Monica Barone, Cecilia Mancusi, Fabrizio Serena, and Alvaro Abella

The starry ray (*Raja asterias*) and the thornback ray (*Raja clavata*) are frequently caught as bycatch of the commercial fisheries in the northern Tyrrhenian and Ligurian Seas, representing the better known elasmobranch species in the area. In absence of data on catch, effort, and age composition in the catch, growth parameters and maturity information combined with mortality and fecundity estimates were used to construct a life-history table for the two species. The demographic traits for the unfished population and for hypothetical combinations of fishing mortality levels and size of first capture were assessed. For the unexploited population of *R. asterias* and *R. clavata* the estimated values of the intrinsic rate of population increase were both positive and respectively $r = 0.378$ and $r = 0.364$. At the current fishing mortality and size of first capture the r for *R. asterias* was 0.228, becoming negative at fishing rate higher than 0.4; for *R. clavata* r was 0.319 but became negative at F higher than 0.3. The soundness of demographic parameters and the sensitivity of the model to the input values estimated for the two species, characterized by different life-history traits, are discussed.

Keywords: demographic analysis, life history table, *Raja asterias, Raja clavata*.

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ICES CM 2010/E:39 Poster

Elasmoit project—elements for the assessment and protection of elasmobranchs in the Italian seas

Monica Barone, Cecilia Mancusi, Giulio Relini, and Fabrizio Serena

Elasmoit was an Italian project with the primary goal of collecting information on the status of exploitation and conservation of elasmobranch fish in the Italian seas. This project was promoted by the Ministry for the Environment, Land and Sea (MiATTM) and coordinated by the Italian Society for the Marine Biology (SIBM) with the participation of the Italian group for the research on sharks, skates, and chimaeras (GRIS). The project started in February 2009 and ended in January 2010. The project especially focused on the pelagic species, as in the Italian seas there were fewer data on captures of these vulnerable species available with respect to demersal species. The main activities of the project were: the collection of data available, from bibliography and research surveys, needed also for a critic revision and implementation of the National Action Plan. A second essential activity was the periodic monitoring of landings at the main harbours of the selected regions (Liguria, Sardinia, Sicily, and Apulia) and on board vessels operating with longlines. At the end of the project, a database of references and biological data was produced, followed by maps of distribution and abundance for the principal species. The original outputs of the project are presented here with special emphasis on the guidelines for the implementation and compilation of the future Italian Plan of Action.

Keywords: Italian seas, national plan of action, pelagic sharks.

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ICES ASC 2010/E:40 Poster

Age and growth of the deep-water shark (*Galeus melastomus*) off the south coast of Portugal

Miguel Baptistaa, Ivone Figueiredob, Rui Coelhoc, and Karim Erzinid

The deep water blackmouth catshark (*Galeus melastomus*) is captured as bycatch by deep-water bottom trawlers targeting crustaceans and deep-water longliners targeting teleosts. Most catches have little or no commercial value and are therefore discarded, but larger specimens have some market value and are usually kept and commercialized. Different staining and sectioning methods were essayed in order to determine the most efficient techniques for ageing blackmouth catsharks, with a modification of the cobalt nitrate technique yielding the best results. Age and growth estimates for the south coast of Portugal were obtained from 195 vertebral centra extracted from specimens ranging from 12 to 75 cm total length and compared with previously published age and growth data. In order to fill a gap in the knowledge of the life history of this species, a MIR analysis was performed to ascertain band formation periodicity. Sexual maturity was also estimated for both females and males. The obtained results provide a useful insight into some life-history traits of this species, contributing to its consideration in fishery management plans.

Keywords: age estimation, *Galeus melastomus*, growth modelling, population dynamics.

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ICES CM 2010/E:41 Poster

Reproductive biology of *Leucoraja naevus* from continental Portuguese waters

Catarina Maiaa, Bárbara Serra-Pereirab, Ivone Figueiredob, and Karim Erzinic

Skate populations tend to be highly vulnerable to overexploitation as a result of their life-history characteristics, namely slow growth, late maturity, and low fecundity. The cuckoo ray (*Leucoraja naevus*), one of the skate species landed in Portugal, is mainly a bycatch species from the artisanal mixed fishery, and for this reason it is very difficult to acquire information about its basic biology. This study provides the first detailed information on the reproductive biology of this species in southern European waters. It was possible to conclude that males and females attain maturity between 50 and 54 cm TL. Spawning females were observed in almost every month, suggesting that reproduction occurs throughout the year. Spawning peaks seem to occur in February, April, and November, based on higher gonodosomatic index values. The species displays a long spawning period and demonstrates a relatively high fecundity in comparison with other skate species. These results provide essential information on the reproductive biology of this bycatch species and are useful for fishery management.

Keywords: cuckoo ray, fecundity, maturity, Portugal, Rajidae.

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ICES CM 2010/E:42 Poster

The use of the French longline cpue to provide an abundance index for porbeagle in the Northeast Atlantic

Gérard Biais and Julie Vollette

A porbeagle catch per unit of effort (cpue) series of the French longline fishery was presented at the 2009 ICES Working Group on Elasmobranch Fishes (WGEF). This fishery has targeted porbeagle in the Northeast Atlantic up to 2009, mainly along the continental edge of the Bay of Biscay shelf and of the south of Ireland shelf. This cpue series was used to carry out exploratory assessments at the 2009 WGEF. Days at sea was adopted for fishing effort unit in order to get a series as long as possible and consequently the cpue is expressed in catch per day at sea. The aggregative behaviour

of the porbeagle and the fishing practices in response to this behaviour, however, raise the question of the ability of this cpue index to track changes in stock abundance accurately. This question has been investigated in recent years, from 2000 onwards, by analysing the logbooks of several vessels.

Keywords: abundance, catch, effort, index, longline, porbeagle.

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Theme Session F

Monitoring biological effects and contaminants in the marine environment: where do we go from here?

ICES CM 2010/F:01

Towards an integrated approach for monitoring the effects of chemical contaminants in Spanish coastal Mediterranean waters

C. Martínez-Gómez, V. M. Leon, J. A. Campillo, and J. Benedicto

In the past 12 years, chemical monitoring surveys in Spanish Mediterranean coastal waters have developed from the use of native mussels to an integrated sampling of native and caged mussels, fish (red mullet), and sediment. In addition, the application of biological effect measurements (using biomarkers and bioassays) in the same matrices is gradually increasing. So far, biological measurements have comprised a suite of biomarkers in fish (EROD, Ala-D, and AChE activities, metallothionein content, DNA integrity, and micronuclei abnormalities) and in mussels (stress on stress, lysosomal membrane stability, metallothionein content, micronuclei frequency, AChE, and antioxidant enzymes) as well as the sea urchin embryotoxicity test with *Paracentrotus lividus* in sediment elutriates. Most of the driving forces behind these changes came from recommendations and Standard Operation Practices provided by expert organizations such as MED POL, ICES, and OSPAR, and these changes have considerably increased the costs of monitoring. The more expensive intensive monitoring activities, however, contribute to a more realistic assessment of the quality and health status of the marine ecosystem. For this purpose, quality assurance and the development of assessment criteria for the selected methods is a prerequisite. These requirements are necessary to meet national and international obligations (EU-MSFD, EU-WFD). Here, we present and discuss the integrated chemical–biological effect approach currently being proposed for implementation in the Spanish Mediterranean monitoring programme 2010–2012. The selected biological measurements, the assessment criteria obtained so far, and quality assurance processes are discussed in terms of feasibility.

Keywords: biomonitoring, embryotoxicity, marine sediments, Mediterranean Sea, mussels, red mullet.

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ICES 2010/F:02

Multiple lines of evidence to identify bioaccumulation mechanisms for mercury (Hg) in estuarine foodwebs with an emphasis on a recreationally targeted fish species

H. Jones, C. Macleod, K. Swadling, S. Tracey, and E. Butler

Heavy metal contamination is a feature of many urbanized estuaries and the Derwent Estuary (Tasmania, Australia) is no exception. Past industrial practices have resulted in elevated metal levels in water, sediments, and biota. Despite significant reductions in loads and improved estuarine conditions there are still risks associated with contaminated sediments and seafood. Muscle tissues in several recreationally targeted fish have mercury concentrations above regulatory guidelines. Flathead (*Platycephalus bassensis*—a common recreationally fished species) has been used for many years as a local indicator of environmental health. Sediment mercury loads in the

mid and lower estuary are comparatively low, but our study has demonstrated that 83% of sized (>300 mm) flathead from the mid-estuary had mercury levels well above the recommended seafood safety limit of 0.5 mg kg^{-1} (mean 0.68 mg kg^{-1}). There were clear spatial differences in contamination with only 33% of fish from the lower eastern estuary (<3 km away) exceeding the safety limit. Previous studies have suggested that flathead are highly resident in nature and relatively stable in the food chain, with recent distribution surveys also suggesting a high degree of residency in this species. The multiple lines of evidence approach used in our study also support this assumption, with data suggesting strong spatial differences in mercury loadings as well as regionally differentiated feeding patterns and mercury concentrations in prey. We present these data along with $\delta^{15}N$ isotope ratios for key components of the food chain and relate this to distribution patterns for flathead and other key species.

Keywords: bioaccumulation, Derwent Estuary, mercury, stable isotopes, telemetry, Tasmania.

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ICES CM 2010/F:03

Suspension of contaminated sediment: a comparative study between trawling and dredging

I .Tjensvoll, C. Bradshaw, M. Sköld, I. Allan, J. Molvær, and H. Nilsson

Soft bottom sediment covers 70% of the world's seabed and is important for many processes in marine ecosystems. Sediment's ability to store large amounts of contaminants that can be released during sediment disturbances, both owing to natural and anthropogenic activities, is well documented. The bottom trawl was introduced in the thirteenth century and was followed by concerns and protests from fishers. Since then, trawl gears have become larger and more efficient and today they can cover an area half the continental shelf annually. In the past, very limited attention has been paid to the effects of sediment resuspension during trawling. Given the extent and the frequency of bottom trawling and the documented penetration of bottom trawls into sediments, it is likely that resuspension is an important process. We quantified large amounts of sediment resuspension during a trawling event in Eidangerfjord, Norway. To sample contaminants released into the water column, passive samplers (SPMD) and blue mussels were used and the results indicate the release of sediment-associated contaminants, their bioavailability, and the potential effect of this resuspension on aquatic species. The results from this study were compared with published data on dredging activities. The management of these two human activities is very different, although similar sediment suspension and environmental impacts are observed.

Keywords: bottom trawling, contaminated sediment, dredging, management, sediment suspension.

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ICES CM 2010/F:04

Relationship between biological, pathological, and toxicological parameters and the cause of death in harbour porpoises (*Phocoena phocoena*) stranded on the coast of Belgium and northern France

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The Marine Animals Research and Intervention Network (MARIN) investigated the cause of death of marine mammals stranded on the coastline of the southern North Sea (Belgium and northern France) or as bycatch delivered by fishers. The aim of the study was to compare biological, pathological, and toxicological parameters involved in the cause of death (traumatic or infectious) of harbour porpoises (*Phocoena phocoena*) collected between 1990 and 2008. In total, 520 porpoises were necropsied and sampled. Two causes of death appeared to prevail: first, infectious diseases: 191 animals had severe parasitosis and pneumonia, and second, bycatch in fishing nets: 120 had died of trauma, mostly as a result of bycatch in fishing gear. Most strandings and bycatches

occurred in winter and there were more males than females. The majority of stranded animals taken as bycatch were juveniles. Compared with porpoises taken as bycatch, animals that had died of an infectious process had a thinner blubber layer (emaciation) and the histological investigation demonstrated a marked lymphoid depletion (spleen, thymus, and lymph nodes). Nevertheless, many porpoises taken as bycatch that could serve as a "control" population also presented evidence of emaciation and infectious diseases, thus confirming the need to carry out a complete necropsy to evaluate their health status. The total PCBs was determined in the blubber of selected individuals: it was higher in males than females and higher in adults than juveniles. Finally, the animals that had died of infectious disease were more contaminated than porpoises taken as bycatch. Our observations are very similar to results previously reported from neighbouring countries.

Keywords: cause of death, harbour porpoises, health status, PCBs, *Phocoena phocoena*.

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ICES CM 2010/F:05

Baltic cod (*Gadus morhua*): skin ulcers, bacteriology, and biomarker response

Magdalena Podolska, Ewa Mulkiewicz, Dorota Napierska, and Edward Grawiński

Ulcer syndrome is one of the most common diseases affecting Baltic fish. Investigation for externally visible symptoms of ulceration in cod was conducted from research vessels in the southern Baltic in 1998–2008. Bacteriological examination of skin ulcers was performed on samples taken in 2007 and 2008. Measurement of blood plasma lactate dehydrogenase (LDH) was used as an indicator of pollution-induced stress in fish sampled in 2005. Generalized linear models were applied to model the prevalence of ulcers as well as enzymatic activity in cod, as dependent on the area of sampling and the biological parameters of fish. The lowest prevalence of ulcers was recorded in fish sampled in the reference area of Leba (middle Baltic). Males were more affected than females. Microbiological examination of cod ulcers revealed the presence of bacteria belonging to the genera *Aeromonas*, *Pseudomonas*, and *Vibrio*. *Acinetobacter* spp. and *Chryseobacterium meningosepticum*, potentially pathogenic for humans, were also reported. The highest increase in LDH activity, compared with the reference area, was found in the Gulf of Gdańsk. Changes in LDH activity could be induced not only by the toxic effects of varied pollutants, but also by infection with *Aeromonas*. It is also possible that fish exposed to chronic levels of pollution may be more susceptible to bacterial infections.

Keywords: bacteriology, Baltic cod, enzyme biomarker, *Gadus morhua*, LDH, ulcer.

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ICES CM 2010/F:06

PAH and biomarker measurements in fish from condition monitoring in Norwegian waters in 2005 and 2008

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Condition monitoring in fish from open seas is performed in Norway every third year. The objectives are to investigate whether fish from Norwegian seas contain elevated levels of components that originate from discharges from the petroleum activity. We present results from the samplings in 2005 and 2008 from four areas: the Egersund Bank (reference area North Sea), Tampen, the Halten Bank, and the Barents Sea (reference area). Naphthalene, phenanthrene, and dibenzothiophene (NPD) and polynuclear aromatic hydrocarbons (PAHs) measured in fish muscle in 2005 were found to be below limit of quantification (LOQ) for all regions. In 2008, sum NPD levels were measured in haddock liver and found to be low for all regions (8–34 ng g^{-1} wet weight).

Bile metabolites from haddock were measured by GC/MS in 2008. The main contributor to sum PAH metabolites at Tampen and at the Egersund Bank was 1-hydroxy phenanthrene, with levels of 510 ± 814 and 133 ± 207 ng g^{-1} bile, respectively. Levels of this metabolite in haddock from the Halten Bank and the Barents Sea were 43 ± 71 and 19 ± 14 ng g^{-1} bile, respectively. Levels of alkylphenols were found to be below LOQ. Levels of vitellogenin in the blood of male cod were generally low from all regions. Measurements of DNA adducts in fish liver did not show changes for cod and saithe, whereas a significant increase were observed in haddock from Tampen compared with haddock from the Egersund Bank. Lipid content in the liver was significantly reduced in haddock from Tampen. Fatty acid profiles revealed that haddock from Tampen had relatively high levels of arachidonic acid, and the ratio between omega-3 and omega-6 (n-3)/(n-6) poly unsaturated fatty acids were significantly lower in neutral lipids, free fatty acids, and phosphotidylcholine/phosphotidylethanolamine, compared with haddock from the other regions.

Keywords: biomarkers, bile metabolites, DNA adducts, fatty acid composition, fish, NPD, PAH, Vtg.

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ICES CM 2010 /F:07

Chlordecone in the marine environment (in organisms from, in biota) around the French West Indies: from measurement to pollution management decisions

Jacques Bertrand, Xavier Bodiguel, Alain Abarnou, Gilles Bocquené, and Jean-François Chiffoleau

Chlordecone is a very persistent insecticide that was used in the banana plantations of the French West Indies between 1972 and 1993. Chlordecone residues have been found in inland water, in agricultural and freshwater products, and in marine organisms. This pollution became of great concern in 2007, and a national action plan was launched to assess the pollution and to improve consumer protection. Within this plan, 408 samples from 55 different species of marine fish and crustacean were taken around the Guadeloupe and the Martinique Islands. Results confirm the presence of chlordecone in marine organisms, with highly variable concentrations (from the detection threshold to 1000 μg kg^{-1}). In 17.9% of the samples, concentrations exceeded 20 μg kg^{-1}, the maximum acceptable level. Two main features of this contamination were characterized (i) As a result of sedimentation of contaminated suspended soil particles, the sheltered bays are more exposed to chlordecone than the open coast, where terrigenous fluxes are dispersed. (ii) Species' biology, particularly their lifestyle and diet, appear to influence contamination levels. Thus, the more contaminated species live in relation to sediment or are at high trophic levels. These results directly support political decisions designed to prevent exposure of consumers to chlordecone. Fishing activities in sheltered bays have been forbidden for potentially highly contaminated species such as benthic crustaceans and top predators. Further studies are underway to assess the importance of the trophic transport of chlordecone within the foodweb, and to evaluate the historical deposition of this insecticide in sediment and its further bioavailability.

Keywords: chlordecone (Kepone), crustacean, French West Indies, fish, organochlorinated contaminant, pollution management, risk assessment.

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ICES CM 2010/F:08

Insights from 30 years of experience in running the French marine chemical monitoring network

Joel Knoery and Didier Claisse

Salient results from over 30 years of monitoring the French coastline for contaminants are presented and the general characteristics of this programme. Emphasis is placed upon the various compromises and the balance between objectives and practical constraints that are necessary to implement a workable, high-quality national network for the observation of marine chemical contamination. Essential compromises and gradual adjustments were made to accommodate the initial objectives of the network with necessary improvements in monitoring the concentrations of contaminants. These include relying upon recognized experts in the field and monitoring operators, and the building of a long-term partnership between the programme's funding agency and its field operators. Induced side-benefits of this particular organization include the development of a very favourable cost-to-performance ratio, and the international coherence of the collected data. Since 2007, the French implementation of the Water Framework Directive (WFD) upended the previous organization and drastically decreased these side-benefits. The principles and strategies used to design and maintain the French network for the observation of marine chemical contamination, which are highly successful and can be applied elsewhere, are presented. Over 30+ years of operation, the programme has identified hot spots of contamination and pointed to unknown contaminants. It allowed the description of the temporal evolution of the chemical status of various ecosystems. Examples of the environmental effects of pesticide bans are shown, as well as studies to trace the sources of chemical contamination, and studies using our historical sample archive to constrain dates and speciation emerging contaminants.

Keywords: chemical status, contaminant, observation network, WFD.

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ICES CM 2010/F:09

Long time-series data showing recent recovery of gastropod populations from the effects of tributyl tin at the Shetland Oil Terminal

Matt Gubbins, Jon Moore, Rob Fryer, and Ian Davies

Surveys of gastropod (dogwhelk, *Nucella lapillus*) populations at the Shetland Oil Terminal in Sullom Voe for the effects of tributyl tin (TBT) from shipping have been commissioned by the terminal's Environmental Advisory Group (SOTEAG) and now represent one of the longest time-series of biological effects data available (1987–2009). These data from 20 shoreline sites around the oil terminal in the Voe and less affected waters of Yell Sound, show a substantial recovery of TBT-induced imposex as measured by vas deferens sequence index (VDSI), relative penis size index (RPSI), and female sterility associated with decreasing shipping traffic, reduced usage of free-association antifoulants and now the complete ban imposed by the International Maritime Organization (IMO) on TBT usage on large vessels in 2008. Data are presented that show in 2009, for the first time and following the IMO ban, no incidence of imposex-induced female sterility at any of the surveyed sites. At some of the most affected sites, some metrics of imposex are now at or close to zero (sterility, RPSI) and the rate of recovery of VDSI is greater than previously recorded. Data are assessed using OSPAR statistical methodologies and assessment criteria and presented alongside data showing associated changes in dogwhelk population structure in the area.

Keywords: biological effect, dogwhelk, gastropod, imposex, TBT.

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ICES CM 2010/F:10

Environmental status assessment of contaminant concentrations in sediment and biota—assessment criteria and data integration

Lynda Webster, Rob Fryer, Ian Davies, Matt Gubbins, Patrick Roose, and Colin Moffat

The assessment of OSPAR CEMP (Coordinated Environmental Monitoring Programme) data on contaminant concentrations in sediment and biota for the OSPAR Quality Status Report (QSR) 2010 required a simple graphical presentation of regional assessments that addresses the primary objectives of the OSPAR hazardous substances strategy: (i) that concentrations should be at, or approaching, background levels for naturally occurring substances and close to zero for synthetic substances; and (ii) that there should be no unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, being caused by exposure to hazardous substances. In accordance with these objectives, two types of assessment criteria were established: those reflecting levels above background concentrations (BCs) referred to as background assessment concentrations (BACs), and environmental assessment criteria (EACs) representing concentrations below which unacceptable biological effects were unlikely to occur. These were applied to annual time-series (and supporting spot sample) data in the ICES Data Centre concerning concentrations of mercury, lead, cadmium, CBs (ICES 7), and PAHs (6 of) in sediments and biota throughout the OSPAR region. This allowed assessments to be presented as "traffic lights", with red indicating that environmental conditions represent an unacceptable risk, green indicating achievement of the OSPAR objective relating to unintended/unacceptable responses, and blue referring to achievement of the objective relating to BCs. An integration procedure was then applied to progressively combine data within contaminants, monitoring matrices, subregions, and ultimately regions to obtain a graded sequence of assessments of environmental quality in relation to priority hazardous substances.

Keywords: assessment criteria, hazardous substances, integrated assessment.

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ICES CM 2010/F:11

Developing a fit-for-purpose and cost-effective UK chemical and related biological effects monitoring programme

Thomas Maes

This review has been undertaken in light of the recent Charting Progress 2 assessment of the health status of UK's marine environment. The proposed changes will ensure that the existing Clean Safe Seas Environmental Monitoring Programme (CSEMP) will continue to fulfil the UK's obligations to OSPAR and importantly address the production of data underpinning qualitative descriptors of Good Environmental Status (GES), as required by the Marine Strategy Framework Directive (MSFD). The current programme has the following features and identified gaps: (i) Offshore programme is extensive (ca. 30 sites) with many sites at, or close to, background response levels. (ii) Elevated contaminant-related biological responses have been identified at a few offshore hot spot locations. (iii) Coastal and estuarine locations have the highest contaminant input and highest contamination levels in both biota and sediment according to CP2. (iv) The inshore contaminant-related biological effects programme is limited and there is a requirement for greater integration with the offshore programme. The proposed key changes are: (i) Offshore programme can be reduced from 30 sites to a core of 11. (ii) The monitoring effort offshore should focus on sites of special scientific interest, with spot checks at sites at, or close to, background response levels. (iii) Annual monitoring should be changed to a rolling three-year programme focusing on different regions each year. (iv) The inshore programme should be developed to include an integrated fish and shellfish chemical related biological effects programme. (v) The inshore programme should be conducted in a rolling three-year cycle to mirror the offshore programme.

Keywords: biological effects, contaminants, integrated monitoring programme.

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ICES CM 2010/F:12

Environmental assessment of the southeastern Baltic Sea with use of the hydrochemical and hydrobiological data

Sergey Aleksandrov

The Baltic Sea is a semi-closed inland sea with a specific hydrological regime and ecology. Eutrophication and accumulation of pollutants are the most important problems. To assess the ecological state of the southeastern Baltic Sea, an analysis of hydrochemical (nutrients and pollutants) and hydrobiological (chlorophyll) parameters was carried out. Assessment of the ecological state and monitoring of these parameters were specified by the EU Marine Strategy Directive and EU Water Framework Directive as one of the main indicators of eutrophication and water pollution. Ecological monitoring was carried out at 18–22 stations in winter, spring, summer, and autumn of 2003–2009. Special attention is paid to the oilfield "Kravtsovskoe", where oil production has been conducted since 2004. Assessment of water quality and eutrophication was carried out according to classifications adopted in Russia and Baltic countries. Spatial distribution of chlorophyll and nutrient concentrations was characterized by increased values in coastal areas, which could result from shallow depths, nutrient and pollutant input from the shore, and periodic summer "blooms" of cyanobacteria. Consequently, coastal areas have higher eutrophic status and lower quality of water than the Baltic proper. In the coastal areas, the water quality is often reduced to a satisfactory and passable condition. Occasionally there is local pollution and maximum permissible concentrations of petroleum products, detergents and PAH are exceeded. This is generally associated with discharge from the shore or oil leaks, including from ships. Long-term monitoring, however, did not reveal any contamination of the marine environment of the southeastern Baltic Sea associated with development (construction, drilling of wells) and oil production.

Keywords: Baltic Sea, eutrophication, oil production, water monitoring, water quality.

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ICES CM 2010/F:13

Assessing the health of blue mussels (*Mytilus edulis*) for site-selection of cultivation areas: potentials and constraints of applied parameters

Matthias Brenner

In a comprehensive approach, intertidal, near- and offshore areas in the German Bight were evaluated to determine their suitability for the cultivation of blue mussels (*Mytilus edulis*). Over a ten-month sampling period, mussels were assessed using biodiagnostic markers (previously applied only in environmental monitoring), such as lysosomal membrane stability and the concentrations of lipofuscin, neutral lipids, and glycogen in cells of the digestive gland. Together with investigations regarding the presence of macro- and microparasites, bacteria, viruses, and toxic algae in mussel tissues, the overall health of animals was described. First results revealed high condition indices, low parasite infestations, and very high growth rates for submerged mussels. In contrast, intertidal mussels had significantly higher parasite loads and lower condition indices. A pattern was obtained regarding the concentration of, for example, neutral lipids in cells of the digestive gland. Because of the permanent feeding mode, submerged mussels accumulated significantly more neutral lipids than intertidal mussels. These differences between sites, however, were not displayed using screening tools sensitive for environmental impacts and individual stress such as the test on lysosomal membrane stability. Here, mussels from all sites demonstrated comparably low values throughout the sampling season. Differences were displayed only on an interseasonal level, with lowest labilization values in spring because of the reproduction of

mussels. The results show that mussels may react differently to the same level of environmental stress according to their habitat conditions. Furthermore, there is a need to evaluate the impact and relevance of health-related investigations on improving the significance of the deployed parameters.

Keywords: biodiagnostic techniques, cultivation, health, *Mytilus edulis*, offshore.

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ICES CM 2010/F:14

Enzyme activities in spermatozoa as indicators of marine environment pollution

Edyta Gosz, Mateusz Barcikowski, and Marek Ziętara

Environmental biochemistry links the responses of living organisms to environmental change at the biochemical level. One of the aims of this study was to identify the enzymes activities in fish spermatozoa. The second was to compare enzyme activities between specimens living at contaminated and uncontaminated localities. We report here recent progress on the spermatozoa energy metabolism of the southern Baltic flatfish species *Psetta maxima*. This species is thought to be an indicator of environmental contamination, and has been reported to live at the border of its occurrence in the research area. For this study, the activity of spermatozoa enzymes were measured from specimens collected during the spawning period in 2008 and 2009 in two sampling sites of the southern Baltic Sea. Concentrations of tributyl tin and heavy metals were detected in the fish tissues. Tributyl tin appeared to be accumulated specifically in ripe turbot testes. Loss of enzyme activities was related to the level of the accumulation. Such biomarkers can be useful for evaluation of the impact of environmental contamination on fish reproduction.

Keywords: Baltic Sea, ecosystem indicator, fish sperm, *Psetta maxima*, tributyl tin.

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ICES CM 2010/F:15

Towards a comprehensive methodology for assessing the health status of coastal and estuarine ecosystems

Olivia Fossi Tankoua, Jean-Claude Amiard, Claude Amiard-Triquet, Brigitte Berthet, Catherine Mouneyrac, and Philip S. Rainbow

Biomarker methodology has been developed since the early 1990s and core biomarkers have been validated for use in biomonitoring programmes. Their lack of ecological relevance, however, is frequently emphasized. Nevertheless, their ability to reveal environmental disturbances well before changes in benthic communities occur is of considerable advantage. The first goal of this presentation was to provide a response to the following question: Can impairments at the infra-individual or individual levels allow an assessment of effects at higher levels of biological organization? Processes that can affect reproductive success, with very probable consequences at the population level provide biomarkers with added ecological value. Particular attention will be devoted to (i) energy metabolism, (ii) behaviour, and (iii) sexual disturbances. Case studies with key species for intertidal mudflat functioning (the endobenthic worm *Nereis diversicolor* and the bivalve *Scrobicularia plana*) will be used to provide evidence of the cascade of biological events leading from chemical stress to local extinction of the species. In conclusion, a three-step comprehensive methodology will be proposed to assess the health status of coastal and estuarine ecosystems. A first step would consist of seeking evidence of impairments revealed by so-called biomarkers with ecological value. When such impairments are demonstrated, it is necessary to identify the main classes of contaminants that may be responsible by using a multi-biomarker approach based on ”core biomarkers”. The quantification and characterization (specific fractions,

metabolites) of chemicals in water, sediments, and biota can then allow the correlative validation of hypotheses based on the biomarker studies.

Keywords: biomarkers, contaminant characterization, ecological relevance, mudflats.

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ICES CM 2010/F:16

Integrated marine contaminant monitoring in the North Sea (ICON): a framework for integrated chemical and biological monitoring

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The North Sea is a highly productive area but at the same time receives large amounts of waste from land-based and offshore sources. North Sea ecosystems are and have been subject to intensive fishing pressure as well as contaminant inputs. There is reason to believe that contaminants in North Sea ecosystems affect marine organisms. In the 1980s there were clear indications that contaminants were related to increased incidence of aberrations in fish embryos in the southern North Sea. Fish disease monitoring since the late 1970s has demonstrated changes in disease prevalence that were partly attributed to contaminant exposure. In addition to the above, there are indications from sublethal health-related measurements (biomarkers) of effects on fish in areas with high offshore activity. The North Sea is an extensively studied marine area and one would perhaps think that there should now be sufficient data available to be used for an integrated assessment of contaminants and their biological effects,. There is, in fact, limited understanding of whether contaminant inputs actually affect marine life in this area or not. In addition, the available data are to a large extent limited to the southern (and presumably most contaminated) part of the North Sea. The aim of the current study was to assess the health of North Sea and Mediterranean ecosystems with regards to contaminants and their biological effects by applying an integrated approach. An integrated framework with which to assess contaminant impacts in coastal and offshore ecosystems was developed through the work of the ICES/OSPAR working group WKIMON. Flounder (*Platichthys flesus*), dab (*Limanda limanda*), and haddock (*Melanogrammus aeglefinus*) were sampled at a range of locations during autumn 2008. Fish were collected by trawling and kept alive on board until sampling. Samples were taken for analyses of a range of biomarkers, fish diseases, and contaminants. In addition, sediment samples were taken from the same locations and mussels collected from onshore sites. Results from the workshop are presented and discussed in view of the integrated framework.

Keywords: biological effects, biomarkers, chemical analyses, ICON, integrated monitoring.

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Issues to consider when monitoring dioxins and PCBs in herring (*Clupea harengus* L.) in the Baltic Sea

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High levels of polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs), and biphenyls (PCBs) are found in herring and other fatty Baltic Sea fish species. Samples from herring are repeatedly taken from different parts of the Baltic Sea to monitor the concentrations of these substances. However, several aspects have to be considered in monitoring, such as the chemical compounds to be specified and the target (i.e. whether focusing on emissions, on environmental contamination, on risk to humans or to other species feeding on herring, or on evaluating emission routes, or modelling foodweb bioaccumulation). Although samples from muscle tissue of fish from the food market can be optimal when evaluating concentrations in and exposures and risks

through human diet, they may have low value for modelling bioaccumulation. Dioxin concentrations in herring have also spatial and temporal patterns, and they are affected by fish age, population structure, and growth rate, and by individual variation. As the concentrations increase with herring age, reliable age determination of the sampled fish is essential but not always straightforward in many dioxin-monitoring questions.

Keywords: Baltic Sea, dioxins, herring, monitoring, PCB.

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Assessing contamination levels in transitional waters using fish-based core metrics: an original approach based on a Bayesian framework

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In the context of the Water Framework Directive, monitoring programmes and related indicators have been developed in European countries to assess the impact of anthropogenic pressures on various components of the aquatic ecosystems. Up till now, most indicators have been developed to predict the effect of pressure on different ecological metrics. We developed an alternative multimetric fish-based index relying on an original Bayesian framework that aims at predicting a level of pressure (for example contamination) given new fish observations provided by monitoring programmes. In a first step, pressure impact statistical models were developed to quantify the impact of pressure on various fish metrics. Then outputs of those models were used to compute probabilities of being at a certain contamination levels given new observations by statistically and objectively combining the core metrics. This approach appears to be consistent with the concept of the stressor-specific multimetric index—a routine measure of metrics on the fish assemblage used to detect the effect of anthropogenic pressures. Moreover, the approach allows uncertainty to be quantified and expert knowledge to be incorporated objectively. Our multimetric index was applied to demonstrate how a traditional fish monitoring programme developed in the Water Framework Directive context may be used to assess the quality of French transitional waters with respect to metallic and organic contaminations.

Keywords: bayesian method, contaminants, monitoring programme, multimetric fish-based index, transitional waters, Water Framework Directive.

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Integration of passive sampling and mussels monitoring for environmental assessment of Scottish inshore waters

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Passive sampling is an increasingly accepted technique in determining concentrations of hydrophobic organic contaminants within the water column. This increasing acceptance comes from the technique's provision of time-averaged freely dissolved concentrations of contaminants; it is the freely dissolved component of the total contaminant concentration that is the most biologically available, and the time-averaged nature of the data minimizes any requirement for frequent analyses when there is significant temporal heterogeneity. Silicone rubber passive samplers were co-deployed with mussels (where salinity allowed) along contaminant gradients within the river, estuary, and Firth of Clyde (in 2008) and the estuary and Firth of Forth (2009) and concentrations of polycyclic aromatic hydrocarbons (PAH) and chlorobiphenyls (CBs) determined in both mussels and the water column. In addition in 2010, passive sampling devices were

deployed in the Firth of Clyde for the determination of freely dissolved PAH and CB concentrations while shoreline mussels were collected and subjected to an array of biological effects assays. The determined freely dissolved concentrations in the Clyde were greatest in the urban and industrial areas (up to 300 ng l^{-1} total PAH) and there were good correlations (R^2 = 0.75–0.85) between log bioaccumulation factor and log K_{ow} for PAHs at individual sites, but less good for CBs. Principal components analysis suggested a number of different contaminant sources within both estuaries. More recent passive sampling-derived concentration data is discussed in the light of observed biological effects and the integrated approach to environmental assessment.

Keywords: contaminants, mussels, *Mytilus edulis*, PAH, passive sampling, PCB.

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Three-year monitoring of organic and inorganic contaminants in Golfe-Juan Bay (Mediterranean, southeast France)

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A three-year monitoring project (2007–2010) has been carried out in Golfe-Juan bay (Mediterranean, southeast France) to identify the main contamination sources and characterize the impact of a wastewater treatment plant and the effect of a recent biological treatment installation, on the global contamination of the bay. The concentration of nine heavy metals (Ni, Cu, Mo, Ag, Cd, Ba, Pb, As, and Mn) and the anionic surfactant linear alkylbenzene sulfonate (LAS) was measured twice a year (in April and October) at 11 locations in the bay, on passive samplers (SBSE and DGT), in transplanted mussels (*Mytilus galloprovincialis*) and in sediment. Passive samplers and mussels were placed for one month at each sampling period, whereas sediment was sampled once in 2008 and in 2010. No major metal contamination was identified in the bay. Seasonal differences on metals dissolved concentration were detected and stations could be differentiated, based on their contaminant signature. If no clear difference was observed in metal concentration between sampled stations, hydrodynamism had a great influence on the contaminants signature similarity of the stations. Significant differences were assessed for LAS between stations, and the anionic surfactant was mainly detected at the rear of the bay, probably because of a non-identified effluent discharge or as a result of the hydrodynamism of the bay.

Keywords: heavy metals, monitoring, mussels, passive samplers, surfactant, sediment.

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The relevance of molecular biomarkers as a component of a weight-of-evidence approach to marine monitoring

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Integrated monitoring programmes measuring the biological effects of contaminants in our seas are now fully incorporated into national and international monitoring activities; with the key aim of identifying and understanding anthropogenic changes in ecosystem health. As part of these monitoring activities we have sampled two well characterized indicator species from sites around the UK and compared these directly with pristine sites in Iceland. Samples were analysed with a suite of traditional biomarkers (measurements included condition index, comet assay, stress, histopathology, and enzyme-based assays) and assessed for the presence of chemical contaminants. Alongside these traditional biomarker techniques we also used real-time PCR to assess gene expression, which has previously been associated with increased levels of contaminants. Genes studied in flounder include CYP1A, vitellogenin, metallothionein, and thyroid receptors,

expression of which are induced by polynuclear aromatic hydrocarbons (PAHs), endocrine disrupters, heavy metals, and brominated flame retardants, respectively. Genes studied in mussels include heat-shock proteins, glutathione-*S*-transferases, and catalase and can elucidate responses to stress. Molecular techniques are coming of age and previous work, based around lab exposure studies, has demonstrated their worth. These results demonstrate, however, that gene expression is also a key tool within environmental monitoring programmes and where possible should be incorporated as part of a weight-of-evidence-based approach. Data are presented to demonstrate the relevance of molecular markers within systematic monitoring programmes and identify which markers are most useful when classifying sites according to biological effects of contaminants.

Keywords: contaminants, flounder, gene expression, mussels, *Mytilus*.

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Measuring freely dissolved concentrations and effects of priority pollutants in the marine environment: a UK survey

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Contaminant monitoring for priority pollutants is an integral part of the UK obligations under the Water Framework Directive (WFD) and OSPAR monitoring programmes. Also, the Marine Strategy Framework Directive (MSFD) requires Good Ecological Status (GES) be maintained. Descriptor 8 of GES states that concentrations of contaminants are at levels not giving rise to pollution effects. It is therefore important to establish whether environmental concentrations of chemicals on existing EC and OSPAR chemical priority lists are of toxicological significance, and whether there are additional substances with potential to cause harm in the UK marine environment. In order to inform this process, passive samplers were deployed to provide information on the presence and freely dissolved concentrations of a wide range of potential target substances for monitoring programmes. The survey covered a wide range of locations around the UK, from industrial estuaries to relatively unaffected offshore waters. Samplers were deployed for periods of 4—8 weeks during spring and summer 2009. In a smaller subsequent follow-up survey in early 2010, samplers were also deployed alongside mussels. The mussels were analysed for priority substances as well as for effects such as stress on stress, DNA damage, neutral red, and a number of biomarkers via qPCR. This presentation includes an overview of the project undertaken, the advantages and disadvantages associated with undertaking such a survey using these methods, the establishment of sampling rates for compounds previously unstudied using these methods, and the move towards establishing "safe" concentrations using these methods.

Keywords: contaminants, effects, mussels, passive sampling.

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Biological effects monitoring in the UK: results from OSPAR Joint Assessment Monitoring Programme activities

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The UK has conducted biological effects monitoring in fulfilment of its obligations to the OSPAR Joint Assessment Monitoring Programme (JAMP) and as part of the UK's Charting Progress assessment of 2009. Over the past five years this has included biomarker techniques such as plasma vitellogenin (VTG), ethoxyresorufin-*O*-deethylase (EROD), bile metabolites, fish disease assessment, sediment, and water quality bioassays and imposex in *Nucella lapillus*. The data have been assessed using assessment criteria to identify hot spots and areas of concern that may require

further investigation. For some datasets, it has been possible to identify trends, for example with imposex following the International Maritime Organization ban on tributyl tin on large ships. The data are presented with preliminary attempts to interrelate the responses and integration with chemical contaminant data. In addition, some observations on how the data could be used to define Good Environmental Status under the European Marine Strategy Framework Directive will be discussed.

Keywords: bioassays, biological effects monitoring, biomarkers, integrated assessment, OSPAR JAMP.

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ICES 2010/F:25

Acethylcholinesterase: methodology development of a biomarker and challenges of its application for biomonitoring

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Acetycholinesterase (AChE) activity is recognized as a well-established environmental biomarker and its track record for biomonitoring could be very instructive for the future implementation of the structured monitoring programme CEMP (Coordinated Environmental Monitoring Programme). AChE (EC 3.1.1.7) is present in most animals and is responsible for the rapid hydrolytic degradation of the neurotransmitter acetylcholine (ACh) into the inactive products choline and acetic acid. Analysis of AChE has been demonstrated to be a highly suitable method for assessing exposure to neurotoxic contaminants in aquatic environments. The methods developed are sensitive to a range of contaminant concentrations, applicable to a wide range of species, and have the advantage of detecting and quantifying exposure to neurotoxic without a detailed knowledge of the contaminants present. The usefulness of AChE as a biomarker for risk assessment and biomonitoring has been reported in many studies worldwide. The earliest study along the French Mediterranean and Atlantic coasts was carried out at the end of the 1980s. The presence of AChE has been demonstrated in a variety of marine organisms and specific field studies were done along the French coasts in fish, crustacean, and molluscs. Our experience acquired in various French national and European field studies and our implementation in the ICES working group on the biological effects of chemical contaminants over 20 years have led us to suggest an approach to the methodological development and validation of AChE as a pertinent biomarker for future implementations in the CEMP and the MSFD (Marine Strategy Framework Directive).

Keywords: acetycholinesterase (AChE), biomonitoring, environmental biomarker, neurotoxic contaminants, risk assessment.

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A new approach to the assessment of polycyclic aromatic hydrocarbon monitoring data

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Polycyclic aromatic hydrocarbons (PAHs) are one of the most ubiquitous groups of pollutants, distributed globally in modern marine environments. A number of PAHs are known carcinogens, are bioactive in marine biota, and may be the precursors to carcinogenic daughter compounds. Long-term PAH data from the French Monitoring Program (Mussel Watch), including remote areas of overseas territories, three years of study following the TV "Erika" oil-spill, and surface and sediment core data were used to examine PAH source identification and apportionment. The basis for this examination included: exploratory analysis of multiple regressions, chemical fingerprints using source-specific diagnostic ratios, PAH class identification, and semi-quantitative determination of their regional present-day source profiles in the English Channel, the Bay of

Biscay, and the western Mediterranean region. A comparison with reference materials such as known hydrocarbons source and/or contamination from proximal PAH recognized hotspots was also made. Finally, quantitative multiple source apportionment of PAHs was determined by using different statistical receptor models and multivariate analysis. This approach to marine chemical PAH data demonstrates that understanding the contributions of the various sources is not only critical for appropriate managing and remediation strategies in coastal areas. It also helps in recognizing spatial and temporal trends of PAH signatures and concentrations, including a comparison with historical information compiled for a given region as well as in determining toxic profiles of these contaminants in the marine environment. Determining background concentrations of PAHs is also critical in the assessment of marine monitoring data.

Keywords: chemical monitoring, PAHs, source regional profiles and apportionment, spatial and temporal trends.

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Biochemical and transcriptional impacts of hypoxia on cadmium and/or pyralene pre-contaminated European eels

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The Gironde Estuary is known to be contaminated by both metallic and organic polluants and to show hypoxic episodes. For these reasons, a multistress experiment was carried out using 120 yellow eels, individually caged and distributed in four 1500-litre tanks (Co, P, Cd, and PCd) over 28 days (salinity: 9). Two tanks (Cd and PCd) were directly contaminated with 5 $\mu g\ l^{-1}$ of cadmium ($CdCl_2$) while the others remained uncontaminated (Co and P). In the same way, eels in two tanks (P and PCd) were fed with pyralene (a mix of several polychlorinated biphenyls)-enriched shrimp pellets (80 ng PCB153 g^{-1} fw) while the other eels (Co and Cd) were fed with uncontaminated shrimp pellets. Five eels in each tank were analysed after 14 and 28 days of exposure. The remaining eels in each tank were equally distributed into two uncontaminated tanks. One tank (N) was normally oxygenated while the other (H) was maintained at an oxygene concentration of 3.3 mg l^{-1} by bubbling through a mix of nitrogen, oxygen, and carbon dioxide gas. Five eels in the eight conditions (CoN, CoH, PN, PH, CdN, CdH, PCdN and PCdH) were analysed after 7 and 14 days of the hypoxia experiment. For each sampling time, metallothionein, cadmium, and transcriptional dosages were assessed on gills, liver, kidney, muscle, and intestine, PCB dosages on muscle and cadmium analyses on otoliths.

Keywords: cadmium, European eels, hypoxia, metallothioneins, pyralene, transcriptional impacts.

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ICES CM 2010/F:30 Poster

Equilibrium studies for the sorption of Cu, Mn, and Fe from complex liquid matrices using C-18 solid-phase material and acetylacetone as the complexing ligand

Joseph Nyingi Kamau, Jane Catherine Ngila, Andrew Kindness, and Tummy Bush

This study presents a preconcentration/separation procedure for the solid-phase extraction of heavy metals in pulp wastewaters, seawater, and complex liquid matrices. The preconcentration procedure was optimized by using model solutions containing heavy metals of interest. The effect of the matrix constituents was also investigated. Equilibrium studies helped to shed light on the bonding and adsorption characteristics. The metal recovery after spiking the pulp filtrate with Cu, Ni, and Pb to constitute a concentration of 0.1 and 0.2 ppm was 120%, 91%, and 93%, respectively. The dynamic flow adsorption system did not fit the Langmuir isotherm, which assumes a homogeneous system with no interaction between adsorbed molecules, even on adjacent sites.

Langmuir isotherm correlation coefficients (R^2) for the linear plots were 0.277, 0.389, and 0.272 for Cu, Mn, and Fe, respectively. The system, however, demonstrated a good fit when using the Freundlich adsorption isotherm model, with correlation coefficients (R^2) of 0.612, 0.810, and 0.750 for Cu, Mn, and Fe, respectively

Keywords: acetylacetone, adsorption, copper, Freundlich, Langmuir, pulp, SPE, wastewater.

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ICES CM 2010/F:31 Poster

Evidence of genotoxic effects in red mullet populations from the Mediterranean coast of Spain

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A previous study performed in four areas along the Iberian Mediterranean coast suggested lower DNA liver integrity in red mullet (*Mullus barbatus*) caught from Cartagena (southeast Spain) in comparison with the other areas (Delta Ebro, Valencia, and Guardamar), though significant differences were not demonstrated. Here we present the results of a study on other types of genotoxic measurements in red mullet. These include erythrocyte micronuclei (MN) frequency and other nuclei abnormalities in peripheral blood samples ($n > 5000$ blood cells/fish) of red mullet (n = [19–34]) caught in seven different areas of the Iberian coast (Barcelona, Tarragona, Delta Ebro, Valencia, Cartagena, Almería, and Málaga). Mean MN frequency (expressed per 1000 cells/individual fish) was significantly higher (1.26; $p < 0.001$) in fish caught from Barcelona than in those from the other areas (0.23–0.59). However, other kinds of abnormalities such as binucleated and lobed nuclei were more frequently observed in fish from Cartagena and Almería. On the basis of our findings, and the fact that the use of this type of biomarker is relatively cheap and blood can be sampled easily on site, this biomarker will be routinely incorporated in the Spanish biomonitoring programme of marine contamination on the Mediterranean coast.

Keywords: genotoxicity, micronuclei, Mediterranean Sea, red mullet.

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ICES CM 2010/F:32 Poster

Stable nitrogen isotopes as tracers of anthropogenic nitrogen: a comparative analysis of three northern Galician rias (northern Spain) in summer

Antonio Bode, Ricardo Prego, and Manuel Varela

Enrichment or depletion in ^{15}N relative to seawater is indicative of intensive nitrification or denitrification processes, such as those affecting urban wastewater, which can be traced along the foodweb. The relative importance of land and marine sources of nitrogen for littoral ecosystems was assessed using stable nitrogen isotopes ($\delta^{15}N$) in the rias of Ortigueira, O Barqueiro, and Viveiro (Galicia, northern Spain). Samples of water, seston, benthic organisms, and sediments were collected in summer 2007 and 2008. Dissolved nitrate, nitrite, and ammonium concentrations in surface water generally increased from the tributary rivers to the open sea in all rias. Nitrite and ammonium were nearly depleted, suggesting low importance of *in situ* nitrification and denitrification processes. Nitrogen contamination, however, was detected in the ria of Viveiro, with higher concentrations of ammonium, chlorophyll, and heavy nitrogen isotopes in the seston of the main river than that of other rivers. Seston demonstrated maximum $\delta^{15}N$ values in the inner rias and was generally enriched relative to sediments. Large differences in seston $\delta^{15}N$ discharged from wastewater treatment plants indicated nearly complete denitrification of organic matter in Ortigueira and only partial decomposition in Viveiro. The isotopic composition of macrophytes (*Ascophyllum nodosum* and *Fucus vesiculosus*) and mussels (*Mytilus galloprovincialis*) further suggested low influence of anthropogenic nitrogen in all three rias, but local $\delta^{15}N$ differences for

some species may indicate point wastewater discharges. Tidal mixing, low river flow, and small urban population sizes in the watershed help to maintain the relatively pristine status of northern Galician rias.

Keywords: coastal, nitrogen, northwest Spain, rias, stable isotopes, wastewater.

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ICES CM 2010/F:33 Poster

Application of the comet assay to study DNA damage in flounder (Platichthys flesus) from the southern Baltic Sea

Orest Kopko, Henryka Dabrowska, Ilona Waszak, and Agnieszka Antoniak

Anthropogenic contaminants occurring in marine environments include many potentially genotoxic substances such as polynuclear aromatic hydrocarbons (PAHs) and heavy metals which can produce a number of changes in the genetic material when taken up by organisms. Genotoxic effects in somatic cells can result in, for example, dysfunction or carcinogenesis, whereas in germ cells they can lead to heritable consequences. Assessment of DNA damage in aquatic organisms as a result of environmental pollution quite often involves the measurement of strand breaks, DNA adducts, or the formation of micronuclei. DNA strand breakage is commonly assessed using a technique called single cell gel electrophoresis (SCGE) or the "comet assay". We have applied this technique to evaluate DNA damage in flounder collected from four sites in the southern Baltic Sea that differ in spectrum and level of contamination. The research constitutes a part of the Beast project, funded jointly by national funding agencies and FP7 ERA-NET within the BONUS+ Programme. The project aims at developing tools for ecosystem health assessment in the Baltic Sea based on application and validation of a range of biological effects methods.

Keywords: bile, Comet assay, DNA damage, flounder, PAH metabolites.

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Changes in total protein, carbohydrate, and lipid in marine organisms in the Cochin Estuary

Ranjitha Raveendran and C. H. Sujatha

The present study was undertaken to determine the biochemical compositions (carbohydrate, protein, and lipid) of the marine organisms *Villorita cyprinoides* var. *cochinensis* in the Cochin Estuary, which is situated on the southwest coast of India. This organism provides highly nutritious food for human consumption as they store large quantities of glycogen and fat. These biochemical compositions are fundamental biomolecules in all aspects of cell structure and function and are also a major source of energy in the human diet. Our understanding of the biochemical composition of marine organisms plays an important role in utilizing their nutritive value. The samples were collected seasonally. The tissues were analysed and the results show that the lipid, carbohydrate, and protein levels were high during the pre-monsoon season and gradually dropped during the monsoon and post-monsoon seasons. The ratio of carbohydrate was lower that that of other nutrients, such as proteins and lipids in animal tissues, especially in aquatic animals.

Keywords: carbohydrate, lipid, marine organism, protein.

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ICES CM 2010/F:35 Poster

From model to fisheries species: behavioural studies to reveal the potential effects of contaminant on fish population

Samuel Péan, Tarek Daouk, Anne-Lise Mayeras, Mathieu Besson, Véronique Loizeau, Xavier Cousin, and Marie-Laure Bégout

Because organic pollutants are stable and are found throughout the natural environment, their effects on animal physiology or their dynamics within trophic networks have been studied for many years. However, behavioural studies are rarely used in ecotoxicology although these have the potential to reveal compensation mechanisms and therefore provide a link between individual behaviours and population characteristics. The aim of our study was to identify relevant behavioural indicators affected by PCB contaminants in two fish species, the common sole (*Solea solea*) and the zebrafish (*Danio rerio*). Juvenile fish were exposed through diet to two environmental concentrations of PCBs and different behavioural traits were compared with those of control fish. For each species, we studied: (i) exploratory behaviour in a T-maze, (ii) 24-h swimming activity, (iii) background colour preference and (iv) group dispersion. Because of ecological differences between the two species, we also examined: (v) cryptic and burying capacities in sole and (vi) larvae locomotory activity of zebrafish. State-of-the-art full-automatic behavioural analyses using Ethovision video tracking solution (Noldus, The Netherlands) to analyse swimming activity measures (e.g. velocity, mobility, distance travelled) was combined with semi-automatic analysis (e.g. interindividual distances, spatial distribution, behaviour quantification) to obtain a wider range of potential behavioural variables. Infrared lighting with dedicated sensitive cameras was also used to study fish and larvae both in the light and in the dark. The differential responses and the relevance of the variable responses observed are discussed in the context of the ecological requirements of fish.

Keywords: behaviour, common sole, ecotoxicology, PCB, zebrafish.

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ICES CM 2010/F:36 Poster

Operational consequences of tolerance of chemicals in monitoring their biological effects in the marine environment

Claude Amiard-Triquet, Philip S. Rainbow, and Michèle Roméo

To improve environmental quality assessments and risk assessments, it is necessary to put more "eco" into ecotoxicological tools by using appropriate species for the area assessed. Organisms chronically exposed to contaminants in their environment often develop tolerance (either genetically or physiologically based), so the origin of specimens used in bioassays can influence their response to chemical stress. Ecotoxicological tests are usually performed on organisms that are easily cultured in the laboratory and genetically stable. If animals from the "real world" are used to improve the realism of toxicological assessment, the implications of potential tolerance must be considered to avoid false negatives or positives. Depending on the tolerance of species to different contaminants and to different levels of exposure, it is necessary to consider a sufficient number of biological models. Because the determination of many different biomarkers and/or other toxicological parameters in different species presents great resource implications, it is necessary to find relevant selection criteria for the models. Thus the choice of species to be studied must consider (i) their representativeness of their environment; (ii) their role in the structure and functioning of the ecosystem. By choosing keystone species as models, any perceived impairments of their responses in terms of biochemical or behavioural biomarkers, reproduction success, growth, or survival will reveal a more realistic assessment of the risk of deleterious effects from individual to ecosystem level. Special attention is devoted to safety factors and to the interspecific variability of tolerance and its consequences for pollution-induced community tolerance.

Keywords: biomarkers, chemicals, ecotoxicology, pollutants, tolerance.

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ICES CM 2010/F:37 Poster

What do behavioural experiments tell us?

Randel Kreitsberg and Arvo Tuvikene

The assessment of chemical contaminants and biological effects in aquatic environments is everyday work for most countries within the ICES community. In most cases concentrations and enzyme activities are transformed into biological effects: into individuals, congeners, communities, or ecosystems. Behavioural experiments can help us to see the effect of pollutant in "real" nature, without extrapolating numbers into effects. Nevertheless, behavioural experiments are difficult to manage and results may not be as unequivocal as scientists would wish. This presentation gives an overview of behavioural experiments with crucian carp (*Carassius carassius*), and the effect of high pH on fish. How do fish perceive information about pH, and are they able to avoid harmful environments? How does fish feeding behaviour alter when affected by high pH? On what level can we compare EOG (electroolfactogram) results with behavioural experiments? These are the questions that will be answered.

Keywords: behaviour, crucian carp (*Carassius carassius*), experiment, fish, high pH, olfaction.

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ICES CM 2010/F:38 Poster

Towards integrated assessment of measurements of the biological effects of contaminants

Ian M. Davies, Matt Gubbins, and members of ICES/OSPAR Study Group on Integrated Monitoring of Contaminants and Biological Effects (SGIMC)

A significant impediment to the widespread adoption of measurements of the biological effects of chemical contaminants in national and international monitoring programmes has been the lack of a systematic approach to assessment of the field data. Analytical methods are becoming standardized, but assessment methods still tend to be ad hoc and case-specific. Combination of biological effects with chemical measurements (or additional effects measurements) should provide an improved assessment of environmental status. ICES/OSPAR SGIMC has recognized that numerical assessment criteria are needed for effects data to be included in environmental assessment programmes. SGIMC has found that the concept of a background level of response (enzyme activity, metabolite concentration, etc.) representing the response found in organisms which have been exposed to low concentrations of the causative contaminants can be applied to biological effects measurements. A higher level response that represents harm to the organism has also been found to be applicable to some, but not all, biological effects measurements. Numerical values for assessment criteria for a range of effects measurements are presented, together with methodology for integrating data across locations and effects measurements.

Keywords: assessment, biological effects, contaminants, integration.

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ICES CM 2010/F:39 Poster

Effects of shrimp farm effluents on ichthyoplankton community structure in two tropical estuaries

Paulo Mafalda Júnior, Marcos Moura Nogueira, Catarina Rocha Marcolin, and Christiane Sampaio de Souza

Shrimp farming has been causing serious environmental problems around the world. In Brazil, despite the growth of this activity in recent years, there has been no integrated assessment of chemical contaminants and the effect on fish. The aim of this study is to compare two estuarine ichthyoplankton communities, the first one located in the Tabatinga River, an estuary subjected to shrimp farm effluents and the other in the Itapicuru River, a pristine estuary. Samples were collected through horizontal hauls using a conic net (200-μm mesh size), coupled to a flowmeter, during ebbing and flooding tides, during dry and rainy seasons. The Tabatinga River presented a lower diversity community where organisms were less frequent and abundant in relation to Itapicuru River's community. *Anchoa* sp. and *Ctenogobius boleosoma* were the most frequent and abundant species in both areas of study, but the Itapicuru River had much higher values than the Tabatinga River. Other important species were *Sphoeroides* sp., *Microphis lineatus*, and *Stellifer rastrifer*. Salinity, temperature, pH, and transparency were the most important variables explaining changes in community structure according to the environmental gradient. The high values of dissimilarity found by SIMPER were confirmed by the results of the MRPP, which identified significant differences in composition between the two estuaries, suggesting that the influence of shrimp farming activity has deleterious impacts for these organisms. Redundancy analysis identified a marked separation between the sampling stations in both estuaries, confirming the differences in ichthyoplankton communities.

Keywords: environmental impact, fish larvae, multivariate analysis, pollution.

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ICES 2010/F:40 Poster

Patterning phytoplankton and environmental parameters in Gyeonggi Bay, Korea, using artificial neural networks

Ji-ho Seo, Joong-ki Choi, Hyu-chang Choi, and Young-seuk Park

The temporal variation and distribution pattern of phytoplankton biomass were described from data obtained from 1986 to 2004 in the Gyeonggi Bay, Korea. Phytoplankton blooms—mainly diatom-dominated blooms—occurred frequently in spring and slightly increased phytoplankton biomass in early autumn. The winter blooms were dominated by the diatom *Thalassiosira nordenskioeldii* and occurred in January or February. Long-term variation of the phytoplankton biomass demonstrated an increase of 1.5–2 times during the last 10 years. A self-organizing map (SOM) unsupervised neural network was used to characterize the phytoplankton distribution patterns based on environmental parameters. The SOM, which included ten environmental parameters, classified the study stations into four main groups based on their environmental parameters, reflecting seasonal characteristics. Our results illustrated that phytoplankton biomass had a seasonal variation according to physico-chemical environmental parameters in Gyeonggi Bay, and was also influenced by massive input of anthropogenic substances from river and tributaries as well as human activities. This research was a part of the project entitled "Development of Forecasting Technology for Seawater Circulation and Ecosystem Change" funded by the Ministry of Land, Transport and Maritime Affairs, Korea.

Keywords: anthropogenic substance, Gyeonggi Bay, phytoplankton biomass, seasonal variation, self-organizing map (SOM).

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ICES CM 2010/F:41 Poster

Bile metabolites of polycyclic aromatic hydrocarbons (PAHs) as a biomarker of pollution in European eel (*Anguilla anguilla*) from German rivers

F. Nagel*, U. Kammann*, and R. Hanel supported by the EU-Data Collection Regulation (2008/949/EC) and the "Stiftung seeklar"

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Polycyclic aromatic hydrocarbons (PAHs) and their metabolites are important environmental contaminants that may lead to increased levels of neoplastic aberrations or tumours in fish liver. Therefore, PAHs and their metabolites in fish bile can be used as biomarkers of PAH exposure in the aquatic environment. The aim of the present study was to examine PAH metabolites in the bile of European eel (*Anguilla anguilla*) from 12 rivers in Germany to investigate the concentrations of PAH metabolites and to elucidate spatial differences. In total, 180 yellow eels (15 eels per river) were collected at downstream sites of the rivers Rhine, Elbe, Havel, Oder, Uecker, Weser, Ems, Schlei, Trave, Eider, Warnow, and Peene in 2009. The deconjugated PAH metabolites in the eel bile were analysed using HPLC with fluorescence detection and normalized to bile pigments. Three PAH metabolites were quantified: metabolites of pyrene, phenanthrene, and benzopyrene. Concentrations of PAH metabolites varied significantly between the rivers. For example, we determined low PAH metabolite concentrations for the Rhine and the Uecker, moderate levels of contamination for the Elbe and the Oder, and a significant accumulation of biliary PAH metabolites in eels from the Trave compared with eel bile from the Uecker and the Rhine. This study presents the first comprehensive investigation of PAH pollution in eels from German rivers and could help to discuss stock assessment of European eel in the light of spawner quality.

Keywords: bile metabolites, European eel (*Anguilla anguilla*), polycyclic aromatic hydrocarbons (PAHs).

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ICES CM 2010/F:42 Poster

The effect of biological peculiarities of fish on contamination with heavy metals: a case study of perch (*Perca fluviatilis*) in Estonian coastal sea

Leili Järv, Mart Simm, Kristiina Fuchs, and Tiit Raid

The concentration of Hg, Cd, Cu, and Zn in perch tissues has been studied in Estonian coastal seas (the northeastern Baltic) since 2002. The aim of the present study, covering 2006–2008, was to explore the possible effects of some basic biological parameters (age, length, sex, maturity) on contamination with heavy metals of perch liver and muscle tissues. The results revealed higher cadmium, zinc, and copper content in the liver tissue while higher mercury concentration was found in the muscles. The differences were statistically significant. The concentration of heavy metals also differed between the sexes. The results indicate that males had significantly higher contamination rate in both studied tissues, which may indicate the stronger immune system of females. The contamination of perch with heavy metals seems to increase during the maturation process, which may be a result of more active feeding owing to enhanced energy needs (higher feeding rates). At the same time age did not have an effect on contamination except for mercury, the concentration of which increased with the age and length in both muscle and liver. In general, the concentration of the heavy metals studied in perch was low and did not exceed the safety limits established by the EU.

Keywords: age, Baltic Sea, heavy metal, length, maturity, perch, sex, tissue.

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ICES CM 2010/F:43 Poster

From seals to cells: protein biomarkers to reveal the effects of persistent pollutants on primary hepatocytes of *Phoca vitulina*

Vera K. Korff, Annika Behr, Antonia Wargel, Kristina Lehnert, Ursula Siebert, and Veronika Hellwig

Harbour seals (*Phoca vitulina*) in the North Sea are burdened with persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs) and perfluorooctane sulfonate (PFOS). Chronic exposure to POPs causes severe effects like immunosuppression, endocrine disruption, and carcinogenicity. Sensitive molecular biomarkers may facilitate an early detection of health risks for wild-ranging seal populations. As the liver is the main organ involved in the metabolism of xenobiotics, we developed an *in vitro* approach using primary hepatocytes of *Phoca vitulina* for incubation experiments to identify potential protein biomarkers. Fresh liver tissue from terminally ill seals (German Bight) was dissociated using a biopsy perfusion method. Isolated hepatocytes were incubated for 24 h with environmentally relevant concentrations of PFOS and an Aroclor-mixture (1254, 1260, 1262), respectively. After incubation, three cell samples (1 μmol l^{-1}, 50 μmol l^{-1} Aroclor, and a control) were harvested and used for toxicoproteomic studies: We performed gel-based proteome analysis and software-based analysis with Delta2D to compare pollutant-incubated samples with control cells. If significant modifications in protein expression levels were confirmed by principal component analysis (PCA), proteins were characterized by MALDI-TOF mass spectrometry. First results reveal PCB-induced upregulations of certain proteins. Analogous experiments in preliminary studies show no PFOS-induced changes in protein patterns. Three indicators for cell viability were evaluated to investigate whether identified protein upregulations were pollutant-induced and not the result of cell necrosis: (i) activity of mitochondrial dehydrogenases (XTT assay); (ii) membrane integrity (LDH release), and (iii) maintenance of hepato-specific metabolism (urea synthesis). Results show no significant changes in cell viability after pollutant incubation.

Keywords: biomarkers, cell isolation, cell viability tests, harbour seals, pollutants, primary hepatocytes, protein expression.

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ICES CM 2010/F:44 Poster

Embryonic and long-term exposure of zebrafish to persistent organic pollutants (PCB and PAH)

T. Daouk, J. Cachot, F. Akcha, H. Budzinski, V. Loizeau, and X. Cousin

In this study, the potential effects of a long-term exposure of fish to two mixtures of polychlorinated biphenyls (PCBs) were evaluated and the toxicity of sediment spiked with four individual polycyclic aromatic hydrocarbons (benzo[a]pyrene, pyrene, fluoranthene, and 7,12-dimethylbenz[a]anthracene) was studied using a new test for hydrophobic compounds (direct contact between sediment and embryos). First, zebrafish juveniles were fed with a contaminated diet for over 300 days in order to monitor bioaccumulation, growth, and reproduction. The results obtained illustrated that PCBs accumulate in time and in a dose-dependent manner. According to the data, lower levels of PCBs were always present in females than in males, which suggests that PCBs could have been evacuated while spawning eggs. Neither the growth rate nor the rate of survival of fish were affected by the presence of PCBs in the experimental fish group. Neither the spawn onset nor size were modified. However, a significant decrease of approximately 20% in the fertilization rate was evident when PCB mixtures were present (drop from 80% in control fish to 60% in PCB-contaminated fish under all PCB concentrations). Second, zebrafish embryos were exposed to contaminated sediments. The results gathered vary depending on the PAH used. However, overall, the embryos displayed morphological alterations (cardiac and yolk oedema, lordosis) cardiac dysfunction, and DNA damage demonstrating the toxicity of PAHs and the suitability of the test. The toxicity of PAH mixtures will further be analysed following the same procedure.

Keywords: embryonic exposure, PAH, PCB, zebrafish.

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ICES CM 2010/F:45 Poster

Histological investigation of the Black Sea molluscs for the integrated assessment of their population condition

Irina Yakhontova and Svetlana Piyanova

First results of an analysis of the condition of the respiratory, digestive, and reproductive systems of Black Sea molluscs and on a pathologic study of the parasitic protozoan *Bonamia ostreae* were obtained. The work was carried out within the framework of the International French-Russian-Ukrainian-Romanian project ECO-NET, 2007–2008. At present the Black Sea population of *Ostrea edulis* is close to extinction while the populations of *Mytilus galloprovincialis* and *Scapharca inaequivalvis* are in a good condition despite increasing human impact on coastal zones. The molluscs *Ostrea edulis*, *Mytilus galloprovincialis*, and *Scapharca inaequivalvis* from wild populations were sampled in the coastal waters of Russia and the Ukraine. Our results revealed whereas the inner organ systems of *Mytilus* and *Scapharca* specimens showed normal histology, indicating satisfactory physiological status, the oysters had necrosis of the mantle, gills, and muscle, haemocytic infiltration in the connective tissues of the digestive gland, mantle, and gills and the presence of gregarines in the gills. These results testify to the effect of indeterminable environmental stressors. The histopathologic analysis demonstrated no bonamiosis in the studied molluscs. This finding was confirmed by diagnosis at the Community Reference Laboratory for mollusc diseases of Ifremer (France).

Keywords: bonamiosis, histological study, *Ostrea edulis, Mytilus galloprovincialis, Scapharca inaequivalvis*.

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ICES CM 2010/F:46 Poster

Implementing the Water Framework Directive method to evaluate the ecological health status of Normandy coastal waters (France) regarding phytoplankton and supporting physico-chemical quality elements

F. Nédélec, F. Bruchon, L. Lampert, and P. Riou

The Normandy Hydrological Coastal Monitoring Network is a project that has been running for almost 10 years with two main goals: (i) to assess the quality and potential eutrophication status of coastal water masses, and (ii) to help implement the Water Framework Directive (WFD) surveillance programme in the region, with regard to biological (here phytoplankton) and physico-chemical quality elements. At most, 30 stations were sampled for chlorophyll *a*, phytoplankton, physico-chemical parameters (temperature, salinity, and dissolved oxygen), and nutrient data from 2000 to 2009 on 18 coastal and 4 transitional water masses. The representativeness of sampling stations relative to the objectives aimed, and the comparability of methods of analysis were addressed in order to optimize the cost and effectiveness of the programme. These hydrological and phytoplankton data demonstrated a clear contrast between oligotrophic-type systems in the western and eastern side of the Cotentin peninsula, and heterotrophic-type systems in the bay of Seine influenced by nutrients inputs from four water basins, including the Seine (70 000 sq km). The EU-validated indicators for biomass (i.e. chlorophyll *a* concentration), for phytoplankton abundance (i.e. blooms of more than 100 000 cells per litre for species ≥20 μm), and dissolved oxygen at the bottom were calculated. The results were discussed for their relevance to evaluate heath status of Normandy nearshore waters. Finally, the implementation of new indicators for phytoplankton composition and nutrient concentration in the region was studied.

Keywords: coastal waters, eutrophication, indicators, monitoring programme, Normandy, France, nutrients, physico-chemistry, phytoplankton, rHLN, Water Framework Directive (WFD).

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ICES CM 2010/F:47 Poster

Meeting the European Marine Strategy Framework Directive recommendations: SABELLA Program (Site Atelier pour le suivi du Bon Etat écologique du LittoraL Azuréen)

Renaud Florent, Guibbolini Marielle, Risso Christine, Boissery Pierre, Grillasca Joël-Paul, Marmier Nicolas, Hurel Charlotte, Burger Alain, Azoulay Stephane, Mangin Antoine, Prüfer Yves, Pacini Patricia, Carrière Sylvie, Loquès Françoise, Trousselier Marc, Bouvy Marc, Piquemal Alain, Andral Bruno, and Francour Patrice

A consortium of institutions is working together on the impact of anthropogenic chemicals discharged into Mediterranean marine coastal ecosystems. The aim of this programme was to answer the recommendations of the European Marine Strategy Framework Directive (2008/56/CE—17 June 2008) and more precisely to identify and validate qualitative descriptors to define a good environmental status, taking into account the effects of contaminants for marine organisms and human consumers. Two bays (Golfe-Juan and Cannes bays) located in southeast France were selected as the study site. In these bays, long-term and large-scale monitoring is focused on some well-known contaminants (HAPs, PCBs, heavy metals), but also on some emerging contaminants such as pharmaceuticals and personal care products (PPCPs) distributed in different compartments (sediment, water, and marine organisms). In this transdisciplinary programme, discharge, transport, distribution, fate, and impact of a variety of contaminants are modelled. Toxicity tests are realized for the emerging contaminants of concern to assess acceptable levels that can be discharged in coastal areas and legislative proposals are put forward. A battery of well-known techniques (physiology, chemistry, biochemistry) are selected to characterize the environmental status of the coastal ecosystems in these bays. At the same time, new techniques (immunology, genetic) that could take into account a large variety of contaminants and different sentinel species in simple and rapid analytical processes using contemporary materials are tested for validation and standardization.

Keywords: analytical development, Mediterranean, monitoring, pharmaceuticals, toxicity.

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ICES CM 2010/F:48 Poster

How to use biological effects tools to define Good Environmental Status under the European Union Marine Strategy Framework Directive

B. P. Lyons, J. E. Thain, G. D. Stentiford, K. Hylland, I. M. Davies, and A. D. Vethaak

The use of biological effects tools offer enormous potential to meet the challenges outlined by the European Union Marine Strategy Framework Directive (MSFD) whereby Member States are required to develop a robust set of tools to define 11 qualitative descriptors of Good Environmental Status (GES), such as demonstrating that "Concentrations of contaminants are at levels not giving rise to pollution effects" (GES Descriptor 8). Here we examine the monitoring of chemical contaminant levels, alongside biological effect measurements relating to the effect of pollutants, for undertaking assessments of GES across European marine regions. We outline the minimum standards that biological effects tools should meet if they are to be used to define GES in relation to Descriptor 8 and describe the current international initiatives underway to develop assessment criteria for these biological effects techniques.

Keywords: biological effects techniques, biomarkers and biomonitoring, Marine Strategy Framework Directive (MSFD).

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ICES ASC 2010/F:49 Poster

Bioassays based on fish swimming behaviour for the marine environment: short-term effects of pyrene on the sea bass

Joana R. Almeida, Carlos Gravato, and Lúcia Guilhermino

A new bioassay based on the swimming velocity of the sea bass (*Dicentrarchus labrax*) was developed to assess the sublethal biological effects of marine contaminants on pelagic fish. The bioassay was tested and validated using several common contaminants of the marine environment and the results obtained with the polycyclic aromatic hydrocarbon pyrene are reported here. Biochemical biomarkers involved in detoxification, antioxidative stress, neurotransmission, and oxidative damage were also determined. Pyrene significantly decreased the swimming velocity of sea bass juveniles at concentrations equal to or higher than 0.07 mg l^{-1}. Some biomarkers demonstrated significant responses in exposed fish and significant correlations were found between these biochemical parameters and swimming velocity. The results obtained indicate that the bioassay is a powerful and low-cost tool for the assessment of the biological effects of environmental contaminants on pelagic fish, being also suitable for use in species other than the sea bass and allowing the simultaneous use of other effect criteria. Furthermore, in another study, this bioassay was successfully adapted to epibenthic marine fish using *Pomatoschistus microps* as model organism. Both methods are useful for monitoring the effects of contaminants and ecological risk assessment in the marine environment. This study was supported by the Portuguese Foundation for the Science and Technology (FCT), FEDER European funds, and European social funds of MCTES (POPH-QREN-Tipology 4.2.) through the project RAMOCS—"Implementation of Risk Assessment Methodologies for Oil and Chemical Spills in the European Marine Environment" (ERA-AMPERA/0001/2007) and a PhD grant to Joana R. Almeida (SFRH/BD/40843/2007).

Keywords: behaviour, biomarkers, pelagic marine fish, pyrene, swimming velocity.

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ICES 2010/F:50 Poster

Toxicity profiling of sediments using silicone passive sampler extracts from the ICON workshop

T. Hamers, P. Cenijn, P. Leonards, F. Smedes, and D. Vethaak

In this study, toxicity profiling was carried out for sediment samples collected at 10 sites (9 from the North Sea and 1 from the Mediterranean) in 2008 during a sea-going workshop on Integrated marine Contaminant Monitoring in the North Sea (ICON). After exposure to the sediment samples, silicone passive sampling sheets were extracted with methanol-acetonitrile. Extracts were transferred to dichloromethane, cleaned up by GPC, transferred to DMSO, and tested in a battery of high-throughput and cost-efficient *in vitro* bioassays. These included: DR-LUC reporter gene bioassay (arylhydrocarbon receptor (AhR) activity), *Vibrio fischerii* bioluminescence bioassay (general toxicity), TTR-binding assay (thyroid hormone-like activity). Preliminary results indicate that AhR activity of the sediment extracts ranged from 28 to >4000 pg TCDD equivalents per gram sheet. Although results are expressed as TCDD equivalents, it is most likely that unstable PAHs and other AhR-agonistic compounds substantially contribute to the observed activity. All extracts were able to reduce the bioluminescence of *Vibrio fischerii* bacteria. The undiluted extract revealed TTR-binding affinity for all extracted sheets. Currently we are testing the extracts in other bioassays (e.g. ER-LUC, Ames test) and performing chemical analysis on the sediment samples and passive sampling sheets. The results are used to identity the similarities in profiles between the

geographical locations and to identity possible new "key" toxicants for the North Sea using effect-directed analysis (EDA). The available results are presented and discussed.

Keywords: bioassays, biological effects, chemical contaminants, passive sampling, toxicity profiling.

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ICES CM 2010/F:51 Poster

Influence of oil and dispersant on the biomass and the photosynthetic activity of microphytobenthos of intertidal mudflats

Marion Richard, Johann Lavaud, Fanny Caupos, and Hélène Thomas-Guyon

Chemical dispersants are used as cleaning agents for oil spills away from the shore and could be used near the coast. The aim of the DISCOBIOL programme was to test the influence of oil and dispersant on intertidal mudflats. The biofilm is the main resource for primary consumers of intertidal mudflats. Damage to the microphytobenthos could induce large changes to the function of the ecosystem. In April 2010, an experiment was carried out to test the effect of two concentrations of (i) oil (65 and 260 ppm), (ii) dispersant (5% of oil), and (iii) a mix of both on the biomass, the quality and the photosynthetic activity of the microphytobenthos. The first centimetres of sediment were collected on intertidal mudflat. The mud was transferred into trays (40 × 60 × 5 cm) and put into 125-l tanks equipped with a tidal cycle system (6 h low tide vs. 6 h high tide). The photosynthetic activity (ETR: electron transport rate) was measured with IMAGING pulse modulated amplified (PAM) before and after the pollution. After the pollution, sediment was collected in cores for analysis of chlorophyll *a*, phaeophytin, and hydrocarbons in the first two 0.5 cm of sediment. The experiment was repeated three times over time. The results are in progress and will be discussed during the presentation. The results of this study will be essential for recommending implementation of the use of dispersants in coastal areas.

Keywords: biofilm, dispersant, imaging PAM, oil.

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ICES CM 2010/F:52 Poster

Assessment of ecological status of the Volga Delta (Caspian Sea) by phytoplankton

Julia Gorbunova and Alevtina Gorbunova

The Volga River is the largest river in Europe that flows into the Caspian Sea and it forms a great delta. The Volga Delta is characterized by rich biodiversity and high biological productivity and is very important for maintaining fish stocks of the northern Caspian Sea region. Investigations of the Delta's environment are complex and include different levels of biota and environmental components on the basis of the Astrakhan Biosphere Reserve. Monitoring of phytoplankton (species composition, abundance, primary production, chlorophyll content) has been carried out since 1960. These indicators provide the assessment of phytoplankton productivity and its seasonal and interannual changes that characterize the ecological status of the Volga Delta. During the twentieth century, environmental conditions in the Volga Delta changed significantly as a result of fluctuations in and anthropogenic regulation of the water discharge, changed input of pollutants and nutrients, and other factors. According to the analysis of long-term data (from the 1960s), the maximum eutrophication of the Volga Delta was observed in the late 1980s–early 1990s. The reason for this is probably the increase of anthropogenic nutrient input because of the intensification of agriculture and fertilizers use, as well as alternating years with different water discharge. In the 1990s, fertilizers use and the input of nutrients into the Volga Delta decreased significantly as a result of the economic crisis in Russia. Our assessment in the 1990s–2000s revealed that there was a decrease of phytoplankton primary production to 1960s–1970s levels and the process of eutrophication was replaced by de-eutrophication.

Keywords: Caspian Sea, de-eutrophication, eutrophication, phytoplankton, primary production, Volga Delta, water monitoring.

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ICES CM 2010/F:53 Poster

Growth inhibition of the marine planktonic algae *Tetraselmis chuii* by nickel and two polycyclic aromatic hydrocarbons

L. R. Vieira, N. Bølling, K. Hylland, and L. Guilhermino

Polycyclic aromatic hydrocarbons (PAHs) and metals are common pollutants of marine ecosystems and so the evaluation of their toxic effects on native key species is a relevant issue for ecological risk assessment. In the marine environment, phytoplankton is of particular concern because it is the basis of pelagic ecosystems. Therefore, the effects of nickel and two PAHs (benzo[a]pyrene and pyrene) on the marine microalgae *Tetraselmis chuii* were evaluated through growth inhibition assays following the OCDE guideline 201. All of the studied substances significantly reduced the growth of *T. chuii* after 96 h of exposure at concentrations that may be found in polluted areas.

Keywords: growth inhibition tests, metals, PAHs, *Tetraselmis chuii*.

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ICES ASC 2010/F:54 Poster

Neurotransmission, energy metabolism, and moult-related biomarkers in the shore crab (*Carcinus maenas*) following cadmium exposure

Sofia Mesquita, Carlos Gravato, Lúcia Guilhermino, and Laura Guimarães

Cadmium is a potentially harmful heavy metal emitted to the aquatic environment through natural and anthropogenic sources. This study investigated the effects of cadmium exposure on several biomarker responses of the shore crab. Intermoult crabs were collected from a reference site (northwest Portugal) and, in the laboratory, they were exposed to cadmium at concentrations ranging from 0.003 to 2 mg l^{-1}, for a 7-day period. At the end of the assay, muscle, epidermis, and hepatopancreas were isolated and several biomarkers involved in key physiological functions of the organisms were assessed: neurotoxicity (cholinesterase activity, ChE), energy metabolism (activity of the enzymes lactate dehydrogenase, LDH, and $NADP^+$-dependent isocitrate dehydrogenase, IDH), phase II biotransformation (glutathione-*S*-transferases, GST), and in the moulting process (*N*-acetyl-β-glucosaminidase activity, NAGase). Some of the studied biomarkers revealed altered responses following exposure to cadmium. In particular, exposure to the test compound significantly inhibited NAGase activity in both the hepatopancreas (at all concentrations tested) and the skin (at 0.8 and 2 mg l^{-1}). Because NAGase is an enzyme directly involved in the ecdysis process, these results suggest that exposure to cadmium may result in delayed moulting, and thus lead to serious impairments of development, growth, and reproduction processes in this species. This study was supported by the Portuguese Foundation for the Science and Technology (FCT) and FEDER European funds (FCOMP-01-0124-FEDER-007383) through the project CRABTHEMES—"Molecular, biochemical and genetic variability in estuarine populations of shore crab (*Carcinus maenas*) exposed to different levels of contamination".

Keywords: *N*-acetyl-β-glucosaminidase, cadmium, *Carcinus maenas*, cholinesterases, moulting.

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ICES CM 2010/F:55 Poster

Study design considerations and challenges for Canadian marine environmental effects monitoring programmes

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Environmental effects monitoring programmes have been developed in Canada for the pulp and paper and metal mining industries in the 1990s and a programme is in development for municipal wastewater. These programmes are regulated under Canada's Fisheries Act and their purpose is to assess the potential impacts of effluent on receiving environments by monitoring effects on fish, fish habitat (as benthic invertebrates), and the use of fisheries resources. The fish component includes an adult fish population survey, measuring indicators of growth, reproduction, condition, and survival of two sentinel fish species collected at an exposure site and at least one reference site. While this monitoring approach has been successful in freshwater studies, there have been many challenges in the marine monitoring programmes in Canada, including challenges with capturing sufficient numbers of fish, high variability in the measured endpoints, sampling occurring outside the reproductive period, and limited availability of life-history information on sentinel species. We have conducted studies of several potential sentinel fish species and identified spawning times, reproductive strategies, and seasonal changes in gonad size, liver size, and condition to refine sampling protocols. This information, in combination with research of species mobility, was used to identify periods of temporal stability and minimum variability in the measured endpoints during the reproductive period, and optimal sampling times to conduct monitoring. These sampling times can be used to standardize monitoring programmes, reduce sample sizes for lethal monitoring programmes (by reducing variability in endpoints), and ensure sampling times are appropriate to assessing reproductive impacts.

Keywords: effluent, fish population, impact assessment, sentinel species, wastewater.

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ICES CM 2010/F:56 Poster

Are mussels any good for marine monitoring?

J. E. Thain and B. Lyons

Marine mussels have been used widely for chemical contaminant monitoring in North America and in some European countries. This paper reviews this work to assess how successful these programmes have been for monitoring marine water quality. In addition, recent studies have indicated that passive samplers may be more useful than marine mussels for monitoring purposes but this story is incomplete and needs to be put in context. Although the chemical contaminant monitoring programmes are in place, corresponding mussel biological effect programmes are less well established. The reason for this is the lack of well-recognized intercalibrated techniques, AQC programmes, confounding factors such as age and genetic differences, lack of assessment criteria, and integrated assessment strategies with contaminants, design of sampling programmes, including field vs. caged *in situ* deployments. All of these factors are presented and discussed with the aim of showing how marine mussels should be used for marine monitoring in an integrated manner and their potential for use in the EU Marine Strategy Framework Directive.

Keywords: biological effects, contamainant monitoring, integrated assessment, marine mussels.

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Theme Session G

Beyond correlations: what are suitable methods for describing and testing non-linear spatio-temporal changes, patterns, and relationships?

ICES CM 2010/G:01

A likelihood method for determining joint time in multiple variables: application to deep-water species

V. M. Trenkel and P. Lorance

A new method for simultaneously comparing time-trends in multiple variables, such as ecosystem indicators or indices of population abundance, is presented. The method allows the determination of the evidence in the data for a given joint time-trend scenario (e.g. whether population trends are the same in different areas). The time-trends are defined in qualitative terms as increasing, stable, or decreasing. Generalized additive models fitted under monotonicity constraints are used to calculate the likelihood of a given time-trend for each variable. The likelihood of a joint time-trend is then the product of likelihoods for the set of variables. The method is demonstrated for the case of exploited deep-water species. The questions investigated are: Did population time-trends in different areas change in the same direction (i.e. is there a single underlying stock)? Did different species in the same area changed in the same direction indicating a fisheries effect? Application of the method shows that for blue ling there is no strong evidence for or against the hypothesis of similar population time-trends in five investigated areas. In contrast, for grenadier the evidence in favour of similar (decreasing) time-trends in all areas was strong, whereas for black scabbardfish population abundance indices in different areas were different. There was no evidence for a common trend across species in each area. A second illustrative example for the method uses time-trends in abundance and length indicators to identify population process changes.

Keywords: abundance indices, likelihood principle, time-series.

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ICES CM 2010/G:02

A multilevel approach to understanding fishery discards in Irish Waters

Mafalda Viana, Norman Graham, James G. Wilson, and Andrew L. Jackson

A central challenge in fisheries is to understand the temporal and spatial variability of both fish populations and fishing behaviour in order to recognize relationships and patterns. Inequalities in the fish-discarding process can be described by the variation in discards within ICES divisions or métiers, but also between the different levels that comprise the sampling programme. Sampling discards in commercial fishing are associated with an intrinsically hierarchical relationship in which boxes of fish are sampled from hauls, which are grouped within multiple trips, performed by vessels which comprise the different fisheries from different areas. Using Bayesian multilevel analysis, this study describes and offers the potential to explain the discarding process in the different fishing areas around Ireland, taking into account the inherent hierarchical structure of the data. The results indicate that discards in different areas vary in a complex, non-linear manner such that the rank order of importance of variance components can differ across spatial scales. This suggests that different factors, including those describing temporal patterns, have varying influence across the spatial areas within Irish waters, which ultimately drive discards. Hierarchical models are a valuable method for analysing discard data and identifying inequalities and hence understanding drivers of high and low discards at different levels within the hierarchy.

Keywords: Bayesian multilevel analysis, discards, spatial patterns, variance.

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ICES CM 2010/G:04

On the utility of self-organizing maps (SOM) and *k*-means clustering to characterize and compare spatial and temporal patterns in marine ecosystem productivity

Bernard A. Megrey and Jae Bong Lee

We present two examples of using self-organizing maps (SOM) and *k*-means clustering to examine spatial and temporal patterns in marine ecosystem productivity. In the first example, time-series of recruitment (*R*) and spawning biomass (*S*) from 17 stocks were compared among functionally analogous species and similar feeding guilds from six marine ecosystems, including Gulf of Maine/Georges Bank, the Norwegian/Barents Seas, and the eastern Bering Sea and the Gulf of Alaska. SOMs facilitated the examination of temporal patterns of synchrony and asynchrony in recruitment and spawning biomass indices among and within ecosystems, among and within ocean basins, among functionally analogous species groups, and among large-scale atmospheric indices. The second example used SOMs to examine spatial patterns in community and ecosystem metrics from three Korean ecosystems: the Japan/East Sea, East China Sea, and Yellow Sea. Results from the time-series data showed consistent within-basin temporal similarities and coherent temporal differences between the Atlantic and Pacific basin ecosystems using ln(*R*/*S*) as a response variable. Comparison between community and ecosystem metrics from the Korean ecosystems showed distinct spatial patterns. The Japan/East Sea and East China Sea ecosystems were more similar and the Yellow Sea was different from the Japan/East Sea and East China Sea ecosystems. Our analysis demonstrates that SOMs and *k*-means clustering are useful for visualizing low-dimensional views of high-dimensional data. They provide a highly visual tool to easily identify patterns in time-series trends or spatial patterns and may be used to augment and complement other standard statistical methods.

Keywords: ecosystem analysis, self-organizing maps.

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ICES CM 2010/G:05

What controls the spawning distribution of the Bay of Biscay anchovy: a multi-model approach

C. Loots, S. Vaz, B. Planque, P. Koubbi, M. Huret, and P. Petitgas

Spawning is an important phase for short-lived species like anchovy (*Engraulis encrasicolus*) as it ensures the renewal of the population through the recruitment process. Data from the PELGAS (PELagiques GAScogne) surveys, taking place since 2000 in the Bay of Biscay, were used to identify the controls of anchovy spawning distribution. Six ecological concepts underlying fish distribution were taken into account. Two are external to the population—environment and site attachment—and four are internal to the population: spatial dependency, population size, demographic structure, and population memory. Each of these ecological hypotheses was represented by one or several explanatory variables that were related to both presence–absence and positive abundance of anchovy using generalized additive models. Models were evaluated into a multi-model approach framework using a distance measure between model predictions and real observations. The Akaike Information Criterion and the log-likelihood were used for measuring model adjustment and prediction capacity. Models were ranked and selected according to these distances and hypotheses that were present in selected models were determined as relevant to explaining spawning anchovy distribution. Presence–absence was mainly determined by physiologically constraining environmental conditions such as temperature and large-scale spatial dependency, whereas inside the areas of presence, positive abundances were determined by trophic conditions, suitable for the successive maturations of the gonads, and population structure such as age-

segregation patterns. The results of this study may show that homing could be a key mechanism that ensures a successful return of the adults to the same spawning areas year after year.

Keywords: anchovy, generalized additive models, homing, multi-model approach, spawning distribution.

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ICES CM 2010/C:06

Beyond correlations: an integrated approach to modelling the effects of climate variability on marine organism growth

Thomas E. Helser, Han-lin Lai, and Bryan A. Black

Recently, dendrochronology methods of cross-dating growth zones laid down in calcareous structures of long-lived marine organisms have been used for paleoenvironmental reconstruction. In particular, annual growth rings in geoduck clams (*Panopea abrupta*), which commonly reach 150 years of age, have been studied as a proxy for reconstructing North Pacific sea surface temperatures (SST). The "master chronology", derived as the weighted average of all individual time-series within a given site after detrending for growth, is correlated with temperature for historical reconstruction. Existing methods to develop the master chronology and its correlation to climate are ad hoc and satisfactory because: (i) the statistical properties of the observations related to the master chronology are unknown, (ii) uncertainty in the growth–climate relationship is unknown and predictability is untested, and (iii) long-term process-related growth information in the data is ignored. In this paper, we develop an integrated approach to analysing the relationship between growth increment data and climate using hierarchical Bayesian methods. By taking advantage of nested data structure, we fit a non-linear hierarchical growth function to detrend increment data from all individuals over several sites simultaneously and test for different covariance structures among random individual effects, environmental effects, and residual error. The non-linear mean conditional growth response was site-specific but shared a common covariance structure of random parameter effects. Covariance related to SST anomalies on annual deviations in growth increments was explicitly estimated, and showed a positive growth–SST response at two of the three sites.

Keywords: Bayesian model, climate change, growth increment, hierarchical model.

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ICES CM 2010/G:07

Application of principal component analysis in the study of spatio-temporal distribution of eastern cod in the Baltic Sea

Pasvel Gasyukov and Svetlana Kasatkina

The model of the non-stationary random field is used to describe the spatio-temporal distribution of the Baltic eastern cod stock. The replicates of fish density fields obtained from the Baltic International Bottom Surveys 1991–2009 for the age groups 2, 3–4, 5–7 in ICES Subdivisions 25, 26, and 28 in the 12 depths strata were used. The mean estimates of density by subdivision and depths stratum and covariance matrix for different age groups were investigated. It is shown that high values and variability of density are typical in subdivisions 25 and 26 and associated with several depths strata (41–60 and 61–80 m). The high correlation of density estimates ($r = 0.4$–0.7) for age groups 2, 3–4 is also associated with these and adjacent depths strata. The patterns of temporal and spatial distributions of cod are described by the components in the expansion by Karhunen–Loeve (which is similar to principal component analysis for the accepted discretization). It was revealed that the mean value and two components of the expansion are sufficient to describe 90% of the variance for age 2 (recruitment) distributions. The same procedure for age groups 3–4, 5–7 requires three components. The spatial distribution is represented by the eigenvectors; the temporal

dynamic is represented by expansion coefficients. The approach allows efficient description of the spatio-temporal distribution of the eastern cod density. The model of the vector random field is proposed as a generalized approach for the combined description of the spatio-temporal distributions of cod, herring, and sprat.

Keywords: Baltic cod, principal component method, spatial distribution, trawl surveys.

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ICES CM 2010/G:08

Methodology for analysing long-term variation in harbour seal diet and relationships with fish abundance

Graham J. Pierce, Elena N. Ieno, M. Begoña Santos, and Alain F. Zuur

Long time-series of dietary data can potentially provide information on how predator diets respond to changing prey abundance (e.g. as a result of overfishing and/or climate change). Here we analyse data on the summer diet of harbour seals (*Phoca vitulina*) in Orkney (northeast Scotland), based on faecal sampling at haulout sites on the island of Eynhallow during 1986–2006. The main component of the diet in summer is sandeels (Ammodytidae, mainly *Ammodytes* spp.). Aside from a patchy distribution of samples and involvement of various different researchers over the 20-year series, the data present several statistical challenges. Thus, individual otoliths in a faecal sample may not represent independent samples and the statistical distributions of prey numbers include an excess of zero values. Linear mixed effects modelling was applied to model temporal patterns in the size of fish eaten (using otolith length as a proxy of fish size). In addition, zero-inflated negative binomial generalized linear mixed models were applied to model trends in the numerical importance of individual prey species and to relate them to trends in prey abundance. We discuss the statistical robustness and biological significance of the trends identified in this dataset.

Keywords: diet, long-term trends, mixed models, monitoring, seal, zero inflation.

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ICES CM 2010/G:09

Localized and non-additive effects of temperature and population abundance on the spatial distribution of arrowtooth flounder (*Atheresthes stomias*) in the eastern Bering Sea

Lorenzo Ciannelli, Valerio Bartolino, and Kung-Sik Chan

We examine the local and interactive effects of both density-independent (bottom temperature) and density-dependent (population size) sources of variability on arrowtooth flounder (ATF) spatial distribution in the eastern Bering Sea. We develop a generalized additive model formulation with spatially variable coefficients to capture the local effects of water temperature and global population abundance and their interaction. Results indicate that ATF avoids water colder than ca. 2°C, limiting its distribution to mostly the outer shelf of the Bering Sea. We also found that ATF habitat expands during periods of high population abundance. These results are in agreement with previous analysis. However, we enrich these previous results by locally characterizing the effects of temperature and population abundance and by quantifying their statistical interactions. We found that the density-dependent habitat expansion is not homogeneous and occurs in greater intensity in the eastern portion of the surveyed grid, toward Bristol Bay and the Alaska Peninsula. Similarly, the effect of bottom temperature is negative in a central corridor across the Bering Sea shelf and positive on either side of it. Finally, the degree of density-dependent habitat expansion is curtailed during cold years. The modelling framework developed here was successful in disentangling spatially variable and interactive effects of mechanisms that determine spatial variability in animal

populations. These approaches can be readily applied to other systems where similar objectives are investigated.

Keywords: arrowtooth flounder, Bering Sea, density-dependent and density-independent habitat selection, spatial distribution, spatially explicit statistical models.

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ICES CM 2010/G:10

Spatial organization, interactions, and trophic regulation in the pelagic Barents Sea

Mette Skern-Mauritzen, Per Fauchald, Edda Johannesen, Ulf Lindstrøm, Erik Olsen, Arne Bjørge, and Nils Øien

Trophic regulation may influence the spatial organization of species. Trophic levels regulated by resource availability (bottom–up) experience strong interspecific competition, possibly resulting in niche segregation and spatial segregation. Trophic levels regulated by predation (top–down) experience less competition and less niche and spatial segregation is expected. We investigated the spatial organization of zooplankton, fish, seabirds, and marine mammals in the Barents Sea using distribution data on from ecosystem surveys in 2003–2007. We applied general additive models to model mean species distributions. Furthermore, correlograms and conical correlation analyses were used to assess the spatial and temporal scales of distributions and spatial community structures at two different scales: the modelled mean distributions and using the residuals from the distribution models. At residual scale, spatial structures were small and short-lived. Predator–prey associations were absent, possibly because of high patch turnover and predator avoidance by prey. At the mean distribution scale, zooplankton densities increased towards the northern Arctic water masses, a gradient likely caused by predation during summer and hence top–down regulation. The pelagic fish species were segregated. The top predators such as cod, baleen whales, and seabirds had limited distributions relative to prey and were partially segregated, suggesting interspecific competition and bottom–up regulation. Thus, the spatial organization supports a wasp-waist regulation, with pelagic fish regulating both lower and upper trophic levels. However, northern predators associated with both pelagic fish and zooplankton and revealed a more complex system structure than in the south, where top predators generally were associated with fish only.

Keywords: pelagic community, predator–prey interactions, spatial distributions, trophic interactions, trophic regulation.

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ICES CM 2010/G:11

Statistical analysis of polychaete population diversity: hyperbolic extremes and dynamics of two dominant spionid species

Benjamín Quiroz-Martínez, François G. Schmitt, and Jean-Claude Dauvin

The objective of this work was to characterize the dynamics of two diverse polychaete populations based on long-term benthic surveys of shallow fine sand communities in the Bay of Morlaix (western English Channel), France. One of the key features of environmental and geophysical field studies is their high variability at many different time and space scales. Because of these external influences and also because of the stochasticity introduced by the reproduction and predator–prey processes, population dynamics are also characterized by high variability over time and space. The abundance and species richness of polychaete populations display high variability, which is analysed here using scaling approaches. We find that population density has heavy tailed probability density functions. We consider relative abundance values, by normalizing the abundance data of one species by the total abundance, for each time-step. We then find that some species are in competition for the same niche, providing a quasi-exclusion of one when the other is abundant. The dynamics of relative species abundance in a community of trophically similar

species are also analysed by estimating a population dynamics diffusion coefficient which characterizes their drift. We find an excellent relation giving the drift coefficient D as a power-law of abundance A of the species: $D = 0.1A^{1.5}$. This new relation may be linked to a general allometric relation. Finally, our approach provides new tools to model such highly variable population dynamics in coastal marine ecosystems.

Keywords: English Channel, heavy tailed density, polychaetes, population dynamics, relative abundance, scaling biodiversity.

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ICES CM 2010/G:13

Spatial overlap of herring and blue whiting in the Norwegian Sea estimated with generalized additive modelling (GAM)

Kjell Utne, Lorenzo Ciannelli, and Gjert Dingsør

During summer, several species of planktivorous fish feed intensively in the Norwegian Sea. Among them are Norwegian spring-spawning (NSS) herring and blue whiting, which are two of the largest fish stocks in the world. In recent years, the abundance of zooplankton in the Norwegian Sea has decreased. Neither NSS herring nor blue whiting have produced strong year classes since 2004 and the condition factor for blue whiting has decreased in the latest years. This has led to studies of the interactions between the species, as the diets of the species overlap in part. We used GAM to quantify how the spatial overlap between the species varies with environmental factors. Spatial overlap metrics was developed both for horizontal and vertical overlap. The analysis showed that several of the covariates initially had a significant effect. After spatial autocorrelation was taken into account through a bootstrap analysis, some of the covariates were less significant and two of the terms had to be dropped from the model for horizontal overlap. This shows the potential importance of spatial autocorrelation when working with a spatial explicit dataset. Geographic position and water temperature were kept as covariates in the models even after spatial autocorrelation was accounted for. The results showed that the vertical overlap was lowest in the area and temperature range with the highest horizontal overlap, and vice versa.

Keywords: bootstrapping, environmental factors, spatial autocorrelation, spatial overlap.

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ICES CM 2010/G:14

Multidimensional time-series visualization: introducing STATIS trajectory plot as an operational tool to detect ecosystem changes

Laurent Dubroca, Nathalie Malet, Annie Pastoureaud, André Vaquer, Adriana Zingone, and Maria Grazia Mazzocchi

Multidimensional databases are now routinely collected for monitoring purposes. Both environmental (physical and chemical parameters) and biological data (such as taxonomic tables) include dozens of variables. Because samplings are repeated in time and/or space, such databases are complex and can be viewed as data cubes. In this framework, describing spatio-temporal changes is complex: on the one hand, time–frequency methods are more adapted to univariate signals and on the other hand, classical data analyses (such as principal component analysis) are not well suited to detect ecosystem changes. STATIS methods (and the related methods: STATICO) are data analysis methods used to find the stable part of the structure of a series of tables (the data cube). These methods proceed in three steps called interstructure, compromise, and trajectory. For multivariate time-series, the trajectory step can lead to a simple graphical representation which includes both environmental and biological variability. In this work, focusing on STATICO methods, we discuss the conditions of application of this method on a multivariate times-series. In

the context of plankton community variability in relation to environmental conditions, simulated data show the trajectory plot following several scenarios: weak to dramatic changes, resilience to regime shift. The operational characters of this tool are then illustrated with two contrasted examples in a coastal area (Mediterranean Lagoon Monitoring Network and LTER Marechiara). According to our experience, the trajectory plot is a graphical tool well suited to enhance communication between ecologists and statisticians.

Keywords: monitoring, multidimensional analysis, STATICO, STATIS, trajectory plot.

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ICES CM 2010/G:15

Investigating spatial and temporal relationships in the fisheries and ecology field using Moran's Eigenvector Maps rigorously

Stéphanie Mahévas, Anik Brind'Amour, Lise Bellanger, Pierre Legendre, and Mathieu Doray

Fisheries and ecological data are characterized by spatial, temporal, and spatio-temporal patterns. For fishery management purposes, it is essential to consider the spatial and temporal characteristics of fishing activities and marine populations to allow a reliable assessment of fishing impact on the populations. However, as sampling strategies are under various cost and sea-accessibility constraints, collected data are rarely replicated in space and time. Rather they verify one of the two following configurations: (i) not enough replicates so that part of the spatial or temporal information has to be degraded to provide replicates or (ii) time and space are completely confounded, hence spatial and temporal variations can only be jointly estimated. Several statistical methods have been developed to address the issue of describing spatial and/or temporal relationships. Among them, the principal coordinate analysis of neighbour matrices (PCNM), recently generalized in the Moran's Eigenvector Maps (MEM) framework, shows promising perspectives. The MEM approach is based on a spectral decomposition of the spatial relationships among the study sites; the eigenvalues of the spatial eigenfunctions are related to Moran's *I* Index of Spatial Autocorrelation. The MEM approach can easily be transferred to modelling temporal relationships. Most applications of MEM select only the positive eigenvalues to describe the spatial relationships. There is, however, no clear statistical support for this practice. This study uses simulations to investigate the ability of the MEM approach to capture contrasted spatial or temporal variability and spatio-temporal variability using all eigenvectors instead of using eigenvectors with positive eigenvalues only. It also uses two case studies: an ecological dataset collected to characterize spatio-temporal structures in coastal fish communities and a fisheries dataset to explore the spatio-temporal patterns in fishing effort. The results indicate which eigenvectors are relevant and should be kept to accurately describe the spatial and temporal relationships.

Keywords: eigenvector-based methods, Moran's eigenvectors maps, sampling surveys, simulations, spatial and temporal variance decomposition.

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ICES CM 2010/G:16

Three-dimensional estimation of chlorophyll *a* fields in the Kerguelen Plateau from southern elephant seal sensors and satellite data

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High-latitude marine ecosystems contribute more than 75% of the global ocean primary production and are vulnerable to climate change. Southern ocean primary production is highly variable in space and time, and only few *in situ* data are available to parameterize or validate coupled physical–biological models. To infer spatio-temporal changes in productivity from 2008 to 2010, 24 elephant seals from the Kerguelen Islands were fitted with a new generation of temperature, salinity, and fluorescence satellite-relayed data loggers. Over 450 profiles were obtained on the Kerguelen plateau through different seasons: temperature and salinity are collected through the whole dive range (up to 2000 m) while fluorescence, allowing chlorophyll *a* distribution to be estimated, is assessed for the top 180 m of the water column. In order to quantify the phytoplankton biomass in areas crossed by elephant seals, a geostatistical modelling of vertical profiles of chlorophyll *a* is proposed, taking into account functional and multivariate aspects of data. Profiles are modelled as curves and interpolated by functional kriging, with remote sensing data covariates. The chlorophyll *a* profiles combined with surface chlorophyll *a* satellite data allow description, at a resolution never obtained before, of the three-dimensional distribution of chlorophyll *a* concentrations through an annual cycle over the Kerguelen Plateau. The Kerguelen Plateau has been chosen as an example zone of interpolation because of spatio-temporal availability of *in situ* and satellite data. The characterization of the distribution of primary production in space and time is a first step towards developing and validating a coupled physical–biological model in the southern ocean.

Keywords: chlorophyll *a*, elephant seals, functional kriging, geostatistics, satellite data, Southern Ocean.

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ICES CM 2010/G:17

Temporal changes in the spatial coupling between bentho-demersal fish and their macrobenthic preys in the Seine estuary

Eric D. H. Durieux, Anik Brind'Amour, and Jocelyne Morin

Estuaries are highly dynamic and productive ecosystems that are driven by both physical and biological factors. Trophic interactions are among the main biological drivers structuring fish assemblages, yet they are rarely included in estuarine habitat models. Using faunal time-series (1995–2002) from the Seine estuary, the present study assesses the spatial coupling between a bentho-demersal fish community and their potential macrobenthic preys. The faunal time-series were composed of two datasets: a fish dataset in which annual autumn surveys were conducted on the same sampling sites and a benthos dataset for which surveys were conducted at different seasons at varying sampling sites. The two datasets were linked annually through a neighbour matrix using a three-table approach (i.e. fourth corner and RLQ analyses). The neighbour matrix was obtained by the intersection of polygons using Voronoï tessellation on each dataset every year. The benthic fauna were grouped using various classifications (taxonomic, energetic, and functional) to determine the most relevant functional group to assess fish–benthos trophic interactions. Annual variability in the fish–benthos interaction was analysed against environmental factors (i.e. river flow, temperature, and salinity) to verify if these factors influenced the spatial fish–benthos coupling. The present study contributes to a better definition of fish habitats in the Seine estuary and finds direct application in conservancy and coastal-zone management.

Keywords: benthos, communities, estuary, fish, fourth-corner analysis, functional habitats, RLQ analysis.

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ICES CM 2010/G:18

Testing for differences in spatial distributions from telemetry data

Bruce J. McAdam, Timothy B. Grabowski, and Gudrun Marteinsdottir

The spatial distribution of species, and temporal variability thereof, are increasingly being studied using telemetric methods in lieu of, or supplementing, surveys. Such methods include data storage tags and arrays of detectors coupled with transmitter tags. One of the most basic tests one might address when analysing these data is whether the distributions of two species, subunits of a stock, genders, age classes, or a single population at different times, are different. Distributions may be in two or three dimensions, or in an abstract space such as depth–temperature space. Owing to the inherent differences between survey and telemetric approaches, however, it is difficult to find a simple and easily applied approach to answer this question. In contrast to surveys, telemetry collects a large amount of data on a small number of individuals. Methods must therefore account for the random effects of individual variation in a way that was not previously necessary. We will demonstrate, for example, that some tests that are suitable for detecting differences in distributions from survey data give false positives (type I errors) when faced with telemetry data. This is essentially because the test treats the large number of data points as a very high n, but in fact the small number of individuals makes the n very small. We present a test for differences in distribution based on Syrjala's test (1996) and review its possible applications in fishery science. In order to enliven this statistical method talk, we will draw on examples from some exciting topics outside fishery science.

Keywords: statistics, spatial distribution, telemetry.

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ICES CM 2010/G:20

Statistical change detection in the spatio-temporal dynamics of the biophysical model outputs: towards an operational monitoring of the environment of the Bay of Biscay

Mathieu Woillez, Pierre Petitgas, Martin Huret, Caroline Struski, and Fabien Leger

Coupled physical–biogeochemical models are now available to generate realistic long-term hindcasts and nowcasts in the physical and lower trophic environment of fish populations. Their potential for understanding the impact of global change and assessing the environmental context of fisheries is high, but requires appropriate methods to detect changes in the spatio-temporal dynamics of the model outputs. Here, we propose a methodology to monitor time-series of maps of environmental indices derived from a 37-year hindcast. Their space–time variability was decomposed using empirical orthogonal functions into time-invariant spatial patterns and corresponding time-varying amplitudes. Then a statistical process control chart was applied to these amplitudes. In that way, changes were detected with known statistical performance, and specified in terms of duration, timing, and location. The procedure was applied to the Bay of Biscay pelagic ecosystem and the results for all indices were assembled in a diagnostic table. The environmental indices characterized the evolution of fronts, river plumes, temperature, water column stratification, horizontal current flow, and primary production. A major result was that sea surface temperature increased in the last decade and particularly in the northern part of the Bay, while the spatial extension of river plumes alternated between wet and dry years. Since 2005, several other indices showed repeated significant deviations: increase in the seabed temperature, in the depth of pycnocline, and change in the coastal currents. The procedure provided an integrated view of the ecosystem variability and change in all its components and their spatial organization.

Keywords: coupled physical–biogeochemical model, ecosystem assessment, empirical orthogonal functions, environmental indices, monitoring maps, statistical process control.

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ICES CM 2010/G:21

Impact of spatial scale on estimating stock–recruitment relationship

Jui-Han Chang, Yong Chen, William Halteman, and Richard Wahle

Pattern and scale have been recognized as two critical issues in ecological studies. Although it is sometimes oversimplified, prevalent ways to make predictions are based on quantifying the observed patterns. However, mechanisms that produce the patterns are operated at a variety of spatial scales. Thus, the choices of spatial scales can influence the possibility of observing the patterns. These concepts have not yet been recognized in studying fish stock–recruitment (SR) relationships, which is one of the most important relationships in fisheries. We hypothesized that the estimation of the SR relationship is optimum at a certain spatial scale, and such a scale varies according to the underlying mechanisms that result in the relationship. Using the Ricker and Beverton–Holt SR model with random effects, we estimated the SR relationship for American lobster in the Gulf of Maine using 12 spatial scales for eastern and western Gulf. The Bayesian method was used with reference priors to estimate the model parameters and determine model goodness-of-fit. The results suggested that at fine spatial scales the relationship is not well defined with large uncertainty. As the spatial scale increases, the uncertainty decreases. An optimum spatial scale can be found with the best model fit for both Ricker and Beverton–Holt models. For the eastern Gulf of Maine where the current is stronger, the optimal spatial scale is larger than the optimal scale for the western Gulf. We demonstrated that choice of spatial scale is critical for understanding and quantifying fish SR relationships.

Keywords: Bayesian, Gulf of Maine, *Homarus americanus*, spatial scale, stock–recruitment model.

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ICES CM 2010/G:22

Developing a Bayesian hierarchical spatially structured model to integrate different survey indices into a statistical catch-at-age model for Atlantic weakfish (*Cynoscion regalis*)

Yan Jiao, Rob O'Reilly, Eric Smith, and Don Orth

As in many marine fisheries, survey population abundance indices from different states and agencies do not always agree with each other. The situation is serious for Atlantic weakfish (*Cynoscion regalis*), because each state has their surveys alongside the two coastal surveys. The current stock assessment model, an ADAPT-VPA model, did not account for both measurement error of catches and spatial autocorrelation, thereby limiting the statistical inference of resulting key parameters of both population dynamics and management importance. A geospatial analysis of relative abundance indices was carried out by modelling these relative abundance indices from different surveys as spatially autocorrelated through a Bayesian spatial hierarchical model. This model of relative abundance indices was then hybridized with a statistical catch-at-age model to allow better integration of difference surveys. We further compared the performance of the proposed Bayesian statistical catch-at-age model with the assumption that the abundance indices are spatially autocorrelated with a statistical catch-at-age model and spatially independent in fitting the Atlantic weakfish fishery. Two hypotheses on spatial autocorrelation pattern were used and compared. A Bayesian method was used to estimate parameters, and performance of the models was compared by goodness-of-fit, the retrospective patterns of the models, and the posterior predictive ability. The Bayesian hierarchical spatially structured model to integrate different survey indices into a statistical catch-at-age model is suggested when there are many surveys with different spatial focuses used in a fishery stock assessment.

Keywords: Atlantic weakfish, Bayesian hierarchical spatial model, spatial autocorrelation, statistical catch-at-age.

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ICES CM 2010/G:23

Estimating spatial and temporal variability of marine species based on observations from vessels of opportunity

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Biological sampling in the marine environment is generally expensive. The use of research vessels is often a logistically complex and expensive operation. As a result, regular monitoring of relevant components in the marine environment is often lacking, or consists of small sample size datasets. These sets generally stem from one or more correlated vessel surveys that sample heterogeneously in space and time. Complementary to the use of research vessels, sampling on board commercial vessels of opportunity can be a powerful strategy to monitor the distribution and abundance of marine species. Here, data collected on board commercial fishing vessels in accordance with the EU discard data collection regulation is used. We focus on the spatio-temporal distribution of young North Sea plaice (*Pleuronectes platessa*). Generalized additive mixed models are used to describe the movement of plaice away from the nursery areas in the North Sea. Some variation in the observations cannot be explained by the spatial and temporal covariates or the sex of the individuals. Examples are differences between vessels caused by features of the fishing operation, such as a skipper effect or gear characteristics, and residual spatial autocorrelation. These covariances are accounted for by including a random describing between-vessel variability and incorporating spatial correlation into the error structure. We present the results of the analysis, and compare those to historical observations of the movement of young plaice. Finally, we discuss the possible model extensions and the use of the results to estimate total removals by the fleet.

Keywords: generalized mixed models, monitoring, plaice, spatial variability.

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ICES CM 2010/G:24 Poster

Integrated forecasts of northeast Pacific fall Chinook salmon returns

Saang-Yoon Hyun and Rishi Sharma

Forecasts of returns are used to determine appropriate levels for ocean and in-river harvests of northeast Pacific fall Chinook salmon. The current preseason forecasts are made by February, six months before fish arrive at natal rivers, so they do not capture ecosystem changes that take place after February. In addition, the ordinary linear regression of the traditional model unnecessarily has the intercept term, which contributes to unusual over-forecasts. Furthermore, there is a concern about autocorrelations in Chinook salmon returns. Finally the current forecast practice does not show uncertainty in forecasts. To accommodate these issues, we developed new forecast methods and compared them with the traditional method: (i) traditional preseason forecasts; (ii) autoregressive preseason forecasts without intercept term; (iii) ocean fishery real-time forecasts; (iv) integrated forecasts from models i and iii; and (v) integrated forecasts from models ii and iii. We demonstrated our methods using data on fall Chinook salmon stocks from British Columbia, Washington, Oregon, and Idaho. We incorporated catch and effort data from summer ocean troll fisheries to detect unusual ecosystem variability in a fish return year and to allow the fishery real-time forecasts. Based on preliminary results, model v was superior to the other models in terms of bias and precision.

Keywords: catch and effort data, ecosystem, fall Chinook salmon, Pacific Northwest, predictive probability density, preseason forecasts.

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ICES CM 2010/G:25 Poster

The use of generalized additive models to examine relationships between environmental variables and commercial catch rates

Sally Roman and Steve Cadrin

Generalized additive models (GAMs) have become an accepted method for assessing non-linear effects of factors on catch rates of commercial species. Catch data reported by the University of Massachusetts School for Marine Science and Technology study fleet from 2006 to 2009 were standardized to catch per unit of effort for Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and windowpane flounder (*Scophthalmus aquosus*). GAMs were employed to determine how fluctuations in catch were influenced by environmental conditions. Explanatory variables included year, season, time of day, latitude, longitude, depth, and bottom temperature. Models were built with stepwise forward selection based on the Akaike information criterion value and deviance explained. Successive models were tested for significant differences with a Chi-square test. Results indicated that spatial variables described the majority of the explained deviance. Other variables were significant, but the contribution to the explained deviance was small. A disadvantage of having a large number of explanatory variables is that an optimal model may be selected in which many variables have significant effects. Another possible artefact of including many explanatory variables is that correlation may occur, which affects model fit. While GAMs can characterize spatial and temporal patterns in catch rates, selection of explanatory variables has implications for the results. If identifying trends in catch rates or shifts in species abundance are an intended outcome, then certain variables such as depth and water temperature may need to be included. Despite these technical challenges, GAMs appear to be a robust method for identifying factors associated with catch rates.

Keywords: catch rates, environmental factors, generalized additive model.

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ICES CM 2010/G:26 Poster

Machine learning functional models of fish population interaction

Allan Tucker and Daniel Duplisea

Our research aims to uncover key relationships between species by modelling the complex interactions between species using probabilistic networks. Modern machine learning approaches such as Bayesian networks offer numerous advantages over traditional modelling approaches, including the ability to exploit human expertise to direct otherwise data-driven models, and uncovering hidden factors that may explain certain artefacts in the data better than any measured variables. The key novelty of our research, however, is the focus on critical subsystems by exploring the functions of species across different populations. Different species may have similar functional roles within a system depending on the region. For example, one species may act as a predator of another which regulates a population in one location, but another species may perform an almost identical role in another location. If we can model the function of the interaction rather than the species itself, data from different regions can be used to confirm key functional relationships, to generalize over systems and to predict impacts of forces such as fishing and climate change. The approach concerns functional network topology and avoids the necessity of describing the specifics of network nodes. Our results so far are promising, demonstrating that similar functional roles can indeed be discovered using simulated data with relatively small sample sizes. Some initial results on real data from the Northern Gulf and the East Scotian Shelf also point towards some interesting discoveries between the two geographical locations, in particular identifying similar competing predator combinations and predator–prey interactions.

Keywords: Bayesian networks, community structure, function.

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ICES CM 2010/G:27 Poster

Linkages between hydrography and fish spawning sites in the southern North Sea—observations 2004 and 2009

Hannes Höffle and Peter Munk

Changing climate may shift environmental conditions out of the hitherto observed range, endangering the reliability of model predictions based on historical observations. The SUNFISH (Sustainable fisheries, climate change and the North Sea ecosystem) project aims to create a basis for evaluating effects of future climate change on the North Sea ecosystem. Part of this programme is to investigate the influence of hydrography on spawning and settling areas of North Sea cod (*Gadus morhua*). Hydrography influences the condition and distribution of spawned fish eggs and may, besides homing behaviour, determine where fish choose to spawn. This study compares hydrography and distributions of eggs and larvae of several commercially important fish species, in late winter 2004 and 2009, investigating potential biophysical linkages. Several areas of high spawning intensity were identified. The hydrography shows a corridor of dense water from the northern North Sea to the English Channel accompanied by a strong boundary between the dense water and water of lower density influenced by freshwater inflow. Peak densities of eggs and larvae were seen along this boundary, giving further support to the hypothesis that hydrographic fronts are important spawning sites for fish. The consequences of these linkages are discussed in relation to potential climatically induced changes in temperature and salinity fronts in the North Sea.

Keywords: climate change, cod, fish eggs, hydrography, North Sea, spatial distribution.

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ICES CM 2010/G:28 Poster

On the testing of marine multispecies models

Bjarki Thor Elvarsson and Gunnar Stefansson

The use of multistock/multispecies models of marine stocks in relation to stock size estimation has increased in recent years. The marine ecosystems that these models attempt to describe are complex, however, and it is computationally impossible to emulate all species interactions. Reasonable approximations need to be made, therefore, regarding the ecosystem in order to obtain results that are of interest. Stock size estimations may be sensitive to these approximations. An ecosystem simulator is presented and used to verify multispecies models such as Gadget. In particular, a two-stock two-area model is simulated and used as input to Gadget using different special assumptions. Various methods for estimating uncertainty are compared, including the use of the Hessian matrix, a bootstrap approach, and Monte-Carlo simulation.

Keywords: bootstrap, gadget, Hessian matrix, Monte-Carlo, multispecies, multi-area, statistical model.

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ICES CM 2010/G:29 Poster

Bootstrap evaluation of length sampling strategies

Gudmundur Thordarson, Warsha Singh, Sisira Haputhantri, and Gunnar Stefansson

A novel approach to evaluate sampling strategies for length measurements of fish is presented. A non-parametric bootstrap technique was used to determine the size and number of samples required to achieve a given accuracy (mean squared error) in a sampled length distribution. The method is developed for distinguishing the peaks and troughs in a length distribution with a specific accuracy. The target fish stock for application of this method was herring (*Amblygaster sirm*) off the west coast of Sri Lanka, but the approach was developed and evaluated using

extensive data on capelin (*Mallotus villosus*) in Icelandic waters. The bootstrapping method takes into account the widely recognized within-sample correlations in length measurements. Bootstrap results illustrated that the number of samples taken from a population is more important than the actual number of measurements taken in a given sample. The study emphasizes the importance of designing and adopting optimal sampling strategies for fisheries data collection programmes.

Keywords: length distribution, mean squared error, non-parametric bootstrap.

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ICES CM 2010/G:30 Poster

Environmental factors related to loggerhead turtle distribution in the Alboran sea

Lucía Rueda Ramírez, Ana Cañadas, Ricardo Sagarminaga, and Steven X. Cadrin

Environmental factors that influence the distribution of the loggerhead turtle (*Caretta caretta*) were identified in the Alboran Sea (western Mediterranean), where estimates of loggerhead turtle bycatch in the pelagic longline fishery in the Mediterranean Sea are among the highest bycatch rates in the world .To explore the factors influencing loggerhead turtle habitat usage of the Alboran Sea, a generalized additive model (GAM)-based approach was applied to non-systematic ship-based line transect surveys that were conducted from 1997 to 2008. Results show that the following environmental variables were related to the presence/absence of turtles in this area: water depth, sea surface height deviation, and longitude. In addition, year, month, and sea state also were found to be important. There is an increasing trend in the presence of turtles in the last years of the survey as well as seasonality, where there is a greater occurrence of turtles during warmer months. In addition, sea state played an important role in detecting the presence of turtles at sea. The number of large-sized turtles measured during these surveys suggests that turtles in the Alboran Sea may be spending more time in the Mediterranean and so delaying their return to the western Atlantic Ocean. Results from this habitat usage analysis could be useful when developing management actions related to bycatch reduction of loggerhead turtles in the Alboran Sea.

Keywords: Alboran Sea, generalized additive models, loggerhead turtle, Mediterranean Sea.

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ICES CM 2010/G:31 Poster

Reliable and robust indicators for control chart-based fishery management

Deepak George Pazhayamadom, Emer Rogan, Ciaran Kelly, and Edward Codling

The importance of indicators as a basis for fishery management advice has been increasing in recent years, particularly where data are limited or of poor quality for traditional stock assessment methods. Qualitative monitoring techniques such as control chart methods from statistical process control theory are highlighted for their efficient detection of signals in systems with high inherent variability. This study attempts to find reliable and robust indicators for fishery advice provision using cumulative sum (CUSUM) control charts. CUSUM control charts are well known for detecting persistent shifts from an equilibrium system state. An operating model was developed and fictional stocks were simulated to reach equilibrium conditions. Random variability was introduced into the model and different scenarios of population perturbations were evaluated. Various age-based catch indicators were calculated and those which reflected the dynamics of spawning-stock biomass were identified as potentially good indicators. It was found that the maturity and selectivity ogives are critical in deciding potential indicators for CUSUM-based fishery advice. An illustration is presented to show how CUSUM control charts can be used to evaluate past events and real-time qualitative assessment using three stocks: Irish Sea cod, Celtic Sea and Bay of Biscay megrim, and Northeast Atlantic mackerel. The CUSUM response was based on ICES precautionary spawning-stock biomass reference limits. Performance of CUSUM was

consistent with the traditional traffic-light approach and was able to produce early warning signals for certain fisheries.

Keywords: control charts, CUSUM, indicators.

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ICES CM 2010/G:32

Environmental and spatial clues to explain anchovy expansion in the North Sea

Kristina Raab, Marcos Llope, Priscilla Licandro, Adriaan D. Rijnsdorp, Leo A.J. Nagelkerke, and Mark Dickey-Collas

European anchovy (*Engraulis encrasicolus*), usually found in the southern seas of Europe, increased its abundance and distribution in the North Sea during the mid-1990s. The causes for this increase are unknown but relevant to the management of commercial species like herring because there is potential overlap in resource use between the two species. The international bottom-trawl survey provides spatially referenced data on adult anchovy since 1965. Using spatially explicit generalized additive modelling, we investigated their main distributional patterns and the effects of environmental and biological variables (such as sea surface temperature, water depth, planktonic prey) on the dynamics of adult anchovy. The aim of the study was to identify which variables co-vary with the spatio-temporal dynamics of anchovy and to identify biologically meaningful relationships so as gain insight into the mechanisms that may control the population increase in the North Sea.

Keywords: distributional changes, small pelagic fish, spatio-temporal modelling, trophic interactions.

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ICES CM 2010/G:33 Poster

Efficacy of using multiple acoustic systems to quantify Atlantic herring (*Clupea harengus*) aggregation metrics before and after fishing events

Jason D. Stockwell, Thomas C. Weber, Adam J. Baukus, and J. Michael Jech

The use of midwater trawls to harvest Atlantic herring (*Clupea harengus*) in the Gulf of Maine has been a controversial topic for many years. Most of the concern revolves around the potential physical disruption of Atlantic herring aggregations and the potential impact on ecological processes and other industries (e.g. other fisheries and eco-tourism) that rely on these aggregations. Preliminary acoustic data collection in fall 2008 using a combination of Simrad ES60 echosounders (38 and 120 kHz), and a Simrad SP90 omnidirectional sonar (20–30 kHz) showed promise for quantifying herring aggregation metrics. We present results from a pilot study conducted in summer 2009 that uses these acoustic systems in a before–after control impact design to quantify and describe herring aggregations before and after midwater trawling with a pair of fishing vessels. We report on the efficacy of using acoustic systems to quantify the potential impacts of fishing on herring aggregations, and discuss the next steps to fully evaluate these potential impacts at spatial and temporal scales relevant to the fishery.

Keywords: acoustics, Atlantic herring, BACI design, commercial fishing.

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ICES CM 2010/G:34 Poster

Analysis of species associations in deep-sea fisheries off the British Isles from an industry haul-by-haul database

Loïc Baulier, Lionel Pawlowski, Pascal Lorance, and Verena M. Trenkel

Deep-sea fisheries in the West of the British Isles have experienced in only two decades many changes regarding the size of the fleets, engine power and fishing gears, fishing grounds and depth while signs of depletion of deep-water stocks and damages to the seabed have led to an increasing number of management rules aiming at ecosystem conservation and at protecting stocks from unsustainable fishing pressure. As deep-water scientific surveys are scarce, abundance indices have been lately estimated using a database containing the catch composition of 29 000 hauls and provided by two organizations from the French fishing industry through a science–industry partnership. Catch composition reflects the combination of the influence of the above factors and the "true" species distribution, itself depending on environmental factors varying in space and time. It is therefore impossible to treat haul-by-haul datasets by standard analyses as they generally require independent observations and normal distributions of continuous variables. Various multivariate analyses and clustering methods were applied in an attempt to characterize the spatio-temporal variability in species abundance and to identify structuring factors and species associations in the catches. Two temporal scales were considered: seasonal and interannual. The relevance of the different methods employed and the information they provide were discussed and results were analysed with stock assessment and management options for those mixed fisheries in perspective.

Keywords: clustering, deep-sea fisheries, multivariate analyses, species associations.

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ICES CM 2010/G:35 Poster

Portuguese crustacean trawl fishery in ICES Division IXa: spatial and temporal distribution patterns of rose shrimp and Norway lobster

Cristina Silva and Fátima Cardador

The Portuguese crustacean trawl fishery takes place off the southwestern and southern coasts, Alentejo and Algarve, targeting deep-water rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*). These two species have a different but overlapping depth distribution. Rose shrimp occurs from 100 to 350 m of depth whereas Norway lobster distributes from 200 to 800 m. Vessel monitoring system data (VMS), logbooks, and scientific surveys provide information on spatial distribution pattern and catch rates. The aim of this study is to analyse if changes in the abundance of target species are associated with effort regime shifts on the fishing grounds. Generalized linear modelling, generalized additive modelling, and time-series analysis will be used to detect correlations, short- and long-term trends both in the fishing regime and in abundance.

Keywords: deep-water rose shrimp, Norway lobster, Portuguese crustacean fishery, spatio-temporal changes.

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ICES CM 2010/G:36 Poster

Environmental effects on seasonal variability in squid distribution—are local conditions important?

Owen C. Nichols and Steven X. Cadrin

Environmentally driven spatio-temporal heterogeneity in the distribution of commercially exploited marine species affects the interpretation of fishery and survey data incorporated into stock assessments. The objective of this study is to test for relationships between intra-annual patterns of long-finned inshore squid (*Loligo pealeii*) distribution and local environmental variables at relatively small spatial scales (<25 km). Squid catch and fishing effort were documented using logbook data from commercial fish weirs in northeastern Nantucket Sound (northeast USA) in May 2007–2008. Seawater temperature was recorded using data loggers affixed to individual weirs, and meteorological data (windspeed/direction) were collected from a nearby weather station. Generalized additive models (GAMs) were applied to examine the relative influence of environmental variables as well as date. In all models, date was the most influential variable, indicating that local conditions at such fine scales are not strong indicators of intra-annual variation in catch. The possible influences of other local variables and larger scale processes, as well as the implications of alternative model structures and data handling methods, are considered.

Keywords: GAMs, generalized additive models, spatio-temporal distribution, squid, temperature.

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ICES CM 2010/G:37 Poster

Recent trends in fishing effort by French otter bottom trawl in the English Channel and consequences on cephalopod resources

Michaël Gras, Jérôme Quinquis, Eric Foucher, and Jean-Paul Robin

English Channel fishing grounds are mainly exploited by French and English fishers. This area is the most significant production zone for long-finned squid (*Loligo forbesi* and *L. vulgaris*) and for cuttlefish (*Sepia officinalis*) in the European Atlantic. Within a series of EU-funded programmes, landings composition of these species and length-frequencies have been sampled monthly at one of the main landing sites: the Port-en-Bessin fish market. The sampling protocol concerned otter bottom trawlers landings with two boats randomly chosen each month. Because loliginid squid and cuttlefish are migratory species, not evenly distributed in the Channel, fishers' behaviour has a consequence on the composition of the sample. In particular, the list of successive fishing grounds exploited by bottom trawlers during the year may be reduced when fuel prices rise steadily and increase journey costs. The aim of this study is to analyse French fishery statistics collected per ICES rectangle in order to describe changes in the areas fished by the trawler fleet and by the boats sampled in the last decade. A series of indicators, such as distance between rectangles fished to landing harbour, number of rectangles visited per vessel in each landing site, or total time of trawling in each rectangle, are explored. The objective is to better understand interannual changes in landings composition and to reveal biases related to the exploitation of different fishing grounds.

Keywords: cuttlefish, fishing effort, long-finned squid, otter bottom trawler, spatial distribution.

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ICES CM 2010/G:38 Poster

Movement patterns of juvenile turbot (*Psetta maxima*) and flounder (*Platichthys flesus*)

J. Martinsson and A. Nissling

The aim of the present mark–recapture study was to assess the movement patterns along the shore within the nursery ground of 0-group turbot and flounder at Gotland, Baltic Sea. Flounder was expected to be stationary and show homing behaviour, as earlier displayed for juvenile plaice (*Pleuronectes platessa*). Because of their different diet, turbot was expected to be more mobile and not show any homing behaviour. Different constraints of the parameters in a random walk model provided a set of four competing models with different assumptions about the presence of homing and drift. The four models were compared for each species. In line with the expectations, the best model for each species showed that turbot was more mobile than flounder, and turbot tended to drift toward the west side of the shore, which showed a relatively low index of organic content. No homing behaviour was displayed by any of the species, in contrast to the expectations for flounder. Moreover, there was no difference in the median distance moved by the individuals of the species from the release site, except when turbot individuals released at the west side of the shore were excluded. The movement patterns are discussed in relation to habitat and prey preferences as well as the absence tides at the site of study.

Keywords: flounder (*Platichthys flesus*), homing behaviour, movement, random walk model, turbot (*Psetta maxima*).

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ICES CM 2010/G:39 Poster

Modelling species distributions using generalized linear modelling: the impact spatial exploitation and climate change

Laure Gardel, Sandrine Vaz, and Youen Vermard

Because of the intensive human use of the eastern English Channel area it is important, in the context of spatial management of living resources, to be able to define its distribution. Data from *in situ* measurements during sea surveys taking place at different seasons of the year (temperature/salinity/chlorophyll *a*/fluorescence), hydrodynamic models (bed shear stress, mean sea level used in the production of the depth map) and remote sensing by a sensor on board a satellite (temperature, chlorophyll *a* concentration, suspended particulate matter) were gathered to describe environmental and physical conditions encountered. For a selection of fish, generalized linear modelling was previously used to produce maps of the mean probable/preferential habitat. These models of marine fish distributions, describing the environmental preferences of key species and some of their ecophases in the Eastern Channel were spatially extended in the southern part of the North Sea. They have been enriched/improved by including the effect of fishing effort to quantify the relative effect of each component of the populations. These models have then been used to simulate the effects of climate change on fish distribution.

Keywords: climate change, GLM, preferential habitat, spatial exploitation.

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ICES CM 2010/G:40 Poster

A reassessment of the relationships between the state of the stock of Manila clam (*Ruditapes philippinarum*) and selected factors (natural and anthropological) in the Arcachon Bay: toward a better use of time partitioning and complementary multivariate descriptive approaches

Nathalie Caill-Milly, Frank D'Amico, and Noëlle Bru

In order to implement a system dynamics model applied to the Manila clam (*Ruditapes philippinarum*) in Arcachon Bay, a first descriptive analysis using normalized PCA and non-parametric statistics (Wilcoxon or Kruskal–Wallis tests) was undertaken to consider the relationship between the state of the population and factors that could influence it (temperature, salinity, food supply, catches, potential competitors, etc.). Surprisingly, food supply did not appear as an important factor, whereas temperature and salinity showed up as important ones with an unexpected time-lag of 1, 2, or 3 years according to the descriptor of the stock. To go beyond the limits of this preliminary work on variables or indicators aggregated at the whole-year level, we turn now in this contribution to new time aggregation patterns (i.e. on shorter periods) built to be more relevant from a biological point of view and more prone to depict the different critical life cycle stages (i.e. sexual maturity, spawning, etc.) or processes (recruitment, growth, etc.) for each studied factor. This reassessment also relies on complementary multivariate approaches (within–between PCA vs. Canonical Correspondence Analysis vs. normalized PCA) that are compared for both chronological series and geographical data when available.

Keywords: multivariate analysis, population dynamics, *Ruditapes philippinarum*.

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ICES CM 2010/G:41 Poster

Spatiotemporal patterns of near-surface acoustic backscattering in the eastern Bering Sea based on multifrequency analysis and geostatistical methods

Mathieu Woillez, Patrick Ressler, Chris Wilson, and John Horne.

Fisheries acoustic surveys often collect multifrequency data to help classify the species composition according to the echo sign. Because fish are usually the primary target species, relatively little effort is spent on confirming the identity of the other scatterers. However, methods to characterize the spatio-temporal patterns of these other scatterers based solely on acoustic data may provide important insights into understanding ecological relationships among these assemblages and those of the target species. Here, we conduct an analysis of multifrequency acoustic data collected in the eastern Bering Sea (EBS) during the summers of 2004, 2006–2008 to describe the spatio-temporal characteristics of a persistent, near-surface acoustic backscattering layer that exists throughout most of the EBS during summer. Analysis methods include unsupervised clustering, which takes into account the spatial context of these data. Our approach initially focuses on the large-scale patterns in the frequency response, and then integrates small-scale patterns (i.e. echogram morphology) by using selected variogram-based textural indices. Categorical maps of each identified class of scatterers are produced and significant changes in their spatial patterns are tracked over time. Results will be used to optimize a field sampling plan to identify the species composition of this unique large-scale, near-surface feature as well as to identify important biophysical forcing mechanisms that influence its spatial distribution and abundance.

Keywords: clustering, eastern Bering Sea, geostatistics, interannual variability, multifrequency acoustics, spatial patterns.

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ICES CM 2010/G:42

Test hypotheses of non-stationary population dynamics through Bayesian model selection among statistical catch-at-age models: an example using Atlantic weakfish (*Cynoscion regalis*) fishery

Yan Jiao, Eric Smith, Rob O'Reilly, and Don Orth

Non-stationary population dynamics has been discussed in many studies but rarely applied to current fisheries population dynamics and stock assessments, especially when statistical catch-at-age models are used. At the same time, model selection uncertainty can be high if one specific model is selected without comparison to other possible models. In this study, using the Atlantic weakfish (*Cynoscion regalis*) fishery as an example, we compared several statistical catch-at-age models to assess the population dynamics. Models that we used included: a statistical catch-at-age model (SCAG) with constant natural mortality, a SCAG with unknown natural mortality but a prior distribution from a mixture of distributions based on life-history information, a SCAG with time-varied natural mortality following a random walk process, a SCAG with a time-varied catchability coefficient following a random walk process, and a SCAG with both natural mortality and catchability following random walk processes. The last four models imply that the population dynamics are not stationary. A Bayesian approach was used to estimate parameters, and performance of the models was compared by goodness-of-fit, the retrospective patterns of the models, and the posterior predictive ability. The estimated non-stationary temporal patterns of natural mortality and catchability were further linked to the climate ocean oscillation indices to diagnose possible mechanism of these temporal variations. A Bayesian model averaging approach, using a Bayesian model selection algorithm with probability of being selected renewed each year, is suggested when more than one model is plausible for a fishery.

Keywords: Atlantic weakfish, Bayesian model averaging, non-stationary population dynamics, statistical catch-at-age.

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Theme Session H

Benthic indicators: responding to different human pressures and assessing integrative quality status

ICES CM 2010/H:01

Benthic indicators for assessment of the quality status of coastal soft-bottom communities: response of different indices to diverse human pressures in the northeastern Atlantic and Mediterranean Sea

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Interest in benthic indicators for soft-bottom marine communities has dramatically increased after a rather long period of relative stagnation because of the need for new tools to assess the status of marine waters within the Clean Act and Framework Water Directive. Our expertise in benthic communities has allowed us to accumulate a large amount of data from diverse unpolluted and polluted conditions (accidental oil spill, sewage, long-term anthropogenic estuarine constraints) in tidal estuaries, harbours, and coastal shelves from the Atlantic and Mediterranean (i.e. English Channel, Atlantic and Mediterranean coast of Spain, Marseilles Gulf and Algerian coasts). We have tested several kinds of benthic indicators, such as "sentinel species" (a particular species which by its presence or its relative abundance takes on the role of "warning" about possible imbalances in the surrounding environment or distortions in the functioning of the community), Shannon–Wiener *H*′ diversity, AMBI and BO2A indices, according to the classification of species into

ecological groups, and ITI according to the classification of species into trophic groups, on diverse available datasets. We discuss the selection and use of biological indicators as "objective" or "subjective" alternatives to diagnose soft-bottom communities and to characterize the state of an ecosystem and address, as early as possible, its modification, whether natural or provoked. It is important to remain pragmatic and to recommend simple methods for the research consultancies who are in charge of the assessment of the benthic quality through numerous impact studies.

Keywords: benthic indicators, comparison of sites, human pressures, objectivity, .soft-bottom communities, subjectivity.

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ICES CM 2010/H:02

The European Marine Strategy Framework Directive: a proposal to define good environmental status for the "seafloor integrity" descriptor

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Annex 3 to the Marine Strategy Framework Directive (MSFD) includes 11 descriptors of "Good Environmental Status" (GES), including "seafloor integrity". This descriptor is defined as follows: "Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected." ICES and the Joint Research Council were tasked to oversee expert task groups (TG) for several of these descriptors who would review scientific information on each descriptor and provide expert guidance on: (i) a scientific consensus on the interpretation of the terms in the descriptor; (ii) what constitutes GES according to the descriptor, including what are "axes of degradation"; (iv) how to deal with issues of ecological scale; (v) what are the ecological attributes of seafloor integrity; (vi) what indicators or classes of indicators for assessing status on the attributes, including how would reference levels be set on the indicators and what pressures are linked to the indicators; (vii) how would information on the indicators be rolled up to an overall evaluation of GES for seafloor integrity; and (viii) research and monitoring needs. This paper summarizes the main conclusions of TG 6 on all of these issues. The focus is shared between the chosen attributes (substrata, bioengineers, oxygen, contaminants, species composition, size composition, trophodynamics, life history traits) and their indicators, how to deal with scale, and how to aggregate results across indicators in assessing GES. The latter issues are important for those using indicators and the conclusions of TG 6 relative to seafloor integrity were influential on the conclusions regarding use of advice from all the descriptor task groups.

Keywords: seafloor integrity, benthos, Marine Strategy Framework Directive, good environmental status.

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ICES CM 2010/H:03

A practical evaluation of biotic indices and indicators of benthic health as a means to assess the sustainability of integrated aquaculture operations in southern temperate ecosystems

N. Keeley and C. Macleod

Aquaculture is an important component of New Zealand's economy and, like many other countries, there is increasing pressure on scientists to ensure operations are sustainable. Although longline mussel culture dominates, high-production salmon farms are increasingly being interspersed among existing shellfish leases, providing a unique set of environmental impacts. Most production in New Zealand is focused in the South Island (Marlborough Sounds) and as a

result, site morphologies and substrates are very similar, although water velocities can vary considerably (from 2 to 25 cm s^{-1}). Natural infaunal populations are relatively diverse but there are marked changes associated with aquaculture operations, with responses depending on the type of farming undertaken. Under high flow (>15 cm s^{-1}) finfish farms abundances of enrichment tolerant species can be exceptionally high (>100 000 individuals m^{-2}) whereas at low flow sites diversity and abundance can be greatly reduced (almost azoic) under certain conditions. In contrast, the benthos beneath mussel farms tends to display a weaker response and sometimes can even have elevated diversity and abundance as a result of substrate modification from mussel shells and other organic debris. There is a need for a standard approach to evaluation of enrichment status. In the northern hemisphere, a variety of biotic indices/indicators have been established as reliable approaches for evaluation of environmental condition. However, these frequently require a complex understanding of species taxonomy and functional biology; something that is often lacking in southern temperate faunas. This study reviews the performance and transferability of selected biotic indices to southern hemisphere ecosystems and considers the levels of functional understanding needed to assess benthic health.

Keywords: biotic indices, benthic indicators, environmental impact, marine aquaculture, Marlborough Sounds, mussel farm, New Zealand, Salmon farm, Tasmania, temperate ecosystems.

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ICES CM 2010/H:04

Development of a new method based on benthic invertebrates for the bio-evaluation of the ecological quality status of estuarine transitional water bodies according to the European Water Framework Directive

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Under the Water Framework Directive, scientists are asked to design bio-evaluation tools to assess the ecological quality status of estuarine ecosystems. Among other quality elements, benthic invertebrate can be used as bio-indicators of the conservation state of these ecosystems. Because of the strong environmental gradients that characterize estuarine ecosystems, the macro-invertebrate community displays particularities in terms of high temporal variability, particular species composition, and patterns that challenge some theoretical principles on which currently used biotic indices were built. Consequently, applying these biotic indices designed for marine waters to estuarine fauna is a source of discussions and uncertainties summarized in the term "estuarine paradox". This study proposes a new biotic index to be used for assessing the estuarine ecoQ status. This method consists of a multimetric approach designed to include the within-habitat variability of the benthic community characteristics (in terms of measures of diversity, abundance, trophic guilds, and sensitive/opportunistic species composition) at the scale of the French Atlantic–Channel coasts. The study was based on a database gathering data on soft-sediment macrozoobenthos (>1 mm, 278 stations) collected in autumn 2008 in 11 estuarine and shallow bay ecosystems. This database was used to (i) identify estuarine habitats, (ii) provide habitat-specific reference conditions, (iii) give a first evaluation of the state of each estuary, and (iv) compare the results with other biotic indices. The results obtained are discussed in terms of choice to be made regarding the consequences of the implementation of the WFD.

Keywords: biotic index, estuaries, macrobenthos, Water Framework Directive.

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ICES CM 2010/H:05

Comparison of biotic indices assessed through benthic macrofauna and sediment profile images along a perturbation gradient in front of the Rhône River

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Four biotic benthic macrofauna indices (AMBI, M-AMBI, BQIES, and BQI) together with the benthic habitat quality (BHQ) index derived from sediment profile images (SPIs) were compared along a gradient of organic matter inputs in front of the mouth of the Rhône River on two sampling dates. The study included analysis of sediment characteristics, particularly organic matter and granulometry. Multivariate analyses of macrofauna species abundances tables show that Bray–Curtis distances reflect the geographical position of the study sites relative to the mouth of the Rhône River. The similarity matrices corresponding to the two sampling dates correlated tightly and all four biotic indices showed the same spatial distribution of ecological quality. We tested the correlations between the benthic habitat quality index (which accounts for surface and subsurface structures and for the thickness of the apparent redox potential discontinuity) with each of the biotic indices, Bray–Curtis distance and sediment parameters. BHQ correlates negatively with organic content of the sediment and positively with depth. BHQ does not correlate significantly with any biotic indices. This suggests that BHQ depends more on the organic content of the sediment than on macrofauna composition. M-AMBI is the biotic index that correlates best with sediment organic content.

Keywords: benthic habitat quality, BQI, macrofauna, M-AMBI, organic content, Rhône River, Water Framework Directive.

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ICES CM 2010/H:06

Assessing the ecological status within European transitional waters (Northeast Atlantic): intercalibrating different benthic indices

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The Water Framework Directive (WFD) has developed several methods to assess the benthic status of European marine waters. WFD implementation requires the intercalibration of such methods, in order to ensure that the status classification is consistent and comparable across countries and water body types. A working group of nine countries (Portugal, Spain, France, Belgium, the Netherlands, Germany, Sweden, Ireland, and the UK) has been established to intercalibrate methods in transitional (estuaries) waters, within the Northeast Atlantic ecoregion. The following steps for intercalibration were agreed upon by this group: (i) to establish common water body types across Europe, based on salinity, tidal range, mixing conditions, intertidal area, and estuary size (six common types were identified); (ii) to compile a common dataset (9337 samples collated, from 59 estuaries and 8 countries, covering 5 out of the 6 types, and most of the ecotopes); (iii) to harmonize the taxonomy of the dataset (using ERMS, WoRMS and Fauna Europaea); (iv) to collate human pressures from each estuary; (v) to set reference conditions for each type; (vi) to calculate ecological quality ratios for each of the 10 methods proposed for intercalibration (BAT, M-AMBI, BOPA, BO2A, QSB, MISS, BEQI, AETV, BQI, IQI); (vii) to interpret the response of these methods to different anthropogenic pressures; (viii) to determine boundaries for each of the five quality classes (from bad to high status), using the 10 methods; and (ix) final agreement in the assessment and intercalibration. This contribution presents the steps already taken and the way forward in this intercalibration exercise.

Keywords: benthic indicators, ecological status, intercalibration, Northeast Atlantic, transitional waters, Water Framework Directive.

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ICES CM 2010/H:07

Assessing the usefulness of some recently proposed modifications to the AZTI marine biotic index (AMBI)

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Initially described in 2000, AZTI's Marine Biotic Index (AMBI) aims to assess alterations in communities of soft-bottom marine benthic macroinvertebrates caused by anthropogenic impacts. Although it was designed to be used in European estuaries and coasts, this index, based on Pearson and Rosenberg's model of responses to organic enrichment, is being used successfully worldwide. Species are assigned to one of five ecological groups (from sensitive to first-order opportunistic species). Abundances of each species are used to calculate the relative proportions of individuals in each sample belonging to each group, and these are used to calculate the index. The index takes a continuous value, between 0 and 6 (from undisturbed to heavily disturbed communities), keeping 7 for azoic sediments (extremely disturbed). AMBI is being used extensively in the ecological status classification within the European Water Framework Directive, forming part of several multimetric and multivariate methods. Taking into account statistical difficulties associated with the use of raw abundance data, modifications to the index were recently proposed. These were to transform abundances prior to its calculation, or to use data other than abundances, which might be more functionally relevant (such as biomass or production data). Using data from the Basque coast and estuaries (northern Spain) collected between 1995 and 2009, where the evolution of human pressures and restoration actions in the area may be taken into account, the performance of AMBI is compared with that of the proposed modifications in order to assess their usefulness.

Keywords: AMBI, BAMBI, benthic indicators, coastal waters, estuaries, NAMBI, PAMBI, soft-bottom benthic macroinvertebrates.

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ICES CM 2010/H:08

The use of benthic indicators in Europe, from the Water Framework Directive to the Marine Strategy Framework Directive

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The European Water Framework Directive (WFD; 2000/60/EG) and the European Marine Strategy Framework Directive (MSFD; 2008/56/EC) were umbrella legislations for fresh and marine waters. It is a challenge for the scientific community to translate the principles of these directives into realistic and accurate approaches. Both directives have common principles, although these were tackled differently. The WFD was executed during the last decade, and many results from it have already been published. The process delivered valuable knowledge of which the implementation of the MSFD could be founded. The ICES Benthos Ecology Working Group aimed to compile the lessons learned from the application of benthic indicators in the WFD implemented within the MSFD through the description of (i) how the principles are theoretically filled in by both directives, (ii) how the process is tackled in the WFD process, and (iii) what these insights might mean for the implementation of the MSFD. A first main principle is the realization of the ecosystem approach. Second, the comparability of benthic indicators, class boundary settings and the relationships between indicators and anthropogenic pressures are highlighted. Third, some aspects related to the monitoring requirements of both directives are discussed. We conclude that testing and integration of the different approaches was facilitated during the WFD process and led to further insights and improvements. This facilitated the selection of the most accurate approach for each purpose

(principle, region, water type, etc.). Expert involvement in the entire process proved to be of vital importance.

Keywords: benthic indicators, Europe, Marine Strategy Framework Directive, Water Framework Directive.

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ICES CM 2010/H:09

Low dissolved oxygen impacts in the northern Adriatic: critical thresholds for benthic assemblages

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Oxygen-depleted areas are the most severe manifestation of ecosystem degradation in shallow coastal waters. Today, nearly 415 eutrophic and hypoxic coastal systems have been identified worldwide. "Dead zones" cause cascading effects ranging from the molecular to the ecosystem level. Ultimately, biodiversity loss and disrupted ecosystem function (e.g. filter- and suspension-feeding capacity, bioturbation) can change structurally complex and diverse benthic communities into far simpler, impoverished ones. Biological indicators, in particular the use of benthic species, are a developing field in these efforts. This calls for the identification of potential indicator species for various levels of impact. The northern Adriatic is a recognized key area for seasonal low dissolved oxygen events. The onset and extent of catastrophic events, however, is difficult to predict, hindering full documentation in the field. Using a specially developed underwater chamber, we experimentally recreate small-scale anoxias in a community setting. The *in situ* experiments successfully mimic full-scale hypoxia/anoxia and reveal a clear sequence of species-specific macrobenthic behaviours and mortalities correlated to specific thresholds. This yield of new details (e.g. predator–prey interactions), at a finer, more nuanced scale of resolution than ever before in the field, is a step forward in compiling a broadly applicable catalogue of behaviours, a list of sensitive/tolerant species, and a range of community compositions to determine *in situ* ecosystem status and stability. This will also help retrospectively pinpoint past anoxias and predict future community compositions. The results provide crucial input for coastal management, which is called upon to reduce additional anthropogenic pressures (e.g. benthic trawling) during critical phases.

Keywords: anoxia, behaviour indices, hypoxia, Mediterranean, soft-bottom macrofauna.

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ICES CM 2010/H:10

Weighing sources of natural variability of transitional water macro-invertebrates: a comparison of metrics

Enrico Barbone, Sofia Reizopoulou, and Alberto Basset

The assessment of human impacts on aquatic ecosystems requires a separate quantification of natural and anthropogenic sources of variability, which may be challenging at least in some water body categories. Transitional water ecosystems are naturally stressed ecosystems, characterized by strong spatial and temporal variabilities arising from both their origin, as ecotones among terrestrial, freshwater, and marine ecosystems, and their rapid internal dynamics. Predictable and unpredictable components on natural variability occur in transitional waters on spatial (gradients vs. patchiness) and temporal (regular vs. pulse events) scales. Benthic macroinvertebrates, as a result of their life cycles, space use behaviour, and benthic habits, represent the guild most exposed to the natural variability patterns in transitional waters. Here, we weigh the relevance of different potential sources of natural variability of benthic macro-invertebrate guilds on both the temporal and spatial scales, as well as according to the structural descriptive component considered (e.g. taxonomic, functional and size spectra abundance, richness, and diversity). Indices derived from

the structural components are compared. The study was carried out using the TWReferenceNET-DB relative to nine Mediterranean and Black Sea lagoons. Synoptic sampling campaigns of benthic macroinvertebrates were performed seasonally at different habitats within every lagoon with a nested design. Taxonomically based structural components of benthic macro-invertebrate guilds and taxonomic indices were commonly more variable that functional and size spectra ones. The relevance of seasonal and habitat components as sources of uncertainty in assessing macro-invertebrate metrics and multimetric indices is quantified and the implication for the implementation of the WFD is discussed.

Keywords: habitat heterogeneity, macroinvertebrates, metric uncertainty, seasonality, transitional waters.

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ICES CM 2010/H:11

Can historical data be used to set reference values—a test on Baltic Sea benthos data

Hans Cederwall

In order to developing a BQI-index to determine ecological status using zoobenthos data, an extensive database was used, also containing historical data from the 1920s. Estimations show that the Baltic Sea had a much lower trophic state during the 1920s than during the 1970s–1980s. It was therefore surprising that the data from the 1920s did not give the highest BQI-index values. The data from the 1920s and the 1970s–1980s has now been used to find out why the data from the 1920s gave lower index values. If only the fractions of sensitive and tolerant taxa were taken into account, the data from the 1920s gave higher values than the data from the 1970s–1980s. When the number of species was also taken into account, the data from the 1920s gave lower values. Because no new species had been introduced between the 1920s and 1970s–1980s, the difference found is attributed to method differences. The Petersen grab was used in all samplings, so the difference between samplings is assumed to be caused by differences in treating the samples. Rough sieving may have pressed fragile animals through the sieve meshes. Small animals may have been missed during the sorting procedure. This should have affected the number of species found as well as the abundance values, but only to a negligible level the biomass values. The results suggest much precaution is necessary when using historical data for setting reference values. Taking the biomass into account when determining the ecological status can be a fruitful way to use the historical data.

Keywords: Baltic Sea, ecological status, historical data, index, reference conditions, zoobenthos.

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ICES CM 2010/H:12

Development of a new index for the assessment of hydromorphological alterations of the Mediterranean rocky shore

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The assessment of the status of coastal waters is required by the European Water Framework Directive. The aim of the present study was to develop a new index for the assessment of hydromorphological alterations of the rocky shore, based on benthic invertebrates. Fifty samples were collected, 10 in each of five preclassified hydromorphological (HM) classes, but five in HM class 4 and 15 in HM class 2. Each sample consisted of three subsamples of 400 cm^2 size, collected in the upper-mediolittoral, lower-mediolittoral, and upper-infralittoral belts. All organisms (amphipods excluded) were identified to the lowest possible taxonomic level. Indicator values ranging from 1 to 9 were defined for each of 225 taxa according to their distribution along the HM classes. Almost 50% of taxa were indicators of heavily altered sites with an indicator value between 1 and 3, more than 30% of taxa of moderately altered sites with a value between 4 and 6, and almost 20% of taxa of unaltered sites with a value between 7 and 9. Indicative weights were also

defined according to the valences distribution among HM classes. Indicative values and weights were combined in a new Benthic Index for Rocky Shore (BIRS). Several combinations of abundance, indicative values, and weights were tested, but the weighted average approach with abundance showed the highest correlation (Spearman's $r = 0.96$, $p < 0.01$) with the hydromorphological gradient. Further work has to be done in order to complete the development of a multimetric index that will upgrade the BIRS.

Keywords: benthic invertebrates, hydromorphological impact, new index, North Adriatic, WFD.

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ICES CM 2010/H:13

Comparison of benthic foraminifera and macrofaunal indicators of the impact of oil-based drill mud disposal

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Benthic foraminifera are commonly used as bio-indicators of pollution in marine environments. The study of their assemblages (density, species composition, and diversity) has proven to be a reliable tool to assess and biomonitor the environmental impact of anthropogenic pollutions. We compare foraminifera and macrofauna as bio-indicators of the disposal of oil drill cuttings at a site off Congo. The most polluted sites are characterized by poor faunas, dominated by some very tolerant taxa. Slightly further from the disposal site, there is an area with strongly increased densities, heavily dominated by opportunistic taxa. Still further, the macrofauna appears to be similar to that at the reference area, but the foraminiferal fauna still suggests a slight environmental perturbation. The foraminiferal FIEI index, based on the species distribution in the study area, appears to be more discriminative than the macrofaunal ITI index, based on *a priori* definitions of the trophic guilds of the various taxa. Our comparative approach allows us to point out the benefits of (i) the use of macrofauna and foraminifera together, and (ii) the definition of the species groups used in biotic indices on the basis of observations made directly in the study area.

Keywords: bio-indicators, biotic index, drilling mud, foraminifera, macrofauna.

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ICES CM 2010/H:14

Analysis of biological quality elements (BQES) and human-induced pressures to assess the benthic ecological status of coastal ecosystems under the WFD (2000/60/EC)

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Assessment of the ecological status of coastal marine ecosystems is requested by the European Water Framework Directive (WFD 2000/60/EC): data analysis and processing of biological quality elements (BQEs: macroinvertebrates, angiosperms, macroalgae, and phytoplankton), together with information on human-induced pressures and the deriving impacts on coastal areas, are strictly recommended by the Directive to evaluate reference conditions. This is a mandatory step in order to define a classification criterion and proceed with the ecological classification of coastal water bodies. In the present paper, the effects of the human-induced pressures on the biological data with regard to macroinvertebrates, angiosperms, and macroalgae were analysed. The data have been collected in the frame of the National Monitoring Program financed by the Ministry of the Environment (Environmental Protection Department). According to the WFD guidelines, the ecological response of the coastal marine ecosystem has been evaluated by using appropriate statistical tools and several indices of ecological status have been tested, by checking their compliance with the requests of the Directive. The research allows us to discriminate among

different kinds of pressure and the related effects on biological elements that characterize coastal marine environments.

Keywords: benthos, ecological status, human pressures, WFD.

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ICES CM 2010/H:15

A proposal for the assessment of the composition and community structure of benthic macroinvertebrates in transitional waters. The QSB index

Araceli Puente, José A. Juanes, Beatriz Echavarri-Erasun, Cristina Galván, and Bárbara Ondiviela

The implementation of the Water Framework Directive (WFD) requires the assessment of benthic macroinvertebrates in transitional waters. According to the WFD, the classification tools for this biological indicator in different status categories should include the level of diversity and abundance, as well as the presence of taxa that are sensitive or indicative of pollution. However, the absence of changes in these variables does not imply that the community could not be disturbed. This fact is especially relevant in highly stressed natural estuarine communities, characterized by their low richness and high dominance. Consequently, the addition of metrics in the evaluation systems focused on the detection of changes in composition and structure of macroinvertebrates communities is encouraged. With this aim, a multimetric tool that includes the assessment of community integrity is proposed, and its suitability to detect impacts has been tested. The QSB tool (Quality of Soft Bottoms) includes richness, abundance, and opportunistic species, and compares the evaluated site with a predefined community type by means of the Bray–Curtis similarity index. The index has been used to assess macro-invertebrate communities in transitional water bodies within the Cantabric River Basin District (Spain, Northeast Atlantic).

Keywords: ecological status, macroinvertebrates, Northeast Atlantic, transitional waters, Water Framework Directive.

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ICES CM 2010/H:16

On the relevance of epibenthic invertebrate community data from standard fishery trawling surveys to qualify soft-bottom habitats

Pascal Laffargue and Jocelyne Martin

In the context of spatial planning for marine resources and ecosystems management, there is a lack of knowledge of benthic habitats and communities in the Bay of Biscay and on the Celtic Sea continental shelf. Until now, and despite many years of standardized fishery surveys, the focus has mainly been on commercial species. Interest in the whole benthic community has been reinforced by the need to identify essential and vulnerable marine ecosystems and to better evaluate the functional role of biodiversity and links with the distribution and production of exploited marine resources. Moreover, it would help to better discriminate environmental and anthropogenic pressures occurring on soft bottoms. We used data on the epibenthic macro and megafauna invertebrate communities ("benthos") from scientific trawling surveys designed to evaluate bentho-demersal fishery resources. To what extent do these "benthos" data give new insights into the structure and function of soft-bottom habitats and what is their relevance to complete benthic habitat qualification and mapping? Beyond describing the biodiversity of "benthos" communities, analysis was dedicated to the links between species sensitivity and functional diversity with natural and anthropogenic pressures. The availability of high-resolution benthic data on fishing pressure from vessel monitoring systems and the natural environment from three-dimensional hydrodynamics models (MARS-3D) offers the opportunity to develop spatially explicit habitat

models. Those models would be useful tools for the evaluation of environmental status and trends under various pressures, in particular the fishing impact on benthic ecosystems.

Keywords: benthic indicators, functional diversity, GOV trawl, habitat mapping, Northeast Atlantic.

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ICES CM 2010/H:18

Physical disturbance impacts on ecosystem function: a comparative analysis using traditional and novel approaches

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The objective of this study was to investigate the recovery of ecosystem function after marine aggregate dredging. A previously dredged area (Area 222), located off the southeast coast of England, was selected for this investigation; the experiment consisting of sites previously subject to relatively high and low dredging intensity, as well as two undisturbed reference areas. Data were analysed using traditional indices (abundance, species richness, and biomass) and functional analysis techniques (somatic production and taxonomic distinctness). Results showed that, whereas the recovery in the high activity site was incomplete, both traditional and functional analyses showed that macrofauna in the low activity dredging site had fully recovered seven years after the dredging ceased. Although both techniques showed some congruence in terms of the period required for recovery, the functional techniques recorded a faster rate of recovery compared with the traditional ones. This suggests that, whereas the aggregate extraction may alter the structure of macrobenthic assemblages, the benthic ecosystem may still be able to perform the same process, albeit with a different community.

Keywords: dredging, ecosystem function, somatic production, taxonomic distinctness.

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ICES CM 2010/H:19

Development of a combined indicator of bioturbation and redox, a proxy for seabed function?

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Marine systems are represented by a wide range of habitats. These systems are dynamic entities that have a high degree of complexity and may harbour high levels of biodiversity. Human-induced pressures (i.e. dredging, fishing, construction, pollution, and others) often produce additional disturbance to these marine systems with repercussions for biodiversity. Current national (e.g. Marine Bill, Charting Progress 2) and international (e.g. WFD, Habitats and Bird Directives, EUMSFD) legislation are focused on the quality and status of the marine environment. To this end, the UK has continued to work on the need to develop indicators that can assist with this process. This work has helped to identify the natural processes and human activities that are affecting marine systems. One of the marine descriptors within the EMSD is "seabed integrity". This descriptor asks Member States to ensure that the structure and function of ecosystems are safeguarded and benthic systems are not adversely affected. To date, we have furthered our understanding of the seabed by, for example, studying benthic systems. For this purpose indicator tools, such as a suite of benthic indices, have been employed as measurers of "the health of benthic systems". In most cases, this information mainly relates to the structure of benthic populations. However, there is a gap in terms of what we can measure with regards to the function of the ecosystem and how individual benthic animals perform their roles within specific ecosystems. There are also not enough data to assess if the functions of the seabed are safeguarded. This work

has defined sediment function as an indicator to measure both carbon and nutrient cycling. These two processes are largely driven by the organisms controlling the redox potential of the sediments via bioturbation activities.

Keywords: bioturbation, EMSD, indicators, redox.

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ICES CM 2010/H:20

Response of different indicators of submerged aquatic vegetation to eutrophication-related environment characteristics in coastal waters of the northeast Baltic Sea

Georg Martin and Kaire Torn

Different parameters of submerged aquatic vegetation (SAV) are used as indicators in assessment schemes for the ecological quality of coastal waters, which is one of the compulsory elements in such systems. A variety of different indices and parameters are used for this purpose in countries around the Baltic Sea region. In a few cases very long time-series exist, proving their effectiveness in following the development of ecological status of coastal waters in eutrophicated areas of the Baltic Sea. In most of the Baltic Sea countries regular monitoring schemes for marine SAV have been established only recently and available time-series to prove or criticize the suitability of the indicators used are very limited. In the current study, available time-series (1995–2009) of SAV indicators used in an Estonian national assessment scheme (depth penetration of SAV and indicator species and share of perennial species in communities) was studied in relation to other environmental variables traditionally used as proxies of eutrophication (concentration of nutrients in seawater, water transparency and concentration of chlorophyll in seawater). The relationships between SAV indicators and eutrophication parameters were studied on different geographical (dataset included information from different sea areas of the Baltic Sea) and temporal scales (influence of possible time-lag in the response of SAV indicators to eutrophication). Results show generally strong relationships between SAV indicators used and eutrophication parameters, whereas in some cases the time-lag of the response of SAV indicators is clearly detectable. Relationships are weaker or unidentified in cases of high eutrophication (e.g. northeastern Gulf of Riga).

Keywords: Baltic Sea, environment indicators, eutrophication, submerged aquatic vegetation.

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ICES CM 2010/H:22 Poster

Biological water quality indices in the changing world

Velda Lauringson, Jonne Kotta, Kristjan Herkül, Ilmar Kotta, Arno Põllumäe, and Triin Veber

Global climate change is a well-acknowledged threat to ecosystems. In addition, coastal seas are concurrently threatened by another phenomenon, much more local in origin while almost comparably worldwide in spread—accelerated eutrophication. Public attention on ecosystem conservation and sustainable management has encouraged development of numerous biological water quality indices in recent years to facilitate the assessment of the ecological status of coastal marine areas. The key area of the present scientific focus is likely methodology, mainly the performance of different approaches and the validation of indices at local disturbance gradients. Large-scale environmental variability has gained attention from the spatial aspect, whereas the time-related component tends to receive less attention. Legislations such as the European Water Framework Directive are focused exclusively on local-scale disturbances. However, large- and local-scale temporal variability in environmental conditions display concurrent impact on the biological variability the indices are based on. The behaviour of biological water quality indices in response to changing climate is unknown, neither is studied the impact of mutual changes in large-

and local-scale disturbances. The present study evaluates the contribution of climate- and eutrophication-related variables to the variability in two benthic water quality indices developed for classifying coastal sea areas according to the European Water Framework Directive in the northeastern Baltic Sea. Both climate and eutrophication contributed to the variability of the indices studied. This result indicates an urgent need to account for large-scale time-related variability in environmental conditions when applying biological water quality indices to the local-scale estimation of the disturbance status of water bodies.

Keywords: benthic indicators, climate change, disturbance, eutrophication, quality assessment, Water Framework Directive.

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ICES CM 2010/H:23 Poster

Evaluation of the influence of offshore cage aquaculture on the benthic ecosystem in the Alghero bay (Sardinia, Italy), using AMBI and M-AMBI

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The impacts of an offshore fish farm in Alghero bay (northwest Sardinia, Italy) on the benthic ecosystem were investigated during 2007 and 2008. Together with chemical and physical characteristics of the area (i.e. currents, sediment analyses), some biological analysis were performed. AZTI's Marine Biotic Index (AMBI) and the Multivariate AMBI (M-AMBI) are used to assess the ecological status of benthic communities within the European Water Framework Directive (WFD). Here, clear gradients of impact were detected using both methods, and they are related to the farm production, prevailing currents, and characteristics of the area (i.e. water depth, distance to the cages). The most degraded situation was detected within 84 m of the cages, whereas the area undegraded was further than 907 m from the cages. The gradient is shown by decreasing AMBI values and opportunistic species percentages, and increasing richness, diversity, and sensitive species. This study highlights the importance of setting reference conditions for different areas when calculating M-AMBI. These reference conditions correspond to those in undisturbed sites, in the opposite of the prevailing currents within the area.

Keywords: AMBI, benthic health, biotic index, cage aquaculture, M-AMBI, Mediterranean Sea.

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ICES CM 2010/H:25 Poster

Measuring the impact of different pressure types with the Benthic Ecosystem Quality Index (BEQI)

Gert Van Hoey, T. Ysebaert, and K. Hostens

Recently, the concepts of natural resources management and marine spatial planning have been incorporated in many directives (Water Framework Directive, Marine Strategy Directive, Habitat and Bird Directive). For the implementation of these directives, policy-makers and managers need tools for evaluating impacts in the marine system, and for the assessment of recovery after enforcement of measures. Biotic indices were designed to objectively evaluate changes in the ecosystem because of impacts or measures. An example of such a tool is the Benthic Ecosystem Quality Index (BEQI), which objectively scales the observed difference between impact and control data in five classes (bad to high; www.beqi.eu). To this aim, the BEQI uses the benthic parameters density, biomass, number of species, and species composition to evaluate changes in benthic community characteristics. In addition, a habitat level is included in the approach to assess changes in the hydromorphological aspects of a water body. The BEQI was tested for several case studies in Belgian and Dutch waters: eutrophication/stratification and restoration measures in the Veerse Meer, invasive alien species in coastal waters, physical disturbance resulting from dredge disposal

along the Belgian Coast, and hydromorphological changes in Dutch estuaries. The results of the analyses indicate that the different parameters of the BEQI index show a clear and specific response to each impact type. Consequently, the tool can be considered useful to give managers scaled information about the impact degree of different pressure types.

Keywords: alien species, benthic indicators, BEQI, dredge disposal, eutrophication, pressures.

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ICES CM 2010/H:26 Poster

Assessing coastal benthic macrofauna community condition using best professional judgement—developing consensus across North America and Europe

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Benthic indices are typically developed independently by habitat, making their incorporation into large geographic scale assessments potentially problematic because of scaling inequities. A potential solution is to establish common scaling using expert best professional judgement (BPJ). To test if experts from different geographies agree on condition assessment, 16 experts from four regions in USA and Europe were provided species-abundance data for 12 sites per region. They ranked samples from best to worst condition and classified samples into four categories. Site rankings were highly correlated among experts, regardless of whether they were assessing samples from their home region. There was also good agreement on condition category, though agreement was better for samples at extremes of the disturbance gradient. The absence of regional bias suggests that expert judgement is a viable means for establishing a uniform scale to calibrate indices consistently across geographic regions.

Keywords: anthropogenic disturbance, best professional judgement, coastal benthic infauna, Europe, North America, quality assessment.

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ICES CM 2010/H:27 Poster

Comparison of two methods for the ecological status assessment of benthic intertidal macroalgae within the Basque coast for the European Water Framework Directive

Marie-Noëlle de Casamajor, Erwan Ar Gall, Michel Le Duff, and Ángel Borja

The Basque coast (southeastern part of the Bay of Biscay) presents specific environmental and biogeographical conditions with regard to the rest of the French Atlantic coast: warmer water temperatures, lower tidal range, and strong regime of swell. Hence, macroalgal communities exhibit some specificities within this area: rare occurrence of fucoids and kelps, smaller number of belts (less marked vertical zonation), and species characteristic of the southern coasts of Europe. The Water Framework Directive uses macroalgae as one of the biological quality elements in assessing the ecological status of coastal waters. In this context, the abovementioned specificities must be taken into account when applying any method of assessment. In the Atlantic French coasts two methods have been tested: a Breton protocol, used on the French coasts of both the Channel and the Atlantic Ocean, and the Spanish method, used in the north coast of Spain. The site chosen to test these protocols is called "The Twins", in the domain of Abbadia (Hendaye), on the border between France and Spain. The sampling survey took place during the same cycle of high tides, at the end of June 2009. The first results on the quality status of macroalgae show that these two

protocols are relevant with coherent indicators, not only with regard to the reference values but also with regard to results obtained for this element on the nearby Spanish Basque coast.

Keywords: macroalgae, methodologies, quality indicator, Water Framework Directive.

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ICES CM 2010/H:29 Poster

Application and adaptation of the Reduced Species List (RSL index) to the Atlantic coasts of southern Spain

Ricardo Bermejo, Juan José Vergara, and Ignacio Hernández

The Water Framework Directive suggests the use of abundance and species composition of macrophytes for ecological quality classification. In the case of the Atlantic coastal waters, three bio-indicators based in seaweed communities have been proposed: the RSL (Reduced Species List), the CFR (quality of rocky bottoms), and the P-MarMAT (Portuguese Marine Macroalgae Assessment Tool). The ecological differences between the coasts where these index have been developed and the coasts of southern Spain make necessary a calibration for these coasts. In this study, the RSL index was adapted for the rocky shores of Cádiz, and a reduced species list developed. Two new parameters are proposed to estimate the index: proportion of competitors and proportion of ruderals, instead of the proportions of Ecological Status Group I (ESG I) and opportunists, respectively. Based on nutrients and turbidity data, 16 sites along the Atlantic coast of Cádiz were classified into three categories—high, good, and moderate. According to this classification, the RSL index was calibrated. The results of both indices (RSL and modified RSL) were compared with the previous classification. Except for proportion of ESG I and species richness, all parameters showed significant differences between the ecological quality classifications. The most significant boundary is the one lying between moderate and good status. Both versions of the RSL index are suitable to assess the ecological status at a middle spatial scale. The results have also shown the existence of two zones with a different intertidal seaweed species composition: Atlantic Cádiz and the Gibraltar Strait.

Keywords: ecological quality, intertidal, macroalgae, seaweed, Water Framework Directive.

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ICES CM 2010/H:30 Poster

Benthic foraminifera as bio-indicators of coastal water quality in the Mediterranean Sea in relation to the implementation of the Water Framework Directive

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In the context of the Water Framework Directive (WFD), the Water Agency Rhône Méditerranée—Corse intends to develop a new benthic biotic index based on foraminiferal faunas. Existing benthic indices, mainly based on macrofauna, present significant drawbacks such as the large sediment volume required, the difficulty of establishing the initial ecological state of the study area and the lack of specialists for taxonomic identification. Foraminifera are unicellular marine micro-organisms that calcify or aggregate particles to form their tests. Their principal asset is that their tests remain in the sediment after their death. Therefore, the analysis of dead fauna gives an image of the environmental conditions in the past. The study of foraminiferal faunas presents other advantages: (i) the sediment volume required to obtain statistically significant data is small, (ii) their life cycle is short so they react rapidly to environmental changes, and (iii) identification of benthic foraminifera to species level is relatively easy compared with macrofauna. In this context, we study benthic foraminiferal faunas from the French Mediterranean coast (mainland and Corsica) to develop a biotic index. For each water body defined by the WFD in our study area, we study the density, diversity, and distribution of foraminiferal faunas. The analyses of the dead

faunas can inform us about the environmental conditions at these stations in a historical past, prior to the sampling period (March 2009). If successful, this foraminiferal bio-indicator method will be proposed for implementation in the Marine Strategy Framework Directive.

Keywords: benthic faunas, biotic index, foraminifera, marine ecosystem, meiofauna.

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ICES CM 2010/H:31 Poster

Intertidal rocky assemblages as a tool for assessing ecological status: a case study on the Basque coast

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Most efforts in the assessment of the ecological status of marine waters have focused on the macroalgal or zoobenthos components separately. The aim of this work is to develop a new methodology for the assessment of coastal waters quality of the Basque coast according to the European Water Framework Directive (WFD, 2000/60/EC), based on both: algae and invertebrates of rocky intertidal communities. Part of the data used to develop this new protocol was collected during a monitoring study carried out in the Abra de Bilbao and adjacent coast (Basque Country, northern Spain) during the gradual application of a sewerage plan for the metropolitan area of Bilbao. Five sampling stations (including a reference site) distributed along the pollution gradient were studied biannually from 1996 to 2008. Data were also collected from five reference sites during year 2009. The habitat selected to develop the index comprises the tidal fringe from 0.5 m to 1.5 m above low spring tides. A quality index of rocky intertidal communities (RICQI; Rocky Intertidal Communities Quality Index) was calculated on the basis of two known gradients: a spatial and a temporal one. The index combines the abundance data of bio-indicator species as well as various measures of the community: species richness and diversity of algae and invertebrates, algal cover (%), fauna cover (%), fauna/total cover ratio, abundance of different macroalgal functional groups, and trophic strategies.

Keywords: bio-indicators, ecological quality assessment, invertebrates, macroalgae, rocky communities, Water Framework Directive.

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ICES CM 2010/H:32 Poster

A baseline biomarker study for the south coast of Ireland, using the dab *Limanda limanda*

Laura Langan

The south coast of Ireland been fished intensively for at least a century, with Cork and Cobh harbours acting as the major landing ports for both commercial fishing and industrial activities. Subsequently, these activities have led to environmental degradation through heavy-metal pollution and chemical contaminants, with little research undertaken in terms of what impact this has had on the benthic fish populations of the area. This study focuses on the sentinel benthic monitoring species *Limanda limanda*, and uses biomarkers for both the gonads and liver (ALP, MT, LPO, DNA damage, GST in liver and total protein) to describe the related health implications on the fish. Furthermore it will provide a baseline for future fish disease monitoring on the south coast of Ireland.

Keywords: biomarker, gonads, Ireland, *Limanda limanda*, liver.

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ICES CM 2010/H:33 Poster

Responses of size spectra indices to "semi-natural" human pressures: the case of salt works

Aurelia Caldararu, Enrico Barbone, Ilaria Rosati, Maurizio Pinna, and Alberto Basset

The structure of the biological communities is the result of the combined action of an environmental selection, determined by the physico-chemical characteristics of an ecosystem selecting species in function of their traits (abiotic filter), and of an interactive selection based on species competitive ability (biotic filter). Body size is a main individual trait, which seems to influence the individual response to both the environmental and the interactive selections; therefore, to some extent body size dependence is likely to affect community organization and the community resilience to stress pressures. In this work, the importance of both abiotic and biotic filters on the taxonomic and body size structure of benthic macro-invertebrate guilds was evaluated in a hyperalyne transitional water ecosystem, the Margherita di Savoia salt works. In two seasons, spring and fall, the selective action of abiotic filter was studied along four levels of an increasing confinement, whereas the action of biotic filter was estimated within every level. The role of a confinement gradient is fundamental in determining differences in terms of species richness, diversity, evenness, and size spectra among the levels. Taxonomic similarity among confinement levels decreases with decreasing physico-chemical similarity of confinement levels. Densities of *Chironomus salinarius, Corophium* sp., and *Hydrobia ventrosa*, are strongly related to the confinement gradient. Body size spectra also showed defined patterns of variation along the salinity and confinement gradients. A multimetric index of benthic macro-invertebrate size spectra (M-ISS) properly described the strength of the semi-natural salinity stress in the Margherita di Savoia salt works.

Keywords: index of size spectra, macroinvertebrates, Margherita di Savoia, salt works.

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ICES CM 2010/H:34 Poster

Macrozoobenthos quality assessment in the Polish part of the southern Baltic Sea using a biotic index "B"

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A study was conducted to develop a method for the assessment of marine benthic fauna quality specific for the Polish part of the Southern Baltic Sea. A biotic index "B", comprising the criteria required by the Water Framework Directive (WFD) normative definitions, regarding abundance dominance structure, species richness and sensitivity of species to eutrophication pressure, was developed. The applicability of the "B" index and other widely used indices (Shannon–Wiener Index H' and Benthic Quality Index BQI) was tested in relation to eutrophication indicators, using long-term HELCOM COMBINE monitoring data (1987–2009) from the Polish coastal and transitional waters. Results showed that "B" index is responsive to anthropogenic disturbance and reflects specific environmental conditions of the Polish marine areas.

Keywords: biotic index "B", macrozoobenthos, southern Baltic Sea.

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ICES CM 2010/H:35 Poster

Sandy beach invertebrates and their relationships to beach geomorphology and erosion rate: studying community structure in a highly vulnerable system in eastern Canada

M. R. MacMillan and P.A. Quijon

Sea level rise influences the rate of shoreline erosion and constitutes one of the many factors causing spatial and temporal change in sandy beach habitats. In eastern Canada, Prince Edward Island's north shore is particularly vulnerable to surges and storms, with shoreline erosion rates as high as 330 cm $year^{-1}$ recorded in the last decade. Because marine invertebrates associated to exposed sandy beaches are assumed to be primarily controlled by species-specific responses to swash climate and sediment characteristics, they should respond to physical changes such as those linked to erosion. We hypothesized that areas exposed to different levels of erosion exhibit different intertidal characteristics and, consequently, different faunistic densities and distributions. We sampled 12 sandy beaches associated with three main geomorphologic types: dune, till, and sandstone deposits. At each beach we surveyed invertebrates and sediments from the intertidal zone (20 samples per beach). Simultaneously, we measured slope and identified erosion levels based on proximity to erosion monitoring stations established in the area. The highest overall densities were found in sandy beaches associated with dune and till coasts, which coincidentally, also exhibited the highest levels of erosion. Species richness was low but also positively correlated with level of erosion and was highest in dune and till beaches. These results suggest that beach geomorphology and erosion rate play a role in community parameters, and that density and species richness should be explored further in order to identify the best indicators (indices or species) to account for community change and sandy beach monitoring.

Keywords: erosion, marine invertebrates, sandy beaches, sea-level rise.

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ICES CM 2010/H:36 Poster

Morpho-functional parameters of macrophytobenthic communities—indicators of different levels of anthropogenic pressure along the Bulgarian Black Sea coastal and transitional waters

K. Dencheva

As a biological quality element from the Water Frame Directive, macrophytes are strongly indicative of negative changes in the marine coastal and transitional ecosystem, because they directly penetrate the biogenic elements with their surfaces and are the first to react to influence from the land. The aim of this paper is to estimate, with the help of macrophytobenthos, the state of coastal and transitional ecosystems and to differentiate them into corresponding ecological status classes as defined in the Water Framework Directive. The highest biomass values of sensitive species were revealed in Sinemorets, Maslen Nos, and Kavarna (92%, 87%, 84%) and the highest values for tolerant species were detected in Burgas Bay, south part of Varna bay, Krapets, and Varna Lake (100%). The same pattern was established for ecological evaluation index. The highest values of specific surface index were estimated for Sinemorets, Maslen Nos, and Kavarna and the lowest ones were calculated in Maslen Nos (22.9), Kranevo (30.16), Varvara (33.51), Kavarna (37.37), and Sinemorets (44.98). The final results obtained through application of universal, cost-effective morpho-functional parameters have revealed good status in the southern parts of the Bulgarian Black Sea Coast, from Maslen Nos to Sinemorets, and the northern parts—Kavarna and Kranevo—but poor status in Burgas Bay, the southern part of Varna Bay, Krapets, and Varna Lake.

Keywords: Ecological Evaluation Index, ecological status classes, eutrophication, macrophytobenthos, specific surface, Water Framework Directive.

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ICES CM 2010/H:37 Poster

A system for the spatially explicit modelling of communities of class-structured benthic organisms

J. A. Beecham, M. D. Platts, and S. Jennings

Benthic communities are determined by structure (bathymetry, currents, temperature, and seabed type) and by interactions with food sources, disturbance, and predation, which are likely to be non-uniform in space. A model was constructed in which spatio-temporal data could be input as a GIS layer and interacted with the functional relationships for colonization, competition, predation, growth mortality, and spawning. These functional relationships can be specified as add-on functions and applied to a complex, spatially organized, functional group by means of operator overloading. By encapsulating the low-level representation of spatial data within the functional group, the model is efficient in its memory access patterns. The size-based structuring, which allows predation and competition between functional groups to be expressed, is combined with an orthogonal variable used to express the proportion of calcified material, such as shell. By expressing the coefficients of biological process as a range of values determined by a function, the data layers could be used to modify the parameters of the biological processes. An example is shown in which a GIS layer describing frequency of beam trawling is combined with an empirical model of mortality resulting from disturbance, to demonstrate the effect of beam trawling on growth and biomass of benthic infauna and epifauna communities. The data layers can also be used to represent information from linked models such as ERSEM, either online through coupling, or offline as a netCDF file.

Keywords: beam trawling, benthic model, calcification, GIS, stage-structured model.

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Theme Session I

Development of environmentally responsible fishing gear using knowledge of fish behaviour

ICES CM 2010/I:01

Fish pots trials in the bay of Douarnenez (Brittany, France)

Sonia Méhault, Fabien Morandeau, Pascal Larnaud, Mathieu Mouchel, and Marc Meillat

Fishing using fish pots is of growing interest along the French coastline. Ifremer, together with the fishing industry, conducted a project to develop new prototypes of fish pot suitable for the local fisheries. After development in flume tanks, five different designs of pots were tested on board the RV "Thalia" in the bay of Douarnenez (Brittany, France). These trials looked at the ergonomy and behaviour of the gear, and tested the effect of pot height and design on catches. Specific interest was in limiting the catch of conger eel (with low market value) while maintaining high catches of other commercial species. Each model of pot was used at three different heights daily (0, 1, and 2 m). Catch data were obtained for 3×5 pots over 13 days. The main catch was common pout and conger eel. Analysis of the catch data showed that the gear design and mesh size have an effect on pot performance and selectivity. One of the pot models (with a bottom side entrance) was efficient at limiting the conger eel catch, with an acceptable catch of common pout. The pot height affected the catch of both species. The models with the most interesting catch potential are currently being used by fishers to be assessed under professional conditions.

Keywords: common pout, conger eel, fish pots, sea trials.

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ICES CM 2010/I:02

Toothfish fishery around Crozet islands: from longline to trap, an alternative solution for "depredation"

G. Bavouzet, G. Duhamel, C. Guinet, J. P. Kinoo, F. Morandeau, Mathieu Mouchel-Grillot, N. Gasco, and J. Roullot

The toothfish (*Dissostichus eleginoides*) fishery, which has been managed with exemplary stock control, is threatened by killer whales and sperm whales taking the fish from longlines, especially around the Crozet islands. This depredation increased by 41% in the period 2003–2008. The natural diet of killer whales has been disturbed and this has decreased the toothfish fishery's efficiency and compromises its economic balance. Preliminary trials with pots (traps) caught crabs around the Crozet Islands, but toothfish avoid traps if crabs are inside. Professional fishers, fishery scientists, and local government are looking for a technical solution to decrease interactions between the ecosystem and fisheries, and to preserve resources through quotas, while maintaining economic activity. The ORCASAV campaign goal is to develop and test alternative fishing gear techniques (trap-based) or longlines able to avoid depredation. Over 45 days, 11 trap models were tested on a specially chartered vessel, the "Austral Leader II". Comparative tests with longlines were done. The results of the campaign should allow assessment of the economic viability of the toothfish trap fishery. This presentation shows the preliminary results of the ORCASAV sea trial. Six fishery companies (united in a consortium: SARPC), three research institutes (MNHN, CNRS, and CRBC-Ifremer), and one trap-maker (Le Drezen) are involved in this project.

Keywords: depredation, fishery, toothfish, trap, longline.

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ICES CM 2010/I:03

Fish pots—"the dark side"

M. Breen

Fish pots have been identified as a potentially "responsible" fishing gear (ICES WGFTFB Topic Group on Alternative Fishing Gears, 2006), in particular with respect to their environmental sustainability in terms of reduced environmental impact, low energy cost, and the welfare of the catch and any incidental catch. However, this gear does have the potential to detrimentally affect the marine ecosystem and the users of this resource in a number of ways: ghost fishing; capture and entanglement of non-target, endangered, and charismatic species; physical impact on the benthic environment; contribution to marine debris and its associated effects; and conflict with other users. This paper will review these potentially detrimental effects with respect to the continued development of fish pots as a "responsible fishing gear". It will identify their main causes and suggest possible solutions and mitigation measures.

Keywords: bycatch, environmental impact, fish pots, ghost fishing, marine debris, responsible fishing gear, unaccounted fishing mortality.

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ICES CM 2010/I:04

The development of the fish pot as a survey tool in inshore waters

M. Breen, J. Mair, and F. Neat.

Inshore waters are often inaccessible to traditional survey gears (e.g. GOV trawl) because of the topography, nature, and sensitivity of the seabed habitats in those areas. Fish pots have been identified as a potentially "responsible" fishing gear (ICES WGFTFB Topic Group on Alternative Fishing Gears, 2006), in particular with respect to their environmental sustainability in terms of

reduced environmental impact, low energy cost, and the welfare of the catch and any incidental catch. This paper will review a series of small-scale trials conducted by Marine Scotland—Marine Laboratory (formerly Fisheries Research Services) in the development of a fish pot design as an alternative survey tool. The preliminary development trials considered a number of specific pot design concepts, including entrance design, the number of retaining compartments in the pot, and bait delivery. In addition, fish pots were compared alongside a demersal trawl and baited cameras in inshore waters in and adjacent to Loch Ewe, Scotland, to assess the effectiveness of each as a survey tool. The fish pots proved the most successful of the techniques in providing quantifiable numbers of fish. In addition, they allow the identification of significant differences in species assemblage at a relatively high resolution (i.e. sampling stations were approximately 1 nm apart). The limitations of fish pots as a technique for providing absolute measures of abundance are recognized and discussed.

Keywords: fish behaviour, fish pots, survey tool.

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ICES CM 2010/I:05

Selection of smaller individuals of herring (*Clupea harengus* membras) through rigid grids, under the influence of abiotic and biotic factors in a herring push-up trap

Mikael Lundin, Linda Calamnius, Lars Hillström, and Sven-Gunnar Lunneryd

The increasing population of grey seals (*Halichoerus grypus*) in the Baltic and Bothnian Seas is threatening the coastal fisheries. The seals raid traditional fishing gears and cause considerable material damage. There is an urgent need to develop seal-safe equipment, which prevents seals from damaging the catch and replaces existing fishing techniques. For a sustainable fishery, the equipment should fish selectively and only catch individuals above a critical size. The purpose of the present study was twofold: first, to test and evaluate rigid grids as a method for selecting smaller individuals of herring (*Clupea harengus*) from the catch in a push-up trap, and second, to analyse which abiotic and biotic factors were important for the selection. The investigation was performed through analysis of video recordings and measurements of water temperature and currents. The results demonstrated that selection of smaller individuals is possible in a fish chamber, as the efficiency of selected herring can be as high as 27% when using a grid, which represents a little above 1‰ of the total area of the chamber walls. The factors that had most effect on the selection were fish quantity in the trap, visits of seals, time of day, and season. There was also a significant negative correlation between selection and current velocity. Highest degree of selection was reached during the night, at the end of June, and in the presence of seals. The study will be continued in 2010 by investigating eventual mortality of grid-selected herrings.

Keywords: Baltic Sea, grey seal, grid, herring, push-up trap, selection.

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ICES CM 2010/I:06

Fish behaviour patterns as a basis for determining catching parameters of fish pots

Yuri V. Gerasimov, Oleg M. Lapshin, and Ivan G. Istomin

In order to design environmentally responsible fishing gear we need to address three problems: does this fishing gear provide optimal selectivity range (e.g. bycatch of undersized fish is minimum); does it disturb or destroy biotopes; and does it provide minimum bycatch of rare or unwanted species? To understand the interrelation between fish behaviour and the catching processes of pots we carried out a series of experiments in laboratory conditions. Based on ecological and physiological parameters we compared 14 freshwater species for maximum compliance and chose perch as a prototype species for cod. Tasks in the experimental study

included determining the catchability of the pots in relation to: pot construction, ingress cone construction, soak time, and environmental conditions (presence of current, reef structures, etc.). Consideration of the catchability of rectangular and cylindrical pots relative to their construction showed no differences, provided they were positioned on sites where there is no overall direction of fish movement. The catchability of the rectangular pot was significantly higher when pots were positioned on sites with unidirectional fish movement. Studies of the catchability and retaining capacities of the pots in relation to ingress cone construction showed that this is more important in determining the retaining capacity of pots than their catchability.

Keywords: bycatch, catchability, environmentally responsible fishing gear, pots.

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ICES CM 2010/I:07

The effect of escape windows on the capture of Baltic cod in floated pots

M. Ovegård, S. Königson, A. Persson, and S. G. Lunneryd

In the Baltic Sea, floating pots fishing for cod (*Gadus morhua*) have been tested as an alternative fishing gear to gillnets. In the development of new fishing gear, it is important to look at many factors, such as reduction of bycatch of undersized fish. Several studies have focused on improving the escape of undersized cod from fishing gear. However, little is known of the size selectivity patterns of escape windows for cod in passive fishing gear. In this field study, pots were equipped with 40-, 45-, and 50-mm square mesh windows in order to estimate the size selectivity of cod at different mesh sizes. Correlations between selectivity parameters and mesh size, and an optimal mesh size for the escape window (regarding the minimum landing size of cod) were sought. Results show that the escape window reduced the undersized cod in the pots to levels lower than other gears used in the cod fisheries. The length of 50% retention was found to be a direct function of length of the fish and mesh size, whereas the selection range remained unchanged regardless of mesh size. The 45-mm escape window proved to be optimal with regard to retaining cod with a minimal landing size of 38 cm. Strong indications also suggested that the relative fishing power of the pots increased with the use of escape windows. An explanation could be that a higher density of fish, as the catch in the pots without an escape window, probably inhibits more large cod from entering the pots.

Keywords: escape window, floated pots, *Gadus morhua*, size selection.

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ICES CM 2010/I:08

Properties of odour plumes from baited traps

Håkan Westerberg and Karin Westerberg

The detection range of a baited pot or trap depends on several, more or less interconnected factors. The concentration and rate of release at the bait of the chemical substance acting as an attractant will be determined by the properties of the bait and by the ambient current speed. A plume of attractant is formed by advection and turbulent diffusion in the area surrounding the pot, with a gradually diminishing mean concentration downstream but often with strong concentration fluctuations. Depending on the type of gear, the hydrodynamic conditions in the plume can be a boundary layer or free-stream conditions. Finally, the actual detection range will depend on the chemosensory detection and reaction thresholds of the target fish. A semi-quantitative analysis is made of the different stages in this transmission chain and of how the overall detection range varies in time. This is illustrated by modelling the odour plume for different cases.

Keywords: detection range, mixing, odour plume, pots.

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ICES CM 2010/I:09

The presence of experienced cod (*Gadus morhua*) facilitates the acoustic training of naïve conspecifics

Björn Björnsson, Hjalti Karlsson, and Sigmar Gudbjörnsson

Cod were trained to associate a 250-Hz sound with food by classical conditioning in the presence or absence of trained fish. Adult cod adapted to sea cages were placed in the experimental cage located 80 m from the shore. There were two feeding trays, placed on opposite sides of the cage, each equipped with a transducer, video camera, and a feeding pipe through which small pieces of herring could be delivered from shore. There were six training sessions per day. In the first experiment, 20 naïve fish were trained on their own. On the third day, the fish started to eat the feed and learned to search for feed on the feeding trays. At the end of the sixth day, there was an indication of an acoustic training and on the ninth day, the fish reacted consistently to the feeding sound. In the second experiment, 10 naïve cod immediately started to follow a group of 9 experienced cod to the feeding trays. In the third experiment, 19 naïve cod and 1 teacher were released into the cage. In the first session, the teacher reacted correctly to the sound signal. After 13 minutes, the first student was seen following the teacher and by the end of the day, there were several students following the teacher. After two days of training, the teacher was removed to see if the students had acquired the acoustic training. Already in the first acoustic session on their own the students reacted correctly to the sound signal.

Keywords: acoustic training, cod, fish behaviour, *Gadus morhua*, sound signal.

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ICES CM 2010/I:10

Determining the seasonal catchability of Atlantic cod *Gadus morhua* pots

Robert Marcella, Michael Pol, and Mark Szymanski

A worldwide interest in investigating and improving the capture of Atlantic cod (*Gadus morhua*) using fish pots currently exists. This interest is fuelled by the potential for cod pots to be an environmentally responsible alternative gear because of their species selectivity, low energy, and low impact. To further development of pots, paired comparisons of two different designs were conducted over an eight-month period in Massachusetts Bay, USA. Newfoundland-style, large, large-mesh static pots were compared with Norwegian-style smaller, small-mesh, off-bottom, dynamic pots in a controlled study from a commercial fishing vessel from November 2008 to November 2009. Results from analysis indicate that cod were most vulnerable to pots during a limited season, and that the smaller mesh pot caught more small cod. Otherwise, the pots performed similarly. We conclude that either pot style may be effective for further development, that seasonality plays an important role and should be exploited for further testing, and observation of nearfield behaviour in cod near pots is still vital and problematic.

Keywords: Atlantic cod, behaviour, *Gadus morhua*, pot.

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ICES CM 2010/I:11

Alternative stimulation to direct fish into fish pots

Bjarti Thomsen

A project to develop fish pots with increased catch efficiency for traditional fish species has been carried out in the Faroe Islands since late 2005. The project has generated a substantial amount of underwater video observation of fish behaviour around fish pots, especially of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). On several occasions fish (cod) has been observed to be attracted to (sudden) movement of other fish. It is not clear whether this is a result of purely visual stimuli or whether sounds and mechanoreceptor stimuli are also involved. To investigate this further electronic vibrating devices have been developed. The initial experiments with these devices have yielded ambiguous results. Further behavioural studies of fish around fish pots will be conducted to clarify whether additional stimulation to bait can be found to attract and direct fish to readily enter fish pots and thereby increase catching efficiency.

Keywords: alternative stimuli, fish behaviour, fish pots.

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ICES CM 2010/I:12

Cod pots—an alternative fishing gear to nets and hooks?

Sara Königson, Sven-Gunnar Lunneryd, and Fredrik Ljunghager

The need to develop alternative fishing gear in the gillnet fisheries of the Baltic Sea has increased in recent years because of the growing conflict between seals and fisheries. A potential alternative are cod pots. In this study we have investigated the fishing efficiency of cod pots used in a commercial fishery over the 2009 fishing season. The catches from cod pots were compared with catches from gillnet and hook fisheries in the same area. A fisher located in the central Baltic Sea was contracted to carry out a pot fishery for cod using up to 96 pots through the fishing season. The cod pots used were floating approximately 0.5 m above the bottom with only one entrance downstream. The pots were baited with herring and linked eight together on a bottom line. In all 4208 pots were emptied during 100 fishing days. The mean catch per pot was calculated as 3 kg of cod (>38 cm, commercial landing size). The catch varied over the season with a maximum catch of 5.2 kg per pot in August and a minimum in April of 1.6 kg per pot. It is possible to empty 100 pots per day and the calculated mean catch per boat is therefore 300 kg per day. All licensed fishers must report their catch and effort to the EU logbook. Reports from fishers fishing more than 10 t of cod per boat in 2009 with hooks or gillnets and in the same area as the pot fisheries were included in the analysis. The mean catch per boat and day was 396 kg, with a maximum of 521 kg in June. The mean catch per boat fishing with hooks or gillnets in 2009 was 25 800 kg. We have estimated that the pot fisheries will have two more fishing days per month than the gillnet and hook fisheries because the pots can be left in the sea until next emptying. With the number of fishing trips carried out in the gillnet and hook fisheries as a base, the calculated catch for the 2009 pot fishery would be 33 600 kg.

Keywords: alternative fishing gear, cod pots.

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ICES CM 2010/I:13 Poster

Size selectivity of the stake net (set-net, *no sao*) for *Metapenaeus ensis* with the mesh size at collecting trap of 12, 15, and 18 mm

Hai P. Nguyen, Dong V. Nguyen, and Phuoc Nguyen

Stake net (set-net or *no sao* (in Vietnamese)) is the most popular static fishing method in Tam Giang, Cau Hai lagoon, Vietnam. This method of fishing comprises fences to herd and guide aquatic animals and a collecting trap. The current mesh size for the collecting trap is 4–6 mm and therefore

the trap retains all specimens, including the juveniles. *Metapenaeus ensis* is the main target species of the fishery. Selectivity studies were conducted in March of 2010 to investigate the size selection of the 12-, 15-, and 18-mm mesh size at the colleting traps. In all 45 aquatic species were found in the catch. In addition, outcomes also showed that the L_{50} of *Metapenaeus ensis* was increasing from 3.14 cm (TL) for 12-mm mesh to 4.76 cm for 15-mm and could reach 5.92 cm for 18-mm. There were significant differences between the length of *Metapenaeus ensis* inside the collecting trap and retained in the cover. The results are discussed with regard to acceptable mesh sizes in the collecting traps for the stake net fishery to reduce the catch of juvenile *Metapenaeus ensis*.

Keywords: *Metapenaeus ensis*, No sao, set-net, stake net, selectivity, static fishing gear, Tam giang—Cau hai.

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ICES CM 2010/I:14 Poster

The push-up trap: an environmental solution in solving the seal problem for small-scale fisheries

Mikael Lundin and Linda Calamnius

The Baltic and Bothnian Seas have experienced a dramatic increase of the grey seal (*Halichoerus grypus*) population in recent decades. This increase has resulted in more raided and damaged fishing gear, leading to serious conflict with the fishing industry. In year 2000 a new type of fishing gear was developed. This type of fykenet, commonly called a push-up trap, is a further development from traditional fykenets and has been considered a solution for small-scale fisheries in the Baltic and Bothnian Sea. The push-up trap is constructed to minimize raiding and damage by seals. In addition, it fishes selectively, allowing inferior quality fish to pass through a selection grid. The catch is easy to collect by filling air in pontoons and the entire fish chamber is raised above the surface. The catch is protected as the traps have double walls, and if the weather is unfavourable it can remain in the fish chamber until emptying is possible. Studies have shown that raiding seals are generally a small minority of specialized individuals. By fitting the push-up trap with a device, these individuals can be caught in a separate section of the trap. The device has been inspected and approved by the Swedish Veterinary Association and the Swedish Environmental Protection Agency. This device can be a substitute for a complicated licence to hunt. The push-up trap could also be used in other areas of the world where fishing industries are experiencing similar problems.

Keywords: Baltic Sea, Bothnian Sea, grey seal, pontoons, push-up trap, selection grid.

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ICES CM 2010/I:15 Poster

Development of an experimental lampara net fishery for Atlantic saury (*Scomberesox saurus*)

D. Rihan and H. Tan

The Atlantic saury, *Scomberesox saurus*, is a fish of the family Scomberesocidae found in the Atlantic Ocean and also in the Mediterranean. The fish grow to ca. 35 cm in length, with a maximum of 50 cm, and have beak-like jaws and a row of finlets behind their dorsal and anal fins. It is an underexploited fish in many parts of its range and suitable for canning and other inexpensive uses. For a number of years Irish fishers have reported seeing large quantities of saury around the Irish coast in the early autumn. Following some preliminary work in 2005, Bord Iascaigh Mhara (BIM) carried out technical trials off the southwest coast of Ireland in 2009 with lampara nets. The lampara is an artisanal method suited to smaller vessels which are able to fish in areas closed or otherwise inaccessible to larger boats by virtue of draft or similar restrictions. During daylight hours the method used to locate fish was to observe feeding seabirds and to shoot around the area of the heaviest activity. This proved productive during daylight hours and small catches were made during the initial sets. At night the net was deployed with two submersible underwater

fishing lamps, using the natural behaviour of saury to be attracted to light. The night-time shots proved less productive, and there were some problems deploying the lampara net and the lights. This paper details the experimental methods deployed and the initial results. It also discusses the requirements for the future development of an Atlantic saury fishery which will require more comprehensive research into the biology of the species, and an understanding of the effects of harvesting this species on marine ecosystems, given it is an important prey species.

Keywords: Atlantic saury, lampara, light, marine ecosystem.

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ICES CM 2010/I:16 Poster

Inshore spawning habitats for English Channel cuttlefish (*Sepia officinalis*): preliminary observations of substratum choice for egg attachment

I. Bloor, F. Bezin, J. P. Robin, E. L. Jackson, and M. J. Attrill

The cuttlefish (*Sepia officinalis*) is an increasingly important resource for English Channel fishers. It is exploited by a range of métiers at almost all stages of its migration cycle. In spring, spawners are caught inshore with traps, a gear that is suspected to generate losses of eggs that female attach to these devices, which are unfortunately removed from the water before hatching. The environmental impact of trap fishing cannot be assessed without knowing what natural substratum is chosen by female spawners. Within the European project CRESH (Cephalopod Recruitment from English Channel Spawning Habitats), new observations are starting in pilot study sites on both English and French coasts. Each pilot site is divided into a set of strata defined according to depth, bottom type, and dominant biotope, and diving observations are made in order to test the hypothesis of differences between substrata in the density of eggs. Although fieldwork has to take into account differences in hydrodynamic conditions between sites, combined observations are necessary to study this issue at the scale of the English Channel stock.

Keywords: cuttlefish, cephalopod, fisheries, habitat, spawning.

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Theme Session J

Environmental sustainability of aquaculture activities in coastal zones

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ICES CM 2010/J:01

Numerical modelling of aquaculture contaminants in a southeastern lagoon of the Caspian Sea

A. Najafi-Jilani and M. Monshizadeh

The water quality in a restricted lagoon on the southeast coast of the Caspian Sea is investigated. Numerical modelling is used to study the effects of contaminants that discharge into the lagoon from an adjacent industrial plant. The numerical model is a coupled hydrodynamic and advection–dispersion model which is calibrated using field measurements. Various ratios of pollutant decay are considered in numerical modelling. The results are used to determine the flushing time of lagoon. It was concluded that the accumulation of pollution in lagoon will occur because of the long flushing time and low-order wind-induced water current. The effect of pollutant decay on the water quality of lagoon is also investigated.

Keywords: aquaculture, Caspian Sea, contaminants, numerical modelling, restricted lagoon.

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ICES CM 2010/J:02

Accumulation and mineralization of fish farming residuals in the footprint area of two different farming locations in a Faroese fjord

Gunnvør á Norði, Ronnie N. Glud, Knud Simonsen, and Eilif Gaard

The dispersion, accumulation, and benthic mineralization of organic matter at two trout farming sites in a Faroese fjord were quantified in relation to feeding rates and local hydrodynamics. At the small farm (2025 m^2) the food supply increased from 642 to 768 kg C d^{-1} during a 2.5-month study period. At the larger farm (31 556 m^2) the feeding activity increased from 2292 to 7361 kg C d^{-1} over a study period of 7 months. Six per cent and 10% of the carbon input in the form of feed settled in the 17 210 and 70 200 m^2 large footprint area of the small and large farms, respectively. During these periods ~40% of the sedimenting material accumulated within the footprints, whereas the reminder was mineralized. The sedimentation of farm residuals corresponded to less than 10% of the natural sedimentation and benthic mineralization was linearly correlated with the concurrent sedimentation rate.

Keywords: accumulation, benthic impact, footprint size, mass balance, mineralization, organic carbon.

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ICES CM/J:03

Working toward consensus: application of carrying capacity in management of bivalve aquaculture

C. J. Byron, D. Bengtson, R. Rheault, D. Alves, D. Beutel, and B. Costa-Pierce

We present a framework for determining carrying capacity (CC) through mass-balance ecosystem modelling and stakeholder involvement that can be used to guide management of bivalve aquaculture. Two Ecopath models were constructed for Narragansett Bay (NB) and coastal ponds (CP), Rhode Island, USA, where aquaculture has doubled in six years and user conflict is high. Stakeholders informed the modelling process at four critical steps: conceptualization of models, evaluation of data sources for parameterization, mass-balancing of the model, and calculation of carrying capacity. Cultured oysters were not a significant part of NB or CP, despite rapid increase in the industry. Cultured oyster biomass in NB is currently at 0.5 Mt km^{-2} and could be increased 625 times without exceeding the ecological CC of 297 Mt km^{-2}. Production CC was calculated to be 3481 Mt km^{-2}, which could exist over only 9% of NB surface area without exceeding the ecological CC. Cultured oyster biomass in CP is currently at 12 Mt km^{-2} and could increase 62 times this value without exceeding the ecological CC of 722 MT km^{-2}. Production CC was calculated to be 1561 Mt km^{-2}. CP could support this high level of biomass production across 46% of its surface area before exceeding the ecological CC. Harvest was 40% of biomass. Both CP and NB were more productive and had higher CC than oligotrophic and heavily cultured New Zealand bays. Involving the stakeholders in the modelling process increased understanding and acceptance of the science, making the results more likely to be incorporated into future management and policy formulation.

Keywords: carrying capacity, Ecopath, stakeholder involvement, mass-balance modelling, user conflict.

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ICES CM 2010/J:04

Can genetic improvements in aquaculture reduce the impact on fisheries? The case of European sea bass (*Dicentrarchus labrax*) fed on a totally plant ingredient-based diet

R. Le Boucher, M. Vandeputte, M. Dupont-Nivet, E. Quillet, D. Mazurais, J. Robin, A. Vergnet, F. Médale, S. Kaushik, and B. Chatain

In recent years, the increase in aquaculture production has led to changes in feed composition with an increasing substitution of fishmeal (FM) and fishoil (FO) with terrestrial plant products. During the same period, selective breeding procedures have been developed with a recent focus on genetic variability for the ability to grow on plant ingredient-based diets. Genetic parameters were estimated in a context of extremely contrasted diets in European sea bass. In total 784 individually tagged fish from 328 families were reared in a common garden design and DNA sampled for parentage assignment using microsatellites. At 192 g they were distributed into four tanks, two fed on a diet (diet M) based on FM and FO, and two fed on a FM- and FO-free diet (diet PB). Body weight, length, and lipid content of the fillets were recorded at 850 days post-fertilization. Traits were analysed with a restricted maximum likelihood (ASREML) methodology. Analyses of data show that: (i) there was no difference for weight, length, and fillet lipid content between diets ($p = 0.06$), (ii) family ranking for these three traits was not consistent among diets (genetic correlations between 0.51 and 0.87), (iii) heritability estimates (PB: 0.37 ± 0.18; M: 0.47 ± 0.24). Our results clearly point out that exploitation of such a variability could (i) modify the genetic gain in current selection programs and (ii) be used to select fish adapted to novel FM and FO free feeds.

Keywords: *Dicentrarchus labrax*, genetic improvement, genotype–diet interaction, plant ingredient-based diet.

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ICES CM 2010/J:05

Economic shellfish farming vulnerability because of microbiological contamination of the Thau lagoon. A modelling approach using an integrative systematic platform

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The Thau lagoon hosts the main shellfish farming production area of the French Mediterranean Coast. It represents an important sector locally, providing employment and economic rents. However, this economic activity is threatened by various ecosystem disturbances, including the increase of microbiological contamination of the catchment that enters the Thau lagoon. Shellfish is frequently polluted because of the filtration of water masses plumed by the catchment outlets. The potential for risks to consumers leads to commercial bans if *E. coli* concentrations of shellfish are higher than the thresholds defined by European regulations. The scope and recurrence of these events determine the sanitary classification of the production area and whether animals require purification processing. The aim of this paper is to assess the socio-economic vulnerability of this local shellfish farming sector confronted with several scenarios of water quality dynamics. The analytical framework is based on a systemic modelling approach developed within the Spicosa project. The development of an integrated model allows a holistic description of the interactions between the anthropogenic activities located around the catchment, the physical and abatement contamination processes, and the governance mechanisms that implement environmental policies. The model provides a multidimensional integrative assessment of different environmental policy options described by different scenarios in terms of (i) cost and efficiency of different policy options and (ii) impacts of different technical management options on the shellfish farming sector. The heterogeneity of impacts depends on the vulnerability of companies. They are calibrated by a field study.

Keywords: dynamic modelling, integrated assessment, microbiologic contamination, shellfish farming.

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ICES CM 2010/J:07

A tripartisan (science, industry, and government) approach to adaptive ecosystem management and sustainable aquaculture development

Catriona Macleod and John Parslow

Although it is extremely important that the aquaculture industry both identify and address any environmental issues that may limit their production and development, it is also important that the industry recognizes those issues which are important to both the broader community and regulators. Shared environmental knowledge provides a fundamental support framework for integrated ecosystem management, and will provide the industry with a social licence to operate. Historically, the aquaculture industry in Tasmania has worked collectively and very closely with regulators in developing their environmental management strategy. However, this has largely been based around aquaculture specific issues and interactions. As our understanding of the connectivity of estuarine and marine systems improves, it is clear that aquaculture needs to be placed in context with other ecosystem processes, and that management strategies require an integrated approach. The Tasmanian aquaculture industry is well placed to step up to the mark on this; in southeast Tasmania industry, regulators, and scientists are involved in a multidisciplinary approach to support regional ecosystem management and sustainable development. Historical , current, and proposed research datasets are being pulled together from a range of research, government, and industry sources to support a modelling and information system that will underpin regional development activities. The local aquaculture industry is engaged in this programme, which will require them to work with other industries, research organizations, and State government to ensure that their operations are supported by a fully integrated adaptive management system with a transparent and accessible information network.

Keywords: adaptive management, aquaculture and environmental sustainability, ecosystem processes, information systems.

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ICES CM 2010/J:08

Monitoring production and environmental effects of seed mussel collectors in Dutch coastal waters

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In the Netherlands, mussels (*Mytilus edulis*) are farmed on bottom plots in two coastal areas: the Wadden Sea and the Oosterschelde. For this, small mussels (seed) are fished from natural beds. At present, the farmers are in a transition process from fishing seed from the bottom to harvesting seed with pelagic collectors. This is a response to pressure from society to reduce bottom dredging and the desire to safeguard a steady supply of seed mussels. A seed collector consists of nets or ropes that are placed in the water column when larvae are present. A stepwise approach is taken: every two years a decision on reduction of seed fishing and expansion of the area reserved for seed collection is made based on the annual yield of the collectors. The first tests with seed mussel collectors started in 2000 and the method showed a rapid development. In 2009 the total yield was 7.9 million kg. The new method and its associated activities may have a number of environmental effects. Two effects will be discussed in more detail: (i) The shift from fishing to using collectors results in a higher mussel biomass, because natural beds are no longer fished and spat survival is enhanced on the collectors. Competition for food between the extra mussel biomass and natural shellfish populations may affect the primary productivity, and thus the carrying capacity, of the area. (ii) Deposition of faeces originating from seed collectors may cause local organic enrichment of the sediment and ultimately changes in local benthic fauna diversity.

Keywords: aquaculture, carrying capacity, deposition, seed mussel collectors.

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ICES CM 2010/J:09

Viral haemorrhagic septicaemia in Norway—possible interactions between farmed and wild fish

Nina Sandlund, Renate Johansen, and Øivind Bergh

VHS (viral haemorrhagic septicaemia) was detected in a Norwegian rainbow trout farm in 2007, the first case for more than a decade. The disease was also diagnosed in two other farms in the vicinity (the same fjord system) in 2007, in further two farms in 2008, and one farm in 2009. VHS virus was cultured and sequenced from each outbreak and all isolates from farmed fish have been found to belong to genotype III, the first detection of genotype III in rainbow trout. The source of the virus is not known, but because of the genotype of the causative virus, and the highest sequence similarity is observed with VHSV isolates from northern European waters, a marine source is most likely. Results from challenge experiments with marine fish larvae of this and other VHS isolates is presented. Globally, VHSV has been isolated from 82 different freshwater and marine fish species. It has been hypothesized that cultured and susceptible fish, such as rainbow trout, may be infected by wild marine fish, with subsequent proliferation of the agent within farms, followed in turn by increased challenge pressure from the farms towards wild populations. Thus, a screening of wild fish so far comprising about 2000 fish from a variety of species in Norwegian coastal waters was initiated, and tentative results will be described.

Keywords: aquaculture, disease, transmission, VHSV, wild fish.

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ICES CM 2010/J:10

Mortalities of *Crassostrea gigas* (Thunberg) cultured in a subtidal bay (Bay of Quiberon, France), in relation to environmental conditions

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The Bay of Quiberon is one of the main French oysters farming areas, with a specific on-bottom mode of culture. In order to understand the role of environmental factors on oysters mortalities and test the existence of eventual "mud effect", a research programme was undertaken in 2008. Within the cultivated area of 3000 ha, five stations were chosen, based on differential depth (between 3 and 10 m) and silt proportion of sediment. Oysters 1.5 years old from the same batch were initially distributed over the stations and then sampled periodically. Sedimentology, bacteriology, and oyster physiology were studied. Sediment toxicity was estimated through bivalve embryo bioassays. High differences in mortalities were recorded between sites, with upper mortalities (above 60% annually) in deep (>7 m) and muddy sites and lower mortalities (below 30%) in shallow sites. Shell blisters with gel, potentially linked to tributyl stain from antifouling paints, were observed in 50–65% of the deepest stations of the bay. Embryo toxicities vary slightly between dates and stations, but they are relatively small (<10% abnormal larvae at 5 g l^{-1} of dry sediment). Submarine observations from divers and shell examinations showed a major impact of predators (starfish and boring snails). A statistical but non-causative relationship has been revealed between oyster thickness index and abnormal mortalities. In this type of culture, the microenvironment in which the oysters live is difficult to capture precisely. As stated in previous studies, several factors may interact to provoke such summer mortalities in oysters.

Keywords: *Crassostrea gigas*, mortality, Quiberon, sediment.

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ICES CM 2010/J:11

Salmon farms, seals, and cetaceans in Scotland: a triangle of troubles

Simon Northridge, Jonathan Gordon, Cormac Booth, and Susannah Calderan

Salmon farms are often sited within the natural range of marine mammals, leading to complex interactions with these important biological assets. Pinnipeds in particular routinely use the habitat around coastal farm sites without causing problems, but serious depredation events can result in direct mortality of fish, escaped fish, and can induce stress, leading to reduced growth and increased disease susceptibility. The management procedure of last resort, lethal removal, effects individual seals, but overall impacts on local populations are usually unknown. The use of acoustic deterrent devices (ADDs) has been shown to affect local densities of odontocete cetaceans, which are more affected by ADD acoustic signals than seals. For this reason, ADD use in Scotland has been restricted in some areas thought to be particularly important for porpoises. We have quantified the effect of ADDs on porpoises at two operating fish farm sites in Scotland over several months. We used automated click detectors (T-Pods) to detect porpoise click trains around sites when ADDs were active and inactive. We also monitored one of these areas over three consecutive summer seasons with and without ADDs using towed hydrophones. There was a change in porpoise click detection rates several kilometres from each site when ADDs were active, but some porpoise activity continued to occur even within 200 m of active ADDs. We also found that once the ADDs are inactivated, porpoise click detections increase almost immediately, suggesting no long-term exclusion effect. These results are discussed in relation to conservation of porpoises in Scottish coastal waters.

Keywords: acoustic deterrent devices, conservation and marine planning, pinniped fishery interactions.

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ICES CM/J:12

Evaluation of dose–response effects of farmed mussel biodeposition on benthic communities

Christopher W. McKindsey, Pauline Robert, and Philippe Archambault

Much work has examined the influence of biodeposition from bivalves in suspended culture on benthic infaunal communities. However, most such studies have been comparative in nature, contrasting sites with culture to various control or reference sites; little effort has been directed at determining the dose-dependent effects of biodeposition on such communities. This study evaluated the dose-dependent response of benthic communities to varying levels of biodeposition using benthic mesocosms in the Magdalen Islands, eastern Canada. Mesocosms (60 cm diameter) were placed *in situ* (i.e. in the natural muddy sand seabed adjacent to an existing mussel farm) and received biodeposition from known densities of mussels which were placed in cages overlying the mesocosms. Densities chosen mimicked biodeposition from mussels at densities of 0, 200, 400, 600, 800, 1000, 1200, and 1400 mussels m^{-2} as well as control areas (i.e. without mesocosms). Replicate 10-cm-diameter samples were collected from each mesocosm following 60 days incubation and the experiment halted. There were clear visual effects from biodeposition and, overall, benthic communities responded as predicted *a priori* to organic enrichment because of biodeposition. Results are discussed with respect to their importance to predictive ecological modelling for sustainable bivalve aquaculture. Shortcomings of the experiment and ongoing work to address this are also discussed.

Keywords: benthic effects, biodeposition, dose-dependent effects, mesocosm, mussel aquaculture,

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ICES CM 2010/J:13

Potential inbreeding of farmed Atlantic cod (*Gadus morhua*) and subsequent quality and effect of embryos released into the environment

Olivia A. Puckrin, Edward A. Trippel, and Craig F. Purchase

Farmed Atlantic cod (*Gadus morhua*) have been found to spawn in sea cages, potentially creating a risk to severely depleted wild cod through the escape of fertilized eggs. High fecundity leads to potentially thousands of siblings within a cage, increasing the likelihood of inbreeding during spawning. However, inbred offspring may be so negatively affected that they cannot survive to reproduce, in which case stocking cages with directly related cod could be a means of ensuring that farmed cod do not interact genetically with wild cod. The objectives of this project were to determine if farmed female cod avoid inbreeding by selecting non-brother males when spawning, and to determine if the offspring of inbred cod face reduced survival and quality. Eggs were collected (winter 2010) after spawning events in ten tanks of trios at the St Andrews Biological Station, each containing a female cod, direct brother, and unrelated male, matched for weight, length, and condition factor. Microsatellite DNA markers will be used to determine the proportion of eggs sired by each male. Mortality, hatch rates, and larval survival, as well as the occurrence of deformities, were monitored in artificially fertilized inbred experimental, and non-inbred control crosses of cod embryos and unfed larvae. Data were collected from 14 replicate trios (sister, brother, unrelated male). The results of these experiments will be discussed.

Keywords: aquaculture, Atlantic cod, fertilization, *Gadus morhua*, inbreeding depression, mating competition, microsatellite DNA markers, offspring viability.

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ICES CM 2010/J:14

Sustainable development of pearl farming industry in French Polynesia

Yannick Gueguen, Nathalie Cochennec-Laureau, Pierre Garen, Gilles Le Moullac, Caroline Montagnani, and Jean-Claude Cochard

The Tahitian pearl farming industry plays a major socio-economic role in French Polynesia, with pearls worth around 100 million euros exported in 2008. This activity, essential to the local economy, has encountered a crisis since 2001 brought ca. by uncontrolled development associated with a decline in pearl quality. In the context of an increasingly competitive market in which the production of high-quality pearls becomes essential, research is needed to ensure durable production. In that context, Ifremer (Institut Français de Recherche et d'Exploitation de la Mer), in close collaboration with the "Service de la Perliculture" ("pearl farming office", a French Polynesian government agency), has developed a research project on the "Sustainable development of pearl farming". Its aim, in accordance with pearl farmers concerns, is to propose methods and tools that will increase high-quality pearl production and support the sustainable development of pearl farming in French Polynesia. The research is organized in three axes: (i) understanding the animal physiology (larval development, growth, rearing and reproduction) with the aim for breeding families of graft donor oysters selected for their capacity to produce pearls of particular colours and/or rapid growth; (ii) understanding pearl formation by studying the grafting processes, the biomineralization mechanism, and the influence of the environment with the aim of increasing high-quality pearl production; (iii) understanding bivalve larvae dispersal and pearl oyster recruitment with the aim of optimizing spat collection. The results presented will summarize our current investigations regarding this project.

Keywords: durable production, pearl farming, sustainable development.

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ICES CM 2010/J:15

Reproductive performance and offspring quality in crayfish (*Cherax quadricarinatus*) broodstock fed different diets

El-Bermawi Nagy

A study was conducted to determine the effect of the nutritional value on maturation of crayfish with the aim of establishing standard techniques for mass production of berried females producing high-quality larvae. Three diets were tested, composed of a mixture of fresh food items (trash fish, shrimp meals, 30% *Artemia* biomass), compared with two types of artificial diets (35% (A1) and 40% (A2) protein). Five crayfish females with an average individual weight of 60.88 g were stocked in circular fibreglass tanks (each 1.5 m^3 with a capacity of 1000 l). The crayfish were fed the experimental diets twice a day with a daily amount calculated as 20% of total body weight. Gonadal maturation, egg hatching rate, and fecundity were estimated. Offspring quality was evaluated through starvation test. The results of our study, however, showed that the crayfish fed diet A2 had a significant better hatching rate (95%) compared with the control. No significant difference of hatching rate (90.9%) was observed for the crayfish fed diet A1. Survival of larvae under starvation conditions was significantly better when they originated from broodstock fed the control diet. No significant effect of the different levels of *n*-3 HUFA in diet was found on reproductive performance of crayfish broodstock. The results of this study suggested that the sole use of the artificial feeds tested could not improve reproductive performance,

Keywords: crayfish, fecundity, fresh food, gonadal maturation, hatching rate, quality larvae.

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ICES CM 2010/J:16 Poster

Sustainable marine fish reproduction and larval rearing development using probiotics: effects of probiotics (bacteria *(Bacillus subtilis*) and algae (*Chlorella* sp.)) used as aquaculture disinfectants on gilthead sea bream embryonic and newly hatched larval rearing development

Ahmed Md. Salem and Shaimaa M. Hebalah

Marine hatcheries are the backbone of marine aquaculture development. Probiotics are different kinds of micro-organisms (bacteria, fungi, and algae) used in fish nutrition in different stages, which invade digestive canal receptors and inhibit the other organisms coming through culture environment, feeds, and those already in the fish digestive canal, thereby improving fish immunity and producing vitamins and enzymes inside the digestive canal. Thus far, few global studies have been done to look at the effects of using probiotics on fish embryonic stages and newly hatched larvae development. In this study, we investigated gilthead sea bream (*Spaurs aurata*) sustainable embryonic stages and newly hatched larval rearing development by adding probiotics directly to the culture water. Twelve experimental tanks (30 l each) were stocked with 225 fertilized eggs (1st day post fertilization; 1st DPF). Tanks were supplied with 20 l/tank aerated filtered seawater. The ten treatments in duplicate were control (C), formalin (F), iodine (I), bacteria (*Bacillus subtilis*; B), algae *Chlorella* sp. (Ch) and (B+Ch). Embryonic stage development was investigated daily (2nd DPF–4th DPF), in newly hatched larvae (2nd day post-hatching (2nd DPH–3rd DPH)) and *B. subtilis* counts (CFU ml^{-1}) were done at the beginning and end of the study. The results of this study demonstrated that (Ch) and (B) produced the best results for growth in length. Other treatments also showed a good trend in total length gain. This application of new biotechnology could be used for gilthead sea bream (*Spaurs aurata*) embryos and newly hatched larvae using probiotics directly in the culture water.

Keywords: algae (*Chlorella* sp.), aquaculture, bacteria (*Bacillus subtilis*), embryonic stages, hatcheries, marine, newly hatched, sea bream, sustainable.

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ICES CM 2010/J:17 Poster

Interactions between wild and farmed cod within a fjord in Norway

A. Stene, J. Kennedy, T. Barnung, A. Hellebø, W. Hemmingsen, and J. E. Rønneberg

Cod (*Gadus morhua*) aquaculture facilities are common along the coast and within the fjords of Norway. Wild fish are found to aggregate around these facilities, probably to feed on the uneaten food which flows out of the cages. To examine the effects of this interaction between the wild and farmed cod, gillnets were set around the cages in order to catch these fish. The fish caught were examined for parasites, deformities, and the fatty acid profiles of the liver were analysed to examine the amount of aquaculture feed eaten by these fish. This was compared with cod caught in a neighbouring fjord where no aquaculture facility was present. Preliminary results show that the majority of the fish caught outside the cage were escapee farmed fish, as deduced from body shape, liver size, and pelvic fin length. These fish also consisted of over 85% females and showed a lower rate of deformities than the fish found within the cage, suggesting that fish with extreme deformities may not survive for long periods if they escape.

Keywords: atlantic cod, aquaculture interactions, deformities, *Gadus morhua*.

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ICES CM 2010/J:18 Poster

Impact of food deprivation on compensatory growth response and activity of juvenile Atlantic cod (*Gadus morhua*)

Maja Walter, Myron A. Peck, and Edward A. Trippel

Compensatory growth is a period of accelerated growth experienced by organisms encountering abundant food after a period of deprivation. The present study tested whether large juvenile (mean wet body weight, BW: 45.4 ± 6.5 g; mean total length, TL: 17.3 ± 0.8 cm) Atlantic cod (*Gadus morhua*) exhibited compensatory growth in response to different types of food deprivation (single bout or periodic) during a nine-week experiment. In all 240 fish were randomly distributed among a total of eight tanks and three treatment groups. Juveniles were either: (i) fed to satiation (control), (ii) deprived of food for three weeks (3WD) and then refed for six weeks, or (iii) experienced cycles of one week feeding and one week food deprivation (DFDF). Daily food consumption was monitored and recent growth was estimated every three weeks based upon changes in BW, TL, and scale tissue RNA–DNA ratios, and fish swimming activity was compared among treatments. Fish experiencing food deprivation had higher rates of feeding (when offered) and obtained higher specific growth rate (SGR) and gross growth efficiency (GGE) than control fish with fish swimming activity being directly related to feeding level. This study indicates that partial growth compensation is possible for juvenile cod. The implications of compensatory growth responses are discussed in light of the practical applications for aquaculture production (e.g. increasing feeding efficiency, decreasing environmental nitrogen loading) and in light of the ecology of young demersal juvenile cod in the wild.

Keywords: activity, aquaculture efficiency, Atlantic cod (*Gadus morhua*), compensatory growth, RNA–DNA ratio.

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Theme Session K

Global change and aquatic bioinvasions

ICES CM 2010/K:01

Dynamics of alien species in the northeast Baltic Sea: factors responsible and comparison with the natives

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Altogether over 100 alien species have been recorded in the Baltic Sea. These originate in different areas around the world and have invaded the Baltic during various times. In recent decades, several new invasions have been detected and several already existing alien species have increased in population size and range distribution. In this study, we investigated spatio-temporal variability of the selected alien species representing different trophic levels (zooplankton, macrozoobenthos, fish) and ecological functions. First, we identified similarities and differences in abundance/biomass dynamics of the selected alien species (including in relation to that of the native species) and tried to find factors responsible for the observed patterns. Further, dynamics of importance of alien species in biotic communities was studied, allowing quantification of their role and impact on the system. Our final analysis aimed at identifying whether the long-term (some datasets go back to the 1950s) observed population abundance/biomass dynamics is caused by climate-induced change in abiotic environments or complex alterations in abiotic and biotic components of the ecosystem, and in this way corresponds to the general regime shifts of the Baltic Sea.

Keywords: abundance/biomass variability, alien species, Baltic Sea, spatio-temporal dynamics.

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ICES CM 2010/K:02

Genomics of adaptation of the Pacific oyster, *Crassostrea gigas*, in the context of its geographic expansion in Europe

Audrey Rohfritsch, Nicolas Bierne, Pierre Boudry, Arnaud Huvet, Serge Heurtebise, Florence Cornette, and Sylvie Lapegue

Originating from the northeastern Asia, the Pacific oyster (*Crassostrea gigas*) has been introduced and translocated, mainly for aquaculture purpose, into several European countries since the early 1970s. The invasive nature of this species has been observed during the last decade in several countries and it was therefore considered as a pest or a noxious species in those areas. In the framework of the national funded project "Hiflo", we aimed to identify the characteristics of such a flourishing species: can its success be explained by global warming only or is it linked to evolutionary processes, implying genetic adaptation of the species to novel environmental conditions? We developed a population genomics approach, known as a "genome scan", which corresponds to the study of numerous loci spread through the genome to quantify the part of the genome affected by a molecular signature of adaptation. For the Pacific oyster, the genome scan was performed with hundreds of loci over a large number of genomic regions. We genotyped 16 populations, early or newly established. The first results indicate a differentiation between some northern populations and the others. Furthermore, a set of markers were detected as "outliers" (i.e. potentially indicating local selection at these loci) and will be further studied based on sequence data in order to confirm their candidate role in adaptation. In parallel, a transcriptome approach is being initiated to investigate the level of local adaptation in northern European populations by comparing the transcription levels of candidate genes between newly and early established populations.

Keywords: AFLPs, *Crassostrea gigas*, invasive, genome scan, microsatellites, Pacific oyster, SNPs, transcriptome approach.

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ICES CM 2010/K:03

Preliminary results of the impact of the invasive species Manila clam (*Ruditapes philippinarum*) on the benthic compartment of the Rance Estuary (western English Channel, France)

R. Jihane Trigui, Nicolas Desroy, Dominique Davoult, Damien Le Guillou, Patrick Le Mao, Aline Migné, Frédéric Olivier, and Eric Thièbaut

The Manila clam (*Ruditapes philippinarum*) was first introduced in France for culture purposes in 1972. The control of both spawn production and growing techniques as well as its high added value then induced, in the early 1980s, an increasing interest in this species. However, its high adaptability to new environments and its fast growth explain its wide proliferation in most French coastal embayments. The purpose of our current study is to define how this species contributes to modify the composition, structure, and dynamics of benthic communities. Living buried in the sediment, this suspension-feeder may affect the biodiversity directly by competitive exclusion of indigenous species or indirectly by modifying their habitat. Moreover, it can strongly influence ecosystem functioning by changing the trophic network and related energy flows. The present study was conducted in the Rance Estuary (France), where *R. philippinarum* was introduced in 1986 for shellfish farming. Since this date, the clam has developed natural populations with abundances reaching more than 600 individuals m^{-2}. In order to describe the structure and diversity of benthic assemblages, a total of 54 stations was prospected in March 2010. Results will be compared with those obtained by Desroy in 1995 on the same sampling sites, before the proliferation of the clams, to assess their role in observed changes. These results will be completed by seasonal assessment of nutrient fluxes among sites of differing *R. philippinarum* densities to define their contributions to nutrient mineralization, bentho-pelagic coupling, and primary production.

Keywords: benthic community, energy flow, Rance Estuary, *Ruditapes philippinarum*, spatial and temporal structure.

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ICES CM 2010/K:05

How the efficient reproductive strategy of an alien species can lead to an innovative biomass control strategy

Alexandra Valdizan, Peter G. Beninger, Bruno Cognie, and Priscilla Decottignies

The introduction of the marine gastropod *Crepidula fornicata* along the European coast is considered a major threat for both the ecology and economy of the colonized sites. This alien species heavily impacts the nature and structure of the habitat, creates local competition for resources and space with suspension-feeders of commercial interest, and disturbs both oyster farming and commercial fisheries relying on dredging. Despite many strategies applied to diminish its considerable biomass, *C. fornicata* stocks are still increasing. Proliferation and extension are consequences of its successful adaptation and of its reproduction. We have investigated the gametogenic cycle of *C. fornicata* in a mid-latitudinal macrotidal shellfish-farming bay within its European range (Bourgneuf Bay, France). Our results show an extremely efficient reproductive strategy, characterized by rapid fertilization of eggs in optimal environmental conditions and an extended brooding period. External fertilization of gametes and development of excapsulated embryos and larvae were also monitored. We propose an innovative strategy that does not present dissemination risks, and might be a possible solution to the biomass decrease of this alien species

on European coasts. This destruction technique would consist of dredging, crushing, and on-site rejection.

Keywords: alien species, biomass reduction, *Crepidula fornicata*, monitoring, reproductive strategy.

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ICES CM 2010/K:06

Ecological models of the impact of the invasive long-spined sea urchin on Tasmanian rocky-reefs communities and fisheries

Martin Marzloff, Craig R. Johnson, L. Rich Little, and Stewart D. Frusher

The climate-driven extension of the range of the spiny sea urchin (*Centrostephanus rodgersii*) from Australia's mainland into Tasmanian waters presents a major threat to the productivity of native subtidal rocky-reef communities. Overgrazing of native seaweed beds by this sea urchin can create and maintain extensive zones of barren habitat, causing major loss of production, biodiversity, and physical structure. In particular, the two most valuable fisheries in Tasmania, blacklip abalone (*Haliotis rubra*) and southern rock lobster (*Jasus edwardsii*), are not viable on *C. rodgersii* barrens. In addition, the fishing depletion of large rock lobsters, the main natural predator of *C. rodgersii*, facilitates the establishment of urchin barrens. Based on data from empirical observations and field experiments, we develop a generic ecological model of the local dynamics of Tasmanian reef communities. The model captures ecosystem shifts from productive kelp bed to sea urchin barren. Through simulations, we assess the effectiveness of alternative management options to control the ecological impacts of the invasive urchin species, either by maintaining native reef communities in their original state, or by restoring the productive seaweed habitat from an urchin barren state.

Keywords: alternative states, barren habitat, blacklip abalone, ecological modelling, ecosystem effects of fishing, management support, phase shift; rocky-reef, sea urchin, southern rock lobster, Tasmania.

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ICES CM 2010/K:07

Spreading and reproduction limitations of the American comb jelly *Mnemiopsis leidyi* in the Baltic Sea

Maiju Lehtiniemi, Jamileh Javidpour, Andreas Lehmann, and Kai Myrberg

Based on the information on salinity and temperature needed for survival and reproduction, areas within the Baltic Sea have been identified where the American comb jelly (*Mnemiopsis leidyi*) could potentially survive and reproduce. In addition, physical drift modelling has been used to investigate the potential dispersion of *Mnemiopsis*, with the assumption that the invasion occurred via advection from the Kattegat through the Danish Straits into the western Baltic Sea. In the low saline surface layer, the dispersion is mainly driven by the wind; in the lower saline layer, the dispersion is controlled by the baroclinic flowfield and bottom topography. Model runs showed that natural spreading via deep-water currents from the Bornholm Basin where it currently occurs, towards north and east, is limited by topographic obstacles and low advection velocities. However, if *Mnemiopsis* were transported in the ballast water of a ship to the northern latitudes it might survive but would not reproduce at a sufficient rate to establish a new population. Thus, as a result of the combined effects of low salinity and low temperature it is not probable that *Mnemiopsis* could establish permanent populations in the central or northern Baltic Sea. It seems that *Mnemiopsis* could only reproduce at higher rate in the southern parts of the sea. If under climate change the salinity in the Baltic Sea further decreases, the establishment of *Mnemiopsis* would be even less probable in the north although water temperature would increase.

Keywords: American comb jelly, Baltic Sea, physical factors, reproduction, survival.

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ICES CM 2010/K:08

The spread of invasive species and the sustainability of shellfish resources: shifting populations of the European green crab threaten prime oyster habitats in Prince Edward Island, Canada

Tyler Pickering and Pedro A. Quijon

European green crabs (*Carcinus maenas*) were introduced to Prince Edward Island, eastern Canada, just over a decade ago. Since then, preliminary observations suggest that the species continue to spread and grow I numbers that may become detrimental to a variety of shellfish resources. To document their potential spread and impact on oyster habitats, we carried out trapping surveys in several estuaries during 2008, 2009, and 2010, and conducted a series of predator–prey (crab-–oyster) manipulations. The trapping surveys confirmed that there is an ongoing spread of green crabs into new suitable areas, while rapidly increasing in numbers in most others. Aiming to facilitate potential mitigation strategies, we ran a series of field inclusions to identify both the size of oysters most vulnerable to green crab predation, and the crab sizes most detrimental to oysters. Specifically, we measured the predation rates of small, medium, and large green crabs feeding on small, medium, large, and extra large oysters. In general, almost no predation occurred on extra-large oysters, but large green crabs preyed more heavily on all other oyster sizes. As expected, small oysters were most vulnerable to predation by virtually every size of green crab. Overall, our results suggest that the outcomes of green crab–oyster predator–prey interactions are heavily dependent on both oyster size and crab size with oysters reaching a partial size refuge from green crabs at ~35 mm. We discuss these results in the light of the oyster industry and the further spread and growth of green crabs in the region.

Keywords: aquatic invasive species, *Carcinus maenas*, *Crassostrea virginica*, predator–prey interactions, spread and establishment, size vulnerability.

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ICES CM 2010/K:10

Predation by the invasive red king crab (*Paralithodes camtschaticus*) on lumpsucker eggs (*Cyclopterus lumpus*) in the Barents Sea

Nina Mikkelsen and Torstein Pedersen

Along the coast of northern Norway, the lumpsucker (*Cyclopterus lumpus*) supports a commercial fishery. The fish deposit their demersal eggs in the sublittoral zone on rocky substrate. An introduced species in the Barents Sea, the red king crab (*Paralithodes camtschaticus*), has invaded the coast of Finnmark in northern Norway and is gradually expanding its area of distribution. The objectives of this study were to estimate the consumption of lumpsucker eggs by red king crab in field and to estimate digestion rates of lumpsucker eggs. Feeding habits of red king crab in spawning areas of lumpsucker were studied in coastal waters of Finnmark in 2003. A remotely operated vehicle was used to detect crabs at spawning sites and 162 crabs were collected for stomach analysis by divers. Lumpsucker eggs were found in 7.5% of all crabs larger than 110 mm in carapace length. The digestion rates of lumpsucker eggs in king crab stomach were studied in a laboratory experiment in 2006. Mature males were fed lumpsucker eggs at 6°C. In this experiment, 50% of the eggs were digested about 10.3 h after ingestion. Consumption of eggs was estimated from the stomach content data and the experimentally derived digestion rates.

Keywords: Barents Sea, digestion rate, lumpsucker, predation, red king crab.

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ICES CM 2010/K:11

How to proof compliance with the standards of the Ballast Water Management Convention

Stephan Gollasch

To address the problem of alien species introductions with ballast water, the International Maritime Organization (IMO) adopted in 2004 the International Convention on the Management of Ships' Ballast Water and Sediments (BWM Convention) to provide a global uniform ballast-water management approach. The biological BWM Convention standards for acceptable ballast water discharges will be presented. To proof compliance with these standards vessel sampling becomes essential and representative sampling approaches are needed to avoid false positive results. Two sampling aspects are presented: (i) how to take a sample which results in a representative overview of organisms and (ii) which methods are to be used to promptly detect viable organisms in a sample. Rapid organism detection technologies are needed to assess promptly whether or not the sampled ballast water is in compliance with the standards of the BWM Convention. This is one of the objectives of the ongoing Interreg IV B Project "Ballast Water Opportunity". The encountered sampling difficulties will be discussed, and a possible ballast water sampling strategy for port state control initiatives recommended.

Keywords: ballast water management, port state control, sampling methods.

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ICES CM 2010/K:12 Poster

Invasive alien species in European marine ecosystems

Anastasija Zaiko, Sergej Olenin, and Henn Ojaveer

Biological invasions by alien species are recognized as an important component of global environmental change, often resulting in significant loss in the economic value, biological diversity, and function of invaded ecosystems. More than 1000 alien multicellular species have been recorded from European seas. Approximately 600 taxa have established self-sustaining populations, the great majority of them in the Mediterranean Sea. The dominating group of exotic species across all European seas is zoobenthos organisms. The most important introduction pathways for alien species are: canals (Mediterranean Sea), shipping, aquaculture, or stocking activities (Baltic Sea and Atlantic coast). Recently, a standardized method, the Biopollution Level (BPL) Index, was proposed to measure the magnitude of bioinvasion impacts. The estimated biopollution level is a combination of abundance and distribution range (ADR) class and the impact of alien species on communities (C), invaded habitat (H), and ecosystem functioning (E). For instance, the slipper limpet (*Crepidula fornicata*) in the North Sea and Atlantic coast occurs at densities of >1700 m^{-2}, resulting in trophic competition and causing reduced growth of commercial bivalves; it also changes sediments to mud deposits, thus reducing diversity and abundance of living plants. Therefore the assigned biopollution level for the species is strong (BPL = 3). Following this approach, the bioinvasion impacts of the target alien species could be quantified.

Keywords: biological invasions, biopollution level index, European regional seas.

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ICES CM 2010/K:13

Invasion genetics of the *Ciona intestinalis* species complex: from regional endemism to global homogeneity

Aibin Zhan, Hugh J. MacIsaac, and Melania E. Cristescu

Determining the degree of population connectivity of marine invasive species and investigating the factors driving the genetic exchange is essential to understanding population dynamics and ultimately assessing the invasion potential of a species. Although the highly invasive vase tunicate, *Ciona intestinalis*, is a well-established model system for evolutionary and developmental biology, its invasion history has been obscured by the poorly understood taxonomy and population genetics. Recent phylogenetic and comparative genomic studies show that *C. intestinalis* is a cryptic complex, consisting of at least three species. Our phylogenetic reconstructions, based on both mitochondrial and nuclear sequences, strongly support four major phylogroups, corresponding to the previously reported spA, spB, and C. spp (spC) and an undescribed cryptic species (spD). Despite large interspecies divergences, no phylogeographic structure is identified within each major phylogroup, and network analyses show only several mutation steps among different haplotypes within each species, suggesting recent range expansion. Although spC and spD remain restricted to their native ranges (Mediterranean Sea and Black Sea), the highly invasive spA and spB show a cosmopolitan and largely allopatric distribution. Population genetic analyses on the two invasive species based on two mtDNA fragments and eight unlinked microsatellites further confirm a high level of homogeneity at both regional and continental scale. Population genetic analyses show a high degree of connectivity among distant populations. Human-mediated long-distance dispersal coupled with high potential for natural dispersal derived from biological characteristics such as high fecundity, broadcast-spawning, and a large effective population size are probably responsible for the observed genetic homogeneity.

Keywords: ascidian, biological invasion, cryptic speciation, gene flow, genetic differentiation, population connectivity.

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ICES CM 2010/K:14 Poster

Seasonal movement patterns of the introduced red king crab (*Paralithodes camtschaticus*) in northern Norway

Jan H. Sundet and Einar M. Nilssen

The red king crab was introduced to the Barents Sea in the 1960s and has spread widely both in Norwegian and in Russian waters, entailing a need to acquire knowledge of the biology and behaviour of the crab in these areas. Twenty crabs of both sexes were tagged with ultrasonic coded acoustic transmitters and released at three sites in Porsangerfjord, Finnmark, Norway. Ten acoustic receivers were placed in a non-uniform grid in the experimental area, allowing us to track individual crabs for ca. 12 months. Results on seasonal movements according to depth and sex throughout the year are presented as well as long-term observations on individual crab behaviour. Daily movement speed of individual crabs is also calculated. Being a small introductory experiment, this study provides valuable information on the behaviour of a successful introduced species, essential knowledge for the understanding of the species and for pinpointing further investigations on the crab's impact on the native ecosystem.

Keywords: acoustic tags, behaviour, red king crab.

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ICES CM 2010/K:15 Poster

Ship's ballast waters discharged in French ports: noxious phytoplankton threat

D. Masson, G. Thomas, and S. Genauzeau

In the 22 million tons of ballast water discharged annually by ships in main French ports are numerous aquatic living species. Among these, there are potentially noxious phytoplankton, which constitute a major threat for the coastal economy, and for aquaculture in the first place. Sampling campaigns in ports during ship's discharges gives numerous indications of potentially noxious phytoplankton species released with a good chance of survival and settlement. This is a particular problem in ports close to Europe's primary oyster farming area.

Keywords: introduced species, noxious phytoplankton, sampling techniques, ship's ballast water.

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ICES CM 2010/K:16 Poster

Assessing the risk of transporting non-native species to Scotland via biofouling on vessels

Tracy McCollin and Lyndsay Brown.

Marine Scotland—Science is undertaking two research projects to assess the biofouling on vessels arriving in Scottish waters. The overall aim of both projects is to obtain information regarding which species are being transported via biofouling and whether particular vessels (e.g. recreational or commercial) or voyages (e.g. UK-based or international) pose a higher risk. For recreational vessels, the Marine Aliens II project has involved partners from all over the UK taking part in coordinated fieldwork to deploy settling panels for different lengths of time at marinas throughout the UK. The panels were placed in exposed and sheltered area of the marina and were left out for two or eight weeks before being collected. As well as indicating differences in settlement rates throughout the UK, it is hoped that the results will indicate whether marina design has an influence on the settlement. The second project, the Scottish Government Biofouling Project, will collect samples from commercial vessels and this will be achieved by visiting dry docks to sample the hulls and other areas of vessels that are subject to reduced water flow and will also use a series of in water methods (e.g. remotely controlled cameras, divers) to record and sample biofouling on vessels. The combination of these methods will allow samples to be collected from a variety of vessels from different origins.

Keywords: biofouling, dry dock, non-native species, Scotland, vessels.

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ICES CM 2010/ K:17 Poster

Foraging behaviour of the American lobster (*Homarus americanus*) in the presence of an invasive crab

M. A. Rossong, P.A. Quijon, P. J. Williams, and P. V. R. Snelgrove

American lobsters (*Homarus americanus*) are one of the main commercial fisheries in the Northwest Atlantic. The recent arrival and establishment of the European green crab (*Carcinus maenas*) within Atlantic Canada has caused concern because of potential interactions with juvenile lobster populations. Adult green crabs are highly skilled predators that explode in population size in newly invaded areas and potentially compete with juvenile lobsters for limited resources. Literature suggests that juvenile lobsters utilize shelter to avoid predation but dependence lessens as lobsters reach adulthood and gain mechanisms of defence from predators. It follows that smaller lobsters remain conditioned to a trade-off between energetic demands and the risk of predation. This study examines the foraging behaviour of juvenile lobsters (25–51 mm CL) and its potential alteration in the presence of an adult green crab. Experimental trials that provided juvenile lobsters with shelter and a feeding patch were paired with identical trials that monitored lobsters in the presence of a green crab. For each trial ($n = 15$ for each experiment) lobster behaviour was

monitored over 8 h. Our results indicate that smaller juvenile lobsters (<35 mm CL) spent significantly less time foraging, spent more time within the shelter, and took more time to find the food source in the presence of a green crab. Thus, fine-scale size differences as those studied here, play an important role in foraging and shelter usage within the lobster juvenile stage. Our study also documents an apparent shift from shelter dependence to increased foraging at 36 mm CL.

Keywords: animal behaviour, benthic ecology, *Carcinus maenas*, crustaceans, invasive species, predator avoidance.

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ICES CM 2010/K:18 Poster

Use of DNA barcoding to detect invertebrate invasive species from diapausing eggs

Elizabeta Briski, Melania E. Cristescu, Sarah A. Bailey, and Hugh J. MacIsaac

The global transhipment of ballast water and associated flora and fauna by cargo vessels has increased dramatically in recent decades. Invertebrate species are frequently carried in ballast water and sediment, although identification of diapausing eggs can be extremely problematic. Here we test the application of DNA barcoding using mitochondrial cytochrome *c* oxidase subunit I and 16S rDNA to identify species from diapausing eggs collected in ballast sediment of ships. The accuracy of DNA barcoding identification was tested by comparing the results of the two independent molecular markers, and by comparing DNA barcoding results with traditional morphological identification of individuals hatched from diapausing eggs. Further, we explored two public genetic databases to determine the broader applicability of DNA barcodes. Of 289 diapausing eggs surveyed, sufficient DNA for barcoding was obtained from 96 individuals (33%). Of these eggs, 61 (64%) were identified to species level, whereas 36% were identified to family/order level. Species level identifications were always consistent between methodologies. DNA barcoding was suitable for a wide range of taxa, including Branchiopoda, Copepoda, Rotifera, Bryozoa, and Ascidia. Branchiopoda and Copepoda were respectively the best and worst represented groups in genetic databases. Though genetic databases remain incomplete, DNA barcoding resolved nearly double the number of species identified by traditional taxonomy (19 vs. 10). Notorious invaders are well represented in existing databases, making these non-indigenous species detectable. DNA barcoding provides a rapid and accurate approach to identification of invertebrate diapausing eggs that otherwise would be very difficult to identify.

Keywords: diapausing eggs, DNA barcodes, invertebrates, non-indigenous species, ship ballast sediment, species identification.

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ICES CM 2010/K:19 Poster

Multiple introductions and invasion pathways of the invasive ctenophore *Mnemiopsis leidyi* in Eurasia

Sara Ghabooli, Tamara A. Shiganova, Aibin Zhan, Melania E. Cristescu, Peyman Eghtesadi-Araghi, and Hugh J. MacIsaac

The introduction and spread of non-indigenous species (NIS) in marine ecosystems accelerated during the twentieth century as a result of human activities, notably international shipping. Genetic analysis has proven useful in understanding the invasion history and dynamics of colonizing NIS and identifying their source population(s). Here we investigated sequence variation in the nuclear ribosomal internal transcribed spacer (ITS) region of the ctenophore *Mnemiopsis leidyi*, a species considered as one of the most invasive globally. We surveyed four populations from the native distribution range along the Atlantic coasts of the United States and South America, as well as six populations in the introduced range from the Black, Azov, Caspian, and Baltic Seas. Allelic and nucleotide diversity of introduced populations were comparable with those

of native populations from which they were likely drawn. Introduced populations typically exhibited less genetic differentiation (lower FST values) than native populations. Population genetic analyses supported the invasion of Eurasia from at least two different pathways, the first from the Gulf of Mexico (e.g. Tampa Bay) to the Black Sea and thence to the Caspian Sea, the second from the northern part of the native distribution range (e.g. Narragansett Bay) to the Baltic Sea. The relatively high genetic diversity observed in introduced populations is consistent with large inocula and/or multiple invasions, both of which are possible given ballast water transport and the extensive native distribution of the ctenophore in the Atlantic Ocean.

Keywords: biological invasion, ctenophore, genetic diversity, internal transcribed spacer (ITS), invasive species, *Mnemiopsis leidyi*.

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Theme Session K:20 Poster

Impacts of invasive species on seagrass health under present and future temperature regimes—a case study from two climate zones

Hannes Höffle, Mads S. Thomsen, Thomas Wernberg, and Marianne Holmer

Global climate change and invasion by non-native species constitute some of the largest and most current threats to the marine environment. Invertebrates and macroalgae are particularly important invaders in coastal ecosystems. Already impacted by other stressors, seagrass beds now also have to face climate change and invasive species. We examine how two seagrass species, the temperate *Zostera marina* and subtropical *Halophila ovalis*, respond to elevated temperatures. We also tested if impacts of drift algae (invasive *Gracilaria vermiculophylla* on *Z. marina*; native *Chaetomorpha linum* on *H. ovalis*) and the invasive snail *Batillaria australis* (only on *H. ovalis*) are accelerated under enhanced temperatures. Response variables included various seagrass performance indices (morphology, biomass, survival, and growth) and sediment biogeochemistry. Survival was primarily influenced by temperature but for *H. ovalis* also by drift algal cover. The influence on growth and biogeochemistry was likewise. Our results suggest that the seagrass species from the temperate zones is less able to cope with elevated temperatures, whereas the impact of drift algae seems to depend on their morphology (i.e. dense mats of filamentous algae vs. coarsely branched *Gracilaria*). In contrast to temperature effects (and to some extent also for drift algal effects) the invasive snail *B. australis* had virtually no significant effects on *H. ovalis*. In conclusion, this study suggests that elevated temperatures are more threatening to temperate seagrass species, whereas effects of drift algae, either alone or in synergy with other stressors, will depend on the species-specific properties of the macroalgae.

Keywords: algal mats, Denmark, introduced species, seagrass, temperature effects, Western Australia.

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ICES CM 2010/K:21 Poster

Lakers as vectors for the introduction and spread of non-indigenous species in the Great Lakes—St Lawrence River

Abisola A. Adebayo, Sarah A. Bailey, and Hugh J. MacIsaac

The movement of ballast water by transoceanic ships has been recognized globally as a primary vector for the introduction of non-indigenous species (NIS). Most research efforts have accordingly been aimed at the management of transoceanic ballast; however, it represents only one aspect of the broader issue of NIS management in the Great Lakes. Great Lakes' ports may receive ballast from domestic and transoceanic vessels, and both ballast types could potentially serve as vectors for NIS introduction. Currently, domestic ballast operations associated with "laker" vessels in the Great Lakes—St Lawrence River are regarded as low risk, therefore, little research has been done to

determine whether these vessels to the Great Lakes contribute to the introduction and spread of NIS. There are 11 freshwater and 5 estuarine ports on the St Lawrence River used by lakers for ballast operations; some of these ports are also visited by transoceanic vessels, opening the possibility that: (i) species native to the St Lawrence River but not present in the Great Lakes could be introduced to the lakes; (ii) NIS species are delivered to the Great Lakes in secondary transfers. Here we examine the invasion risk St Lawrence River ports pose to the Great Lakes by examining (i) invertebrate community similarity between St Lawrence River and Great Lakes' ports; (ii) the diversity and abundance of NIS in the ballast water of lakers, and (iii) the environmental match between St Lawrence River and Great Lakes' ports.

Keywords: ballast water, colonization pressure, lakers, non-indigenous species, propagule pressure.

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ICES CM 2010/K:22 Poster

Invasion of the southern bight of the North Sea by the American jackknife clam *Ensis directus*: ecological consequences and fishery perspectives

J-S. Houziaux, F. Kerckhof, B. Merckx, M. Vincx, W. Courtens, E. Stienen, V. Van Lancker, J. Craeymeersch, G. Van Hoey, K. Hostens, and S. Degraer

The American jackknife clam (*Ensis directus*), first detected in the German Bight of the North Sea in 1978, was observed for the first time in the Belgian sector in 1987. Since then, increasing numbers of specimens wash ashore every year, suggesting that the species forms large nearshore populations likely to significantly alter the local biological communities. A research project was started in 2009 to study this issue, extending the studied area to Dutch waters. On the one hand, the population dynamics will be investigated as well as its impact on the local fauna, making use of pre-1987 macrobenthic datasets; using knowledge acquired since some years on benthos–sediment relationships in this area, optimum habitats for this alien species will tentatively be determined through a modelling exercise ("habitat suitability modelling") and acoustic seabed mapping. On the other hand, the impact of altered composition of macrobenthic communities on populations of seabirds will be evaluated. These data will further allow us to evaluate the feasibility, sustainability, and ecological impact of a targeted Ensis fishery within Belgian waters, incorporating lessons learned from commercial vessels operating in the nearby Dutch waters. In this contribution, our preliminary results are presented and discussed.

Keywords: bioinvasion, *Ensis directus*, fishery, macrobenthos, North Sea, seabirds.

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ICES CM 2010/K:23 Poster

Non-indigenous faunal species of the intertidal and subtidal hard benthic substrates in the "Abra de Bilbao"

Francisco Javier Tajadura Martín, María Bustamante, and José Ignacio Sáiz Salinas

Non-indigenous fauna are now recognized as one of the most serious threats to the natural ecology of biological systems worldwide. To analyse its abundance in the internal and external areas of the "Abra of Bilbao" we carried out a survey during summer 2009 of nine intertidal and eight subtidal localities. This comprised a visual estimate of the faunal species abundance in 50×50 quadrats. We considered as native species those which are known to be endemic to the Basque biogeographical region. Non-indigenous species are those introduced as a result of human activities. Cryptogenic species are those whose identity as either native or non-indigenous remains ambiguous, whereas indeterminates include specimens that could not be reliably identified to species level. In the intertidal zone, 62 taxa were identified. In terms of abundance, cryptogenic species represent 54.1% of the total cover, natives 40.3%, non-indigenous species 5.3%, and indeterminates 0 3%. In relation

to species richness, cryptogenic and non-indigenous species only represent 4.8% of the total diversity each, whereas native species represent 74.6% and indeterminates 14.3%. In the subtidal zone, 63 taxa were identified. In reference to the abundance, native species represent 78.4% of the total cover, cryptogenic species 14.7%, non-indigenous species 6.3%, and indeterminates 0.6%. As for the faunal diversity, native species represent 73.1% of the total richness, non-indigenous species 11.1%, and cryptogenic and indeterminate species 7.9% each.

Keywords: hard benthos, intertidal, non-indigenous species, subtidal.

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Theme Session L

Spatially explicit models for plankton and fish: processes, model integration, and forecasts

ICES CM 2010/L:01

Integrating larval dispersal into a full life-history stock assessment model

Daniel R. Goethel and Steven X. Cadrin

Although spatially explicit individual-based models (IBMs) of larval fish provide invaluable information on connectivity and distribution of early life-history stages, results are difficult to incorporate into management decisions. One way in which IBM outputs have been used is in full life-history simulations used to investigate spatial population structure or the effects of various management strategies. Little work has been done, however, to incorporate IBM results directly into a stock assessment framework. We describe a method for incorporating IBM estimates of larval mixing rates directly within the objective function of a forward projecting, multiregion statistical catch-at-age model. This model allows for full life cycle closure by following fish from birth (age-0) instead of from age-1, and allowing for larval drift and adult movement between subpopulations. Larval IBM results are used as a "data" source in the model and each IBM particle is treated as if it were a "tagged" fish in a mark–recapture dataset. The objective function for the assessment model includes multiple data sources including catch-at-age, abundance indices, mark–recapture tagging data, and larval IBM data. This is one of the first quantitative, full life-history metapopulation models presented within a stock assessment framework. In addition, it provides a new way for IBM data to be directly incorporated into management decisions, because such decisions are often based on stock assessment outputs.

Keywords: larval IBM, metapopulation model, movement model, stock assessment.

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ICES CM 2010/L:02

Linking biogeochemical and upper trophic level models using an xml-based semantic coupler

J. A. Beecham, J. Bruggeman, J. N. Aldridge, and S. Mackinson

When computer models are coupled together it is necessary to describe both the physical connections between the models (file formats, network protocols, and the like) and semantic information about what the data mean (grid type and dimensions, names of organisms and variables and the units in which numerical quantities are expressed). In some cases, there are incompatibilities but mechanisms exist to convert between different representations, for example converting units of wet mass per unit volume into molar units of chlorophyll or carbon. Couplerlib is a library for doing this where the semantic information is stored as a dictionary of xml definitions for unit conversions and names and hierarchies of functional groups. We have linked

two models; one is the biogeochemical model BFM, embedded in the physical model GOTM (General Ocean Turbulence Model), and the other is the Ecosim ecological model. The xml dictionary expresses the semantic relations between the entities in the two models and a second xml file specifies which groups are linked (in this case phytoplankton and zooplankton). When the two models are linked and exchange information on a daily basis, the plankton dynamics predicted by the GOTM-BFM model feed through to the dynamics of the groups in Ecosim that feed on them and the predation effects can be seen in GOTM-BFM. Currently, this model linking approach is being extended to three-dimensional models running across networks of computers.

Keywords: EcoSim, GOTM-BFM, model coupling, plankton, semantic linking.

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ICES CM 2010/L:03

Modelling the foodweb (nutrient to fish) of the Baltic Sea

W. Fennel

An NPZDF model with an explicit two-way interaction between an NPZD model and a fish model component is presented for the example of the Baltic Sea. In the Baltic, the fish stock is dominated by two prey species (sprat and herring) and one predator (cod). The dynamics of the fish model is driven by size (mass–class) dependent predator–prey interactions, while the interaction between the NPZD and fish model components is established through feeding of prey fish on zooplankton and recycling of fish biomass to nutrients and detritus. The model strictly conserves mass. The performance of the NPZDF model is illustrated by simulating fishing scenarios and effects of eutrophication for a box model. In principle, the model allows us to build a fish model component into a three-dimensional ecosystem model of the Baltic Sea or other systems. Some issues related to embedding the model into a three-dimensional model systems are discussed and problems of representing fish stock dynamics in a coarse resolution model are addressed.

Keywords: foodweb model, nutrients to fish, predator–prey interactions, 3d modelling.

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ICES CM 2010/L:04

Development of a climate-to-fish-to-fishers model: proof of principle using long-term population dynamics of anchovies and sardines in the California Current

Bernard A. Megrey, Kenneth A. Rose, **Error! Reference source not found.**, Kate Hedstrom, Jerome Fiechter, Miguel Bernal, Shin-ichi Ito, Salvador Lluch-Cota, Chris Edwards, Dave Checkley, Alec MacCall, Tony Koslow, Sam McClatchie, Ken Denman, and Francisco Werner

An ecosystem approach to understanding large-scale patterns in exploited fishery systems increasingly relies on the use of numerical models. In the past, physical, lower, and higher trophic level models were developed, tested, and run independently of each other. Recently, advances in physics and biology have created the needed pieces for end-to-end (climate-to-fish-to-fishers) ecosystem models, including humans as a dynamic component. We present our progress to date on the development of an end-to-end modelling framework within the widely used ROMS (Regional Ocean Modelling System) circulation model. The NEMURO Nutrient–Phytoplankton–Zooplankton (NPZ) submodel provides the lower trophic level dynamics, and a multispecies, individual-based, full life cycle submodel simulates fish population and community dynamics. Commercial fishing is incorporated as one of the predator species. We describe our preliminary version of the modelling framework using anchovies and sardines in the California Current System. Using a relatively coarse 30-km resolution ROMS model, we demonstrate how the various submodels can be solved simultaneously for a multidecadal historical simulation (1958–2006) and present preliminary model results on key physical features (e.g. interannual variation in upwelling), lower trophic dynamics

(e.g. zooplankton community composition and productivity), and anchovy and sardine growth, spawning, mortality, and movement patterns. Although many biological and computational challenges remain in developing climate-to-fish-to-fishers models, maintaining a concerted investment of effort now will pay off with management-ready, end-to-end forecasting tools in the future.

Keywords: anchovy, California Current ecosystem, end-to-end ecosystem models, sardine.

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ICES CM 2010/L:05

Spatial structure in E2E models of shelf ecosystems

John Steele (WHOI), Mike Heath (Strathclyde), and Jim Ruzicka (OSU)

For shelf ecosystems, the typical open ocean model of a vertically structured planktonic ecosystem subject to horizontal advection does not apply. First, nutrients are introduced laterally from offshore or from river input. Second, the benthos are usually an integral component of the foodweb, both for consumption of plankton products and for nutrient regeneration. Third, fish production is determined both by benthic and planktonic processes. As a result, a different balance between physical and ecological detail is required to incorporate the diversity of spatial patterns and the complexity of ecological processes, while still producing a manageable model of the overall system. The problems and possible solutions are illustrated by analyses of structure within and between Georges Bank, North Sea, and Northern California Current ecosystems.

Keywords: None

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ICES CM 2010/L:06

Modelling habitat quality of demersal life stages of plaice under past and future climate scenarios

Lorna R. Teal, Ralf van Hal, and Adriaan D. Rijnsdorp

Climate change affects a range of abiotic factors in the oceans that are tightly linked to the production and distribution of fish populations. Such changes in environmental variables (e.g. temperature) may directly affect populations at the individual level by causing changes in physiological rates. Understanding such ecophysiological responses is crucial in gaining mechanistic understanding of observed changes in species distribution patterns or behaviour in relation to climate change. In this study, we hypothesize that increasing temperatures in the North Sea affect the habitat quality of plaice in terms of the potential scope for growth and thus may lead to changes in their spatial distribution. Dynamic energy budget (DEB) models are used to predict weekly length-dependent growth rates of juvenile and adult plaice on a ~10 × 10 km spatial grid of the North Sea. Past and future temperatures for each grid cell are obtained from the ECOSMO model and used to calculate scope for growth for both past climate conditions and future predictions. Seasonal as well as annual variability in food availability are taken into account and winter survival of 0-group plaice is investigated following different summer feeding conditions. Changes in the spatial distribution of habitat quality (potential scope for growth) are discussed in relation to observed offshore shifts of plaice in recent years.

Keywords: dynamic energy budget, environmental forcing, juvenile flatfish, habitat quality, growth, *Pleuronectes platessa*.

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ICES CM 2010/L:07 Poster

Integrating a sequence of models over different life stages to predict the response of fish populations to environmental drivers: anchovy in the Bay of Biscay

Martin Huret, Pierre Petitgas, and Caroline Struski

Fish populations show complex life cycles with different life stages exploiting a variety of habitats. Larval dispersal and fish movements spatially connect the habitats of the different life stages. Each life stage has particular habitat requirements and the availability of these may change in space and time with climate change. The response to hydroclimate variability and change may conflict in the different life stages. Therefore, to predict the response of populations to climate change, one needs to integrate over the entire life cycle. Spatially explicit models of anchovy spawning and larval dispersion were used sequentially to evaluate the population potential responses. We used the outputs of a coupled physical–biogeochemical model to access to the environmental forcing fields. A bioenergetic model resolved individual fish growth and reproduction and determined over different geographic regions the spawning time, duration, and total fecundity. The model provided the initial conditions for running a larval individual-based model to determine the drift and the survival of the larvae. Climate change scenarios were constructed by deviating major forcing parameters of the physical–biogeochemical model (wind, air temperature, short wave radiation, river run-off) from the current situation (reference years). These results of the scenarios were contrasted with the hindcast-simulated series. In scenarios with higher temperature, the spawning season was earlier, which affected the larval drifts, a situation which could be detrimental. The challenges in modelling life cycle closure are discussed.

Keywords: Bay of Biscay anchovy, climate change, complete life cycle model, DEB fish model, larval IBM.

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ICES CM 2010/L:08

Climate change effects on the Baltic Sea ecosystem: a model study

Thomas Neumann

The expected climate change is of growing interest on the regional scale, including the Baltic Sea. However, simulations with global models do not sufficiently resolve the regional impact. Consequently, dynamic downscaling methods are being used to convert the results obtained in global models to the regional scale. In the present study, two regional datasets for greenhouse gas emission scenarios, A1B and B1, for the period 1960–2100, were used to force transient simulations with a three-dimensional ecosystem model of the Baltic Sea. The results showed that the expected warming of the Baltic Sea is 1–4 K, with a decrease in salinity and a much reduced sea-ice cover in winter. In addition, the season favouring cyanobacterial blooms is prolonged, with the spring bloom in the northern Baltic Sea beginning earlier in the season.

Keywords: Baltic Sea, climate change, biogeochemical cycle.

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ICES CM 2010/L:09

Modelling secondary production in the Norwegian Sea with a fully coupled model system

Solfrid Sætre Hjøllo, Geir Huse, Morten D. Skogen

The copepod *Calanus finmarchicus* is the dominant species of the mesozooplankton in the Norwegian Sea, and constitutes an important link between the phytoplankton to the higher trophic levels in the Norwegian Sea food chain. An individual-based model (IBM) for *C. finmarchicus*, based on super individuals and evolving traits for behaviour, stages etc., is coupled two ways to a physical–biological model system. One year of modelled *C. finmarchicus* spatial distribution,

production, and biomass values are compared with point-wise and integrated observations, and found to represent these satisfactory. Sensitivity tests of model setup (i.e. number of super individuals, initial values of traits for behaviour and food preferences) show that the modelling system is robust and provides a valuable tool for studies of ecosystem responses to causative forces such as fish predation or climate change. From a longer simulation, interannual variability and regional differences in biomass and production are studied.

Keywords: *Calanus finmarchicus*, IBM model, Norwegian Sea.

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ICES CM 2010/L:10

Synergistic and antagonistic effects of fishing and climate on the southern Benguela ecosystem assessed by the ROMS–N2P2Z2D2–OSMOSE coupled model

Morgane Travers-Trolet and Yunne-Jai Shin

Fishing and environmental impacts on marine ecosystems are suspected to be synergistic (i.e. stronger than initially estimated by the single impact of each perturbation). But fishing and climate effects are difficult to disentangle. To study their potential synergism or antagonism, an alternative approach to the analysis of field data time-series is to use ecosystem models as virtual laboratories, where forcing variables can be controlled. In this study, we use the coupled end-to-end model ROMS–N2P2Z2D2–OSMOSE to test the potential response of the southern Benguela ecosystem to several combinations of fishing and windforcing. This model is composed of three models, representing the hydrodynamics of the Benguela upwelling (ROMS) and the spatial dynamics of nutrients, phytoplankton, and zooplankton (N2P2Z2D2), coupled through size-based predation to the spatial dynamics of the main species of fish of the ecosystem (OSMOSE). We simulated a set of scenarios combining a range of values of fishing pressure on predators (from no fishing pressure to threefold the current levels of fishing mortality) and values of windstress forcing (from –90% to +90% of the current windstress) and used the change of biomass at four trophic levels (phytoplankton, zooplankton, forage fish, and top predators) to assess the ecosystem response to the forcing couple values. The scenario analysis allowed us to draw a matrix of ecosystem response according to various fishing and windforcings, highlighting the conditions for synergistic and antagonistic effects of these factors.

Keywords: Benguela ecosystem, climate and fishing effects, end-to-end model, model coupling.

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ICES CM 2010/L:11

Modelling the spatio-temporal dynamics in growth and survival of larval cod and sandeel in the North Sea by using individual-based models integrated with spatially explicit three-dimensional hydrodynamic and biogeochemical models

Zeren Gurkan, Asbjørn Christensen, and Henrik Mosegaard

Bioenergetic individual-based models (IBMs) describing growth and survival of the larval and early juvenile Atlantic cod (*Gadus morhua*) and lesser sandeel (*Ammodytes marinus*) in the North Sea are formulated with focus on responses to the local physical and feeding conditions. Prey encounter and physiological processes are parameterized explicitly, which allow the influence of prey fields on larval growth and survival to be observed in three-dimensional settings of hydrodynamic and biogeochemical conditions that are obtained from three-dimensional nutrient–phytoplankton–detritus–zooplankton (NPDZ) models and validated by continuous plankton recorder (CPR) survey time-series data. Analyses were first carried out with typical environmental conditions to identify survival windows and critical phases and to simplify the models. Second, spatio-temporal dynamics of the larval cohorts were simulated by the IBMs in the three-

dimensional setting to obtain insight into the potential climate change effects in relation to spatio-temporal distribution and composition of warm and cold-water zooplankton communities.

Keywords: Atlantic cod, bioenergetics, climate change, continuous plankton recorder, fish larvae, growth, individual-based model, lesser sandeel, North Sea, prey, spatial dynamics, survival.

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ICES CM 2010/L:12

Will North Sea nutrient reductions impact larval fish survival?

Myron A. Peck, Ute Daewel, Marc Hufnagl, Johannes Pätsch, and Jens Rasmussen

Eutrophication is one of the main drivers of change in coastal and shelf sea ecosystems worldwide but disentangling its effects on fisheries from those of other anthropogenic stressors remains problematic. Using a coupled modelling approach, we examined the potential consequences of mandated (OSPAR-related) reductions in river nutrient loads to the North Sea on zooplankton productivity and the survival of larvae of three commercially important marine fish. An ecosystem model (ECOHAM4) provided spatio-temporal estimates of net primary production and bulk zooplankton biomass. The latter was converted to a size-structured prey field based on size-spectrum theory. Prey availability was then compared with biophysical model estimates of temperature-specific prey thresholds required for larval survival of Atlantic herring, Atlantic cod, and sprat. Nutrient reductions of 50–70% were needed to obtain OSPAR water quality criteria, which reduced peak zooplankton biomass in the most productive North Sea areas from ~125 to ~70 mg C m^{-3}. In those areas, minimum zooplankton biomass requirements of larval fish were between ~10 and 30 m^{-3} but could exceed estimates of *in situ* zooplankton biomass depending upon the slope of the zooplankton size spectrum (a key parameter for model coupling). Therefore, we speculate that nutrient-driven changes in phytoplankton and zooplankton species composition may have the largest impact(s) on trophic coupling and the productivity of higher trophic levels. Both technical (conversion of ecosystem model estimates into a size-structured prey field) and ecological (species-specific physiology and feeding requirements) aspects of this spatio-temporal modelling work are discussed.

Keywords: ecosystem modelling, eutrophication, larval fish, survival, trophic coupling, zooplankton biomass.

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ICES CM 2010/L:13

Modelling of anchoveta and sardine populations in the Humboldt Upwelling System with a spatial ecosystem and populations dynamics model (SEAPODYM)

Olga Hernandez, Inna Senina, Patrick Lehodey, Arnaud Bertrand, Vincent Echevin, Aurélie Albert, Ramiro Castillo, Patricia Ayon, Miguel Niquen, Ricardo Oliveros-Ramos, and Philippe Gaspar

A Spatial Eulerian Ecosystem and Population Dynamic Model (SEAPODYM) is used in a data-assimilation study aiming to estimate model parameters that describe dynamics of anchoveta and sardine on the Humboldt Current system (HCS) off Peru. SEAPODYM was first developed to investigate the population dynamics of large pelagic fish (e.g. tuna) in relation to their biophysical environment. It has been adapted for this study on small pelagic species, and configured to a regional domain using the ROMS–PISCES coupled physical–biogeochemical model as an input. The parameter estimation is carried out using maximum likelihood estimation approach and consists in minimizing a cost function (i.e. a log-negative likelihood). In its original version, the model was parameterized through assimilation of commercial fishing data. Here, we incorporated additional information on fish abundance and distribution from acoustic data and larvae campaigns. We conducted our first optimization experiments using a climatological run, and then

an interannual run covering the period 1992–2000 that includes the strong El Niño event of 1997–1998. Monthly catch data are used to include the fishing mortality in the model. We present these preliminary results and discuss the possible mechanisms leading to fluctuations in anchovy and sardine abundance in the HCS system.

Keywords: anchoveta, end-to-end model, habitats, parameter optimization population dynamics, sardine, SEAPODYM, upwelling ecosystem.

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ICES CM 2010/L:14

Implementation and data assimilation on the 3D-IBM for the European anchovy (*Engraulis encrasicolus*) in the north Aegean Sea (eastern Mediterranean)

George Triantafyllou, Kostas Tsiaras, George Petihakis, Dimitris Politikos , Stylianos Somarakis, Shin-Ichi Ito, Bernard A. Megrey, and Annika Pollani

A complex biophysical model comprising Princeton Ocean Model (POM) and European Regional Seas Model (ERSEM) was coupled with an individual-based model (IBM) for the European anchovy (*Engraulis encrasicolus*) in the framework of the SESAME–MEECE–REPRODUCE EU projects. The model was applied in the northern Aegean Sea, an area where anchovy is relatively well studied and, along with sardine, is the most important species for the fishing industry. For the representation of the fish population, the approach of "super individuals" (SI) was adopted, each one characterized by x, y, z coordinates—age, length, and weight. Physiological processes are resolved through a bioenergetics model, while population processes are solved separately, describing the evolution of the number of individuals in each age class, accounting for fishing and natural mortality. From the six life stages included, the first two (eggs and early larvae) are considered as passive tracers. For the remaining stages, in order to simulate fish movement to optimal areas, a dynamic programming method is used where food resources and processes are balanced in a memory and learning procedure. In addition to horizontal migration, a vertical movement is also incorporated as a combined function of the regular diurnal migration, prey concentration, and water temperature. Furthermore, in an attempt to exploit the interacting mechanisms between the two models, a low-rank Kalman filter was implemented for the assimilation of satellite data. Considering the economic value of the anchovy, the prediction of existing stocks is of paramount importance, particularly in the context of overfishing and climatic changes.

Keywords: Aegean Sea, anchovy, data assimilation, fish model.

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ICES ASC 2010/L:15

ICHTHYOP 3.0: a Lagrangian tool to simulate ichthyoplankton dynamics

Philippe Verley

ICHTHYOP is a free Java tool designed to study and forecast the effects of physical and biological factors on ichthyoplankton dynamics. The third version of the tool is organized as a simulation platform which, on one side, processes input time-series of the variables archived from hydrodynamics model such as ROMS, MARS, or OPA-NEMO, and on the other side, executes actions involved in fish early life: spawning, advection, dispersion, vertical migration, growth, settlement, recruitment, mortality, etc. The tool allows us to run a single simulation or series of simulations based on predefined sets of parameters in a user-friendly graphical interface. Particle trajectories can be mapped on Web Map Services or they can be exported to KMZ format (for visualization with Google Earth). It also generates NetCDF output files that can be post-processed easily using graphic and statistical software. The presentation will exemplify the operational

forecasting capabilities of the tool, doing a demo by retrieving real-time data from the pre-operational PREVIMER gateway (via the Web thanks to OpenDAP data access services) and visualizing the plankton dispersal with Google Earth. It will also focus on the novelties of the third version of ICHTHYOP and show how the simulation platform is suited to plug-in any hydrodynamics models and to implement various plankton behaviours. ICHTHYOP is a generic version of previous modelling experiments from the IRD (Institut de Recherche pour le développement). It is now fully supported by the multipartnership project PREVIMER. Information about ICHTHYOP and access to the download page are provided at http://www.previmer.org/ichthyop.

Keywords: fish early life, individual-based model, Lagrangian model, operational forecasting, particle tracking, simulation platform.

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ICES CM 2010/L:16

Consumption of zooplankton by pelagic fish in the Norwegian Sea based on a fully coupled three-dimensional model system

Kjell Rong Utne, Solfrid Hjøllo, Geir Huse, and Morten Skogen

The Norwegian Sea harbours some of the largest pelagic fish stocks in the world. During summer, these stocks feed on various kinds of zooplankton, with *Calanus finmarchicus* as the most important prey species. In recent years, the fish abundance has increased and this has co-occurred with a pronounced reduction in zooplankton biomass in the area. The reason for these fluctuations is still unknown. To improve our understanding and ability to quantify ecosystem processes, a coupled model system of the Norwegian Sea has been developed. This three-dimensional model system includes an oceanographic model (ROMS), a biochemical model (NORWECOM) and individual-based models (IBMs) of zooplankton and planktivorous fish. The zooplankton (*Calanus finmarchicus*) model and the models for Norwegian spring-spawning herring, mackerel, and blue whiting use super individuals to represent the entire stocks. Here we present some model simulations that focus on predicting consumption of zooplankton by planktivorous fish in 1997, with a special focus on the consumption of *C finmarchicus*. Bioenergetics models are used to simulate individual fish growth. The estimated total consumption agrees well with earlier studies based on other methods for estimating the consumption. The findings are important for ecosystem understanding, and the model system may be an important tool for future ecosystem studies in the Norwegian Sea. However, the approach is general and easily exported to other ecosystem models.

Keywords: blue whiting, *Calanus finmarchicus*, ecosystem, feeding, herring, mackerel, migration.

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ICES CM 2010/L:17

Modelling copepod populations in the Gulf of Maine: building prediction capability through a process-oriented approach

Rubao Ji, Cabell Davis, and Christoph Stegert

Zooplankton are sensitive to climate change and may amplify subtle environmental signals because of their non-linear responses to environment forcing. It is critically important to understand the underlying biological–physical mechanisms that control the variability of zooplankton populations, such that the predictions on how the climate change might affect plankton and higher trophic levels become possible. In this study, we use a coupled hydrodynamics/foodweb/population-dynamics model to identify the key processes controlling the observed seasonality and distributional patterns of key copepod populations in the Gulf of Maine region including *Pseudocalanus* spp., *Centropages typicus*, and *Calanus finmarchicus*. The importance

of life-history traits (e.g. development, reproduction, mortality, diel, and seasonal migration) vs. physical processes (e.g. advection and diffusion) are examined. Specifically, we address the following questions: (i) the importance of temperature-dependent development for cold-water vs. warm-water species; (ii) the difference between egg-carrying vs. broadcasting reproduction strategies; (iii) the importance of bottom–up effect through food-dependent development and reproduction; (iv) the role of predation and cannibalism; (v) the impact of diel and seasonal migration on seasonality and distribution; and (vi) the population persistence in an advective system. The implication of this modelling study on data-need, observing system design, and climate change scenario testing will also be discussed.

Keywords: biological–physical interaction, copepods, modelling, life-history traits, plankton.

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ICES CM 2010/L:18

Coupling models of hydrodynamics, prey, and larval haddock on Georges Bank

Colleen M. Petrik, Cabell S. Davis, and Rubao Ji

The annual variation in year-class size of fish populations is important because of its influence on the fishable biomass of the population. This recruitment variability is still not well understood, but for some populations (e.g. Georges Bank haddock) there is a strong relationship between it and processes during the larval stage. Spatially explicit coupled biological–physical individual-based models are ideal for studying the processes of feeding, growth, and predation during the larval stage. We seek to gain insights into the recruitment variability of Georges Bank haddock using such a model. We coupled a hydrodynamics model, a nutrient–phytoplankton–zooplankton–detritus model, a stage-based copepod population model, and a larval haddock individual-based model. Observations of larval haddock growth are strongly correlated with concentration of their copepod prey *Pseudocalanus* spp. This presented a challenge in coupling the copepod and larval haddock models because prey selection is species- and stage-specific, thus a size-based model was not adequate. The model was used to calculate growth and survival over the larval period as well as partition mortality into starvation, predation, and advective losses.

Keywords: biophysical model, haddock, Georges Bank, individual-based model/

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ICES CM 2010/L:19

Tidal variability and its structuring influence on the North Sea ecosystem, modelling impacts of tidal vs. climatic drivers

S. Winger Svendsen, C. Schrum, U. Daewel, and D. Pushpadas

Because of its capacity to homogenize the water column in shallow areas, tides can be considered as one of the key physical forcings in the North Sea ecosystem. The North Sea exhibits mainly co-oscillating tides that can be described as Kelvin waves that enter from the Atlantic at the northwestern boundary and propagate around the North Sea basin in an anticlockwise direction. In areas with bottom depth less than 50 m the energy of the tidal waves is dissipated at the seabed, leading to intensive mixing of the water masses. Here we applied a three-dimensional coupled physical–biological ecosystem model in order to investigate the response of the North Sea ecosystem to changes in both tidal and atmospheric forcing. We performed scenario runs considering different combinations of the most dominant partial tides in the North Sea, including the main contributions from sun and moon and the declination tides, as well as their longer periodic changes. To assess the tidal impacts vs. climatic effects on the productivity of the North Sea ecosystem, we performed sensitivity studies to resolve the effects of windforcing, solar radiation, and air temperature on total productivity and ecosystem structuring. Our results show a

significant impact of variations in tidal forcing on lower trophic level production and ecosystem structuring. Using a coupled plankton–fish model we investigate how tidal and climatic variations impact carbon transfer into higher trophic levels and how growth and larvae survival are influenced.

Keywords: climate, ecosystem, modelling, production, tides.

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ICES CM 2010/L:20

Advances in biophysical modelling of Chilean jack mackerel in the South Pacific

Carolina Parada, Sergio Núñez, Aquiles Sepúlveda, Samuel Hormazábal, Vincent Combes, and Emanuelle Di Lorenzo

Large numbers of Chilean jack mackerel (CHJM) migrate toward reproductive oceanic zones during spring. This transboundary species is a relevant fishing resource inside Chilean and international waters. Little is known about the life history of this species in the South Pacific. The main spawning peak occurs in November in oceanic waters (at least from 92°W to 75°W) and is related to the subtropical front. The connectivity and mechanisms of transport from oceanic spawning areas to northern nursery areas (north of 30°S), as well as the impact of environmental drivers in survival, are unknowns. A coupled biophysical model of the early life history of CHJM was implemented for the South Pacific. A three-dimensional hydrodynamic model of the region—OFES–NPZD—was coupled to an individual-based model of the early life history in an attempt to elucidate these processes. The models were successful in resolving eddies and mesoscale features covering the region between 5°N and 50°S and from the coast to 110°W with a 10-km horizontal resolution and 54 vertical levels. The study involved: validation of the hydrodynamic models, the use of a biophysical model as a simulation platform to assess the impact of environmental drivers on survival, and larval drift–connectivity toward coastal nursery areas, the realization of simulations based on realistic initial conditions from ~10 years of data, and modelling the full early life history. Model outputs will be validated with satellite and field data (age-0 juveniles). Results showed that spawning and nursery areas are connected, which is related to dynamic meanders, and that the physical output agreed with satellite data.

Keywords: biophysical model, Chilean jack mackerel, connectivity, environmental drivers, larval drift.

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ICES CM 2010/L:21

Integrating data, fieldwork, and models into an ecosystem-level forecasting synthesis: the Forage-Euphausiid Abundance in Space and Time (FEAST) model of the Bering Sea Integrated Research Program

Kerim Aydin and Ivonne Ortiz

The Bering Ecosystem Study/Bering Sea Integrated Research Program (BEST-BSIERP, http://bsierp.nprb.org/index.htm) is a five-year programme involving over 90 principal investigators, jointly sponsored by the National Science Foundation (NSF) and the North Pacific Research Board (NPRB) to provide a synthesis of key hypotheses that govern the effects of climate on the Bering Sea ecosystem, and provide a set of tools for forecasting long-term production and distribution of marine resources (e.g. plankton, fish, birds, and mammals). A key component of this work is the FEAST model (Forage-Euphausiid Abundance in Space and Time) a three-dimensional, 10-km resolution model of fish and zooplankton of the Bering Sea built on the ROMS (Regional Oceanographic Model) platform. The fish component models size-based interactions between key fish and zooplankton species of the Bering Sea based on both the results of the BSIERP fieldwork

and data from the collection of over 300 000 fish stomachs over the last 30 years in the region. The model includes a component for testing management strategies and for spatial prediction of fisheries and fish production given future climate (IPCC) scenarios as input drivers. Here, we show results of model predictions related to recent, present, and immediately future field conditions combined with data assimilation and validation. We focus on predictability using the wide range of resources at our disposal today. What is possible, what is missing, what predictions are robust, and what surprises we might have in store as we move to attempting to forecast longer term (20–50 year) outlooks for marine ecosystems?

Keywords: Bering Sea, fish food habits, fishery, management strategy evaluation, process model.

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ICES CM 2010/L:23 Poster

Development of a Chesapeake Bay Ecological Prediction System

Christopher W. Brown, Raleigh R. Hood, Wen Long, Douglas L. Ramers, Catherine Wazniak, Jerry Wiggert, Raghu Murtugudde, Mary Beth Decker, Guillaume Constantin de Magn, Doug Wilson, and Jiangtao Xu

A system was developed to routinely provide short-term predictions of hydrodynamic and biogeochemical parameters in Chesapeake Bay for the purpose of monitoring the ecological condition of the bay. The system currently generates daily now-casts and 3-day forecasts of several state variables, such as sea surface temperature and salinity, and the likelihood of encountering several noxious organisms, such as the scyphomedusa *Chrysaora quinquecirrha*, the potentially ichthyotoxic harmful algal bloom species *Karlodinium veneficum*, and the pathogen *Vibrio cholerae* in Chesapeake Bay. These biological predictions are generated by driving multivariate empirical habitat suitability models with real-time and 3-day forecast data acquired and derived primarily from an implementation of the Regional Ocean Modelling System (ROMS) configured and tuned for Chesapeake Bay (ChesROMS). The predictions, in the form of digital images, are available via the World Wide Web to individuals and interested agencies to guide research, recreational, and management activities. All components of the infrastructure to the predictions—the empirical habitat models, ChesROMS, pre- and post-processing scripts, and website—are integrated into a forecasting system and housed under one roof at the NOAA Chesapeake Bay Office. The system can be easily modified to predict the probability of other important target species, and the ecological approach taken can be transported to any location where sufficient data to define the habitat of the species in question exists.

Keywords: Chesapeake Bay, USA, ecological forecasting, habitat suitability models.

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ICES CM 2010/L:24 Poster

The analysis and identification of biological production of dimethyl sulphide (DMS) and dimethylsulfoniopropionate (DMSP) by phytoplankton in the Cochin Estuarine System

V. T. Dayala, C. H. Sujatha, and P. S. Akhil

The oceans emit sulphur to the marine boundary layer in the form of dimethyl sulphide (DMS), which is a non-sea salt sulphate compound. Recently progress has been made in the study of DMS in oceans because it is a major component of biogenically reduced sulphur compounds emitted from the surface ocean to the atmosphere. Seasonal studies, including pre-monsoon, monsoon, and post-monsoon, were carried out in the Cochin estuarine system. Phytoplankton and DMS samples were taken for qualitative and quantitative analysis. Physicochemical variables were also measured. Biological gaseous DMS is mainly produced by the decomposition of dimethyl sulfonio propionate (DMSP), which is produced by phytoplankton micro-organisms such as

coccolithophores, phaeocystis, dinoflagellates, diatoms, etc. Our field data strongly suggest that DMS to DMSO (dimethyl sulfoxide) is an important process in our water column, and it is clear that considerable internal cycling in the DMSP/DMS/DMSO system occurs in the euphotic zone. Given that DMS is considered to be a major contributor to the greenhouse effect, the present work has a special significance in the study of the environment.

Keywords: cochin estuary, DMS, DMSP, phytoplankton.

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ICES CM 2010/L:25 Poster

Population-selectivity and the influence of spatially heterogeneous fishing

David B. Sampson

Different age classes of fish usually do not experience the same rates of fishing mortality because fish size and behaviour change with age. Differential fishing mortality-at-age is usually described as selection or selectivity. Processes causing selectivity operate at the level of the fishing gear but also more broadly at the level of the population. In this paper, a relatively simple model of population-level selectivity is developed from a set of survival equations that are coupled to allow movement of fish between spatially distinct subpopulations. The model has a particularly surprising emergent property. Even though the same asymptotic gear-selectivity applies across all subpopulations, the overall population selectivity will be dome-shaped unless fishing mortality is uniform across all subpopulations. Hence, the sometimes-controversial feature of "cryptic biomass", which follows from having domed selection, may be a natural consequence of the non-uniform application of fishing.

Keywords: domed selection, fishery age-selectivity, spatially explicit cohort model.

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ICES CM 2010/L:26 Poster

Applications of a spatially explicit model for predicting tuna population dynamics under oceanographic forcing

Inna Senina, Patrick Lehodey, Beatriz Calmettes, and John Hampton

We present a model—SEAPODYM—describing basin-scale tuna population dynamics driven by environmental variables. Biochemical and physical variables as well as prey fields are used to predict the biomass of an age-structured population. Main dynamical processes such as spawning, recruitment, seasonal, and feeding migrations and natural mortality are explicitly accounted for in the Eulerian framework. To address the parameter estimation problem, we use an adjoint technique and perform an optimization of a likelihood function constructed from spatially distributed catch and length frequency data. The model has been applied to describe the dynamics of four tuna species in the Pacific ocean. Here we focus on the application to skipjack tuna (*Katsuwonus pelamis*) that was carried out using several environmental forcings, provided by coupled ocean–biogeochemical models at a resolution of 2°x 1 month. For each model configuration, a number of computer experiments was conducted in order to estimate observable parameters and to obtain the best fit between the data, both spatially and temporally. Our study shows that the model is highly sensitive to the environmental variables and, therefore, that the data assimilation resulted in different sets of model parameter estimates. However, predicted distributions of larval, young, and adult skipjack are similar, the species habitat and the movement patterns are consistent with the results of tagging studies. Temporal dynamics is characterized by a decrease in the skipjack stock that started in the late 1970s. This is mainly the consequence of a decreasing trend in primary production predicted by coupled ocean models.

Keywords: data assimilation, ecosystem, spatially explicit modelling, tuna population dynamics.

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ICES CM 2010/L:27 Poster

The effect of prey patchiness on the growth and survival of larval sandeel in the North Sea: an examination using individual-based modelling

Zeren Gurkan, Asbjørn Christensen, and Henrik Mosegaard

Disentangling the processes that take place in the early life stages of fish is crucial to achieving sustainable management of fish stocks under possible climate change effects. This study examines the influence of food availability and patchy distribution of the planktonic prey on the growth and survival of lesser sandeel (*Ammodytes marinus*) larvae in the North Sea. A generic bioenergetic individual-based model (IBM) for larval fish is developed and adapted for this purpose. The input food conditions are described by the prey field formed by modelling the patch and prey size-spectrum dynamics using transect sampling data, a basic zooplankton matrix model and continuous plankton recorder (CPR) survey time-series data. The results analyse the importance of patchiness of zooplankton abundance at the near-surface waters because intensive aggregations of zooplankton abundance have been recognized as important, especially for the larval and juvenile fish as they need to encounter food at greater than average concentrations for sufficient survival.

Keywords: bioenergetics, continuous plankton recorder, fish larvae, growth, individual-based model, lesser sandeel, North Sea, patchiness, prey, size spectrum, survival.

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ICES CM 2010/L:28 Poster

Modelling the dispersal of Cape hake ichthyoplankton

L. Garavelli, A. Grüss, B. Grote, N. Chang, M. Smith, E. K. Stenevik, D. M. Kaplan, C. Lett

In the Benguela upwelling system off South Africa and Namibia, the early life history of commercial demersal fish species, such as the Cape hakes *Merluccius paradoxus* and *M. capensis*, has traditionally been less documented than for small pelagic species such as anchovy and sardine. However, recent surveys contain information on the seasonal and spatial distribution of Cape hakes eggs and larvae in this region. Interestingly, Cape hakes appear to spawn mainly in July to September, whereas the anchovy and sardine spawning period peaks in October to December. Cape hakes also spawn further offshore and deeper than anchovy and sardine. To investigate the reasons for these differences, we have developed a spatially explicit model of hake egg and larval dispersal, coupling a regional model of oceanic circulation (ROMS) to an individual-based model of ichthyoplankton dynamics (Ichthyop). Our simulation results suggest that differences in the drift routes of eggs and larvae from spawning grounds to nursery areas, which are mainly cross-shore for hakes and alongshore for anchovy and sardine, may partly explain the different spawning seasonality. Our results confirm field studies suggesting that the two hake species follow partly distinct drift routes to nursery areas on an "inshore" route for *M. capensis* and an "offshore" route for *M. paradoxus*. We then incorporate the simulated values of egg and larval connectivity between spawning grounds and nursery areas into a spatial age-structured population model. The ultimate objective of this model is to help in the assessment and design of Marine Protected Areas for the South African Cape hake resource.

Keywords: biophysical model, eggs and larvae, marine protected area, *Merluccius*, South Africa.

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ICES 2010/L:29 Poster

Feeding ecology of herring (*Clupea harengus*), sprat (*Sprattus sprattus*), mackerel (*Scomber scombrus*), and horse mackerel (*Trachurus trachurus*) in the Belgian part of the North Sea

Karl Van Ginderdeuren and Yves Prössler

Mid-trophic pelagic fish play a key role in marine ecosystems, linking zooplankton prey and top predators. They are also of great economic importance as fishery target. Further studying these trophic links is of great value towards maintaining fish stocks as well as improving economic implications towards fisheries. Quantifying these links requires diet and feeding rate studies. Diet compositions reflect feeding ecology and diet changes are directly linked to an "actor"—climate control, anthropogenic impacts, seasonality, interannual variations, etc. In this study, interactions between pelagic fish and lower trophic levels are examined by looking at fish diet composition, food selectivity, and stomach fullness. Fish and mesozooplankton samples were collected at several stations in the Belgian part of the North Sea on a monthly basis, in order to examine a temporal and spatial gradient. Taking both plankton and fish samples allows direct comparison results. The diet of sprat is dominated by calanoid copepod species (*Temora longicornis* and *Centropages* sp). Herring feeds mainly on calanoids as well, but adds amphipods, cumaceans, decapods, bristle worms, and mysids to its diet. In general, small numbers of copepodites were found, indicating selectivity towards adult prey. An onshore–offshore gradient in plankton composition corresponds to a shift in fish diet. Mackerel were clearly piscivorous, preying upon sandeels, but added copepods and pelagic crustaceans to their diet. Horse mackerel seemed to favour both benthic and pelagic hunting grounds, resulting in copepods and typical benthic fauna (e.g. ensis spat) in their stomachs.

Keywords: Belgian part of the North Sea, herring, horse mackerel, mackerel, mesozooplankton, pelagic, sprat, stomach content.

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ICES CM 2010/L:30 Poster

Field consumption estimates of the European sardine in the North Aegean Sea during summer

Nikolaos Nikolioudakis, Marianna Giannoulaki, Athanassios Machias, and Stylianos Somarakis

The calculation of realistic consumption estimates of fish is fundamental information in models that attempt to couple lower and upper trophic levels. Daily ration estimates can be derived from tank experiments or from field sampling over diel cycles, followed by the application of various consumption models. In the present work, estimates of daily rations of European sardine, *Sardina pilchardus sardina*, juveniles and adults (i.e. ≤100 mm and >100 mm total length), were derived from field samples collected during July 2007 and July 2008 in the northern Aegean Sea. The basis for the calculation of separate consumption estimates for juvenile and adult fish during each sampling period was (i) a significant change in the length weight relationship of sardines and (ii) the observation of a change in the vertical positioning of fish in the water column at approximately 100 mm total length. The consumption models applied were those of (i) Eggers, (ii) Elliott and Persson, and (iii) MAXIMS on mean stomach fullness index values. Instantaneous gastric evacuation rates were found to be within the range of values estimated for other small pelagic fish and similar both between the two sampling periods and ontogenetic groups examined. Interannual as well as ontogenetic differences in consumption rates were found, with juveniles always exhibiting higher daily ration values than adult fish.

Keywords: consumption, daily ration, gastric evacuation, sardine.

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ICES CM 2010 L:31 Poster

First passage times and encounter rates in patches: an IBM for zooplankton motion

Luciana Sabia , Marco Uttieri, Giacomo Zagami, and Enrico Zambianchi

In nature, food resources for zooplankton are often distributed in thin horizontal layers. Zooplankton tend to stay as much as possible within these areas where resources are abundant by adapting their swimming behaviour. Outside these layers, zooplankton motion is aimed at increasing the probability of encountering a patch. In the present study, we focus our attention on the effectiveness of different motion behaviours in finding areas rich in food. An individual-based model (IBM) was implemented to simulate five different search strategies, and the time taken to find a patch was analysed through the FPT (first passage time), i.e. the time required for an animal to reach a target at a given distance. Several conditions were tested, accounting for the relative distance between the initial position of the track and the patch. Simulations indicate that pure random walks reach a target faster but cover longer distances, whereas correlated random walks mediate between FPT and track length, suggesting different exploration strategies. Our modelling results can be compared with real trajectories, providing new insights into the efficiency of finding food patches with the lowest energetic costs.

Keywords: first passage time, individual-based models, swimming behaviour, zooplankton.

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ICES CM 2010/L:32 Poster

Spatially explicit model of sole larvae in the southern North Sea: sensitivity of the dispersal to hydrodynamic/environment variability and biological parameters

G. Lacroix and F. Volckaert

Sole (*Solea solea*) is one of the most valuable commercial species in the North Sea. The size of the spawning stock is above the level of sustainable exploitation, but fishing mortality is high. The stock is therefore at risk of being harvested unsustainably. Moreover, interannual recruitment variability is very high. It is crucial to understand the contribution of hydrodynamics, environment, and biological parameters to recruitment variability in order to propose appropriate measures for the management of the North Sea stock. Here we use a particle-tracking transport model coupled to a three-dimensional hydrodynamic model to study the relative effect of hydrodynamic variability, environment variability (throughout temperature), and biological parameters on the dispersal of sole larvae in the southern North Sea. The sole larvae transport model developed in the frame of the SOLEMOD project couples the three-dimensional hydrodynamic model COHERENS with an individual-based model (IBM) of the sole larvae. It has been implemented in the area between 48.5°N 4°W and 57°N 10°E. The impact of the hydrodynamics is tested by simulating different years within the period 1995–2006. The sensitivity to environmental variability is assessed by adding a temperature dependence of the spawning period. The sensitivity to biological parameters is assessed by adding (i) diel and tidal vertical migration, (ii) larvae mortality. Results are analysed in terms of final larvae distribution, larval retention in nurseries, and connectivity.

Keywords: IBM, larvae dispersal, North Sea, particle-tracking model, *Solea solea*.

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ICES CM 2010/L:34 Poster

Movement models for geolocation of pelagic fish using oceanographic fields with complex boundaries

Francois Royer, Inna Senina, and Patrick Lehodey

Datasets retrieved from electronic archival tags prove particularly challenging to classic filtering methods, because pelagic animals evolve in domains with complex boundaries and dynamic physical habitats. Non-Gaussian observational errors, faulty sensors, and data loss (sometimes in large, repeated batches) further complicate the modeller's task. A new development for positioning pelagic fish from archival tag data is presented here, with a focus on tackling complex boundaries such as coastlines. The method leverages a recently proposed Bayesian filter, consisting in solving the filtering equations on the discretized spatial domain, and updating using measurements collected by the tag's different sensors (ambient temperature, light intensity, or sunrise/sunset times). Two implementations of the random walk model are presented, assuming a Gaussian kernel (for diffusive movement) and a uniform kernel (for speed-constrained movement). An application using archival tag datasets is presented to show the robustness of the method, using sea surface temperature and light data to locate fish near complex boundaries.

Keywords: advection–diffusion, finite differences, front propagation, gridded Bayesian filter, light geolocation, sea surface temperature.

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ICES CM 2010/L:35 Poster

Is drift modelling useful to improve the recruitment index for Baltic sprat (*Sprattus sprattus*)?

Ulrike Luschtinetz, Daniel Stepputtis, and Stephan Dick

The 0-group hydroacoustic abundance estimate in a defined area in the eastern Baltic Sea (SD26 and SD28) is used as recruitment index in the Baltic sprat assessment. This index is derived from the Baltic International Acoustic Survey (BIAS), carried out in autumn every year. The use of a subarea for index calculation ideally requires a stable fraction of recruits to be found in the area used for index calculation, compared with the entire distribution area of the stock. Previous simulation studies have shown high interannual variability in drift patterns of Baltic sprat eggs and larvae. Drift simulations of sprat eggs and larvae based on an operational hydrodynamic model (Bundesamt für Seeschiffahrt und Hydrographie—BSH) were used to investigate the interannual variability in the proportion between the different areas. Based on these findings, a drift-corrected version of the recruitment index was calculated and its performance was tested in the assessment.

Keywords: Baltic, drift, egg, hydrodynamic model, larvae, recruitment, *Sprattus sprattus*.

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ICES ASC 2010/L:36 Poster

Assessing Marine Protected Areas network and alternative management scenarios for the sustainable exploitation of fish resources in the southwestern lagoon of New Caledonia

B. Preuss, D. Pelletier, and L. Wantiez

Following a supposed decline of fish resources in the southwestern lagoon of New Caledonia during the 1980s, the government implemented a network of marine reserves, most of which have been monitored through field surveys for 15 years. This lagoon is a large coastal coral reef seascape, subject to substantial pressure from fishing and other activities. Therefore, the relevance and efficiency of an MPA for a sustainable exploitation of resources is a complex issue. Based on modelling of key fish resources and fishing activities, the aim of this study is (i) to determine the

key parameters of the biology and the ecology of species regarding stock management issues, (ii) to evaluate the sustainability of the exploitation, depending on alternative management scenarios under a range of hypotheses about fish connectivity between habitats. Using the ISIS-FISH model with sensitivity analysis, we select the most critical parameters of population dynamics for best stock management. Moreover, we focus on spatial consideration as coral reefs are very fragmented habitats, and fishing pressure is highly heterogeneous in the study area. MPAs are currently the main management tool for lagoonal fisheries in the southwestern lagoon of New Caledonia. The ISIS-FISH model with habitat consideration is used to evaluate through simulations the relevance of a range of management scenarios to ensure the sustainable exploitation of main fish resources.

Keywords: assessment, coral reef ecosystems, fishery management, modelling, MPA, sensitivity analysis.

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ICES CM 2010/L:37 Poster

Novel biophysical life cycle model for European anchovy in the northwestern Mediterranean: towards a fishery management tool

A. Ospina-Álvarez, I. Palomera, P. Garreu, A. Nicolle, and C. Parada

Recruitment of European anchovy is thought to depend largely on the passive transport of eggs and larvae from spawning to nursery areas. Here we consider an individual-based, discrete, and stochastic model (IBM) for the transport and advection of anchovy eggs and early larvae in the northwestern Mediterranean. This is the first time that an IBM has been applied to field data of eggs and larvae densities from the Gulf of Lions (GoL) and the Catalan Sea. To this aim, we consider: (i) the effect of egg-buoyancy changes through development and (ii) the effect of diel vertical migration (DVM) through larval growth, on transport or retention. Ichthyoplankton samples were obtained during June 2007/2008 DEPM surveys. Egg-density measurements were carried out in a density gradient column to obtain an equation describing the egg-density changes through development. A DVM scheme adjusted by larvae stages' ability to swim was implemented. The output of a Mars3D hydrodynamic model was coupled to ICHTHYOP-IBM, allowing the analysis of transport owing to mesoscale processes. We found that the coupled hydrodynamic–IBM model is sensitive to initial conditions of eggs in the water column, the egg vertical displacement owing to buoyancy, and vertical movement of early larvae. The GoL is the main spawning area of anchovy in the region. The shelf-slope current along the continental slope off the Catalan Sea advects surface waters. Applying coupled hydrodynamic–IBM models to the simulated advection and transport spectra allows us to determine to what extent the recruitment of anchovy populations in the Catalan Sea depend on transport mechanisms.

Keywords: anchovy, IBM model, Northwest Mediterranean, recruitment, transport.

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ICES CM 2010/L:39 Poster

A spatially explicit model to study anchovy reproduction patterns under climate change scenario in the Humboldt current system

Timothée Brochier, Vincent Échevin, and Jorge Tam

Small pelagic fish reproduction success is known to be dependent on environmental conditions, and is very variable in unstable areas such as upwelling current systems. Here we present an individual-based model of anchovy first stage of life, with recruitment criterion based on environmental factors provided by a three-dimensional hydrodynamic model of the Humboldt Current System (HCS). We tested different recruitment criterion based on retention rate in (i) the continental shelf, (ii) the plankton-rich area supplied by a satellite chlorophyll *a* climatology, or (iii) the plankton-rich area supplied by ROMS-PISCES. To test the realism of the recruitment criterion,

we used field observations of spawning distributions in Peru (northern HCS) to force the IBM spawning patterns, and then compare the predicted reproduction success with the corresponding field observations of recruitment. We then apply this model in the frame of climate change using future scenarios such as hydrodynamical forcing, based on a downscaling of the IPSL-CM4 large-scale ocean circulation corresponding to the two contrasted climate scenarios, the so-called preindustrial and quadrupling CO_2. The adult spawning pattern in this new environment is then determined via an iterative (multigeneration) process by natural selection on the early life stage.

Keywords: climate change, early life stage, individual-based model, Lagrangian, recruitment criterion, small pelagic fish.

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ICES ASC CM 2010/L:40 Poster

Seasonal zooplankton dynamics in the southern and northern North Sea captured by ecosystem and stage-structured population models

Christian Lindemann and Andreas Moll

The seasonal zooplankton dynamics of marine systems are characterized by a few key players. In the North Sea, one of these species is *Pseudocalanus elongatus*, a calanoid copepod displaying different seasonal dynamics in northern and southern areas of that ecosystem. These dynamics are probably best captured by models using an explicit representation of a structured population as opposed to merely a "bulk" zooplankton carbon formulation. The present study describes efforts to couple a stage-structure population model constructed for *P. elongatus* to a three-dimensional ecosystem model (ECOHAM4). The copepod model includes 10 state variables within five life stages, one each for abundance and biomass. The dynamic trophic interactions in the ecosystem model include functional groups for fast- and slow-sinking detritus, bacteria, diatoms, flagellates, and micro- and mesozooplankton. Simulations were run for the Northwestern European Continental Shelf (NERC) using realistic meteorological and hydrographic conditions for 2003–2004 to examine simulated seasonal zooplankton population dynamics compared with *in situ* data for southern (GLOBEC observations) and northern (FLEX observations) areas. In the northern area, two peaks in zooplankton biomass were predicted with a lag between bulk and structured zooplankton biomass maxima in spring and lower biomass levels for both zooplankton types during summer. Compared with the northern area, the zooplankton biomass in the southern area peaked earlier in the season. In both areas, productivity of *P. elongates* was controlled more by food availability than temperature. Model parameterizations and trade-offs between zooplankton estimates obtained using bulk ecosystem and structure–population models are discussed.

Keywords: ecosystem model, generation time, North Sea, *Pseudocalanus elongatus*, stage-structured zooplankton population model.

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Theme Session M

Fisheries-induced adaptive changes and their consequences: why should we care, and what can we do?

ICES CM 2010/M:01

Intra-stock variability in reproductive investment strategies: consequences for the estimation of fisheries-induced evolution

P. J. Wright, F. M. Gibb, C. Millar, and D. Tobin

The stocks of many marine fish comprise several spawning components that differ with respect to life-history traits. For example, recent field studies indicate that the maturity and fecundity–size relationships of both cod and haddock differ among North Sea spawning components. In this paper, we report on how these differences in reproductive characteristics have developed over the last decades, in terms of the rate of change in probabilistic maturation reaction norms and in weight-specific fecundity. Spawning components from the most heavily depleted and climatically variable region have undergone the largest declines in size and age at maturation, with cod and haddock from the northern inshore region now maturing at much smaller sizes and at a year younger than those from the northern offshore region. Maturation differences between these spawning components persisted when juveniles were raised under a common environment, suggesting that present differences were not solely reflective of local environment. Fecundity at size has also increased in the inshore northern North Sea, despite a general decline in somatic condition. These observations are consistent with a fishery-induced adaptive change in reproductive schedules. Nevertheless, warming during the summer maturation decision phase may also have contributed to the rapid decline in maturation reaction norms. This study demonstrates that a failure to account for substock structuring can lead to erroneous conclusions about the magnitude of reproductive changes within a stock.

Keywords: cod, fecundity, haddock, probabilistic maturation reaction norms, temperature effects.

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ICES CM 2010/M:02

The bioeconomic consequences of fisheries-induced adaptive changes

Fabian Zimmermann, Christian Jørgensen, Stein Ivar Steinshamn, and Mikko Heino

Many fish stocks face severe harvest pressure. The consequences are not limited to reduced stock size and productivity, as the increased mortality may set up new selection gradients that can lead to evolutionary change. But what are the potential economic impacts of fishery-induced adaptive changes? To study this, we used a simplified evolutionary life-history model focused on age at maturation as basis for the stock dynamics, coupled with a fishing module that describes costs, harvest, and economic yield. Size-dependent natural mortality and fishing mortality are the driving forces of selection, and life history evolution is modelled as a quantitative trait. In the analysis, we vary the size-selectivity of the fishing gear and the level of fishing mortality or effort. Together these determine fishery yield and hence the economic yield. This allows for an impact analysis of harvest strategies on life history evolution as well as the long-run influence on revenue. The goal is to assess if and under what levels of discounting rates fishery-induced evolutionary effects may be economically relevant.

Keywords: bioeconomic model, discounting, economic yield, fishery-induced evolution, reproductive investment.

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ICES ASC CM 2010/M:03

Recent size and run-timing trends in Irish Atlantic salmon (*Salmo salar*) were not responses to fishery management-induced evolution

Philip Bacon and Philip McGinnity *et al.*

Evolution, including evolution that is fishery induced, requires heritable traits. A driftnet fishery off the Irish coast took large numbers of Atlantic salmon between 1960 and 2006 and was selective in terms of return-date and, potentially, size. Data from a ranched salmon population show that the sizes of returning mature adults fell by around 3 cm between 1980 and 2006, despite a 4-cm increase in average length of released smolts over the same period. However, a range of quantitative genetic models showed that the heritability of the body length of returning mature adults was nearly zero. Thus, the size reduction was most unlikely to have any appreciable genetic component. The dataset of 21 cohorts was too short to ascribe the de-trended change in size reliably between six marine environmental "surrogate" covariates, which in total may account for 10–64% of size variation. Return-date heritability could not be estimated directly, but an annual declining trend in seasonal return-date reversed abruptly one generation after an altered selection protocol for hatchery broodstock excluded early returning fish. But this return-date change was paralleled by wild grilse from a population on the east coast of Scotland, so causation via strong heritability is also most unlikely.

Keywords: Burrishoole, climate change, environmental change, evolutionary rates, fishery-induced evolution, fishery management, long-term population data, population dynamics, run-timing, *Salmo salar*, size-at-age, time-series.

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ICES CM 2010/M:04

A comparative analysis of contemporary rates of fisheries-induced evolution

Jennifer A. Devine, Peter Wright, Heidi Pardoe, and Mikko Heino

It is becoming increasingly accepted that fisheries can cause phenotypic changes in exploited stocks within a few generations. However, the debate is still ongoing over whether these rates are considered fast or slow. Here we have estimated contemporary rates of evolution in Haldanes for length at maturation from probabilistic maturation reaction norm midpoints, and reproductive investment for several stocks from the North Atlantic, Northeast Arctic, and Barents Sea, and the North Sea. Some of these stocks currently support fisheries, whereas others have been under moratorium for several generations. Compared with other species undergoing anthropogenic-induced trait changes, fishery-induced change appeared to be slower. Because there is little published information on rates of natural phenotypic changes for these fish stocks, a random-walk model was used to provide baseline estimates of trait evolution under natural selection pressure. Phenotypic change is slower over long time intervals, therefore, absolute Haldane estimates were compared with baseline rates to show whether these estimated rates could be defined as "fast" or "slow". We then discuss management implications and relate this to exploitation. We focus on whether it is possible to use this information to provide an early warning system for managers before stocks show severe changes that can impact system productivity and economic yield.

Keywords: contemporary evolution, fishery-induced evolution, Haldanes.

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ICES CM 2010/M:05

Assessing temporal quantitative genetic differentiation in exploited populations by combining data on phenotypes and neutral genetic markers

Bruno Ernande

Temporal phenotypic trends in life-history traits, including maturation age and size, growth, and reproductive effort, have been observed in many commercially exploited fish stocks. Given that exploitation alters markedly the mortality regime of exploited populations and that most life-history traits exhibit genetic variability, it is likely that these phenotypic trends are partly evolutionary adaptive responses of fish to exploitation. Concomitantly, trends in life-history traits may also arise from phenotypic plasticity, which may also be adaptive, in response to exploitation and/or other environmental factors. When dealing with observational data, one main difficulty lies in assessing the respective contribution of these two non-mutually exclusive potential causes of changes in life-history traits and a direct genetic evidence of an adaptive evolutionary response in commercially exploited stocks is still lacking. This talk will present how a measure of temporal quantitative genetic changes within a single population, Qtemporal, can be defined similarly to the classical measure of quantitative genetic differentiation between populations known as QST and compared with temporal neutral genetic changes, Ftemporal, in order to assess the contribution of adaptive evolution to temporal phenotypic changes. In a second step, it will explain how the Qtemporal metric can be estimated by combining data on temporal neutral genetic changes together with data on temporal phenotypic changes, while accounting at the same time for environmental covariates that may be responsible for phenotypically plastic changes. Finally, an application of the method to life-history changes in North Sea sole will be presented.

Keywords: directional selection, effective population size, evolution, fishery-induced adaptive changes, Ftemporal, genetic differentiation, phenotypic plasticity, Qtemporal, random genetic drift, stabilizing selection.

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ICES CM 2010/M:06

Regional and temporal variance in spawn timing vs. fisheries economics: a recipe for anthropogenically induced contraction of the natural spawning period of Pacific halibut?

Timothy Loher

Pacific halibut (*Hippoglossus stenolepis*) represents one of the northeastern Pacific's most valuable fisheries, generating ~70 million pounds of annual productivity. Because adoption of quota management the fishery has occurred over a roughly nine-month season that is closed in winter to protect spawners. The closure period was adopted following surveys that suggested spawning typically begins in November, peaks in January, and ends by March. Over the last 20 years, Canadian and Alaskan harvest has usually ceased on 15 November, but season-opening dates have been allowed to vary by approximately one month, influenced by market forces and administrative considerations. Archival tagging data have recently been used to quantify the active spawning period on the basis of short-period vertical migrations that are believed to represent egg release. This has confirmed field reports suggesting that commercial fishing has often begun prior to the end of spawning. As such, late-spawning individuals may be subjected to greater fishing mortality than those that spawn early. If spawn timing is heritable, continued adoption of season dates that do not equally protect all reproductive strategies may reduce population-level fitness and long-term yield. Halibut recruitment is believed to be environmentally driven, and prolonged spawning and regionally variable spawn timing may represent environmental bet hedging. Relationships between spawn timing, regional oceanography, and management parameters will be discussed, with attention to the potential for fishery-induced evolution (FIE). Management modifications will be presented in which halibut life history might be more accurately reflected, and FIE minimized, while attending to the objective of maintaining fishery value.

Keywords: fishery-induced evolution (FIE), Pacific halibut (*Hippoglossus stenolepis*), selective mortality, spawn timing, time-area management.

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ICES CM 2010/M:07

Can fisheries-induced evolution shift reference points for fishery management?

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Biological reference points are important tools for implementing the precautionary approach. In general, reference points are not static, but may change when a population's environment is changing or when the population itself is changing. Fisheries-induced evolution is one mechanism that can drive changes in population characteristics, leading to "shifting" reference points through two possible pathways: by changing the underlying biological processes and by leading to changes in the perception of a system. The former implies that "true" reference points are changing, whereas the latter implies that the yardstick used to quantify a system's status is changing. Unaccounted shifting of either kind means that reference points gradually lose their intended meaning. This can lead to increased precaution, which is safe, but may be costly. Shifting can also occur in the direction of danger, such that actual risks are higher than accepted. Our qualitative analysis suggests that all commonly used reference points are susceptible to shifting through fishery-induced evolution, including the widely used limit and precautionary reference points for spawning-stock biomass (Blim and Bpa) and fishing mortality (Flim and Fpa). Our findings call for increased awareness of fishery-induced evolution and highlight the value of specifying reference points based on adequately updated information, to capture changes in the biological processes that drive fish population dynamics.

Keywords: biological reference points, fishery-induced evolution, fishery management, population dynamics, precautionary approach, uncertainty.

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ICES CM 2010/M:08

Evolutionary impact assessment: Accounting for the evolutionary consequences of fishing in an ecosystem approach to fisheries management

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The past few years have witnessed a growing awareness that fishing might induce evolutionary changes in exploited stocks. With fishing mortalities sometimes exceeding natural mortalities by as much as 400%, adaptive responses to the altered selective environment caused by fishing seem inevitable. Case studies suggest that fishery-induced evolution can occur within just a few generations, and that evolutionary recovery from the incurred changes may be slow. Many traits are likely to be affected, including maturation schedules, growth rates, reproductive investment, behaviour, and morphology. As a result, fishery-induced evolution may change fishery yields, stock stability, recovery potential, trophic interactions, geographical distributions, touristic benefits, and the intrinsic values of species and ecosystems. Such changes modify the ecological

services through which living aquatic resources provide value to society. The need for extending traditional fishery management to account for the potential evolutionary effects of fishing thus seems compelling. Here we describe evolutionary impact assessment (EvoIA) as a set of methods for assessing the evolutionary consequences of fishing and for evaluating how alternative management options may help or hinder evolutionary recovery. EvoIAs (i) contribute to the ecosystem approach to fishery management by clarifying how evolution alters stock properties and ecological relations, (ii) support the precautionary approach to fishery management by addressing a previously overlooked source of uncertainty and risk, and (iii) help realize the Johannesburg Summit's commitment to the restoration of sustainable fisheries by allowing fishery managers to address the potential evolutionary consequences of fishing.

Keywords: ecosystem approach to fishery management, fishery-induced evolution, impact assessment.

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ICES CM 2010/M:09

Evolutionary vulnerability of prototypical life histories

Erin S. Dunlop, Mikko Heino, and Ulf Dieckmann

Although empirical evidence of fishery-induced evolution has been documented in several species, it remains open whether and how patterns of evolutionary response vary among species with different life histories. For example, results of evolutionary analyses corroborate that species with longer generation times are generally more vulnerable to the selection pressures induced by exploitation. Yet, the question of how other life-history attributes of a species influence the outcome of fishery-induced evolution has remained largely unstudied. Relevant attributes include natural mortality levels, average lifespan, patterns of determinate or indeterminate growth, semelparous or iteroparous reproduction, as well as typical somatic growth rates and ages at maturation. Although some of these attributes may readily respond to fishery-induced selection pressures, others are constrained by the overall life-history strategy and bauplan of species and might therefore set boundary conditions for processes of fishery-induced evolution. Here we present a suite of eco-genetic models parameterized for particular life-history prototypes. Each of these prototypes represents groups of species with a typical combination of life-history attributes, including anchovy-like, cod-like, salmon-like, ray-like, and whale-like life histories. Using measures of evolutionary vulnerability, we establish transferable knowledge and generalized predictions about the expected life-history impacts of alternative fishing regimes on exploited fish stocks. The resultant insights are intended to support fishery scientists and managers in their responsibility of prioritizing measures of monitoring and protection among a multitude of exploited stocks.

Keywords: evolutionary vulnerability, evolutionary recovery, fishery-induced evolution, multi-trait evolution.

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ICES CM 2010/M:10

Calculation of expected rates of fisheries-induced evolution in data-poor situations

Ken H. Andersen

A central part of an impact assessment of the evolutionary effects of fishing is a calculation of the expected rates of fishing induced by current fishing practice, as well as an evaluation of how alternative fishing patterns may reduce evolutionary impacts of fishing. I will present a simple size-based framework to perform the modelling part of an evolutionary impact assessment. The framework is based on size-based prescriptions of natural mortality, growth, and fishing mortality, and uses basic quantitative genetics to calculated expected rates of evolution on size at maturation, growth rate, and investment in gonads. Life history theory is used to reduce the necessary

parameter set by utilizing relations between parameters. The reduction of the required parameters makes the framework particularly well suited for data-poor situations where only the size at maturation or the asymptotic size is known. Calculations with the framework are fast and a web-based implementation is presented. A discussion of the confidence of the predictions and the fundamental limitations of the modelling framework is undertaken.

Keywords: evolutionary impact assessment, life-history theory, quantitative genetics.

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ICES CM 2010/M:12

Using historical DNA to study fisheries-induced genetic change in Atlantic cod (*Gadus morhua*)

N. O. Therkildsen, J. Hemmer-Hansen, and E. E. Nielsen

The notion that fisheries exert a strong selection pressure on the targeted stocks has attracted considerable research interest over the past decade. Experimental studies, modelling efforts, and statistical treatment of phenotypic data have suggested that the extensive harvesting in recent history very likely has caused evolutionary change in important life-history traits of several fished populations, particularly in size and age at maturity. Although this body of evidence is growing, we still lack direct documentation of genetic changes at the DNA level underlying the observed changes in wild stocks. Historical DNA, recovered from archived otoliths, provides a unique opportunity to test the hypothesis of fishery-induced genetic change in "real time". To this end, we studied allelic variation in genes expected to be important for growth and maturation traits in populations of Atlantic cod (*Gadus morhua*) – one of the historically most intensively fished species. We compared allele frequency distributions for >800 loci in contemporary and historical (up to 80 years old) samples to look for temporal genetic changes. By generating time-series of data on genetic variation, this approach provides a promising avenue for shedding light on the evolutionary importance of fisheries-induced (or environmentally driven) genetic changes and can also reveal potential reductions in the general level of genetic diversity resulting from fisheries collapses.

Keywords: Atlantic cod (*Gadus morhua*), candidate gene, fishery-induced evolution, genetic change, historical DNA.

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ICES CM 2010/M:13

Temporal changes in maturation of North Sea gadoids (cod, haddock, whiting, and Norway pout)

Lise Marty, Marie-Joëlle Rochet, and Bruno Ernande

Decreasing trends in age and size at maturity have been observed in several commercially exploited fish stocks, which may be explained by two non-mutually exclusive processes: fishery-induced evolution owing to increased mortality, or phenotypic plasticity in response to environmental variability. The concept of probabilistic maturation reaction norm (PMRN) can help to disentangle the different sources of variation in maturation. It describes the probability of maturing as a function of an individual's age and size and thus allows the removal of the contribution of growth and mortality variations to changes in maturation. Because somatic growth accounts for most environmental factors influencing maturation through phenotypic plasticity, the remaining trends detected by PMRNs are likely to result from genetic changes. However, other environmental sources may contribute directly to the probability of maturing without affecting growth and be confounded with genetic effects if non-evaluated. We applied the PMRN method to four stocks of North Sea gadoids (cod, haddock, whiting, and Norway pout) using data collected

during the International Bottom Trawl Survey. We found decreasing trends in PMRN midpoints at several ages between the mid-1970s and 2000 in two of these four stocks (cod and haddock). The comparison between four species from a same family allows assessing how differences in life cycle and other life-history traits affect the response to exploitation in terms maturation. The influence of alternative factors that may affect maturation propensity (namely annual estimates of capelin and zooplankton abundances as index of trophic resources, temperature, and competitive biomass) was investigated.

Keywords: exploitation, growth, life-history evolution, North Sea gadoids, phenotypic plasticity, probabilistic maturation reaction norm.

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ICES CM 2010/M:14

Genetic adaptation in common sole (*Solea solea*) under natural and artificial selection

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The management of commercial marine fish species requires a thorough understanding of natural and anthropogenic selective influences that impact natural populations. The study of the level of adaptive genetic variation in natural sole populations across Europe to assess the geographical distribution and the influence of overfishing on functional genetic diversity at relevant genes, might provide indications for genetic (local) adaptations. My study has four main objectives: (i) the bioinformatic analysis of sole transcriptome sequences (based on next generation sequencing) to develop markers linked to candidate genes potentially involved in life-history traits such as growth, maturation, and temperature adaptation; (ii) the high-throughput screening of contemporary and historical sole populations using both neutral and gene-linked SNPs/microsatellites to assess jointly the connectivity and potential local adaptation in sole; and (iii) the experimental validation of genetic adaptations in a controlled breeding population of sole to assess genotype by environment interactions. Preliminary results have already revealed the existence of various interesting polymorphisms in candidate genes, now analysed on a spatio-temporal scale. This project is highly relevant to sole management by mapping genetic management units and by pinpointing potential irreversible anthropogenic effects on adaptive genetic variation. The project is integrated into the EU projects FishPopTrace and FinE, studying the traceability/connectivity and evolutionary impact of fisheries on marine populations.

Keywords: aole, connectivity, functional diversity, high-throughput screening, management, overfishing, SNPs, traceability.

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ICES CM 2010/M:15

On the interplay of environmental changes and fishing pressure in exploited fish stocks

David S. Boukal, Andre M. de Roos, Lennart Persson, and Mikko Heino

Fish in many exploited stocks grow faster and mature earlier at either larger or smaller sizes compared with pre-exploitation periods. These changes can be driven by both genetic and phenotypic responses. At the same time, these stocks may adjust to other changes in the environment, such as increasing/decreasing overall productivity or changes in temperature. Using a model of planktivorous fish with annual spawning and size- and density-dependent individual growth, we ask if the interplay of environmental change and fishing pressure could lead to stabilizing, disruptive, or directional selection on age and size at maturation in the stock. This question is particularly relevant to habitats exposed to significant directional change in the environment, the prime example being many inland reservoirs.

Keywords: density-dependence, environmental change, fisheries, harvesting, life-history evolution, population dynamics.

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ICES CM 2010/M:16

The molecular basis of phenotypic adaptive changes in the common sole (*Solea solea*): disentangling fisheries from climate-induced evolution

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Recent studies have strongly indicated fishery-induced evolution of important life-history traits, such as age and size at maturation, growth, or reproductive effort in exploited fish populations. Most evidence is based on the analysis of phenotypic data, showing changes in maturation reaction norms, which for many species and populations have changed markedly over historical times corresponding to the intensity of fishing. However, the molecular basis of fishery-induced evolution has not been proved yet and requires further attention. We studied the neutral and adaptive genetic changes potentially induced by fisheries through the retrospective analysis of DNA from historical otolith collections from the North Sea sole population, which has been subjected to heavy harvesting for over 60 years. We evaluated the evolutionary trajectories of candidate genes involved in the growth axis and the brain–pituitary–gonad axis. We quantified the selective effects of fisheries on adaptive genetic variation and compared this pattern with a relatively stable neutral genetic baseline. Finally, we assessed the agreement between fisheries selection gradient and the direction of molecular genetic changes observed in sole, while estimating the proportional importance of alternative drivers (such as temperature increase) for creating the observed life-history changes.

Keywords: adaptive variation, climate change, fishery-induced evolution, management, overfishing, sole.

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ICES CM 2010/M:17

How strong is fisheries-induced selection? An assessment of selection differentials caused by fishing

Ulf Dieckmann, Mikko Heino, Shuichi Matsumura, and WGEVO participants

Evolution can be studied from two complementary angles: by studying the presence of ingredients for evolution—selection and heritable variation in fitness-related traits—and actual responses to selection. Empirical studies on fishery-induced evolution in the wild have primarily relied on the latter, backed up by theoretical models that show that fishing is a potent selective agent and by selection experiments showing that heritable variability is generally present; very few studies have actually tried to estimate selection differentials generated by fishing for any real stock. Indeed, demonstration of a correspondence between selection differentials and observed rates of phenotypic change is sometimes raised as a missing piece of evidence without which claims about fishery-induced evolution lack credibility. The Working Group on Fisheries-Induced Evolution (WGEVO) is now addressing this knowledge gap by estimating stock-specific selection differentials for a large number of stocks using a relatively simple age-structured model. The model is parameterized using data on present-day life history, natural mortality, and fishing mortality; the model then yields estimates of selection differential for the evolving traits in the model: growth, maturation, and reproductive investment. Our preliminary results support the notion that fishery-induced selection can often be strong.

Keywords: fishery-induced evolution, fishery management, growth, phenotypic plasticity, probabilistic maturation reaction norm, reproductive investment, selection differential.

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ICES CM 2010/M:19

Evolutionary impact assessment of North Sea flatfish fisheries

Adriaan D. Rijnsdorp, Fabian M. Mollet, and Jan Jaap Poos

The impact of fishery-induced evolution on the productivity of North Sea flatfish is explored using published results of an eco-genetic individual-based model. Under the current management, flatfish evolve towards smaller size-at-age, earlier maturation, and higher reproductive investment, and as a consequence the biological reference points change and cannot be considered sustainable. The evolutionary change can be reversed by implementing a dome-shaped exploitation pattern protecting the large fish, but this would result in a short-term loss in yield. Management scenarios are explored to study how a dome-shaped exploitation pattern can be achieved by imposing spatio-temporal management measures based on the differences in seasonal distribution patterns by age groups and taking account of the importance of sole and plaice for the economic performance of the fishery.

Keywords: exploitation pattern mesh size, fishery management, fishing mortality rate, harvesting-induced evolution, maximum sustainable yield, North Sea plaice, selectivity.

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ICES CM 2010/M:20

Plastic and evolutionary responses in correlated life-history traits

Fabian M. Mollet, Bruno Ernande, Thomas Brunel, and Adriaan D. Rijnsdorp

We fit an energy allocation model, describing body growth as the difference between energy acquisition and energy expenditure and including a discontinuity in expenditure at the onset of maturation, through otolith back-calculated growth curves of North Sea plaice and sole collected over a period of more than 60 years. Time trends since 1940s show an increase in energy acquisition and reproductive investment and a decrease in the onset of maturation in both species. A part of these observed trend traits is a result of a plastic response to population density, eutrophication, and temperature and effects from correlation between the traits. However, the remaining time-trend is significant and suggests a genetic change that is consistent with a fishery-induced evolutionary response. This is the first multivariate analysis of temporal changes in multiple life-history traits based on individual data and accounting for phenotypic correlations. Multivariate viability selection differentials are estimated by comparing trait distributions-at-age within a cohort over successive sampling ages. Further research is needed to link these selection differentials to the observed evolutionary response accounting for phenotypic correlations and overlapping generations.

Keywords: energy allocation, energy acquisition, fishery-induced evolution, flatfish, maintenance, onset of maturation, otolith-size back-calculation, *Pleuronectes platessa*, reproductive investment, *Solea solea*.

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ICES CM 2010/M:21

Culling experiments shed light on fishing-induced evolution in salmonids

Raul Primicerio, Per-Arne Amundsen, Anders Klemetsen, and Rune Knudsen

Salmonid populations exposed to strong selective harvest may undergo evolutionary change. Culling experiments allow to address the evolutionary impact of gillnet fishing on maturation schedules of salmonids. Two culling experiments on Arctic charr and whitefish populations from northern Norway provide evidence of evolutionary change towards earlier maturation at a smaller size consistent with theory. The Arctic charr population showed slow and only partial recovery from fishing-induced evolution during a prolonged period of suspended harvest. The observed, rapid life-history change has important demographic and management implications, influencing the size structure and recruitment of these populations.

Keywords: evolution, gillnets, life history, salmonids.

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ICES CM 2010/M:23 Poster

Estimation of probabilistic maturation reaction norms (PMRN) under controlled conditions

Beatriz Diaz Pauli, David N. Reznick, and Mikko Heino

The probabilistic maturation reaction norm (PMRN) is a statistical tool commonly used in the study of fishery-induced evolution because of its potential to disentangle genetic effects on maturation from environmental ones. PMRNs characterize maturation schedules of fish stocks from time-series data accounting for the variation owing to different growth and mortality rates. When growth and mortality are the main sources of phenotypic variation on maturation, changes in the PMRN (e.g. its midpoint (age and size at which maturation probability is 50%) suggest genetic change). However, little is known about other potential sources of plasticity of maturation in fish stocks and how they shape PMRNs. Laboratory experiments allow us to estimate PMRN in controlled environments. We can add extra sources of variation in maturation, such as temperature or social structure, and therefore estimate multidimensional PMRNs. We performed such experiments with male Trinidadian guppies, *Poecilia reticulata*, (i) under control standard conditions (i.e. eliminating main environmental sources of plasticity) and (ii) under modified social structures (i.e. presence or absence of mature males and females). Our aim was to assess (i) how two-dimensional PMRNs are affected by unaccounted sources of plasticity and (ii) how different social structures shape the maturation schedules in live-bearing fish, as such studies cannot easily be carried out on commercially exploited species.

Keywords: laboratory experiments, probabilistic maturation reaction norm, social effects.

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ICES CM 2010/M:24 Poster

Fisheries-induced evolution in northeast Arctic cod: empirical evidence

Mikko Heino, Olav Rune Godø, and Ulf Dieckmann

Over the last eight decades, northeast Arctic cod has shown a marked change towards earlier maturation at smaller sizes. At the same time, harvesting shifted from primarily targeting mature cod in the spawning grounds to targeting a mixture of immature and mature cod in the stock's feeding grounds. Under such changes in mortality regime, life-history theory predicts that the stock is expected to evolve towards maturation at smaller sizes. Thus, the observed maturation changes seem to corroborate the theory. However, alternative explanations can be entertained. Earlier maturation is expected when total mortality increases as a direct demographic response. Earlier maturation could also occur as a phenotypically plastic response to changes in the

environment (e.g. as a compensatory response when lower stock density allows individuals to grow faster and mature earlier). An analysis of probabilistic reaction norms for age and size at maturation suggests demographic changes and growth-related phenotypic plasticity contribute to the documented maturation trend, but that they are not sufficient to explain it. This strengthens the support to the hypothesis that cod have adapted to fishing by maturing earlier. However, there can be other important sources of plastic changes in maturation. With the available data, we can account for four additional factors: temperature, body condition, total-stock biomass, and capelin abundance (the main forage species of northeast Arctic cod). These turn out to show the expected effects on maturation (negative for total-stock biomass and positive for the others), but nevertheless, a significant trend towards earlier maturation at smaller sizes still remains. Thus, our analysis strongly supports the hypothesis of fishery-induced maturation evolution in northeast Arctic cod.

Keywords: fishery-induced evolution, fishery management, *Gadus morhua*, phenotypic plasticity, probabilistic maturation reaction norm.

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ICES CM 2010/M:25 Poster

Daphnia pulex before and after introduction of an alien predator: evidence for adaptation to a new mortality regime?

Ingrid Wathne, Knut Helge Jensen, Katja Enberg, and Mikko Heino

Size-selective predation shapes species and induces changes in life-history traits. Exposure to size-selective mortality will make being the size that is vulnerable dangerous and possibly fatal; thus, if small individuals are targeted, selection might favour faster growth to escape the vulnerable size range, whereas if large individuals are targeted, earlier maturation and/or slower grow are likely to evolve. Evolution caused by selecting large individuals has been shown for several fish species targeted by size-selective fishing gear (i.e. fishery-induced evolution). Also, introduced species may generate shifts in the prey's life history. Here we used probabilistic maturation reaction norms (PMRNs) to look for evidence of introduction-induced evolution in *Daphnia pulex* following an introduction of an alien predator (European perch, *Perca fluviatilis*) targeting large *Daphnia* to a lake that naturally hosted no planktivorous fish. We estimated PMRNs for clones collected before and after the introduction, and examined whether their PMRNs differed systematically. Introduction is a situation analogous to size-selective fishing and was expected to lead to a shift in predation pressure favouring early maturing clones. Growth trajectories and size and age of maturation were determined for both pre- and post-introduction clones. Studying one type of predation (natural) can often tell us something about the other (human-induced).

Keywords: *Daphnia pulex*, induced evolution, introduced species, life history, reaction norm, size-selective mortality.

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ICES CM 2010/M:26 Poster

The historical genetic drift due to overfishing is compensated by the large effective sizes and migration rates of southern hake stock populations

Alfonso Pita, Montse Pérez, and Pablo Presa

Previous population genetic studies on European hake stocks from the North Atlantic have shown the lack of any stable spatial or temporal genetic structuring among them. Once the lack of genetic structuring in this species had been demonstrated, a further interesting research step was the assessment of the putative genetic impact caused by intensive fishing pressure in recent decades and especially from the early 1980s. Such a genetic impact can be assessed using the appropriate

genetic markers within species and historical samples collected in the same fishery. In this research, we studied the genetic diversity of microsatellite markers from the southern hake stock using serial samples from the 2000 decade and an historical sample from 1976. All parameters used to estimate genetic diversity indicate that the whole set of populations from the southern stock is consistently panmictic in space and time. Moreover, any significant change was observed in their genetic diversity of actual populations as compared with the reference population collected 30 years ago. Assuming a large fishing pressure on this stock through decades, its genetic stability can be explained by a compensation between the overfishing-induced genetic drift and both the large migration rate between populations (Nem >5.00 per generation, not including that from the northern hake stock) and the consistently large effective size of its populations. Continuous genetic monitoring of the exploited hake stocks is needed in order to detect early any significant decay of their genetic diversity that could compromise their future viability.

Keywords: fishery evolution, fishery-induced genetic changes, *Merluccius merluccius*, southern hake stock.

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ICES CM 2010/M:27 Poster

Fishery changes and implications: a socio-economic, fishery management, fishers' knowledge, and climatic perspective!

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Comprehensive assessments are the basis of the sound management of fish stocks. Traditional fishery management has been based on data from scientific surveys, port sampling, and self-sampling contracts with fishers. Biological information on catch composition, growth, and maturity-at-age has been the basic input to fish stock assessments together with catch per unit of effort series. Changes caused by, for example, climate variability and shifts in management regimes, may be far more extensive and important than fluctuations in stock size and demographic changes. Fish stocks may migrate to new or even "old" geographical habitats, implying changes in the ecosystem, a shift in the food chain, habitat challenges, variability in growth, etc., and a need for new management regimes in cooperation with additional countries. Fishers may have to start exploiting other resources, which means adjusting to new species, to new fish plants, and new markets. All this may have important consequences for local communities depending on fisheries with respect to employment on fishing vessels, fish plants, export, transport, logistics, shipbuilding, technology development, subcontractors to the maritime and marine industry, etc. These changes may, in turn, crumble traditional fisheries. This has important implications for infrastructure, community planning, and global value chains. Analyses focusing on such implications and industrial clusters are presented. Integration of such data into fishery management and coastal area planning are discussed and analytical tools are proposed.

Keywords: climate, fishery management, socioeconomy.

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ICES CM 2010/M:28 Poster

Changes in sardine (*Sardina pilchardus*) maturation since the mid-twentieth century: can environmental and genetic effects be disentangled?

A. Silva, S. Faria, and C. Nunes

Probabilistic maturation reaction norms (PMRN) were used to investigate changes in the maturation of sardine cohorts and to discuss whether genetic effects, environmental effects or both are plausible explanations of maturation changes. Long-term changes in maturation were described using samples collected from landings off the western Portuguese coast since 1947.

Estimates of the length at 50% maturity (L_{50}) were calculated for 44 years of the study period and were shown to be good proxies of PMRN midpoints of recruit spawners (Lp_{50} for age 0–1 fish). Data collected during acoustic surveys were used to explore density-dependent and environmental effects on the maturation probability of recruit spawners since 1996. Sardine probability of maturing at a given length declined from the early 1950s to the late 1960s, corresponding to an increase of ca. 2 cm in both L_{50} and Lp_{50}. This trend reversed abruptly in the early 1970s but became shallower or even halted in the early–mid-1990s. Long-term changes in maturation probability showed a direct relationship with fish condition in the growing season preceding maturation. The maturation trend also agrees with reported warming of Portuguese coastal waters since the 1970s while survey data support the relationship between Lp_{50} and SST in the growing season. The hypothesis of a genetic change, possibly induced by high fishing exploitation, could explain the positive trend in maturation probability since the 1970s but is not consistent with the earlier reversal of that trend. On the other hand, the consistency of trends in L_{50}/Lp, condition, and temperature provides support to the hypothesis of direct environmental effects on sardine maturation probability.

Keywords: condition, maturation probability, Portuguese waters, sardine.

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ICES CM 2010/M:29 Poster

Implications of fisheries-induced evolution for stock rebuilding and recovery

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Worldwide depletion of fish stocks has led fishery managers to become increasingly concerned about rebuilding and recovery planning. To succeed, factors affecting recovery dynamics need to be understood, including the role of fishery-induced evolution. Here we investigate a stock's response to fishing followed by a harvest moratorium by analysing an individual-based evolutionary model parameterized for Atlantic cod (*Gadus morhua*) from its northern range, representative of long-lived, late-maturing species. The model allows evolution of life-history processes including maturation, reproduction, and growth. It also incorporates environmental variability, phenotypic plasticity, and density-dependent feedbacks. Fisheries-induced evolution affects recovery in several ways. The first decades of recovery were dominated by demographic and density-dependent processes. Biomass rebuilding was only lightly influenced by fishery-induced evolution, whereas other stock characteristics such as maturation age, spawning-stock biomass, and recruitment were substantially affected, recovering to new demographic equilibria below their preharvest levels. This is because genetic traits took thousands of years to evolve back to preharvest levels, indicating that natural selection driving recovery of these traits is weaker than fishery-induced selection was. Our results strengthen the case for proactive management of fishery-induced evolution, as the restoration of genetic traits altered by fishing is slow and may even be impractical.

Keywords: eco-genetic model, fishery-induced evolution, fishery management, *Gadus morhua*, maturation, probabilistic maturation reaction norm, reproductive investment, stock collapse.

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Theme Session N

Oceanography and ecology of HABs: physical/biological interactions, climate change, and other current issues

ICES CM 2010/N:01

Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: a synthesis and progress towards a forecasting capability

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Blooms of the toxic dinoflagellate *Alexandrium fundyense*, commonly called "red tides" have been a serious problem in the Gulf of Maine since 1972. The blooms are associated with the accumulation of potent neurotoxins in shellfish and some fish species, leading to paralytic shellfish poisoning (PSP) in human consumers—a potentially fatal poisoning syndrome. This talk will summarize more than a decade of large-scale field and modelling activities in the nearshore waters of the region, leading to a conceptual model of bloom dynamics that is consistent with cruise observations and with patterns of shellfish toxicity, and to numerical models that are being used for weekly and seasonal forecasts. The long-term implications of the blooms and their deposition of dormant cysts will also be discussed, as we hypothesize that the western Gulf of Maine region will experience more frequent and more intensive PSP outbreaks in the coming years, compared with the last decade. The challenges and potential for an operational red tide forecasting system in the Gulf of Maine will also be discussed.

Keywords: bloom dynamics, cysts, forecast, GEOHAB, harmful algal bloom, red tide.

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ICES CM 2010/N:02

A multidisciplinary and multiscale approach to understanding (harmful) phytoplankton dynamics in a northwestern Mediterranean bay

Elisa Berdalet, Oliver N. Ross, Mireia L. Artigas, Clara Llebot, Gisela Llaveria, Rubén Quesada, Jaume Piera, and Marta Estrada

The mechanisms underlying the population dynamics of species causing harmful algal blooms (HABs) are complex because they result from the interplay of a spectrum of physico-chemical and biological factors, to which the organisms respond with a variety of strategies. It is not clear, still, whether the responses of harmful species are different from those of other phytoplankton. In order to resolve some of these questions we started a multidisciplinary study in 2007 in Alfacs Bay (Ebre Delta), an active aquaculture site in the northwestern Mediterranean that is exposed to recurrent HAB events. Through a series of meteorological and hydrographical observations combined with modelling exercises, we try to understand how the circulation in the Bay affects the retention, dispersion, and thus the net development of (harmful) phytoplankton populations. The small-scale characterization of the physical water column properties is performed using a high-resolution acoustic Doppler current profiler and a SCAMP (temperature microstructure profiler to deliver information about turbulence). With this approach, we aim to explain the observed preferential vertical concentration of the target organisms (harmful or not). The field studies are complemented by physiological research in the laboratory, which has already shown a particular sensitivity of dinoflagellates to small-scale turbulence. For hypothesis testing, we combine these field and laboratory observations with an individual based (Lagrangian) turbulence model. Here, we present some of our progress and highlight our future goals which includes the deployment of a real-time automated physico-optical observation system to provide a better understanding of the *in situ* biological (growth and grazing rate) dynamics of (harmful) phytoplankton.

Keywords: None

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ICES CM 2010/N:03

Long-term changes in Baltic Sea cyanobacterial blooms and their causes: a modelling study

Ute Daewel and Corinna Schrum

Cyanobacterial blooms in the Baltic Sea occur regularly in summer and are related to a number of environmental factors (temperature, salinity, global radiation, nutrients, vertical mixing). But their timing and distribution is not only determined by the prevailing environmental summer conditions but also by the preceding winter conditions as is shown by coupled physical–biological modelling. Here we aim to evaluate the link between cyanobacterial blooms, winter nutrient concentrations, and the long-term environmental situation by using the coupled physical–biological model ECOSMO applied to the North and Baltic Sea system. Long-term 60-year (1948–2007) ensemble model runs were performed with changing initial nutrient conditions and river loads. We will assess both the direct impacts on the production in the respective year as well as the longer term impacts in the subsequent years. Because of the long characteristic time-scales in the Baltic Sea, we found the initial nutrient conditions and its vertical structure to be crucial to cyanobacterial blooms on time-scales from years to decades. This includes specifically the nutrient concentration in the subsurface, which, depending on the climatic situation in winter and spring, strongly determines the N/P ratio in the euphotic zone in summer and hence the succession of the respective bloom. By analysing the 60-year hindcast simulations we are not only able to emphasize the importance of the initial conditions but also to compare the impacts of North Sea nutrient intrusions with that of river nutrient loads on the frequency and strengths of cyanobacterial blooms in the Baltic Sea.

Keywords: Baltic Sea, cyanobacteria, ecosystem modelling, long-term modelling.

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ICES CM 2010/N:04

Advances in operational ecosystem modelling and the prediction of nuisance algal blooms at the UK Met Office

Ray Mahdon , Karen Edwards, Rosa Barciela, Peter Miller, Jamie Shutler, and Stephen Roast

The UK Met Office is applying coupled three-dimensional carbon-cycle and biogeochemical models for both the open-ocean and UK shelf-seas, which have been developed in collaboration with partners in the National Centre for Ocean Forecasting and the Met Office's Hadley Centre for Climate Research. For the UK shelf-seas, we use the MRCS (Medium-Resolution Continental Shelf—POLCOMS hydrodynamic model) coupled to the European Regional Seas Ecosystem Model (ERSEM). The shelf-seas ecosystem forecasts have been operational since March 2007 and are supplying users with operational products, providing ocean forecasts and serving as a basis for developing predictive capabilities. One important application of our shelf-seas ecosystem model is providing support for the UK agencies responsible for ecosystem health, water quality monitoring, and nuisance algal bloom prediction. In collaboration with the UK Environment Agency (EA) and the Plymouth Marine Laboratory (PML), the AlgaRisk 08 project is designed to help focus monitoring efforts and develop a forecasting system for nuisance algal blooms, as well as permitting the EA to advise local authorities and meet EU Marine Water Framework Directive requirements. In order to achieve this, the project combines operational model output (including physical and biological fields) with Earth Observation data to create a forecasting tool for nuisance algal blooms. This work presents the AlgaRisk08 model design along with initial results and an assessment of system performance during several summer 2009 bloom events in the UK, focusing particularly on the southwest of England and the Clyde region of Scotland.

Keywords: nuisance algal blooms, operational modelling.

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ICES CM 2010/N:05

Transport of toxin producing dinoflagellate populations along the coast of Ireland within a seasonal coastal jet

Robin Raine, Hazel Farrell, Patrick Gentien, Liam Fernand, Michel Lunven, Beatriz Reguera, and Sonsolez Gonzalez Gill.

During an investigation into the distribution of *Dinophysis* spp. in coastal waters off the south coast of Ireland a thin layer of *Dinophysis acuta* was observed as a subsurface thin layer containing up to 55 000 cells l^{-1}. The layer did not coincide with the fluorescence maximum, and was found to be a patch of maximum dimensions ~10 × 7 km. The patch was observed to move westwards with a seasonal coastal jet previously recorded in the area, and was also evident owing to the aggregation of isopycnals at the seabed. The role of shear in maintaining the coherence of the layer is examined. The patch was followed for 6 days, and was shown to be moving within the coastal jet at a speed of ca. 6.5 km d^{-1} towards a nationally important shellfish production area. These observations have substantial implications for regional monitoring of toxic blooms in that they document how harmful populations may be transported in coastal jets along coasts to aquaculture sites.

Keywords: coastal jet, *Dinophysis*, Ireland, transport.

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ICES CM 2010/N:06

A short-range prediction model for forecasting HAB events in the bays of southwestern Ireland

Robin Raine, Georgina McDermott, Joe Silke, Kieran Lyons, Glenn Nolan, and Caroline Cusack.

A simple model is presented which predicts harmful algal events in the bays of southwestern Ireland during summer. Fundamental to the model is the physical forcing of circulation in these bays, principally a wind-driven two-layer oscillatory flow acting in a thermally stratified water column. This mechanism exchanges substantial proportions of the bay volumes, and harmful algal events arise with the associated transport of harmful populations into them. The model is based on the criterion that wind-driven water exchanges result in exchanges of phytoplankton, which, if the time of year is correct, result in toxic events. Using Bantry Bay as an example, hindcasting showed that the model has a high degree of success using a wind index based on the sequence of winds that would generate water exchange. The model was implemented by estimating indices from the 5-day weather forecast, and was trialled in summer 2005, during which a predicted water exchange events were accompanied by influxes of harmful algal blooms into the bay.

Keywords: dinophysis, harmful algal blooms, Ireland, prediction.

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ICES CM 2010/N:07

ASIMUTH: Applied simulations and integrated modelling for the understanding of toxic and harmful algal blooms

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GMES (Global Monitoring for Environment and Security) is the European initiative for the establishment of a European capacity for earth observation. Through the ASIMUTH project, scientists and industry from five countries along Europe's Atlantic margin will form a network to produce the first realistic harmful algal bloom (HAB) advisory and forecasting capability as a GMES downstream service to the European aquaculture industry. The early warning of severe blooms will allow fish and shellfish farmers to adapt their culture and harvesting practices in time, in order to reduce potential losses. In recent years, there has been much discussion of satellites being able to track surface algal blooms. Understanding biological phenomena in the ocean requires a more complex approach than this, though there is some merit in using satellite-derived chlorophyll images to delineate high biomass near-surface algal blooms. Much cutting-edge HAB research work has focused on subsurface profiles, where certain HAB species are present in thin layers of limited geographical extent often associated with strong density interfaces. Clearly, in order for a toxic/harmful algal bloom forecast to be realistic, physical factors including changes in water column structure and transport pathways are necessary. ASIMUTH is the next step towards providing an operational advisory service by integrating these physical drivers (derived from GMES downstream services) with all available biotoxin, phytoplankton count, and bioassay data. A distributed advisory manned service desk and thematic experts distributed across the participating countries will network to provide regular advisory products and forecasts of impending toxic and harmful algal events.

Keywords: aquaculture, food safety, harmful algal bloom, modelling, forecast.

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ICES 2010/N:08

Sensitivity of host–parasite dynamics in non-uniform physical environments

M. Sourisseau, T. Duhaut, and P. Gentien

During the last 15 years, algal virus ecology, parasite activity, and bacteria lysis have appeared as key factors in the termination of phytoplankton blooms and in phytoplankton species successions. In the same time, numerous papers have treated the mobility of dinoflagellates as a competitive advantage in an environment structured by light and nutrients gradients. In this paper, we illustrate for the first time, the importance of host behaviour in determining the efficiency of the host/parasite dynamics in a heterogeneous environment. The studied host/parasite pair was *Alexandrium minutum* and *Amoebophrya* sp.. This host/parasite pair have recently been observed in a small estuary (the Penze River) and regulate dinoflagellate species successions. This theoretical study, using a 1D IBM model under idealized conditions, considers the possible interactions at play in the host/parasite dynamics. These interactions are the infection efficiency, the behavioural of the organisms (parasites and hosts), and the density gradient. Several of these processes determine either organism coexistence or host extinction.

Keywords: None

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ICES CM 2010/N:09

Population dynamics of *Dinophysis acuminata* in the Ría de Pontevedra (northwestern Spain): physical–biological coupling in a coastal upwelling system

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Fine-resolution measurements of phytoplankton and physical parameters were made from 31 May to 14 June 2005 in the coastal upwelling system of the Ría de Pontevedra (northwestern Spain). A sequence of upwelling–relaxation–upwelling–downwelling events was recorded with a moored acoustic Doppler current profiler (ADCP). During the upwelling pulses, *Dinophysis acuminata* populations were found aggregated in near-surface patches (up to 8×10^3 cells l^{-1}) located in the warmer (15–18°C) surface (0–6 m) waters. In contrast, on 13 June 2005, when downwelling conditions occurred, *D. acuminata* reached its highest concentration (9×10^3 cells l^{-1}) and spread in a near-surface layer throughout the whole Ría. In this study, results from the examination of tides, currents, temperature, salinity, satellite images, and wind records, together with the fine-scale vertical distribution of plankton species highlight the potential role of physical processes in promoting and transporting *D. acuminata* populations in the Ría de Pontevedra. Understanding both local fine-scale circulation patterns, regional physical processes, and physical–biological coupling at different scales will improve our knowledge of the spatial and temporal occurrence of *D. acuminata* blooms in coastal upwelling systems.

Keywords: coastal upwelling system, *Dinophysis acuminata*, harmful algae blooms, physical–biological interactions.

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ICES CM 2010/N:10

Technological adaptation to harmful algal bloom events: a socio-economic analysis

José A. Pérez Agúndez and Rémi Mongruel

The economic impacts caused by commercial bans in shellfisheries owing to harmful algal blooms (HAB) depend on the frequency and on the intensity of their occurrence. Shorter bans mainly affect the cash flow for shellfish farming companies. Longer or high-frequency events can lead to revenue losses as a consequence of the accumulation of unsold production. Moreover, in the mid- to long-term, recurrence of HAB may impact consumers' perception and lead to decreasing demand and market prices. Safeguarding and accelerating detoxification mechanisms are technical responses to these sanitary closures. Safeguarding consists in maintaining the cultivated bivalves in safe water circulated systems in the event of an HAB alert. Detoxification consists in purifying the bivalves contaminated by force-feeding and increasing the animals' metabolic functions. A successful implementation of these processes depends on their technical feasibility, on regulatory compatibility, and on their socio-economic viability. The adoption of these technological changes drives associated production costs and modifies profitability thresholds. This paper focuses on socio-economic viability analysis, taking into account the economic heterogeneity of the French shellfish farming sector and the social impacts that this new production processes can provide. First, a technical–economic analysis describes the different technical processes of safeguarding and accelerated detoxification and assesses their associated costs. Second, their socio-economic viability is explored, focusing on the case study of the Bourgneuf shellfish farming in Pays de la Loire (France).

Keywords: detoxification, economic viability, harmful algae blooms, safeguard, shellfish farming.

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ICES CM 2010/N:11

Biogeochemistry of cyanobacterial blooms in the Baltic Sea

Oleg P. Savchuk

Summer blooms of filamentous heterocystous cyanobacteria have been a persistent feature of the Baltic ecosystem, especially in recent decades. The occurrence, duration, extension, and intensity of the blooms vary from year to year, whereas our ability to predict them quantitatively is still limited. One of the major large-scale biogeochemical drivers of the blooms are opposite variations of nitrogen and phosphorus pools caused by long-term dynamics of hypoxic zone. The expansion of hypoxia leads to a reduction of dissolved inorganic nitrogen through denitrification and an increase of dissolved phosphate through internal loading. Simultaneous nitrogen depletion and phosphorus enrichment result in a shift of the marine ecosystem towards nitrogen limitation, which is favourable for nitrogen fixation by cyanobacteria that generate additional nitrogen to the nitrogen-limited ecosystem comparable with external inputs from the land and atmosphere. The shrinkage of the hypoxic zone through improved oxygen supply induces opposite consequences. Thus, because of the biogeochemical peculiarities of the Baltic Sea, the environmental significance of the Baltic diazotrophic cyanobacteria goes far beyond the damage caused by toxicity and recreational nuisance of other HABs. The increase in primary production and sedimentation of organic matter caused by nitrogen fixation results in higher oxygen consumption and further expansion of hypoxia. This positive feedback in biogeochemical cycling affects numerous and diverse ecosystem links, from foodweb interactions and dynamics of fish populations to counteraction of anthropogenic reductions of nitrogen load.

Keywords: denitrification, fish dynamics, hypoxia, nitrogen fixation, phosphorus release.

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ICES CM 2010/N:12

Monitoring of toxic phytoplankton in three Icelandic fjords

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Toxic phytoplankton has been monitored in three Icelandic fjords (Hvalfjordur, Breidafjordur, Eyjafjördur) from 2005 to 2009, in connection with culturing and harvesting of blue mussel *Mytilus edulis.* Sampling of phytoplankton was done every week from spring to autumn each year for screening toxic species (net samples) and for cell counting (water samples). Toxic species of two genera of dinoflagellates (*Dinophysis* spp. and *Alexandrium* spp.) and one genus of diatoms (*Pseudo-nitzschia* spp.) were found. *Dinophysis* spp. was found in all the fjords every year with growth period from June to December. Highest concentrations (17 000 cells l^{-1}) of *Dinophysis* spp. were found in Hvalfjordur and cell numbers in the other fjords often reached several thousands per litre. *Alexandrium* spp. was found in all three fjords with highest cell numbers in Eyjafjordur. In 2009, *Alexandrium* spp. was extremely abundant (max. 16 000 cells l^{-1}) in Breidafjordur and Eyjafjordur for several weeks but less so in Hvalfjordur. The main growth period for *Alexandrium* spp. was from late June to middle of August. High variability was found between years in both cell numbers and time of occurrence for *Dinophysis* spp. and *Alexandrium* spp. in all three fjords. DSP and PSP has been recorded in the mussel in 2007 to 2009 in and after periods of high cell numbers. *Pseudo-nitzschia* spp. was found in all three fjords with great variability s between years. ASP has never been detected in mussels in this period. Harvesting the mussels has been closed for several weeks each year.

Keywords: fjords, monitoring, toxic phytoplankton, toxicity in mussels.

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ICES CM 2010/N:13 Poster

Climate change, algae blooms, and eutrophication in the Curonian Lagoon of the Baltic Sea

Sergey Aleksandrov

Coastal lagoons are most vulnerable to impacts of natural environmental and anthropogenic factors. The Curonian Lagoon is the largest coastal lagoon of the Baltic Sea, relating to the most highly productive water bodies of Europe. Hydrochemical and hydrobiological monitoring (nutrients concentrations, primary production, chlorophyll, and others) was carried out monthly from 1991 to 2009 at 9–12 stations. According to the trophic classification, the Curonian Lagoon may be considered a hypertrophic water body. In the modern period in the Curonian Lagoon, unlike many inland and coastal marine waters, eutrophication of water is continuous, which is reflected primarily in the abundance and production of algae. The water temperature appears to be the key environmental factor determining the seasonal and long-term variability of chlorophyll and nutrients concentration, phytoplankton biomass, and primary production, and therefore, the level of biological production and the trophic status. More intensive summer warming up of water in 1990–2000 combined with several other factors (freshwater, slow water exchange, and high nutrients concentrations) creates conditions for "hyperblooms" of cyanobacteria. Hyperblooms of cyanobacteria seriously affected the ecological state of the Curonian Lagoon, leading to the deterioration of the chemical water parameters, death of fish in the coastal zone, and pollution with cyanobacteria toxins. Symptoms of exposure are observed at different trophic levels (including zooplankton and fish). The climate warming in 1990s–2000s caused ongoing eutrophication of the Curonian Lagoon, despite significant reduction of external nutrient loading. The warming up of the water resulting from global climatic changes represents a risk for coastal water bodies, because this stimulates the "hyperblooms" of cyanobacteria.

Keywords: climate change, Curonian Lagoon, eutrophication, hyperbloom of cyanobacteria.

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ICES CM 2010/N:14 Poster

Design of a marine monitoring network for the south coasts of the Caspian Sea

M. Monshizadeh and A. Najafi Jilani

An integrated marine monitoring network is designed and developed for the south coasts of the Caspian Sea. The main parameters considered in measuring system are the seawater flow, hydrodynamics parameters, such as current velocity and direction, and water wave specifications, water quality parameters such as total suspended solids, pH, and temperature. The appropriate measuring devices are investigated and applied in both shallow-water and deep-water areas. The transferring procedures for measured data are designed to convey the time-series from offshore and nearshore measuring devices to the coastal monitoring station. The latest methods for data-quality control, gap checking, filtering, and mining are investigated and discussed and the most appropriate methods are recommended and applied in the Caspian Sea marine monitoring network. The protocols for receiving and transferring the large volume of measured data in a permanent monitoring network are also discussed. The placement of the measuring devices in shallow and deep-water regions are discussed, based on the bathymetry conditions and sea states in the coastal marine monitoring station.

Keywords: Caspian Sea, data mining, integrated network, marine measurements, marine monitoring.

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ICES CM 2010/N:15 Poster

Experimental effect of river discharge addition on parasite–host dynamics between Amoebophryidae (MALV II) and their dinoflagellate hosts in Mediterranean coastal waters

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The extending geographical distribution of harmful dinoflagellate blooms constitutes one of the most visible effects of recent global changes on marine phytoplankton. One explanation for this expansion is the absence (or the inefficiency) of natural pathogens for dinoflagellates in their new areas of introduction. Amoebophryidae (or Marine Alveolate Group II) are eukaryotic parasites that are able to efficiently control their dinoflagellate host populations. They are considered truly marine organisms, restricted to coastal and oceanic waters. Most of the harmful dinoflagellate blooms, however, are initiated in semi-confined areas such as harbours, lagoons, and estuaries. These ecosystems are occasionally under freshwater influence, resulting in sudden dilution of the planktonic communities, combined with fluctuation of salinity and nutrient concentrations. Such low salinity may help the host to escape its strictly marine parasites. Dinoflagellate dynamics and the specific presence of Amoebophryidae were investigated experimentally using mesocosms, in which different volumes of river discharge were added to a natural lagoonal community. River discharges significantly favoured the growth of *Prorocentrum triestinum*. The increase in abundance of this dinoflagellate was rapidly followed by a greater Amoebophryidae infection under river discharge addition. The direct effect of the experimental environmental conditions on the diversity and abundance of parasites and their pathogenicity is then discussed.

Keywords: Amoebophryidae, harmful algal blooms, MALV II, mesocosm experiments, *Prorocentrum triestinum*, river discharges.

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ICES CM 2010/N:16 Poster

Influence of organic nitrogenous nutrients on the growth and domoic acid content of *Pseudo-nitzschia* multiseries and *Pseudo-nitzschia australis* in cultures

G. Calu, E. Lefaux, Z. Amzil, P. Weigel, and V. Martin-Jézéquel

Studies have shown that numerous diatom species can assimilate organic nitrogen, but the influence of organic nitrogen sources on harmful diatoms blooms is poorly known. That is the case for diatom species of the genus *Pseudo-nitzschia*, which produce domoic acid, a neurotoxin responsible for amnesic shellfish contaminations. Moreover, the role of amino acid nutrients on their toxicity has not been clearly elucidated. Previous studies have reported that *Pseudo-nitzschia* multiseries can grow on urea and glutamate sources. In the present work we demonstrate the influence of urea on the growth and increase of domoic acid content of the toxic strains *Pseudo-nitzschia* multiseries CCL70 and *Pseudo-nitzschia australis* C1, isolated from English Channel waters. We also investigate the influence of some other organic nitrogen sources on the *Pseudo-nitzschia* multiseries strain CCL70 grown in batch cultures. Our results show that this strain produces more toxin in the presence of urea than in the presence of arginine or glutamine, but is not able to grow on glutamate sources. These results raise the question of the role of nitrogen in *Pseudo-nitzschia* and domoic acid metabolism.

Keywords: arginine, domoic acid, glutamate, glutamine, *Pseudo-nitzschia*, urea.

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ICES CM 2010/N:17 Poster

Occurrence of domoic acid in Scottish waters—the potential of solid-phase adsorption toxin tracking to monitor HABs events

Guillaume Hermann, Elizabeth Turrell, and Laura Morley

Previously proposed as a tool to facilitate monitoring of lipophilic shellfish toxins (LSTs) in shellfish harvesting areas, solid-phase adsorption toxin tracking (SPATT) was assessed for its capability to adsorb and recover domoic acid, an amnesic shellfish toxin (AST) responsible for many site closures in Scottish waters. During the past year, field studies were undertaken at aquacultures sites in Scottish Waters (Loch Ewe) and SPATT bags containing SP700 resin beads were deployed on a weekly basis in conjunction with sampling of phytoplankton and local bivalve shellfish. During four sampling sessions through summer 2009, an automated water sampler was deployed in the loch, flushing daily SPATT cartridges containing the same SP700 resin and collecting a water sample for phytoplankton identification. SPATT extracts were analysed by two different quantitative methods of analysis: by LC-MS/MS and by ELISA immunoassays kits. Although no direct correlation could be drawn between the concentration of the algal toxins in SPATT extracts and the phytoplankton community in water samples, significant variation of toxin concentration could be observed between sampling periods. Moreover, the finding of domoic acid in the SPATT cartridge shows that the resin binds strongly enough to the resin so that it could be extracted later on. Results suggest that the use of SPATT cartridges may be employed as an early warning technology to inform shellfish harvesting strategies and potentially as a tool to improve understanding of AST events in Scottish waters.

Keywords: AST, domoic acid, HABs, SPATT, toxin.

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ICES CM 2010/N:18 Poster

Modelling the life cycle of dinoflagellates—the role of life cycle transitions in regulating bloom dynamics

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Blooms of (harmful) dinoflagellates are frequently observed in coastal regions. The dominant species can build up high concentrations, despite low growth rates. Many of them have complex life cycles, which involve benthic resting stages. The transitions between planktonic growing cells and benthic resting cysts may play an important role in the formation and termination of the blooms. We have developed a numerical model that examines the regulation of dinoflagellate blooms by life cycle events. Our model distinguishes between two life cycle stages, one for photosynthesizing growing cells and one for resting cysts. The transfer between the two life cycle stages (en- and excystment) is a function of temperature and the number of cells. The model has been calibrated based on data from laboratory and field experiments for the dinoflagellate *Biecheleria baltica* and coupled to a water column model. We show that the model is able to represent successfully the seasonal cycle of dinoflagellates. Although our parameters are based on observations of a cold-water dinoflagellate, the approach can be easily applied to warm-water bloom-forming species with a pronounced life cycle. This study allows us to gain a better understanding for the underlying dynamics of dinoflagellate bloom formation.

Keywords: bloom, dinoflagellates, encystment, excystment, life cycle, model.

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ICES CM 2010/N:19 Poster

Composition of summer phytoplankton in the southeastern Baltic Sea

Evgenia Lange

In the Baltic Sea summer, phytoplankton succession is defined by blooms of nitrogen-fixing potentially toxic cyanobacteria *Aphanizomenon flos-aquae*, *Nodularia spumigena*, and to a lesser degree by species of *Anabaena* genus. In the southeastern part of the sea (SEB), summer blooms mainly of *Nodularia spumigena* have been registered since the first half of the last century. In July–August in 1999–2007 phytoplankton biomass was determined by cyanobacteria *Aphanizomenon flos-aquae* (17–37% on average), excluding 1999 (6%) and 2001 (2%). The summer of 1999 was characterized by high level of solar radiation, inhibiting vegetation of *Aphanizomenon.* In 2001 the wind conditions were extremely unfavourable for algae development. *Nodularia* was prevailing only in 1999 and 2004 and at the deep-water stations (>60 m) in 2006. The maximum biomass 0.96 g m^{-3} was registered in 1999. Up to 2003 inclusively, the cryptomonads *Plagioselmis prolonga*, *Teleaulax* sp. also predominated in terms of biomass. Low phytoplankton biomass was registered in 2001–2003 (0.06–0.12 g m^{-3} on average), and the highest one in 2007 (1.13 g m^{-3}; depth 20–40 m). In 1999, 2002, 2003, and 2006 the surface temperature was high (20–23°C), whereas in other years it was only 15–19°C. In 2003 the North Sea water inflow caused abnormal hydrologic and hydrochemical conditions. In SEB in the years following 2003 an increase in phytoplankton biomass was observed, largely because of *Aphanizomenon*; the cryptomonads did not dominate; the role of the haptophytes *Chrysochromulina* spp. and cyanobacterian species belonging to Chlorococcales was increased.

Keywords: Baltic Sea, cyanobacteria bloom, phytoplankton, potentially toxic species.

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ICES CM 2010/N:20 Poster

Pseudo-nitzschia occurrence in "Pertuis Charentais" (France) after the Xynthia storm

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An exceptionally large bloom of *Pseudo-nitzschia australis* (Diatomophyceae) occurred from 15 March to 23 March 2010 in the Pertuis Charentais area (west coast of France). This bloom induced a large toxicity of shellfish, leading to four weeks of administrative sales prohibition. Such a large bloom had never been observed in this area at this stage of the year. This could be linked to the Xynthia storm (28 February 2010), considering the geographical connection with flooded areas and maximum *Pseudo-nitzschia* occurrence. Hydrodynamics and environmental parameters are related to bloom size and induced toxicity in crustaceans and shellfish.

Keywords: domoic acid, *Pseudo-nitzschia australis*, pertuis Charentais, shellfish, Xynthia storm.

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Theme Session O

Synergies and conflicts of multiple uses of marine areas by using marine spatial planning

ICES CM 2010/O:02

An integrated modelling approach to support ecosystem-based management of multiple uses in the German EEZ of the North Sea

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Marine spatial planning in the German EEZ of the North Sea was previously driven by offshore wind farm development and the designation of conservation areas. Just recently, a more comprehensive marine spatial plan has been accepted and the designated sectoral preference areas are now legally binding. Although the preference areas for wind resource development have been designated, concrete wind farm construction plans within those areas have to be approved on an individual basis. For the German EEZ we developed a spatial explicit integrated modelling approach accounting for the distribution patterns of the commercially important resource plaice, the activity pattern of the fishing fleet targeting plaice, the revenues generated in the areas of interest, and the spatial extent of wind resource development. We developed a Bayesian Belief Network–GIS framework to assess potential consequences and outcomes of different spatial management scenarios that describe different options for the level of offshore wind resource development and related fishing effort displacements. With the help of the BN–GIS framework, we explored in particular the risks of an increased vulnerability of plaice to fishing pressure and the consequences for the fishing industry.

Keywords: management scenarios, marine spatial planning, North Sea, uncertainty.

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ICES CM 2010/O:04

"Value-creation" in municipal marine spatial planning? A case from arctic Norway

John Isaksen and Eirik Mikkelsen

Value creation and economic performance from use of marine resources seem to be given increasing weight as an objective for coastal-zone planning and management, at least in government policy papers. When Norwegian municipalities prioritize between types of marine activities and individual actors, they have to consider a number of aspects. These range from indigenous people's rights, national nature conservation rules, and health and safety considerations, to value creation and recreational interests of the area's inhabitants. Value creation from industries located within a municipality may benefit individuals, firms, and public bodies both inside and outside that municipality. The extent to which marine activities produce local benefits (to actors within the municipal area) may influence the municipalities' priorities and decisions in coastal-zone management. Furthermore, higher authorities' focus on value creation may not readily translate into municipal priorities in coastal-zone planning. This paper assesses how and to what degree Norwegian municipalities have considered concerns for and arguments on value creation in their coastal-zone planning (in particular in Alta municipality, in Finnmark County). We also discuss the possibilities municipalities have for considering value creation in coastal-zone management, given their room for "manoeuvrability" within national legislation and regulations, the data available for considering value creation from marine activities in a planning context, and how "value creation" actually has been understood and emphasized.

Keywords: coastal-zone planning, local benefits, municipality, value creation.

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ICES CM 2010/O:05

Marine spatial planning: Norway's management plans

Alf Hakon Hoel and Erik Olsen

Since the adoption of a government White Paper on ocean governance in 2001, Norway has worked on the development and implementation of marine spatial planning in the format of regional management plans. Management plans for the Barents Sea and the oceans off northern Norway and the Norwegian Sea were adopted in 2006 and 2009, respectively, and a management plan for the North Sea is in the works. A key aspect of the plan is integrated assessment of the cumulative impacts on the marine ecosystem from human activities (fisheries, petroleum, marine transportation, etc.) on the one hand, and external sources (climate change, long-range pollution) on the other. Another important feature is the identification of valuable and vulnerable areas requiring special management measures. A monitoring system is set up with indicators and reference levels. The plan has been implemented through the regular governance structure without the establishment of new, formal institutions. An inter-ministerial committee oversees the work, guided by three working groups. A revised version of the Barents Sea plan will be adopted late in 2010, taking marine spatial planning in Norway into its second generation.

Keywords: Barents Sea, ecosystem approach, marine spatial planning, Norway.

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ICES CM 2010/O:06

The emergence of a new marine renewable energy industry—what are the implications for fisheries?

Michael C. Bell, Jon C. Side, Sandy Kerr, Kate R. Johnson, Susana Baston, and Colin R. Bullen

In the light of increasing global energy demands and the need to reduce greenhouse gas emissions, attention has recently turned to the sea as a large and renewable source of kinetic energy. Developments for wave and tidal energy extraction currently exist more in potential than in actuality, but there is huge impetus from political, environmental, and commercial interest groups for rapid growth of the marine renewable energy sector over the immediate future. Such growth will inevitably have repercussions for other stakeholders in the marine environment. Concerns from fishery interests are likely to centre on access to fishing grounds and on changes to the physical structure and ecological functioning of fish habitats. Taking the example of the Pentland Firth and Orkney Waters, the site of the world's first seabed licensing round for commercial wave and tidal energy developments, we examine the extent to which fishery and energy resources overlap. We also consider in more general terms how marine spatial planning decisions may affect fishery yield and the spawning potential of target stocks. The potential nearfield and far-field environmental effects of energy conversion devices, and their repercussions for marine productivity are as yet poorly understood. Marine spatial planning decisions need to be informed by both ecological and socio-economic considerations.

Keywords: fisheries, marine renewable energy, spatial interactions, tidal energy, wave energy.

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ICES CM 2010/O:07

Web application to support the process of marine spatial planning

M. Fetissov, R. Aps, M. Kopti, and J. Kotta

This paper presents a web application developed by the Baltic Sea Region Programme 2007–2013 BaltSeaPlan project with the aim of supporting the process of marine spatial planning. The web application could be seen as a tool for collaborative (participatory) processes with the objectives: (i) to capture the knowledge for later use (identifying and mapping spatial resources and competing human uses), (ii) to communicate the knowledge captured so it is easy to understand for other stakeholders, (sense-making/communication), and (iii) to simulate the marine space allocation for the competing sea use cases with the aim of avoiding and resolving possible conflicts of interest. The web application is based on the template of ESRI Silverlight Standard Map Application for Visual Studio 2008 Professional. Map layers are developed using ArcGIS Desktop 9.3 and published on the ArcGIS Server 9.3. The future scenarios approach is used to study the expected future developments and anticipate the unexpected, particularly in conditions of uncertainty and complexity. This issue is exemplified by the analysis of the participatory process with regard to the pilot MSP areas of the Bay of Pärnu (Gulf of Riga, Baltic Sea) and the sea area off the Saaremaa and Hiiumaa Islands (Northern Baltic Sea).

Keywords: Baltic Sea, marine spatial planning, participatory process, web application.

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ICES CM 2010/O:08

Global links and local roots in the offshore realm: orchestrating visions, entrepreneurs, and policies in marine spatial planning in Europe

Gesche Krause

As a tool, marine spatial planning (MSP) is a process that focuses on the spatially explicit nature of many ocean activities and resources. It should be designed to include robust participation of all stakeholders, be structured to compel responsibility, transparency, and accountability, and include local knowledge and visions for the future of the oceans. However, contrasting societal objectives exist in coastal and offshore areas, with different types of stakeholders, visions, conflicts, limitations, and potential alliances. This is rooted in the essential dissimilarity of the origin, context, and user-dynamics of the coastal vs. offshore areas. In this context, the importance of a high degree of local social capital is often overlooked, because successful community debate and concerted activities are only possible if sufficient social capital, which facilitates coordinated actions, exists. In the offshore areas, most social relationships between the different stakeholders are new and untested, leading to a high degree of uncertainty and limited trust between the groups. This leads to a very different suite of demands for legal and policy frameworks for the offshore realm than for coastal areas. Recognizing public goals, values, and thresholds and being explainable and implementable in a consistent way to different people and groups is in the mandate for MSP. Because in the oceans of the globe, transformation, transition, and change are determined by interactions between humans and nature, it is timely to consider natural and societal dynamics in conjunction. The inclusion of stakeholder participation, transparency, and communication in this process is crucial.

Keywords: aquaculture, marine spatial planning, multiple-use, offshore wind farms, social capital, social resources.

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ICES CM 2010/O:09

Meeting the quest for spatial efficiency: progress and prospects of extensive aquaculture within offshore wind farms in Europe

Bela Hieronymus Buck

Along the German North Sea coast, the observed high spatial competition of stakeholders has encouraged the idea of integrating open ocean aquaculture with offshore wind farms beyond the 12-mile zone. This study provides an overview of the current state of transdisciplinary research on the potential implementation of such a multifunctional use concept on a showcase basis, covering biological, technical, economic, and social/policy aspects as well as private/public partnerships and the relevant institutional bodies. We show that the cultivation of seaweeds and blue mussels is biologically and technically feasible in a high-energy environment using modified cultivation strategies. First results of fish farming will also be presented. The point of departure of our multi-use concept is that the solid groundings of wind turbines could serve as attachment points for aquaculture installations and become the key to the successful commercial cultivation of any offshore aquatic organism. Spaces between the turbines are also attractive, however, for farming projects, because public access is restricted and thus the cultivation site is protected from outside influences. An economic analysis of different operation scenarios indicates that the market price and the annual settlement success of juvenile mussels are the main factors that determine the breakeven point. Social and policy science research reveals that the integration of relevant actors into the development of a multi-use concept for a wind farm–mariculture interaction is a complex and controversial issue. Combining knowledge and experience of wind farm planners as well as mussel fishers and mariculturists within the framework of national and EU policies is probably the most important component for designing and developing an effective offshore co-management regime to limit the consumption of ocean space.

Keywords: co-management, ICZM, multiple use, offshore aquaculture, offshore wind farms.

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ICES CM 2010/O:10 Poster

MESMA: It's all about weighing interests

R. ter Hofstede, O. Bos, J. van Dalfsen, P. Jones, S. Katsanevakis, G. Sutton, M. Rabaut, A. South, V. Stelzenmuller, and M. Vincx

The seas around Europe are home to an exceptionally wide range of marine habitats, which must also support a variety of marine industries. The challenge for marine spatial management is to find an optimal balance between the competing demands of economic use, ecological development, and nature conservation, while at the same time maintaining sensitivity towards traditional practices. The EU FP7 project MESMA (www.mesma.org) focuses on marine spatial planning and aims to produce integrated management tools (concepts, models, and guidelines) for monitoring, evaluation, and implementation of spatially managed marine areas, based on European collaboration. MESMA is expected to supply innovative methods and integrated strategies for governments, local authorities, stakeholders, and other managerial bodies for planning and decision-making at different local, national, and European scales, for sustainable development of European seas. This will comprise an easy accessible data system, containing information on the distribution of marine habitats and species, economic values, and human uses. The main tasks in the project are the development of a generic framework, the testing, and evaluation of this framework within several case studies throughout Europe, and the development of a toolbox to support the dialogue between politicians, stakeholders and the public in general on marine spatial management. This approach makes it possible to compare pressures on an interregional level, and at a multipressure level for specific regions. MESMA aims to provide a firm basis for the design and implementation of European policies such as the Common Fisheries Policy and the Marine Strategy Framework Directive.

Keywords: CFP, ecosystem-based approach, marine spatial management, MSFD, SMA, sustainable development.

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ICES CM 2010/O:11 Poster

Offshore mussel (*Mytilus* sp.) farming in the Belgian EEZ

Van Nieuwenhove Kris and Delbare Daan

Although Belgium has a yearly consumption of about 30 million kg of mussels, it has no production of its own until very recently. Mussel larvae are present all over the Belgian EEZ and mussels are growing on almost every hard substrate (buoys, harbour heads, etc.), but the short coastline of Belgium is used for tourism, harbour activities, and nature conservation, leaving no space for coastal mussel farming. In 1998, a pilot project was started to investigate the possibility of offshore mussel farming in the Belgian part of the North Sea. The shallow depth and unwanted trespassing of ship traffic prevented farmers from using subsurface longlines. Instead, they had to develop a new technology for mussel farming, the cage culture. This method exists in winding mussel rope inside or outside a floating metal frame. In the last decade, different types of cages were tested, with mixed success. The main problems are securing the cages, high investment costs, and difficult handing of the cages at sea. Today only one mussel farmer is still active in one offshore area. Although his production is small (about 12 tons), further expansion of his farming activities are ongoing. Now that the production area is well established, new production techniques are being investigated, in order to reduce investment costs and make handling at sea easier.

Keywords: mussel farming, offshore, windfarming.

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ICES CM 2010/O:12 Poster

Offshore wind farms and their potential for shellfish aquaculture and restocking

Claus Stenberg, Mads Christoffersen, Carsten Krog, Patrizio Mariani, and Per Dolmer

Wind farms in European coastal waters have become relatively common and are quickly expanding. In Denmark, 11 offshore wind farms are in operation and another 23 new installations are expected to be operational by 2025. Within the next 15 years, a consistent fraction of Danish coastal waters will then be allocated to wind energy production challenging the effective management of these areas. Wind farms are often placed in relatively shallow waters (<20 m) because of engineering and economic constraints. The areas used for wind farms are usually old fishing grounds, and mariculture in these areas could be a way to compensate for the loss of fishing. This study aims to investigate whether the production of shellfish can be combined with the operation of wind industry in coastal waters. Danish waters offer very different physical and biological conditions, primarily because of a salinity gradient from the relatively fresh Baltic to the more saline North Sea. This opens the way for the general assessment of possibilities and constraints in shellfish mariculture, which are addressed by experimental and modelling approaches. Three of the world's largest offshore wind farms will be used as cases. These wind farms are situated in the North Sea (Horns Rev Offshore Wind Farms), Kattegat (Grenå Offshore Wind Park), and the Western Baltic (Nysted Offshore Wind Park) and provide a general framework for the assessment of the synergies and trade-offs of these coupled activities.

Keywords: area limitation, mariculture, offshore wind farms, shellfish.

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ICES CM 2010/O:13 Poster

MSP, ecosystem approach, and Baltic Sea marine environment in good status

Hermanni Backer

Regional trans-boundary cooperation in the environment of the Baltic Sea has undergone rapid development during the last 10 years through the efforts of HELCOM to implement the ecosystem approach. One of the reasons behind the high level of recent activity is EU enlargement as well as the process towards, and efforts to implement, the EU Marine Strategy Framework Directive of 2008. Regional definitions of good marine environment status have been adopted as part of the work towards the HELCOM Baltic Sea Action Plan of 2007 based on the ecosystem approach, and developed further through related assessment activities. More exact definitions of environmental targets and the aim of the recent Baltic Sea regional activities has been a more efficient integration of environmental commitments to sectoral policies. In the work of the European Commission, the wider marine aspects are covered by EU Maritime Policy, and regionally similar aims are included in the EU Strategy for the Baltic Sea Region. Maritime spatial planning (MSP), aiming for an integrated approach, is highlighted in both of these initiatives. But what is the relationship between commitment to reach good environmental status and the wider aims of maritime policies in the Baltic Sea?

Keywords: Baltic Sea, good environmental status, HELCOM, marine spatial planning, maritime, sustainability.

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ICES CM 2010/O:14 Poster

Disturbances of natural physical fields caused by variable uses of the sea—an important issue for marine spatial planning. Example of the Baltic Sea

Eugeniusz Andrulewicz and Zbigniew Otremba

The introduction of new energy and/or new materials into marine environment may result in modifications of existing natural physical fields and therefore introduce invisible barriers. Until now, a number of Environmental Impact Assessments have not taken into consideration or have not even attempted to describe disturbances caused by invisible fields/barriers on marine organisms. These disturbances may mainly affect the feeding and reproduction migrations of fish and mammals. In the present paper, the authors offer an overview and description of following natural physical fields in the marine environment: acoustic, magnetic, electric, electromagnetic, optic, salinity, and thermal. Further, the authors describe and analyse modifications/disturbances introduced by technical installations such as existing and planned traffic links (bridges, tunnels), high-voltage power cables (HVPC), oil and gas extraction platforms, new infrastructures of ports and terminals, planned numerous wind power farms, and gas transmission lines. The authors conclude that because of the increasing number of technical installations in marine areas, physical field disturbances should be deeply analysed and economic aspects should not take priority over the health of the marine ecosystem. Marine spatial planning should also take into account planning of possible long-lasting modifications of natural physical fields.

Keywords: Baltic Sea, marine spatial planning, marine technical constructions.

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Theme Session P

Reversing the burden of proof: results-based management of fisheries

ICES CM 2010/P:01

Implication of science policy network structure for agreement about science

Douglas Clyde Wilson

This paper reports the results of a social network analysis of the science policy network around the management of the northern prawn fishery in Australia. This fishery has a reputation of being one of the best managed in the world. It combines both a fully developed co-management approach to management and high-quality individual access rights. The overall network hierarchy, while varied, is relatively low compared with most other fisheries. Fishers, scientists, environmentalists, and government managers interact on a number of committees of various types. These committees are organized around strategic and tactical management tasks, a structure which makes this fishery relevant to understanding results-based management. Social network analysis is a sociological technique based on the analysis of data on relationships between people, such as the frequency and quality of their interpersonal context. A formal, web-based survey gathered data of three types: on the frequency and characteristics of respondent's interactions; on their own attitudes and opinions about the knowledge base for management decisions; and on respondent's individual characteristics. Several hypotheses were tested that examined how network location influences the degree to which those who disagree about the social objectives of management are able to come to a clearer agreement on a common knowledge base about the fishery.

Keywords: decentralization, governance, results-based management, social network analysis.

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ICES CM 2010/P:02

Overcoming the Tragedy of the Commons—an experimental talk

Sarah B. M. Kraak

In situations of declining or depleted fish stocks, exploiters seem to have fallen prey to the "Tragedy of the Commons", which occurs when the maximization of short-term self-interest produces outcomes leaving all participants worse off than feasible alternatives would. Standard economic theory predicts that in social dilemmas, such as fishing from a common resource, individuals are not willing to cooperate and sacrifice catches in the short term, and that, consequently, the resource is overharvested. However, over the last decades, a multitude of research has shown that humans often achieve outcomes that are "better than rational" by building conditions where reciprocity, reputation, and trust help to overcome the temptations of short-term self-interest. The evolution of the natural human tendency to cooperate under certain conditions can be explained, and its neurophysiological and genetic bases are being unravelled. Nevertheless, fishery management still often deploys top–down regulation and economic incentives in its aim to regulate fisher behaviour, and underexploits the potential for spontaneous responsible fisher behaviour through setting conditions that enhance natural cooperative tendencies. Experiments and fieldwork have shown that such conditions include reputation-building and indirect reciprocity, face-to-face communication, knowledge of the state of the resource, and self-decision on rules and sanctions. "Many policies based on this assumption [of the Tragedy of the Commons] have exacerbated the very problems they were intended to ameliorate" Elinor Ostrom, Nobel Prize Economics Laureate 2009. "Men abide by their agreements when neither side has anything to gain by violating them" Solon (ca. 638–558 BC).

Keywords: cooperation, fishery management, governance, indirect reciprocity, public goods experiments, reputation building, tragedy of the commons.

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ICES CM 2010/P:03

Organizational and legal problems in reversing the burden of proof in results-based management of fisheries

Jill Wakefield

The imposition of the burden of proof occurs in Western legal systems to guard against unfairness in the enforcement of the law. Criminal law imposes the burden of proving an allegation on the prosecutor, while under civil law the burden of proof may shift from the claimant to the defendant, as in a discrimination case or environmental pollution case. Where damage has been caused to the environment, strict liability or a rebuttable presumption of liability may be imposed on the polluter as a result of legislation. A presumption of liability for ecosystem degradation could be imposed jointly and severally on those fishing an area where fish stocks are reduced below sustainable levels. This poses the problems of how to reach a legal definition of sustainability, how the level of extraction is to be determined, and whether controls are in place to exclude the possibility that overfishing has been caused by fishing by third parties. Management of the seas and oceans is according to a precautionary approach, which ought to apply the precautionary principle to exclude the risk of overfishing. In pharmaceutical assessments, the precautionary principle operates to create a large margin of error and exclude the risk of exposure to products that may cause damage. In fisheries, the application of the precautionary approach neither creates a margin of error and nor does it take account of known risks of illegal, unregulated, or unreported fishing. Before results-based management can be achieved, the underpinning organization needs to be put in order.

Keywords: burden of proof, risk, precautionary approach, precautionary principle, sustainability.

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ICES CM 2010/P:04

Confronting the bycatch issue: an incentive-led approach to maximizing yield in the US sea scallop fishery

Catherine E. O'Keefe, Greg DeCelles, Daniel Georgianna, Kevin D.E. Stokesbury, and Steven X. Cadrin

In response to rising costs and increased regulatory intervention, industry-based programmes for bycatch reduction, resource surveys, and fishery monitoring have been promoted by fishers, scientists, and fishery managers. Bycatch of yellowtail flounder in the US sea scallop fishery is a constraint to achieving optimum yield of scallops. Since 1999, the rotational area scallop fisheries on Georges Bank have been subject to total allowable catches for yellowtail flounder bycatch. Bycatch of yellowtail flounder has often forced early closures of these scallop fisheries, resulting in economic losses of over US$100 million. To address this constraint, we collaborated with the scallop-fishing industry to initiate a bycatch avoidance programme. We designed a system to collect information on incidental catch that expands the use of existing vessel monitoring service technology and relies upon the active fishing fleet to provide data. Vessels supply us with real-time communications about incidental catch rates during fishing activities. In turn, we compile the information for the fleet and send it back to active fishing vessels. Although providing spatially and temporally specific data on catch rates of non-target species, the fishing fleet gains valuable information about distribution of these species in order to avoid bycatch "hot spots". The system has been designed as an inexpensive method to employ traditional fishery-dependent data and create individual-based incentives for bycatch avoidance to benefit the entire fishery. This case

study demonstrates an example of results-based management through a small-scale incentive-led approach to achieve maximum yield of scallops by confronting bycatch restrictions.

Keywords: results-based management, sea scallops.

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ICES CM 2010/P:06

A framework for qualitatively evaluating management plans in a results-based perspective

Marie-Joëlle Rochet, Verena Trenkel, and Jake Rice

Currently many multiyear management plans are being developed either for rebuilding depleted stocks or for avoiding difficult negotiations when management decisions must be revisited on a regular basis. Management plans are commonly evaluated by model simulations that describe the ecological and economic dynamics, and the management loop from data acquisition to decision-making and implementation. Unfortunately, these are complex processes with high uncertainty in many relationships, so the simulations needed to evaluate each plan can be demanding to develop and validate. Besides, the simulations generally evaluate the management plans against their own objectives, and/or a general risk criterion. Under the results-based management paradigm, the fishing industry or particular fishing sectors will develop their own management plans, potentially leading to a huge number of plans to be evaluated. Guidelines for evaluating the plans on a qualitative level before launching quantitative evaluations will be essential. Here we propose a framework for evaluating management strategies in a qualitative way. A strategy is defined by (i) an objective, (ii) a coordinated plan of actions to reach this objective. We evaluate (i) under which assumptions the stated management objective is sustainable and (ii) whether the proposed plan of actions can reach the objective against theoretical criteria derived from general fishery models, and practical rules determining success of management plans from empirical review papers. We also examine whether metrics to monitor the completion of the plans can be provided by the fishers. We demonstrate this framework by analysing a series of management plans recently implemented or under development in the EU, and management plans implemented in Canada to recover depleted stocks.

Keywords: management plans, management strategy, qualitative evaluation, stock rebuilding, sustainability.

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ICES CM 2010/P:07

Improving complex governance schemes around western Baltic herring through the development of a long-term management plan in an iterative process between stakeholders and scientists

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Despite its relatively small stock size and economic value, western Baltic spring-spawning herring (WBSS) is managed in a highly complex governance scheme, with demanding scientific challenges and an elaborate political process of resource allocation among fishing fleets. WBSS herring spawns in the western Baltic Sea, where it is exploited by several EU fishing fleets. It migrates into the Kattegat and Skagerrak areas, where it mixes with North Sea autumn spawning herring (NSAS), in an age- and season-dependent pattern with high variability, and where it is exploited by both EU and non-EU fleets. For the two separate management areas, TACs are set at different times in the yearly TAC-setting process, which can result in conflicts over quota allocations to individual fleets. Industry stakeholders of two Regional Advisory Councils—the Pelagic and Baltic Sea RACs—and scientists involved in the FP7 JAKFISH project engaged in collaboration, aiming to improve stock management through joint development of a robust long-term management plan. A common

understanding of relevant scientific and political issues was developed and used to conduct management strategies evaluations in an interactive process. In this paper, we review the project's achievements and analyse the effectiveness of the collaborative process itself, and how it affected individual endeavours of the scientific and stakeholder groups. Finally, we reflect upon the concept of results-based management and how such science–stakeholder collaborations could play a role in a results-based management system.

Keywords: herring, governance, long-term management plan, management strategies evaluation, stakeholders, western Baltic.

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ICES CM 2010/P:08

Effective data utilization with a Bayesian hierarchical correlation model

Henni Pulkkinen and Samu Mäntyniemi

When reversing the burden of proof in fisheries, there is an interest among stakeholders to decrease the uncertainty in scientific estimates of fish stocks and thus obtain higher exploitation possibilities with same estimated risks. Especially poorly studied bycatch species have an increasing role when applying results-based management and an ecosystem approach to fishery management. The amount of information available from a specific fish stock is often limited, and the resources to gather new data can be small. However, information can be available from other stocks of the same or closely related species. Using all available information is cost efficient and makes it possible to reduce the amount of uncertainty around the key parameters of interest. By using Bayesian computation and hierarchical modelling, different hierarchical levels are set for correlation to connect closely related and more distant stocks together. For example, two levels of hierarchy can describe the stocks within the same species, and stocks of other related species. Also, genetic, geographical, and environmental similarities could be considered as a measure of closeness. A database called FishBase is used as a data source because it gathers a large amount of information from various species and is easily accessible. With this approach, it is possible to use different databases and earlier studies to build informative priors for subsequent studies. This can result in less uncertain estimates and better ground for fishery management. A demonstration will be given for learning from length–weight and length–fecundity relationships in order to update our understanding of fecundity.

Keywords: Bayesian, hierarchical modelling, management, stock assessment, uncertainty

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ICES CM 2010/P:09

Reversing the burden of proof in fisheries: methodological challenges

Sakari Kuikka, Samu Mäntyniemi, and Mika Rahikainen

We review the methodological challenges regarding the reversal of burden of proof, which has relevance in the context of results-based management. We suggest an approach that offers an ecosystem approach to management. It depends on reversing the burden of proof so that the fishing industry becomes responsible for demonstrating that operations remain within the pre-set negative impacts on multiple environmental factors, rather than managers being responsible for demonstrating that the industry is out of compliance. In results-based management, industry has incentives to invest in better knowledge, which leads, in the long run, to benefits for those who depend on fishing activities. It seems likely that this interest can be created only by setting informative priors on the impacts of fishing. This prior, and the related management conclusions, are given to industry by applying, for example, hierarchical Bayesian models. The management conclusion may follow the risk-averse decision rules so that each additional element of uncertainty decreases their exploitation possibilities. Thereafter, industry has either to accept the consequences

of these priors, or start carrying out scientific activities (like new surveys) which can be used to update priors and, thus, offering more exploitation possibilities.. In the context of results-based management, the hypothesis testing in classical statistics faces a problem, because improvement of data may only lead to a rejection of a conservative null hypothesis such as "bycatch has no biologically meaningful impact".

Keywords: fishery advice, socio-economics, results-based management.

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ICES CM 2010/P:10

Statistical framework supporting decision-making in fishery management within uncertainty context in biological and fleet behaviour knowledge

Stéphanie Mahévas, Hervé Monod, Sigrid Lehuta, Robert Faivre, and David Makowski

Fisheries management requires quantitative diagnosis of the impact of management measures. It has been largely argued that not accounting for uncertainty (parameters, processes, fishers' reactions to management measures) could lead to unreliable predictions of management impact on fisheries. ISIS-Fish is a flexible simulation tool of fisheries dynamics used to assess the impact of management scenarios on the dynamic of the fishery. This fishery model is time-discrete, spatially explicit, and fishers' behaviour is described within its fleet dynamics model. With respect to its flexibility and its spatial features, ISIS-Fish is a promising tool for participatory policy development, especially for testing the establishment of Marine Protected Areas. As soon as ISIS-Fish is parameterized, running simulations is rather easy, but without a rigorous approach that takes uncertainty into account, it could lead to incorrect interpretation of results. We propose a statistical framework based on sensitivity analysis methods to perform an uncertainty analysis of the comparison of the impact of several management scenarios. This approach relies on designs of numerical experiments (plans of simulations). Because of cost constraints linked to simulation time of complex models and uncertainty characteristics, the design must be carefully selected. This study proposes a comparison of several designs and provides recommendations on the selection of the appropriate one. We illustrate this approach on a demersal fishery to derive conclusions on the robustness of the forecast of management measures (TAC and MPA) impact to uncertainty.

Keywords: decision-making, diagnostic, ISIS-Fish, simulation tool, simulation designs, uncertainty.

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ICES CM 2010/P:11

Implementing a management system for the Baltic Sea fisheries with reversal of the burden of proof: a scenario

R. Aps and H. Lassen

The objectives for fishery management are usually given in general terms (e.g. as defined in the preamble of the CFP) and include: (i) sustainable exploitation of the resources, (ii) ecosystem considerations (e.g. bycatch and habitat effects), (iii) economic feasibility for the industry, and (iv) fair sharing among the countries—regional balancing. In order to achieve effective management it is important to distinguish between the objectives at different levels (i.e. overall sustainability is at one level whereas the profitability of the individual commercial enterprise is at a different level). The discussion on "reversing the burden of proof" as presented in the green paper on the CFP reform is an attempt to make this distinction and to push issues that do not necessarily involve societal concerns down towards the execution of the fisheries. Sustainability is defined at a general—ecosystem—level while the individual enterprises do not determine the development of an ecosystem although the combined pressure may do so. For governments to delegate responsibility to, for example, the industry, there must be an organization at the same level and

with legal responsibility to match the government. Such organizations do not exist now but Regional Advisory Councils, for example, could be developed into such organizations. Development of organizational structures at a regional level both on the government side and on the industry side are prerequisites for such a management strategy.

Keywords: BS RAC, Baltic Sea, fishery management, reversal of the burden of proof.

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ICES CM 2010/P:13

Reversing the burden of proof in fishery management in the context of an integrated ecosystem approach

M. Fitzpatrick, N. Graham, A. Hatcher, D. J. Rihan, D. G., Reid, G. Sutton, and P. MacMullen

The implementation of an ecosystem-based approach to the management of marine resources will create additional layers of uncertainty and complexity, which may be incompatible with current management approaches. Shifting to a results-based management approach while also derogating greater responsibility in decision-making will require a reversal of the burden of proof. Because an ecosystem approach implicitly requires integration across sectors and areas, it follows that sectorally and spatially integrated approaches to reversing the burden of proof will also be required. This paper explores how reversing the burden of proof has been approached in some fisheries globally and also in the management and regulation of other marine resource sectors, including aggregate extraction, aquaculture, and offshore renewable energy. Comparisons are made to the current approach in European fisheries, which operate under a system where the burden of proof rests largely with government institutions. Through examples, we show how multi-sector and societal demands can result in marine use conflict and increasingly how there is a burden of proof requirement to provide information which demonstrates the legitimacy of an activity. We explore how some sectors of the fishing industry have responded and how the provision of higher resolution data has provided evidence revealing that perceived conflicts may in practice be unfounded. Finally, we examine the implications of an integrated ecosystem approach for results-based and devolved or self-management as possible outcomes of reform of the Common Fisheries Policy.

Keywords: burden of proof, ecosystem approach, fisheries, results-based management.

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ICES CM 2010/P:14

Fishers' knowledge as an enabler for results-based decentralized fishery management

Brendan Flynn

The assumption that fisheries management can be decentralized down to local, regional, and sectoral levels needs to be more critically examined. It may merely result in creating an intervening tier of excessive management within the already complex CFP regime. Equally, the handing over of implementation competences to relatively weak institutional fora, such as the RACs, may be problematic. Moreover, national and subnational authorities can have mixed capacities and interests in taking up the regulatory challenge. The ideal of decentralized results-based fisheries management assumes that stakeholders, most of all fishers themselves, actually have the capacity to self-manage. Yet will cooperation between locally nested fishing communities and local regulator state agencies be forthcoming? Is the assumption that fishers can manage themselves accurate? This paper then points to possible synergies and conflicts between the emerging "fishers' knowledge" literature and the rhetoric of a more decentralized CFP. It is argued, based on an Irish research project, which the author had led, that there is indeed considerable capacity and goodwill on the part of fishers themselves to manage specific fisheries. Concrete regulatory ideas were

repeatedly suggested and even hard decisions considered in the case studies. However, there were limitations to the depth of actual scientific expertise fishers had, and thus a gap exists between the "hard" fisheries science used by regulatory agencies, and local fishing communities' own perceptions based on industry experience. Without finding systematic procedures and methodologies to bridge this gap, and without finding ways to encourage greater systematic dialogue between local regulators and fishing communities, it is very possible a shift towards greater decentralization may just represent problem displacement.

Keywords: fishers' knowledge, decentralized fisheries management.

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ICES CM 2010/P:15

Results-based management of bycatch in a rationalized fishery

Gretchen Anne Harrington and Stefanie Lyn Moreland

This paper explores using results-based management to minimize the Bering Sea pollock (*Theragra chalcogramma*) fishery's bycatch of culturally and economically valuable Chinook salmon (*Oncorhynchus tshawytscha*). The pollock fishery is the largest single-species fishery, by volume, in the United States, annually generating over a billion dollars in revenue. This fishery is managed under the American Fisheries Act, which rationalized the fishery by identifying the eligible vessels and processors and allocating pollock quota among these participants. In Alaska, after escapement goals have been met, Chinook salmon harvests are fully utilized by subsistence, commercial, sport, and personal use fisheries. Results-based management is being implemented through incentive plan agreements—industry-developed contractual arrangements—which enact incentives for each vessel to avoid Chinook salmon bycatch. The incentive plans are one component of a proposed management plan that limits Chinook salmon bycatch, sets performance standards, and increases federal bycatch monitoring. Federal regulations would establish the performance-based requirements for the incentive plans, recognizing that an incentive plan can be more responsive and adaptive than regulations to the inherent variability in Chinook salmon bycatch and the fact that the ease and cost of salmon avoidance differs by vessel. Incentive plans can be more effective because they can use tools, such as fees and penalties, not available to government managers. Participants would demonstrate the incentive plan's efficacy to managers and the public through annual reports; shifting the burden of proof to the pollock industry to show that they are minimizing their impact on Chinook salmon.

Keywords: Alaska fisheries, bycatch management, Chinook salmon, results-based management, pollock.

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ICES CM 2010/P:16

The Scottish Conservation Credits Scheme—an example of implementing a result-based approach to fishery management

N. Bailey, C. Needle, S. Holmes, P. Fernandes, N. Campbell, B. O'Neill, A. Gibb, and G. Chalmers

Since 2008, Scotland has been running a programme known as "Conservation Credits", designed to reduce mortality on cod using a variety of measures. Fishers adopting the measures, including spatial and technical solutions, are credited with additional days' fishing and can thereby mitigate some of the economic difficulties created by the EU cod plan effort management regime. In this paper, we present features of the scheme including the stakeholder involvement and co-management afforded by the Conservation Credits Steering Group, the range of conservation measures and background to their inclusion in the scheme, the industry involvement in developing and trailing measures and the tools used to evaluate outcomes and disseminate results. Under the EU Council provisions for such schemes there is a requirement to evaluate the contribution to

reducing mortality so that, if results require it, adjustments can be made to the overall effort ceiling available to the Member State concerned. The paper goes on to outline approaches used for investigating the effects of the measures such as Real Time Closures (RTCs), Amber Zones, and a variety of gear measures. In addition to addressing this challenging task, we also present overall outcomes in terms of discard reduction and cod catch because, from a mortality perspective it is the net effect which matters. Finally, the paper discusses the ongoing maintenance of schemes of this kind, the logistics of delivery, the incidental benefits, and the scope for development and transfer to other situations.

Keywords: cod catch, conservation credits, discards, effort, gear measures, real time closures (RTCs), steering group.

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ICES ASC 2010/P:17 Poster

Technical and economic efficiency analysis applied to artisanal fisheries

M. M. Oliveira, A. S. Camanho, and M. B. Gaspar

The research sought to determine the efficiency of vessels using data envelopment analysis models. Using data on the prices of each species in the wholesale market, revenue efficiency was also estimated to complement the technical efficiency analysis. An advantage of this approach resides in the ability to separate technical from allocative aspects in the efficiency assessment, allowing a graphical representation of the performance of vessels in two dimensions. This approach allows the specification of targets for inefficient vessels that corresponds to the amount of captures by species, which allows revenue to be maximized.

Keywords: artisanal fishing, clam fishery, data envelopment analysis, dredge fleet, revenue efficiency, technical efficiency.

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ICES CM 2010/P:18 Poster

A meta-analysis of rates of depletion and recovery of overfished stocks

S. A. Murawski

The design and implementation of effective recovery plans for overfished stocks is a commitment made by many nations at the World Summit on Sustainable Development in 2002. For this paper, I surveyed fishery stock assessments worldwide for specific examples of stock depletion, followed by significant and sustained reductions in documented fishing mortality rates. The instantaneous rates of decline and subsequent recovery were calculated using spawning-stock biomass or its proxy. In the predominant number of cases, positive rates of recovery followed fishing mortality rate reductions. Overall, the cumulative distribution function of the rates of decline was similar in shape to rates of recovery, as were the medians (with a sign change). There was substantial variation in the stock-specific relationships among depletion and recovery rates leading to a typology of stocks explained by life history, economic, and other factors. Further, I explore and develop rule-of-thumb formulas for recovery times based on empirical and theoretical rates of recovery.

Keywords: fish stock depletion, overfishing, recovery plans, recovery rates.

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ICES CM 2010/P:19 Poster

Bycatch in trapping fishery of the crab *Cancer bellianus* off the Azores

M. Inacio, E. Isidro, J. Gonçalves, and M. Pinho

The crab *Cancer bellianus* is almost a virgin stock in the Azores with occasional landings in some ports during summer. There is, however, interest in developing targeted commercial fisheries. Information published until now is scarce and is related to aspects of the biology and abundance of the species. The distribution of the species is given for the depth strata between 100 and 900 m. The potential distribution area of the resource will then include coastal areas and seamounts around the Azores. The objective of this work is to assess the bycatch associated with a potential fishery operating in those areas. For this purpose experimental trap fishing data from surveys and experimental commercial fishing from 1994 to 2004 were used. Results show that *Cancer bellianus* is more abundant in depth strata 200–600 m with a mode at 400 m (ca. 10.7 individuals by trap). In these depth strata several benthic species are caught, including crustaceans, molluscs, echinoderms, and teleost fish. Twenty-nine different species were observed. However, the abundance of the accessory species by trap was relatively low (less than 1 individual by trap and set). The expected impact of a potential trap fishery on the Azorean ecosystem and some management considerations related to the fishery technology, exploitation areas, and effort are discussed.

Keywords: bycatch, *Cancer bellianus*, exploratory fishing.

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ICES CM 2010/P:20 Poster

Science as a mediator for conflicting uses of the coastal zone: an analysis for the Guadalquivir Estuary

Javier Ruiz and Miguel Losada

The coastal zone acutely concentrates natural processes and economic pressures to a level not comparable with other marine or terrestrial ecosystems. The density of human population and its activities as well as its rates of growth are higher on the shore than inland. Overall indices of human welfare are also higher in the coastal zone. The coast also concentrates ecological processes for the cycling of both elements and life cycles. Despite its low comparative area, it accounts for ~43% of the world's ecosystem services and 90% of global fish landings. This scenario for conflicts between human targets and ecological risks is particularly sharp at zones such as the Guadalquivir Estuary, which has been under human influence for more than three millennia. The original territory was extensively modified by uses like navigation or agriculture and more recently by urbanization, aquaculture, and salt production. Conflict among uses and between them and the high environmental value of Doñana National Park came to a head at the end of the twentieth century. It was in deadlock until it was agreed to accept knowledge-based decisions and a scientific evaluation of the risk involved. This paper describes the conflict scenario, the scientific actions undertaken to evaluate processes and risks, as well as the expected outputs of the method. The latter will be the base for decision-taking on the structure and functionality of an extremely sensitive territory in the socio-cultural, economic, and ecological arenas.

Keywords: coastal zone, estuary, Guadalquivir.

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ICES CM 2010/P:21

A pilot study about anchovy and sardine "sentinel" surveys in the Bay of Biscay: a partnership between scientists and fishers

D. Delaunay, J. Massé, L. Pawlowski, and D. Ciolek

Anchovy and sardine are small pelagic species occupying partially the same geographic areas in the Bay of Biscay. Two abundance indices are available through acoustics and the DEPM method (Ifremer and AZTI). The level of biomass is strongly dependent on recruitment success, and thus on the survival of eggs, larvae, and juveniles. Ideally, only monitoring throughout the entire life cycle could provide accurate biological data usable for integration into models for management strategy evaluation. "Sentinel" surveys suggest an innovative data collection strategy for additional information through a partnership between fishers and scientists by enlisting commercial vessels for the monitoring of sardine and anchovy populations. It combines acoustic acquisitions, fishing operations for biological sampling, and collecting physical parameters on board commercial vessels. Such surveys have been carried out since April 2009 regularly throughout the year by pelagic pairtrawlers and purse-seiners in two key areas where the success of recruitment is sensitive. An adequate sampling strategy is adopted by the team "captain/scientist" according to the situation, in order to profit from fishers' experience through a rigorous scientific approach. The data collected are therefore validated by both scientists and fishers.

Keywords: anchovy, collaboration scientists/fishers, population indicators, sardine.

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Theme Session Q

Marine biodiversity—the science and management needed to meet 2010 commitments

ICES CM 2010/Q:01

What information can acoustic data provide on marine biodiversity?

V. M. Trenkel and L. Berger

Acoustics-derived indicators have primarily been used in the context of single-species management in the form of species biomass or abundance indices, often disaggregated by age class. The latter requires trawl hauls for species identification and age/length structure determination or other methods to achieve the same aim. Very little use has been made of acoustics to derive other indicators, despite the fact that these methods have huge potential, both in terms of simultaneously sampling across several trophic levels as well as at a range of spatial and temporal scales, which are not paralleled by any bottom-trawl sampling programme. In this presentation, we review existing indicators and propose new ones. In particular, we make proposals on how acoustic data can be used to estimate indices of water column diversity, making use of multifrequency information and backscattering strength groups, which broadly reflect trophic levels. The proposed indices are evaluated using data from the Bay of Biscay.

Keywords: acoustics, diversity indices.

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ICES CM 2010/Q:02

Challenges and landmarks in assessing the environmental status of a marine ecosystem: case study of the Baltic Sea

Henn Ojaveer and Margit Eero

HELCOM Baltic Sea Action Plan (BSAP) aims to achieve good environmental status (GES) of the Baltic Sea by 2021. The three adopted strategic goals under the BSAP describing the desired state of the marine environment—"Baltic Sea unaffected by eutrophication", "Marine life undisturbed by hazardous substances", and "Maritime activities carried out in an environmentally friendly way"—will ultimately lead to the fourth BSAP goal of "Favourable conservation status of Baltic Sea biodiversity". In this paper, we evaluate the status of the Baltic Sea biodiversity and environment in relation to the BSAP targets, by using 145 state and pressure indicators, several of which date back to the early 1970s. Our approach is based on the methodology of knowledge-based systems, which allows us to combine widely different types of information into a single coherent framework and facilitates communication of the obtained results outside the scientific community. We focus particular attention on the sensitivity of this assessment to some critical steps, such as defining reference values and procedures of aggregation of different indicator information. Accordingly, we present results of the estimates of the current status in relation to GES targets, together with long-term trends in biodiversity, environment, and human pressures, and the robustness of these two approaches is discussed.

Keywords: Baltic Sea, good environmental status, indicators, knowledge-based systems, monitoring.

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ICES CM 2010/Q:03

Temporal changes in the diversity of shelf-sea fish communities

Jeremy Collie and Marie-Joëlle Rochet

The North Sea and Georges Bank fish communities have exhibited changes in size and species composition over the last decades. Hypotheses that may explain these changes include climate change that may induce shifts in the foodweb, historical and contemporary fishing pressure, and selective fishing of certain species or sizes, and fishing-induced changes in life-history traits. We use a comparative approach to examine the support for these different hypotheses. Using standardized trawl-survey data, we identify the useful indicators of species diversity, and functional diversity as measured by changes in size structure and changes in functional groups. The North Sea and Georges Bank fish communities have much in common, including shared species and congeneric species. However, the communities differ in that the North Sea has experienced higher fishing mortality rates and has relatively less fish biomass in the larger size classes. We use a length-based multispecies model to investigate how these differences in size distribution may have originated.

Keywords: biodiversity, fish community, Georges Bank, multispecies model, North Sea, selective fishing.

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ICES CM 2010/Q:04

Marine biodiversity, fisheries, and food security: time to deal with the elephant (seal) in the living room

Jake Rice

This paper will first review the major commitments that have been made in international agreements with regard marine biodiversity. It will highlight the changes in objectives for management and the areas where traditional objectives of fishery management need to be

reconsidered and in some cases adjusted. In general, meeting the biodiversity conservation commitments are likely to require reductions in harvests by capture fisheries in at least the short term, and possibly medium term, for far more fisheries than it will lead to increased opportunities for harvesting. In the long run as status of exploited stocks improve, catches may increase to some extent. However, it is unlikely that in the longer term all biodiversity objectives can be achieved with harvest levels observed in the 1990s and early 2000s. The paper will then review current projections for future human requirements for food security, and forecasts of the expected trends in food production from traditional crop and livestock sources. The potential impacts of global climate change are also discussed. There are major discrepancies between projected needs for food security and expected productivity from traditional sources. Many planners are looking to fisheries to fill a major part of this gap. However, harvests available from sustainable fisheries in the setting of current biodiversity objectives will fall far short of those needs. Information on opportunities to substantially increase food production from capture fisheries and aquaculture will be summarized, but the opportunities exist only by shifting capture harvests to lower trophic levels, and greatly increasing intensive aquaculture in coastal areas and freshwater sites. These changes move us further from the biodiversity conservation objectives. The paper offers no clever solution to these issues, but is intended to open a dialogue on where society wants to go in addressing these urgent but incompatible challenges.

Keywords: biodiversity, climate change, fisheries, food security.

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ICES CM 2010/Q:05

Biodiversity management for sustainable fisheries

Shijie Zhou and Gudrun Martensdottir

Commercial fishing has extensive and diverse effects on exploited fish stocks. Most management procedures aim to attain maximum sustainable yields but often ignoring the effects of fishing on biodiversity at inter- and intraspecies levels as well as the reversing effects of the biodiversity on the fisheries. Although sustainability is widely adopted as a management goal, fishery legislations and management plans contain few explicit biodiversity goals. Within-species diversity, an important level of biodiversity for fisheries, has been largely overlooked by both scientists and managers. Maintaining inter- and intraspecific biodiversity to support sustainable fisheries may require fundamental changes of fishing strategies. At species level, fishing reduces abundance of target species and may also incidentally kill non-target species. The strategy for maintaining species diversity and supporting sustainable fisheries depends on the trophic relationship between the target and non-target species. At population level, fishing disproportionally removes large fish. In some fisheries, one sex (typically the male) may suffer from a higher fishing mortality rate. Relevant scientific research and management policies worldwide are reviewed and a conceptual fishing strategy that may help to maintain natural population structures will be discussed. It is hoped that this presentation will stimulate debate between fishery scientists and conservationists on future fisheries and biodiversity management.

Keywords: diversity, fishing strategy, intraspecies, species, sustainability.

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ICES CM 2010/Q:06

Ordination of measures of biodiversity in reduced space: sense or nonsense?

Olga Lyashevska

Biodiversity measures the degree of difference within biological systems. Ideally, a single measure would unify biodiversity assessments across science. Given the multidimensional nature of biodiversity, in practice, we search for a minimal necessary and sufficient set (m^*) of metrics. Starting with a decomposition of biodiversity indices, I constructed the manifold permutation matrix from which m^* must be found. Simulated ecological communities were generated from lists of benthic marine species found around Ireland and selected by taxonomic sampling. I tested the sensitivity and relationships among various indices of biodiversity using multivariate statistics with a population of simulated communities. The main goal of this analysis is to show how an orthogonal set of marine biodiversity metrics can be formed from which to select the most sensitive and easily measured diversity properties of the community. Having quantified an individual indicator performance, I will test whether currently used biodiversity indicators can be sensibly reduced to a smaller number and what we might miss out by doing it. Modelling results of this kind will help make practical the measuring of biodiversity in marine ecosystems, in line with the ICES mission.

Keywords: biodiversity, community composition, indicators, ordination.

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ICES ASC 2010/Q:07

Trophic structure and fisheries interactions in the Gulf of Lions (northwestern Mediterranean)

D. Bănaru, C. Mellon-Duval, D. Ross, J-L. Bigot, A. Souplet, J-M. Fromentin, A. Jadaud, and D. Kaplan

The Gulf of Lions ecosystem was described using the Ecopath mass–balance model of trophic interactions, with the aim of characterizing its functioning and structure and to understand the effects of the multispecies fisheries operating in this area. The model is composed of 39 compartments, including seabirds, 2 groups of cetaceans, 17 groups of fish, 12 groups of invertebrates, 5 groups of primary producers, detritus, and discards. Input data were based on landings database, aerial, acoustic and bottom-trawl surveys, stock assessment working groups, stomach analyses, and published information. Results showed that the functional groups were organized into four trophic levels with the highest one represented by dolphins, anglerfish, Atlantic bluefin tuna, European hake, and European conger. European pilchard and European anchovy dominated in terms of fish biomass and catches. Benthic crustaceans and zooplankton played key roles in the ecosystem and important coupled pelagic–benthic interactions were described. The seven different analysed fisheries were operating at a mean trophic level situated between 2.6 for coastal small boats and 4.2 for purse-seine, indicating an intensively exploited ecosystem. Following the increasing exploitation of European hake, a Marine Protected Area with limited access of fisheries was established in the Gulf of Lions. Ecosim and Ecospace scenarios referring to this area will be presented.

Keywords: Ecopath with Ecosim, fisheries impact, foodweb, Gulf of Lions, Marine Protected Areas.

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ICES ASC 2010/Q:08

Weighing natural variability and anthropogenic impacts: a case study of demersal fish and epibenthic communities in the Belgian Part of the North Sea

Annelies De Backer, Sofie Vandendriessche, Jan Wittoeck, and Kris Hostens

Nowadays, ecosystem-based management is the ”key” to maintain biodiversity and ecosystem functioning. To allow an ecosystem approach, however, the natural variability in the various ecosystem components and communities needs to be mapped. The distribution of the macrobenthos in the Belgian Part of the North Sea (BPNS) is well studied, and four major species assemblages have been defined, which are mainly linked to sediment type. Distributional patterns of the epibenthos and demersal fish, however, were studied for the first time during the present study. Patterns were derived from 2004–2009 monitoring data gathered at 80 sampling stations. The observed spatial gradients corresponded largely to the macrobenthic habitat types. The coastal–offshore gradient is the dominant structuring factor on a regional scale (BPNS), which is reflected by a transition from a coastal system characterized by shrimp, ophiuroids, and crabs to an offshore system with lesser weever, hermit crabs, and dab. On a local scale (sandbank system), the seasonal and interannual effects primarily determine the community structure, although topography (gully–sandbank position) also plays a role. The knowledge of natural spatial and temporal variation of these epibenthic and demersal fish assemblages is necessary to allow for adequate impact assessment of anthropogenic disturbances. This will allow us to take the appropriate management measures to preserve biodiversity and maintain the quality and occurrence of habitats.

Keywords: Belgian Part of the North Sea, demersal fish, distributional patterns, epibenthos, natural variability.

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ICES CM 2010/Q:09

How do we include biodiversity in fishery management: analysis for the real world?

Keith D. Farnsworth

Economic valuation is the only quantitative justification for public decisions on conservation, but its poor foundations are starkly exposed when we try to value marine biodiversity. Substitutability and individual preference ranking, fundamental assumptions of welfare economics, are invalid for marine biodiversity. We cannot substitute for lost biodiversity; it is not a commodity, but a scientific measure of the complexity of a biological system and individual citizens cannot have an informed opinion about its worth. Most economists have settled for valuing the services that biodiversity hypothetically provides to humanity, but relationships between biodiversity and ecological services remain largely obscure. A scientific approach defines biodiversity in terms of functional information, evaluated instrumentally through changes in expected biological fitness over networks of organisms. Such an objective (non-anthropocentric) approach is left irrelevant by the ”cultural” gap between science and public decision-making. The remaining alternative is to dramatically simplify confronting society with a discrete choice between an ecologically healthy and productive sea or one that is barren. Economists may best set mutually exclusive policy choices, such as fishery subsidies or conservation spending, for both objective (e.g. accountancy) and subjective (hypothetical market) methods. Ecological modelling of exploited marine systems should provide realistic scenarios for these choices. Discrete economic choices could be considered an important part of EAFM, which includes the design of economic instruments for implementing the choices made. I propose that biodiversity issues are best incorporated into fishery management by posing simple, discrete options of future scenarios in an economic context.

Keywords: biodiversity, ecological approach to fishery management (EAFM), economic valuation, policy.

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ICES CM 2010/Q:10

Practical issues affecting the utility of field survey data for biodiversity monitoring

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There is growing emphasis on monitoring biodiversity in European waters, with the EC's Marine Strategy Framework Directive (MSFD) listing biodiversity as one descriptor of "Good Environmental Status" (GES). Member States already have various monitoring surveys in place (e.g. groundfish surveys) which may provide a cost-effective way of assessing some elements of biodiversity. The MSFD recognizes the "need to ensure, as far as possible, compatibility with existing programmes". Although existing field surveys are a potential source of quantitative data for examining spatial and temporal biodiversity patterns, it must be acknowledged that such surveys were often not originally designed to monitor "biodiversity", and long-term surveys may have had changes in survey design at some point, and/or subtle changes in survey protocols over time. Field surveys for infauna and plankton typically collect and preserve samples at sea, and subsequent laboratory work includes the use of reference collections, quality assurance, and longer term sample storage. Surveys with towed gears can collect large amounts of complex biological material, which is typically processed at sea. The taxonomic knowledge, experience, and enthusiasm of sea-going and laboratory-based staff may influence the biodiversity information collected (e.g. time spent sorting complex catches, species identification). Hence, matrices of species-station data can contain "artefacts" that need to be addressed before deriving biodiversity metrics, and may necessitate data filtering. This paper uses field data from selected surveys to illustrate how various factors can affect "biodiversity information".

Keywords: benthos, biodiversity, fish, survey design, temporal change.

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ICES CM 2010/Q:11

Macro-ecological patterns in fish biodiversity and survey abundance

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Previous work has identified maximum body size as an important functional life-history trait for marine fish species influencing their growth, natural mortality, recruitment, and resilience to exploitation. We use data from a large number of scientific bottom-trawl surveys from West Greenland to the Adriatic to compare the distribution of species richness and average number of individuals caught per hour of trawling across different fish communities. Although highly variable, the data reveal several overall patterns. Going from north to south the total species richness and the total number of individuals caught per hour of trawling increase, whereas the average log maximum size of the individuals caught per haul shows a consistent decrease. In contrast, the average log maximum size of the species recorded remains stable throughout the area. We discuss to what an extent these patterns reflect general similarities and differences in fish community structure with latitude, are caused by differences in survey design and trawl gear used, or could be generated by differences in current and past levels of exploitation.

Keywords: fish biodiversity, maximum body size, trawl surveys.

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ICES CM 2010/Q:12

Identification of sensitive benthic habitats in the eastern English Channel based on functional traits and the Kostylev approach

Aurélie Foveau, Sandrine Vaz, and Vladimir E. Kostylev

Mesoscale information on offshore benthic species and assemblages is often lacking and the use of fish assessment research surveys allows the observation of the macro-epifauna and megafauna of large geographic areas. The species sampled by trawling represent mainly the sessile part of the macro-invertebrate fauna, which is the part of benthos most susceptible to the adverse effects of fishing activities. Therefore, these species may serve as accurate indicators of benthic habitat sensitivity to bottom trawling. The aim of the present study was to determine the distribution of the main epibenthic habitats and their sensitivity to fishing effort in the eastern English Channel and southern North Sea. The Kostylev habitat template mapping approach was adapted to predict the sensitivity of benthic habitats. Moreover, a functional approach (study of the species biological traits) was applied to complete and validate this habitat sensitivity modelling. This kind of information may be very relevant to planning future human activities in the area and to mitigating potential impacts of bottom fishing. It may also be useful for understanding of the factors affecting the distribution of fish.

Keywords: epibenthic invertebrate communities, functional traits, habitat template, sensitivity, trawling impact.

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ICES CM 2010/Q:13

Functional diversity indices: what do we exactly measure and at what scale?

A. Brind'Amour and P. Legendre

Traditional metrics of biodiversity (e.g. species richness, evenness of the community) consider that all the species within a community are equally different and thus functionally interchangeable. Ecological communities are composed of species that may have different biological roles or respond differently to various pressures, yet their substitution is unlikely to be realistic. A family of biodiversity indices, the functional-based indices, is measured by the range of species traits (e.g. morphological or ecological) in a community and therefore includes the species functional identity in the diversity measure (functional diversity, FD). It has been suggested that communities and ecosystems with large FD values will operate more efficiently in terms of productivity, resilience, and resistance to invaders. FD indices are based on quantitative or qualitative information about functional traits of species. The similarity among species can be represented in an n-dimensional trait space or by a distance-based matrix and derived indices are either related to that space (e.g. convex hull volume) or to classifications (e.g. branch length) calculated from the distance-based matrix. Although there is an increasing number of FD indices, there is still very little quantitative work on the relative behaviour of the different indices with regard to the loss and/or the gain of species. This paper uses simulated communities to estimate quantitatively how different FD indices respond to the gain or loss of functionally similar species (i.e. twinning criteria) or functionally different species (i.e. monotonicity criteria).

Keywords: functional diversity, monotonicity, simulations, species loss, species–traits matrix, twinning.

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ICES CM 2010/Q:14

Baseline benthic biodiversity of the Belgian part of the North Sea: lessons learned and the way forward with ecological restoration goals

J-S. Houziaux, J. Haelters, F. Kerckhof, S. Degraer, and T. Jacques

The determination of "baselines" is a necessary step in the implementation of ecological "restoration". A baseline can be defined as the ecosystem state under levels of anthropogenic pressure that do not negatively affect its functioning. Historical situations providing us with information on marine ecosystem structure and functioning prior to anthropogenic impacts are thus invaluable to determine the extent of human-induced environmental change and to set targets for the future. The ecology of the Belgian Part of the North Sea, now subject to intensive human-induced disturbance, has been intensively studied since the 1970s. Earlier, in the first decade of the twentieth century, ecological surveys were also conducted by Gustave Gilson, an early contributor to ICES science. The resulting unpublished archive (specimens and written records), kept at the Royal Belgian Institute of Natural Sciences, was researched between 2003 and 2009, and was supplemented with an analysis of the pre-1900 literature. The data were compared with the recent situation, targeting subtidal sediments and their benthos. Historical "baselines" were drawn for benthic habitats located offshore (*Ostrea edulis* beds; gravels) and nearshore (coastal sediments) and were placed in their context of anthropogenic pressure. Observed long-term (>100 years) biodiversity shifts are consistent with the expected impact of human activities during the twentieth century. How such detailed historical data alter our perception of "ecosystem health", thus far mainly based on post-1970 knowledge, is discussed and has implications for the definition of meaningful and achievable marine ecological restoration goals (e.g. under the EC "Habitat" and "Marine Strategy" framework directives).

Keywords: baselines, benthos, ecological restoration, environmental management, long-term changes, seabed integrity.

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ICES CM 2010/Q:15

Marine and coastal biodiversity: a comparison between indicators identified by institutions and those proposed by the scientific community

Julia Fossat, Dominique Pelletier, and Harold Levrel

Biodiversity is often defined as the variability among living organisms on earth, from genes to ecosystems, and the ecological and evolutionary processes that sustain it. Biodiversity is thus a complex, polymorphous, and debated concept. The multiple dimensions of biodiversity raise the issue of its evaluation. A variety of indicators have been defined as proxies for biodiversity. Some are used in institutional frames, such as the Convention on Biological Diversity or SEBI2010 (Streamlining European 2010 Biodiversity Indicators) and others are proposed by the scientific community. Biodiversity indicators have to be feasible and useful communications tools while summarizing many complex concepts and processes. But which features characterize indicators of marine and coastal biodiversity? What are the similarities and differences between institutional indicators and those proposed by the scientific community? In this communication, we present an analysis of institutional and scientific indicators of marine and coastal biodiversity with respect to a range of 18 criteria identified in several indicator frameworks. Multivariate analysis was used to classify the numerous indicators identified in both contexts. Criteria pertain to the headline (state, function, protect, use, and pressure on biodiversity), the level of biological organization (genes, species, and ecosystems), the scale of implementation, the level of aggregation, the availability and quality of data, the update frequency, and the implementation of indictors.

Keywords: biodiversity, coastal ecosystems, indicator, institutional.

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ICES CM 2010/Q:16

The power of integrating genetic and otolith microchemistry data to investigate population connectivity in common sole

E. L. Cuveliers, G. E. Maes, A. J. Geffen, and F. A. M. Volckaert

Many marine species are characterized by high fecundity, pelagic larvae, and high dispersal potential, resulting in high gene flow and weak genetic structure. It therefore remains a challenge to measure connectivity and reliably define management units in the open marine environment, which is lacking obvious physical barriers to dispersal. Although genetic assignment methods are limited by high gene flow and low genetic structure, otolith techniques are in turn dependent on distinct environmental differences. The combined use of otolith microchemistry and genetic markers, however, can provide valuable, powerful, and complementary information on population structure. In this study, estimates of stock composition based on genetic data and otolith microchemistry were compared for the common sole (*Solea solea*) in northern Europe. The degree of genetic differentiation between samples caught at several geographic locations, from Skagerrak and Kattegat in the north to the Bay of Biscay in the south, was analysed with 12 microsatellite markers and a mitochondrial marker (cytochrome *b*). The elemental composition of otoliths from 244 adult sole was measured using laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS). In all 13 elements were measured at the core and the outer edge of the otoliths, corresponding to different life-history stages. In general, there was a lack of genetic differentiation, suggesting high levels of gene flow at the spatial scale studied. On the other hand, elemental concentrations did differ significantly between the ”core” and ”edge”, suggesting that the adult sole were caught in very different environments than their birth location. The integration of results of both techniques is discussed in the light of an optimal strategy to assess the level of connectivity in sole and other flatfish.

Keywords: common sole, connectivity, microsatellite markers, otolith microchemistry.

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ICES CM 2010/Q:17

Algal forests and the replenishment of Mediterranean rocky fish

Cheminee Adrien, Mangialajo Luisa, and Francour Patrice

Fucoids forests (e.g. the canopy-forming *Cystoseira* spp.) structure the Mediterranean rocky infralittoral habitats, providing food, shelter, and nursery habitat for many organisms including fish. In the last decades a decline of *Cystoseira* forests has been recorded in several Mediterranean areas, as a result of direct and indirect effects of human activity. The loss of *Cystoseira* forests leads to a severe transformation of the habitat, which loses its three-dimensional structure. The goal of this study is to determine the consequences of this habitat transformation on rocky fish assemblages, and more specifically on their replenishment through juveniles' settlement. Preliminary investigations during summer 2009 in natural habitats indicated that fish juveniles' settlement for *Symphodus* spp. was greater in *Cystoseira* forests than in less complex macroalgal assemblages (e.g. *Dictyotales*). Moreover, experimental habitat manipulation mimicking the alteration of a *Cystoseira* canopy (e.g. using artificial plastic algae) showed greater abundances of *Symphodus* spp. juveniles on artificially forested substratum than on bare substratum. Density-dependent effects were tested by a multifactorial experiment, showing that juveniles' densities did not differ between dense and sparse cover treatments, highlighting the importance of the presence of a canopy. Nevertheless, ongoing experiments were set up to investigate the presence of a threshold level of plant density which may determine habitat selection by fish juveniles. Our results suggest that the loss of forests may strongly affect the recruitment of littoral fish, highlighting the need for protection and restoration of these forests.

Keywords: canopy, *Cystoseira* spp., fish, habitat, juveniles, settlement, *Symphodus* spp.

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ICES CM 2010/Q:19

Global patterns in fish species richness

Henrik Gislason, Simon Jennings, Daniel C. Reuman, Carolyn Barnes, and Frédéric Melin

Previous analyses have revealed a global pattern in fish species richness in which richness declines from the tropics towards the poles. To analyse this pattern further we combined data on fish species richness, trophic level, and maximum body size as provided by FishBase for large marine ecosystems (LMEs) with satellite-based estimates of average sea surface temperature and annual primary production. Total richness is shown to depend on temperature in approximately the same way as fish metabolism, whereas the relative number of species per log maximum size bin and per trophic level is shown not to change much with temperature. This suggests that a strong lawful relationship exists between the richness of marine fish communities and the maximum body size and trophic composition of their constituent species. The relationship between richness and the area and primary production of each LME is also examined.

Keywords: fish biodiversity, large marine ecosystems, maximum body size, trophic level.

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ICES CM 2010/Q:20

Mobilizing marine biodiversity research: the Canadian Healthy Oceans Network

P. V. R. Snelgrove, P. Archambault, S. K. Juniper, P. Lawton, A. Metaxas, C. McKindsey, P. Pepin, and V. Tunnicliffe

The Census of Marine Life has provided a framework for collaborative research in marine biodiversity. Here we present a model for academic and government partnership that has created the Canadian Healthy Oceans Network (CHONe), a national research programme that is uniting researchers to provide new insights into marine biodiversity and provide scientific guidelines for policy in conservation and sustainable use of marine biodiversity resources in Canada's three oceans. This initiative is structured around three interlinking themes. Theme Marine Biodiversity addresses the relationships between biodiversity and habitat diversity by testing hypotheses that link functional and species biodiversity to habitat complexity. Theme Ecosystem Function addresses how ecosystem function and health are linked to biodiversity and natural and anthropogenic disturbances. Theme Population Connectivity addresses how dispersal of marine organisms, typically by early life stages, influences patterns of diversity, resilience, and source/sink dynamics of species and biological communities using source–sink studies of existing management areas as model systems, and comparative studies of different dispersal metrics to estimate metapopulation connectivity. We will synthesize the outcomes of these themes across the Network to identify approaches to bridge science and policy, and communicate these results to the complex networks of user groups who ultimately influence policy application.

Keywords: baseline, biodiversity, connectivity, ecosystem function, policy.

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ICES CM2010/Q:22 Poster

Rebuilding European fisheries through TAC regulation?

Sebastián Villasante

This paper constitutes the first comprehensive assessment of the success of the Common Fisheries Policy (CFP) in conserving the stocks. We combined official data from 1990–2007 for (i) the TACs recommended by ICES and the proposed and approved TACs and (ii) biomass, recruitment, catches, fishing effort, and current exploitation rates for 40 marine populations subjected to TAC regulation. The differences between the fishing quotas and the scientific recommendations provided by the ICES were calculated to be 19% after the first CFP reform and 21% after the second one. In some species, these differences showed a threefold increase, in particular those currently considered to be beyond biological safety limits. Regarding the most important index of abundance, the results also show a biomass and recruitment reduction of 75% of the stocks and 90% of catches, whereas the fishing mortality of almost 40% of stocks remained constant in the 1990–2007 period. In addition, of all populations analysed under TAC regulation, only 20% presents an increase in the exploitation rate (Ucurrent), 17% did not show significant changes, and the remaining 63% showed a reduction between 1990 and 2007. According to Worm *et al.* (2009), these results could contribute to the recovery of stocks. However, contrary to the results obtained by Worm *et al.* (2009), who reported that 6 out of the 10 (60%) marine ecosystems examined showed Ucurrent values that were significantly higher than the maximum sustainable yield (Ummsy), the results of this study demonstrate that 86% of the populations regulated by TACs continue to follow an alarming pattern of exploitation.

Keywords: Common Fisheries Policy, global assessment, impact of TAC regulation, overexploitation of fishery resources.

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ICES CM 2010/Q:23 Poster

Commercially harvested "southern" surfclams found in Long Island Sound, New York, well north of their typical range

Matthew P. Hare, James R. Weinberg, Olga Peterfalvy, and Maureen Davidson

The "southern" surfclam, *Spisula solidissima similis*, commonly occurs in shallow marine habitats along the US Atlantic coast, south of Cape Hatteras (latitude 35°N). A different surfclam species, known as *Spisula solidissima solidissima*, is common north of Cape Hatteras. The present study used molecular genetic methods to determine the identity of a commercially exploited population of surfclams in Long Island Sound (at latitude 41°N), well to the north of Cape Hatteras. Based on the clam mitochondrial DNA, all of the Long Island Sound specimens were identified as the "southern" surfclam. This finding significantly extends the known northern geographical range of the "southern" surfclam. This study is significant because it provides new results about species diversity and biogeography of commercially harvested bivalves along the northeast coast of the US. It also raises questions about whether the "southern" surfclam occurs elsewhere north of Cape Hatteras and whether the two surfclam species occur together anywhere. Because both species are harvested commercially and because they have very different life histories, these new results could potentially impact their fishery management. Finally, we demonstrate that the two species can be distinguished from each other on average using shell morphometric analyses. However, it will not be possible to reliably identify individuals to species in the field because the shells of the two species look similar overall, and there is considerable within-species variation in shell shape.

Keywords: commercial harvest, cryptic species, marine bivalves, mitochondrial DNA, morphometrics, range extension, surfclam, *Spisula*.

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ICES CM 2010/Q:24 Poster

Modelling effects of fishing on biodiversity

Tak Fung, Keith F. Farnsworth, Axel G. Rossberg, and David G. Reid

Fishing is the biggest direct human impact on marine ecosystems, and can alter biodiversity by causing local to regional extinctions and changing the abundances of targeted and non-targeted species. Large-bodied fish are particularly vulnerable to fishing because of their low population growth rates and tendency to be preferentially fished, and removal of their biomass may cause marked trophic cascade effects. Managing for marine biodiversity requires knowledge of how biodiversity changes with increased fishing intensity, including the rates of change. However, theoretical investigation of this is restricted by the limited resolution of biodiversity in and/or high data requirements of most marine ecosystem models. The Population-Dynamical Matching Model (PDMM) avoids these restrictions by allowing species-rich model communities to emerge from rules determining speciation and invasion, acting over an evolutionary time-scale, and species population dynamics, acting over an ecological time-scale. These model communities are species-resolved from the smallest organisms (phytoplankton) to large-bodied top predators. The PDMM is calibrated for a fished marine community and used to investigate biodiversity change as fishing mortality rates increase. Two scenarios are modelled: fishing mortality rates are (i) independent of species body sizes and (ii) disproportionately large for large-bodied species because of preferential fishing. Biodiversity is measured by indicators such as species richness, Simpson's Index of Diversity and the Shannon–Wiener Index. The results obtained show how biodiversity can change with fishing intensity, give insights into the importance of disproportionately fishing large-bodied fish and help in assessing the utility of biodiversity indicators for management.

Keywords: biodiversity, cascade, fishing, foodweb, indicator, marine ecosystem, modelling, mortality, trophic interactions.

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ICES CM 2010/Q:25 Poster

The challenge of incorporating historical information to define a baseline to assess the state of the ecosystem and marine biodiversity—the Portuguese ecosystem

Hugo Mendes and Maria de Fatima Borges

The process of identifying a reliable baseline against which to measure trends in biodiversity indicators and the state of an ecosystem against fishing effects is a challenge, because records using consistent instruments and reliable sampling methods have only been taken during the last few decades. Nevertheless, considering only the most recent available time-series may be misleading and loses the perspective in setting recovery goals. Here we review historical anecdotal information and define criteria for its usefulness for a definition of initial state of the ecosystem. MSFD GES descriptors are applied and discussed.

Keywords: baseline, ecosystem, historical, indicator, marine biodiversity.

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ICES CM 2010/Q:26 Poster

Modelling kelp forest distribution in Norway

Trine Bekkby, Eli Rinde, Kjell Magnus Norderhaug, Hartvig Christie, Hege Gundersen, Lars Erikstad, and Vegar Bakkestuen

Spatial planning and coastal management require extensive knowledge of the distribution of habitats and the main factors influencing them. The highly productive *Laminaria hyperborea* kelp forests cover large areas along the Norwegian coast, hosting a broad diversity of species and providing the basis for commercial kelp harvesting and coastal fishing. However, as Norway has a

long and complex coastline, detailed mapping is practically and economically difficult, and other approaches are needed. This presentation shows how we develop a statistical spatial predictive model from modelled and field-measured geophysical variables and field observations of *L. hyperborea* distribution. The presentation also shows how this method is used to identify and quantify kelp forest areas grazed by sea urchins (*Strongylocentrotus droebachiensis*), and how this is used as a method to assess divergence from the natural ecological state.

Keywords: distribution, GIS, kelp forest, *Laminaria hyperborea*, spatial predictive modelling.

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ICES CM 2010/Q:27 Poster

Barents Sea Ecosystem Resilience under global environmental change (Bar-Ecore) 2010–2013

B. Planque, E. Johannesen, K. Michalsen, R. Primicerio, M. Fossheim, R. Ingvaldsen, and M. Aschan

The influence of climate warming on the Barents Sea ecosystem is documented by the long-term ocean temperature increase observed since the 1960s and the projected increases of up to 3°C by 2050. The impact of climate warming on Barents Sea communities may be exacerbated by fisheries. The project addresses the effects of climate warming on the structure, dynamics, and resilience of the Barents Sea ecosystem, integrated with the effect of fishery. Detection and forecasting of changes in ecosystem resilience and robustness under global warming and fisheries will be based on a broad battery of inferential tools including multivariate analyses of spatio-temporal changes in community structure, retrospective and prospective modelling of population distributions, mapping of life-history and feeding traits affecting species vulnerability, analysis of trophic interactions and foodweb structure, and early warning signals of abrupt changes detecting reductions in ecosystem resilience. The main outputs of the project, including a vulnerable species list, mapping of future populations distributions under warming scenarios, characterization of regime shifts, reliable early warning signals of abrupt ecosystem changes, provide tools needed for management of the Barents Sea ecosystem under global environmental change.

Keywords: Barents Sea ecosystem, climate change, fisheries, regime shifts, resilience.

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ICES CM 2010/Q:29 Poster

Benthos and fish communities in the Barents Sea

L. L. Jørgensen, M. Fossheim, E. Johannesen, A. Dolgov, and P. Lubin

The Barents Sea is a high-latitude shelf sea with strong environmental gradients, especially along the polar front where Arctic and Atlantic water masses meet. The spatial heterogeneity gives rise to distinct communities of benthos and fish. Within the Barents Sea, more than 300 species of benthos and 200 fish species have been recorded. Here, the spatial distribution of the main benthos and fish communities and their overlap is presented for the first time for the whole Barents Sea shelf, including previously inaccessible ice-covered areas in the north. Latitudinal gradients in biodiversity, abundance, and size are discussed. The results of this study form the baseline for the Bar-Ecore (Barents Sea Ecosystem Resilience under global environmental change) project where the main objective is to evaluate the effects of global environmental change on the future structure and resilience of the Barents Sea ecosystem.

Keywords: assemblages, biodiversity, climate change, resilience, spatial distribution.

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ICES CM 2010/Q:30 Poster

Quantifying biodiversity impacts in static net fisheries

Al Kingston and Simon Northridge.

Investigations into the environmental effects of fishing gears have previously focused primarily on demersal towed gears. With the exception of selectivity trials for target species and investigations into protected species bycatch, the other ecological effects of static nets, such as total organism removal, have not been widely studied. Given the increasing scientific and public interest in conservation and biodiversity issues, understanding the wider effects of all fishing gear types is becoming increasingly important. Furthermore, the imminent introduction of potentially widespread Marine Protected Areas (MPAs) in EU waters may lead to changes in patterns of fishing effort. Baseline data on the effects of different fishing gears will enhance our knowledge of potential impacts and should help improve the efficacy of future management measures. In this paper we present comparative catch data from over 3500 hauls, collected since 2004 during the course of the UK's cetacean and protected species bycatch monitoring programme. We also present preliminary results from experimental trials, consisting of approximately 50 semi-controlled hauls, which were designed to estimate the relative effects of different static net types. Our results demonstrate that differences exist in the overall catch characteristics, including species compositions, catch rates, and size distributions from different static net types. Consequently, the environmental footprint of the static net sector may change significantly if fishers respond to area closures or other management measures by switching to alternative net types. To ensure that biodiversity objectives are met, this type of information should be incorporated into, and guide, environmental and fishery management discussions.

Keywords: catch compositions, ecological effects, fishing effort, MPAs, static nets.

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ICES CM 2010/Q:31 Poster

Habitat classification and target setting for a systematic conservation planning approach in the eastern English Channel

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Classifying marine habitats is a growing research field and is of interest to conservation planners and managers. Most studies focus on the seabed in order to determine benthic habitat types, with the broad goal of providing management units for marine conservation. In addition, a few studies have developed targets for how much of each of these habitat types should be conserved. The eastern English Channel is an important region for fishing, shipping, aggregate extractions, and tourism but also supports a number of important marine biological features. The aim of this study is to provide conservation targets for the area based on different habitat types and using two different approaches. The first is a rapid approach and based on the EUNIS classification system and existing seabed species distribution data. The second is a more data-intensive approach and will define habitat types based on water column and seabed parameters. Both approaches will use species–area relationships to determine the targets and this will provide important data for conservation planners. It will also allow comparisons between the results of rapid and data-intensive approaches and so inform future research plans for developing these targets.

Keywords: conservation target, eastern English Channel, habitat type, marine conservation planning.

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ICES CM 2010/Q:32 Poster

Diversity of the dinoflagellate genus *Alexandrium* along the French coasts, based on morphological and molecular phylogenetic analyses

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The genus *Alexandrium* is mainly known in France with recurrent toxic blooms of *A. minutum* in some Channel estuaries since 1988 and *A. catenella* in a Mediterranean lagoon since 1998. In spite of difficulties in discriminating it from the other Peridiniphycideae, ten other *Alexandrium* species have been identified during the 1990s, based on morphological features. More recently, molecular approaches have been undertaken to ensure a correct identification of species. Today, ribosomal DNA sequences have been obtained for *A. andersonii*, *A. catenella, A. insuetum, A. leei, A. margalefii, A.minutum, A. ostenfeldii, A. pseudogonyaulax, A. tamarense*, and *A. tamutum*, confirming the presence of these species. Only *A. affine* and *A. taylori*, which are scarcely encountered, have not yet been genetically characterized. These sequences have been used to analyse the phylogeny of these taxa, including other sequences from different geographic origins. For the first time, *A. andersonii* has been positioned in the 18S rDNA phylogeny of *Alexandrium* species. Moreover, *A. leei* diverges early in the genus and forms a deep independent branch without apparent genetic affiliation to the other *Alexandrium* species. It grouped with a Korean strain of the same species but a high genetic divergence was observed notwithstanding an apparent morphological homogeneity. This result raises questions about the origin of the French strain that has been observed since 1993 on the Atlantic coast.

Keywords: *Alexandrium*, dinoflagellates, diversity, France, morphology, phylogeny, taxonomy.

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ICES CM 2010/Q:33 Poster

A comparison of two systematic conservation tools: Marxan and Zonation. A case study in the eastern English Channel

J. Delavenne, S. Vaz, R. J. Smith, C. S. Martin, L. Dupuis, F. Coppin, and A. Carpentier

With the increasing use of spatial conservation prioritization in land or sea management, a number of systematic conservation tools have been developed. They have different characteristics and respond to different conservation objectives. Marxan and Zonation are two tools based on a complementarity approach but aiming at two different conservation objectives—the minimum and the maximum coverage set, respectively. In this study, both software outputs were compared using the same dataset comprising physical and biological features and with varying costs allocated to the planning units. The eastern English Channel was an interesting area to carry out this study as a large range of biological data were available. Not all the solutions' characteristics produced by both softwares were directly comparable and we chose to focus on the irreplaceability outputs. The cost parameter appeared to have the largest effect on the solutions proposed, whereas the comparison of both softwares' outputs for the same cost did not lead to important differences in the proposed areas for conservation.

Keywords: eastern English Channel, marine conservation planning, Marxan, spatial conservation prioritization, zonation.

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ICES CM 2010/Q:34 Poster

Basin-linked population genetic structure of turbot

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Many marine species have the capacity to disperse over vast geographical areas, either passively by drifting eggs and larvae following ocean currents, or actively by migration of juveniles and adults. The apparent lack of physical barriers in the sea leads to the expectation of weak or absent population structure. However, it has become increasingly clear that distinct genetic patterns do exist for many marine species, even on a small geographical scale. The presence of subpopulations might suggest that mechanisms other than physical barriers shape population differentiation. There is good evidence that mechanisms such as oceanic currents, larval retention, dispersal constraints, philopatry, and associated local adaptation do play a role. Turbot is a valuable commercial species in Europe, living in the Northeast Atlantic Ocean, Mediterranean and Black seas. Previous genetic studies showed low or non-existing genetic differentiation. However, most of these studies were basin-specific, included relatively few samples/locations or used an incongruent set of markers. Here we analyse the population structure of turbot on a pan-European scale with genetic fingerprints of 22 microsatellite markers. On a large-scale we refute the hypothesis that turbot is a truly "panmictic" marine species, although on a small geographical scale patterns are less distinct. Finally we evaluate the biological implications for fishery management.

Keywords: connectivity, genetic stock identification, microsatellites, *Psetta maxima*, population structure.

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ICES CM 2010/Q:35 Poster

Can shape provide an idea of fish feeding preferences?

S. Chambord, C. Villanueva, M. Rouquette, and B. Ernande

Biodiversity is a concept that covers a number of issues that can elucidate diversity-related functional roles in our understanding of ecological ecosystem functioning. Biodiversity can shape ecosystem structure and functioning especially if we focus on predator–prey interactions. Moreover, the mechanisms governing prey–predator relationships will shape the emergent foodweb structure just as individuals' characteristics determine the emergent demographic structure of a population. We determined the trophic ecology of fish species in the eastern English Channel by combining gut-content and geomorphometric analyses. We inferred the mechanisms of resource utilization by Atlantic sea bass and plaice by coupling measured geomorphometric determinants of prey–predator interaction with the observed diet in order to determine functional relationships between fish morphology and diet. Results were then analysed using cluster and correspondence analyses to describe correlation between ecomorphological and dietary matrices. Such empirically determined allometries will consequently be used to simplify the description of predator–prey interactions by collapsing its dimensions to few more relevant morphometric characteristics per species.

Keywords: biodiversity, eastern English Channel, fish, geomorphometry, predator–prey interaction, stomach content analysis.

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ICES CM 2010/Q:38 Poster

Effects of macrobenthic diversity and species composition on meiofauna and ecosystem processes in shallow sandy littoral sediments (southern Baltic Sea)

Barbara Urban-Malinga, Aleksander Drgas, and Zalewski Mariusz

A laboratory experiment was performed to study the effect of macrofaunal species composition and diversity on biogeochemical processes (O_2 uptake, nutrient excretion, porewater chemistry) and meiofaunal vertical distribution, diversity, and community structure with special emphasis on nematodes. Three macrofaunal species differing in terms of burrowing activity, typical for the sandy shallow littoral of the Gulf of Gdańsk (southern Baltic Sea; *Nereis diversicolor*, *Cerastoderma glaucum*, and *Mya arenaria*) were selected for the study. Macrofauna significantly affected vertical distribution and densities of meiofauna, nematode generic and functional (trophic) diversity and community structure. Although shallow burrower *C. glaucum* had minor effects on meiofauna distribution and community structure, the impact of deep burrower *N. diversicolor* was the most pronounced both in monoculture and in mixtures with other species. All treatments with *N. diversicolor* had similar effects on sediment processes such as O_2 consumption and nutrient release, suggesting a prominent role of this species in ecosystem functioning. The observed effects of macrofauna on meiofauna, in general, and nematodes, in particular, are related to porewater chemistry and biogeochemical processes rates in order to better understand mechanisms responsible for the effect of diversity on ecosystem functioning.

Keywords: bioturbation, ecosystem processes, macrobenthos, nematodes.

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ICES CM 2010/Q:39

Importance of intraspecific genetic diversity of the estuarine copepod *Eurytemora affinis* at multiple spatial scales

Gesche Winkler, Sami Souissi, Julian Dodson, and Vincent Castric

Ecosystem health and the conservation of biodiversity are of major concern in coastal ecosystems, such as estuaries, as they are often exposed to local anthropogenic pressures in combination with global climate change. However, much biodiversity remains cryptic, especially genetic variability related to sibling species in zooplankton. In this study we focus on the most important copepod in the estuarine transition zone, *Eurytemora affinis*, which occupies a key position in estuarine foodwebs between primary production and higher trophic levels. *E. affinis* is subdivided into morphologically similar but genetically divergent clades distributed across the northern hemisphere. The objective of the study is to determine genetic diversity at a small spatial scale within estuaries and at a larger scale of a latitudinal cline among estuaries. Diversity patterns of *E. affinis* revealed pronounced genetic structure along the latitudinal cline in northern Europe, whereas at smaller geographic scales similarities in genetic variability among estuaries are likely related to connectivity and dispersal. Within European estuaries, no genetic differences were observed between neighbouring populations, whereas restricted gene flow between populations was evident in the St Lawrence Estuary. We suggest that genetic diversity and differentiation among populations of *E. affinis* strongly depend on the interplay among evolutionary history, landscape features, and environmental settings. The present results combined to available information on the life-cycle traits of different populations of *E. affinis* would improve the existing individual-based models validated for this species complex. It is important to incorporate such detailed information in future coupled biological/physical models.

Keywords: estuarine copepod, *Eurytemora affinis*, genetic biodiversity, geographic scales, population genetic structure.

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ICES CM 2010/Q:40 Poster

Greater shearwaters in the Gulf of Maine and Georges Bank (Northwest Atlantic): can we identify seabird foraging hot spots using at-sea and bycatch data?

Marie C. Martin and Gina Shield

Greater shearwaters (*Puffinus gravis*), seabirds Procellariiforme have been little studied because of their remote nesting locations and pelagic distribution at sea. They complete extensive annual migrations between their southern nesting grounds at Tristan da Cunha and the North Atlantic's productive waters. During these migrations, birds may interact with fisheries of approximately 30 countries; however, the degree of interaction and incidental mortality is largely unknown in most waters. In the United States, greater shearwaters have been regularly documented as incidental bycatch in its northeastern gillnet fisheries since 1991. Utilizing 19 years of bycatch data and 7 years of at-sea distribution data, we investigate some of the species foraging hot spots and important use areas in the Gulf of Maine and Georges Bank. In addition, we present some of the first data on condition, sex, and age bias in bycaught greater shearwaters through necropsy examination of 135 specimens from the Northwest Atlantic between 2008 and 2009.

Keywords: at-sea survey, bycatch, foraging ecology, top predator distribution.

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Theme Session R

Delivering more science with fewer resources: How do we make best use of our investment in science through joint programming, communication, and knowledge management?

ICES CM 2010/R:01

OLFISH electronic logbook: bridging the gap between fisher, manager, and scientist through cohesive data-logging

Amos Barkai

One of the main setbacks to integrated knowledge management between fishers, managers, and scientists is the lack of and an inability to capture, reliable, eligible data. For scientists, unreliable data leads to a poor basis for stock assessment models and management programmes. For industry, the lack of sound data significantly reduces fishing efficiency, because past performance cannot be studied properly. As a result, poor management decisions based on unreliable analyses are made, often with substantial cost and risk to fish resources and the fishing industry. A key step in addressing this issue is unifying all sectors with regard to data collection and management. In response to this need, Olrac, a South African Company, has developed an electronic logbook software, OLFISH, with the aim of bridging the data-gaps between fisher, manager, and scientist. The adaptive and flexible design of OLFISH makes it an effective and useful tool for all marine-related interest groups, from the fishers themselves to commercial managers, government agencies, and scientists alike. OLFISH is used extensively in many fisheries around the world. Three case studies are presented: (i) Albatross Task Force: Their use of the OLFISH software to collect and analyse data regarding interactions between seabirds and fishing activities around the world. (ii) Olfish EU logbook solution: An adaptation of the software to comply with EU regulation (EC) No 1077/2008. (iii) Environmental Defense Fund: A pilot project introducing elog technology to the Gulf of Mexico's commercial and recreational fleet.

Keywords: data management, electronic logbook, fishery management, Olfish, Olrac.

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ICES CM 2010/R:02

A systems approach to fisheries science and management: beyond management strategy evaluation

Steve Cadrin, Brian Rothschild, Azure Westwood, and Cate O'Keefe

Operations research is typically applied to fishery science in the form of "management strategy evaluation", in which an operating model is used to simulate fishery and survey data, the data are analysed by a stock assessment model, assessment results are used for predefined management decisions, management decisions iteratively feedback on the operating model, and performance of the harvest control rule is evaluated with respect to stated objectives. A systems approach to fishery science and management applies a broader, more holistic approach in which scientific and administrative investments can be optimized and objectives can be iteratively refined. The last two decades of global fishery management illustrate a series of evolving objectives: (i) avoiding recruitment overfishing; (ii) incorporating uncertainty in a precautionary approach; (iii) achieving maximum long-term yield by avoiding growth overfishing; (iv) achieving optimal yield for multiple socio-economic utilities; and (v) considering ecosystem approaches and utilities. Despite the substantial changes in system requirements associated with these developments, investments in fishery science have remained remarkably static, continuing conventions for fishery sampling and resource surveys that were designed in the context of past objectives and old technologies. The application of new technologies is typically evaluated and implemented within the narrow objectives of each programme rather than in the broader context of related programmes and performance of the entire system. A systems approach to fishery science and management offers a more strategic tool for maximizing investments in fisheries beyond the evaluation of alternative harvest rules.

Keywords: management strategy evaluation, systems analysis.

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ICES CM 2010/R:03

Ensuring the uptake and impact of marine fishery research

John Holmes and John Lock

An increasing emphasis is being placed on ensuring the uptake and impact of research in marine fishery management and policy-making. Key factors in ensuring the required uptake and impact are how effectively researchers, fishery managers, and their scientific advisors communicate with each other in establishing the needs for new scientific knowledge at the research planning stage, and the results and policy implications of research when the research has been completed. The MariFish network, which comprises the major European funders of marine fisheries, therefore carried out a study in 2007–2008 of current practices relating to the communication of knowledge needs and research results. This paper summarizes the findings of the study, which identified the strengths and weaknesses of current practices in Europe, and consequently how two-way communication and the effectiveness of generating evidence of marine fishery policy-making and management can be improved. Conclusions and recommendations for "good practice" include: (i) the need for fishery ministries to have sufficient in-house scientific capacity to act as "intelligent customers"; (ii) the importance of building good relationships between researchers, fishery managers and their advisors, and with the fishing industry; and (iii) the need to carefully develop the skills and career paths of interpreters of research who play a key role in allowing effective communication and exchange between the research and policy/management communities.

Keywords: agenda setting, research communication, uptake and impact.

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ICES CM 2010/R:04

Sharing knowledge: the potential pitfalls and power of project databases

Alison Simmance and John Lock

We have all received requests from others to submit details of our research projects to a database, under the mistaken belief by the initiator that capturing details of projects in a database will automatically help spread knowledge and avoid duplication. More often than not, such requests are ignored or a quick dumping of unedited data is seen to suffice. The MariFish project attempted to develop a fully comprehensive listing of all research currently being undertaken by the 18 European partners. The aims were quite clear: to help identify possible overlap, duplication, and gaps. Despite the good intentions of all partners, the information provided was less than comprehensive. Reasons given were lack of time, text not in English, and no central registry for national projects. As a result of this failure to achieve a comprehensive picture of national fishery research programmes, another approach was used to capture as much information about current research on a specific, high priority area of research—discards. The technique adopted was more direct, using personal contacts, explaining fully why the information was needed, and using a central resource to edit and load data. Once a comprehensive picture of current research was achieved, a detailed analysis was undertaken to help assess whether capturing this information produced any benefits. A clear picture of discard research emerged, including what the current emphasis is, where collaboration could occur, and where there are gaps. The conclusion is that project databases are potentially powerful, but have to be set up with care and forethought.

Keywords: collaboration, database management, discards, fishery management.

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ICES CM 2010/R:05

Monitoring of recreational fishing of sea bass (*Dicentrarchus labrax*) in France: output from a dual methodology (telephone survey and logbook of volunteers)

Johanna Herfaut, Harold Levrel, Mickael Drogou, and Gérard Véron

The first national survey on recreational fishing in France (2006–2008) revealed that sea bass was the main target species for recreational fishers. At the same time, the Data Collection Framework required that EU Member States monitor catches of sea bass. Therefore, in 2009, a new study has been launched to monitor sea bass recreational fishing more accurately. The method used was based first on a telephone survey conducted in the coastal departments of facades of English Channel, North Sea, and Atlantic. The 2006–2008 national database allowed us to extrapolate results to other departments and to obtain assessment on a national scale. Second, the telephone survey gave us the opportunity to recruit volunteer fishers. These volunteers complete logbooks with accurate description of their fishing trips: species caught, weights, sizes, locations (based on ICES subareas) and times of fishing are detailed. Logbooks are returned every three months (or every 20 outings) over a period of a year to monitor all fishing seasons. Both sources of information are then combined to produce estimation of catches and meet the requirements of the DCF. The coupling of these two surveys is achieved through ten types of recreational fishers. These types have been defined previously through the frequency of fishing (number of outings) and the mode of fishing (angling, spear fishing, etc.). The main goal of this dual methodology was to supply both representative and accurate data on recreational fishing. We will present in this communication the results obtained from it and what are the main problems we faced.

Keywords: catch assessment, logbook, recreational fishing, sea bass, telephone survey.

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ICES CM 2010/R:06

How fish surveys provide a "backbone" of jellyfish research

Thomas Bastian, Martin K. S. Lilley, David Stokes, Steven E. Beggs, Christopher P. Lynam, Graeme C. Hays, John Davenport, and Thomas K. Doyle

Jellyfish populations are apparently increasing in response to environmental changes (e.g. climate change, eutrophication, overfishing). These increases may ultimately affect commercially important fish stocks. To address this issue it is critical to understand broad-scale distribution and abundance of jellyfish. However, owing to financial and logistical constraints, dedicated jellyfish surveys are rare and alternatives must be found. Here we demonstrate how collaboration with fishery scientists has allowed us to scale-up our jellyfish research from small-scale targeted surveys to effective shelf- and basin-wide studies. Jellyfish bycatch data from the Irish Ground Fish Survey (Irish Marine Institute) have provided new insights into the distribution of the jellyfish *Pelagia noctiluca*, over a widespread area (>160 000 km^2) around Ireland and the UK, where the species has had major impacts on the aquaculture industry. In the northern half of the Irish Sea, we were able to assess basin-wide jellyfish distribution and abundance by using bycatch records from the Methot-Isaacs–Kidd (MIK) Survey for pelagic juvenile gadoids, carried out by AFBI (Agri-Food and Biosciences Institute), Northern Ireland. Such datasets are extremely useful to investigate possible trends in interannual variations of jellyfish abundance, as has successfully been done in few other places in the world. We therefore encourage further development of collaborations between academic marine biologists and fishery scientists in the field, in order to gather enough information to address the current concern about the role of jellyfish in marine ecosystems and their potential impacts on human activities in an effective, robust manner.

Keywords: broad-scale distribution, fishery survey, Irish Sea, jellyfish bycatch, Northeast Atlantic.

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ICES CM 2010/R:07

Communication networks in ecosystem-based fishery management: multidisciplinary knowledge management in the Chesapeake Bay, USA

Troy W. Hartley

Starting in 2008, over 80 state and federal agency partners and research institutions, with funding from the US Environmental Protection Agency and support from the US National Marine Fisheries Services, developed a new operational approach for ecosystem-based fishery management (EBFM) in the Chesapeake Bay. The EBFM project will lead to the adoption of fishery management plans (FMPs) that consider the interconnections between five key species in the Chesapeake Bay (striped bass, menhaden, American shad, blue crab, and oyster), their physical and living environments, and the human influences on the species and environments. This approach had engaged Bay managers, scientists, fishing industry, and other stakeholders in developing ecosystem-based FMPs through species teams that are developing background synthesis of the biological understanding for each species, and issues briefs on the major ecosystem interconnections and needs. Next, four Quantitative Ecosystem Teams (QETs) are developing performance measures related to habitat suitability, stock assessment, socio-economics, and foodweb issues, respectively, clarifying interdependences and opportunities for extending management actions into the watershed (i.e. crossing federal–state–local government scales). This paper presents a communication network analysis (CNA) of the EBFM pilot and its participants. CNAs employ survey instruments to construct communication maps among individuals involved in the EBFM pilot QETs. Network analysis software (InFlow) is used to measure the network structure (e.g. density, path lengths) and function (e.g. the centrality measures—beweenness, closeness) that manages two-way

communication, information flow, and knowledge sharing among participants. Findings have ramifications for designing multidisciplinary, multistakeholder fishery management programmes.

Keywords: Chesapeake Bay, ecosystem-based fishery management, network analysis.

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ICES CM 2010/R:08

The Charm Project: defying the Channel's loss by facing environmental challenges across borders

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The eastern English Channel is facing major challenges as a result of human actions that are causing unprecedented impacts on ecosystem health. This is a crisis that needs to be tackled as it threatens the collapse of the living resources and benefits to human society offered by this ecosystem. The Channel Habitat Atlas for Marine Resource Management (CHARM) project provides a major opportunity to respond to this crisis. Implementing an ecosystem-based approach, the aim of the project is to awaken consciousness and emphasize a commitment of a cross section of international experts on the Channel to focus on how to better sustain and conserve this fragile ecosystem. Since 2003, scientific efforts have been geared towards describing and determining the state of the ecosystem as well as defining better management and conservation options in order to slow down the system's degradation. Scientific experts have been developing synthesized data focused on specific issues and actions to achieve a better understanding of the system's health and pin down current threats while outlining the consequences related to identified challenges. Critical needs that have been identified and covered by the project to date include: (i) to provide information on biology and ecology of aquatic living resources, (ii) to establish ecological links and functioning, (iii) to improve our understanding of fishery dynamics, (iv) to create and distribute the available data, and (v) to improve knowledge of ecosystem management and conservation. The success of the scientific initiatives launched by the project since its inception is reflected in the increasing scientific recognition of the CHARM Consortium and its ongoing growth, in terms of collaborations and scientific production.

Keywords: anthropogenic activities, aquatic living resources, eastern English Channel, fisheries, foodweb, legislations, marine conservation planning, spatial habitats.

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ICES CM 2010/R:09

Habitat suitability modelling for sardine in a highly diverse ecosystem: the Mediterranean Sea

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Information integrated from different parts of the Mediterranean was used in order to model the spatial and temporal variability of the distribution grounds of sardine. Acoustic data recorded with a 38-kHz split-beam echosounder from the Aegean Sea (eastern Mediterranean), the Adriatic Sea (central Mediterranean), the Sicily Channel (central Mediterranean), and the Spanish waters (western Mediterranean) were analysed along with satellite environmental and bathymetry data to model the spatial distribution of sardine during summer, autumn, and early winter. Similarly, egg distribution data from the Spanish waters were used to model the potential spawning habitat of

sardine during early winter. Satellite data were used as proxies to infer spatial variations of environmental factors and assess possible ecological relationships. Generalized additive models (GAMs) have been applied in a presence/absence approach. Model results were evaluated based on the estimation of receiver operating characteristic (ROC) plots. The environmental factors that were considered to affect sardine habitat during the different periods of year were identified and discussed. The selected model was used subsequently to identify those regions within the entire Mediterranean basin having higher probability of supporting sardine's presence. Habitat suitability maps were produced for each year, period, and study area as well as for the entire Mediterranean basin, indicating suitable habitats for sardines. The temporal stability of these areas was also examined. The usefulness of such habitat suitability maps in environmental research and fishery management in a highly diverse environment like the Mediterranean is discussed.

Keywords: habitat suitability modelling, Mediterranean Sea, sardine, small pelagic.

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ICES CM 2010/R:10

Identifying the potential habitat of anchovy *Engraulis encrasicolus* during different life stages in the Mediterranean Sea

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Information integrated from different parts of the Mediterranean was used to model the spatial and temporal variability of the distribution grounds of anchovy at different life stages. Acoustic data recorded with a 38-kHz split-beam echosounder from the Aegean Sea (eastern Mediterranean), the Adriatic Sea and the Sicily Channel (central Mediterranean), the Spanish waters and the Gulf of Lions (western Mediterranean) were analysed along with satellite environmental and bathymetry data to model the spatial distribution of adult and juvenile anchovy during summer, autumn, and winter. Similarly, egg distribution data from summer surveys were used to model the potential spawning habitat of anchovy. Satellite data were used as proxies to infer spatial variations of environmental factors and assess possible ecological relationships. Generalized additive models (GAMs) were applied in a presence/absence approach. Model results were evaluated based on the estimation of receiver operating characteristic (ROC) plots. The environmental factors considered to affect anchovy during the different periods of year were identified and discussed. The selected model was subsequently used to identify those regions within the entire Mediterranean basin with higher probability of supporting suitable anchovy habitats. Potential habitat maps were produced for each year, period, and study area as well as for the entire Mediterranean basin indicating suitable areas for anchovy's presence. The temporal stability of these areas was examined. The usefulness of such habitat suitability maps concerning the different life stages of a species in environmental research and fishery management is discussed.

Keywords: anchovy, habitat suitability modelling, Mediterranean Sea, small pelagic, spawning habitat.

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ICES CM 2010/R:11

"Fischbestände online"—a new website for the communication of scientific knowledge to a non-scientific community

Kristina Barz and Christopher Zimmermann

"Fischbestände online" is a new project developed in cooperation with the German fish-processing industry and retailers. Its objective is the development and maintenance of an Internet portal with up-to-date descriptions of the state of wild marine fish stocks relevant to the German retail market. The website aims at providing scientifically correct, brief, and understandable, information, primarily to the retail and processing companies. Along with a new system for labelling the origin of fish products, this will allow them to develop individual trading policies to prefer fish from sustainable sources. The website offers no direct recommendations about what to buy or not to buy, but provides a sound basis for the development of policies. The information can also be used by NGOs for developing their information leaflets for consumers. By 2012, information will be provided for 130 wild marine fish stocks belonging to 30 species. The structure of the website was developed jointly between science, industry, and NGOs: A one-page species outline gives general information on biological characteristics, distribution, and use. Three- to four-page stock descriptions are generated for every relevant stock and include specific information on state of the stock, stock development, management, environmental impact of the fishery, and impact by the environment on the stock development, including illustrations. In addition, they provide all relevant figures on spawning-stock biomass, recruitment, fishing mortality, landings, bycatch/discards, total allowable catches, and any information on eco-labelled fisheries. All stock descriptions will be peer reviewed to ensure a high quality of the information provided. The first species outlines and stock descriptions are available at http://fischbestaende.portal-fischerei.de (in German). The site is under technical development and the supplied information will be extended continuously over the course of the next years.

Keywords: advice, communication, industry and retail policy, state of marine fish stocks.

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ICES CM 2010/R:12

Data archaeology and rescue: recycling old information for new concerns

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Long-term data are essential to disentangle climate driven changes from those caused by natural fluctuations coupled with regional and local scale impacts such as fishing, pollution, and habitat loss. We describe two case studies where data stretching back 50-100 years have been used to explore climate-driven change. Records of fish surveys dating back to before World War I were retrieved as written records from cellars, drawers, and cupboards at the Marine Biological Association of the United Kingdom (MBA), garages of long deceased members of staff, as well as from obsolete electronic media. These were then analysed to disentangle the interaction between fishing pressure and climate change on bottom fish assemblages. This work has contributed to the policy arena via IPCC 2007 as well as the UK Marine Climate Change Impact Programme (MCCIP). In parallel with this work, broad-scale and long-term records of intertidal species were collated building on pioneering surveys from the 1950s which provided a baseline from a previously warm period allowing comparison with recent patterns determined by re-surveys between 2002 and 2010. These have shown major shifts in biogeographic ranges during the recent period of rapid warming. This work has informed policy via MCCIP as well as providing contextual information for management of marine conservation areas. High-quality publications have resulted from both studies. They have also informed current debate on adaptation to climate change.

Keywords: data archaeology, climate change, fishing pressure, long-term studies.

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A change in fishery science to focus on the outcome rather than the output

Tom Rossiter

The world of marine science is rapidly changing. It seems that the more we learn, the more we appreciate the need to understand further, and today the demand for good marine science has never been greater. The customer base has shifted and dramatically. Historically, marine science has been targeted towards marine scientists; today the customer is society in its broadest sense and unfortunately all too often marine scientists have failed to communicate and deliver what the customer wants. This paper will look at three aspects of the issue. First, it will describe the customer base, focusing on fishers, and trace its development over the past two decades. Second, it addresses the question of "lack or underdevelopment" by scientists in terms of research and development (R&D) and links this to value for money (VFM). Finally, it presents a number of fishing and gear technology case studies, which have successfully addressed the challenge, and makes recommendations for the future.

Keywords: customer, communicate, R&D, VFM.

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Fishers: the forgotten scientists

Edward Hind

Fisheries managers and scientists are currently attempting to improve the knowledge base for fisheries management through collation of multi-institutional and multidisciplinary research. Although these attempts at knowledge management are necessary for good practice in fishery science, they could be in vain. Building on previous research in North America, Europe, and the Indo-Pacific, research in Ireland shows that fishers feel omitted from knowledge management exercises connected to fishery management and as a result are sceptical of scientific knowledge communicated to them by fishery managers. This reduces fishers' will to take fishery management policies based on science seriously and can compromise their compliance with fishery regulations and their cooperation with fishery managers. Novel interview techniques conducted on fishers based in Galway Bay show that fishers do indeed have unique knowledge that should be part of the knowledge base for fishery management. Far from being simply ecological, fishers' knowledge gives detailed insights into the strategies of fishers. Analysis of these strategies by fishery managers could greatly inform fishery management policy. Inclusion of fishers' knowledge would help to legitimise fishery management and science among fishers. This legitimization would increase the chance of fishery management policy being successful. However, despite recognition by some scientists that fishers' knowledge could be used alongside traditional scientific knowledge to provide a basis for better fishery management policies, it is rarely used by fishery managers. The omission of a proposal to include stakeholder knowledge in recent proposed reforms to the European Union's common fishery policy suggests that fishers will remain forgotten scientists.

Keywords: Common Fisheries Policy, fishers' knowledge, Galway Bay, Ireland.

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ICES ASC 2010/R:15

BONUS: Building the Joint Baltic Sea Research Programme

Kaisa Kononen and Andris Andrusaitis

In 2004, ten national research funding agencies around the Baltic Sea and ICES initiated the building of a joint marine research programme. Creating a common administration and funding mechanism, the joint Science Plan and Implementation Strategy (SPIS) was supported through a FP6 ERA-Net project. In 2007, a dedicated implementation structure of the new programme—BONUS EEIG—was created, and the first call for transnational research proposals announced in 2008. The first call covered all SPIS themes, and in effect was a bottom–up trial to test the response of the scientific community and the stakeholders. Projects of the first BONUS call will be completed in the end of 2011. It is planned that around the same time BONUS EEIG will announce next call, now within the frames of Article 185 of the EU Treaty, allowing the European Community to participate in research programmes undertaken jointly by several Member States. Before this happens, BONUS EEIG will formulate the Strategic Research Agenda for 2011–2014, create stakeholder platforms, develop a mechanism for integration of research infrastructure, and complete the construction of administration and management modalities. This paper will approach the issue of producing more useful knowledge with consolidated transnational resources through analysis of the first BONUS call, and the mid-term feedback from the scientists. The challenges of combining scientific excellence with practical relevance of research will be discussed on the example of the Baltic Sea Programme.

Keywords: Baltic Sea, joint programming, marine research.

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ICES CM2010/R:16

How to benefit from fishers' knowledge and know-how in a scientific approach. A combination of means that could make fishers actors of science

J. Massé, D. Delaunay, F. Sanchez, and D. Ciolek

It is common to hear in fishing harbours that "scientists don't count the fish where the fish are … scientists don't know to fish … they do surveys in the wrong season". This is partly right. For the anchovy fishery in the Bay of Biscay, different attempts have been made to profit from the knowledge of both fishers and scientists. Fishers have long qualitative experience throughout the year, whereas scientists have often more usable quantitative data collected in specific surveys. In order to combine both knowledge and understanding on target pelagic species (mainly sardine and anchovy), two operations were carried out: (i) collection of the contribution of commercial vessels during three spring acoustic scientific surveys (PELGAS07, 08, 09) combined with fishing operations and observations by a scientific vessel, both following a systematic parallel-transects sampling strategy, and (ii) a pilot study of "sentinel surveys" aboard fishing vessels, consisting of visits five times a year to two key areas with acoustic and fishing observations using a strategy based on the captain's experience and in-time information, supervised by a scientist on board to ensure the consistency of collected data for further quantitative use. These two experiments enhanced exchanges between fishers and scientists working together on the same field. They allowed better mutual understanding of the interpretation and meaning of integrated knowledge of the biology of target species, fish exploitation, and fishery management strategies.

Keywords: anchovy, communication, fishers/scientists, joint surveys.

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ICES CM 2010/R:17

Knowledge management and the National Oceanography Centre. Perspectives from the National Oceanographic Library

Jane Stephenson

The National Oceanography Centre (NOC) is a newly established, national research organization, delivering world-class integrated marine science and technology from the coast to the deep ocean. Working in partnership with the UK marine research community, the NOC addresses key science challenges, including sea level change, the oceans' role in climate change, predicting and simulating the behaviour of the oceans through computer modelling, development, the future of the Arctic Ocean, and long-term monitoring technologies. It is the UK's leading institution for sea-level science, coastal and deep ocean research, and technology development. Its vision is to place UK marine science in a wider Earth system and socio-economic context, providing scientific knowledge that underpins policy development and wealth generation, and will aim to influence the European and global strategic research agenda. In this context, the National Oceanographic Library supports the mission of the organization and has developed and is developing strategies and processes to manage its knowledge and the knowledge needed to support the science. This includes managing research outputs, archives management, open access publishing, and knowledge transfer, desk-side training, bibliometrics, web delivery, collaborative work with data management, and access to published external information. This paper will present examples of these knowledge management strategies and processes, identifying strengths and challenges, as experienced within the National Oceanographic Centre.

Keywords: collaboration, information specialist, knowledge management tools, oceanographic research.

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ICES CM 2010/R:18

Using systematic review methodology to build an evidence base for marine and fishery policy

Andrew S. Pullin

There are a number of areas of environmental management, such as marine sciences and fisheries, where considerable evidence has been accumulated that might inform policy decisions. However, in policy areas where conflicting views are held by different stakeholders, fragments of evidence can be used to obfuscate the true picture and inhibit progress toward consensus solutions. Systematic review is a rigorous methodology designed to maximize transparency and minimize bias in developing an evidence base on questions of concern to policy and practice. The systematic review process is partly social and partly scientific and can be used to build consensus for action to address specific problems or contribute to strategic policy frameworks to address broad societal goals (such as sustainability of fish stocks). This talk will introduce the concept of systematic review and provide some examples of the how this methodology could be used to address marine policy issues.

Keywords: evidence-based policy, knowledge exchange, research synthesis.

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Ensuring the uptake and impact of marine fishery research

Alister Scott and John Lock

The need to manage knowledge better grows all the time, as the amount of knowledge in the world continues to increase and the need for that knowledge to inform related decisions becomes ever clearer. These simple statements hold as much truth and challenge for the field of marine fisheries as any other field: the science is complex and expensive, the amount of knowledge is growing all the time, and the consequences for stakeholders are serious. And yet the term "knowledge management" can sound scary—complicated, specialized, arcane. By contrast, it is our conviction that it does not need to be. A set of simple ideas and approaches can help you rapidly assess how well you are acquiring, sharing, and using knowledge in your organization, and where you might go next. This talk will outline the findings of extensive research and consulting within the MariFish ERA-Net. We will outline the main barriers to knowledge management, a range of common mistakes made by those wanting to start managing knowledge better, and will finish by outlining nine Golden Rules of Knowledge Management. The aim of the talk is to dispel fears, build confidence, and offer simple ideas and tools.

Keywords: fishery management, knowledge management.

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ICES CM 2010/R:20

The importance of communication and knowledge management for realizing the European bio-economy

Line Matthiessen

In the Europe 2020 Strategy, smart, sustainable, and inclusive growth is at the heart of the political agenda. The bio-economy is an important cornerstone in achieving these aims: it fosters sustainable growth by using renewable biological resources from land and aquatic environment as inputs to sectors such as the food and feed industries, chemicals, detergents, paper and pulp, textiles, bio-fuels, and biogas. It also reflects European society concerns, such as globalization and economic crisis; guaranteeing food security while adapting to a changing climate; reducing the environmental impact of agriculture and industry; maintaining an affordable, safe, healthy and nutritious food supply. The European Commission, DG RTD leads the preparation of the European strategy and action plan for bio-economy. The bio-economy partnership is also part of the Innovation Union under the Europe 2020 strategy. To successfully implement these actions, active involvement of and cooperation among stakeholders at all levels are crucial. The Commission is in the process of developing a new communication strategy for the bio-economy. It aims at (i) open and informed dialogue between policy-makers, scientists, industry, and society at large and (ii) successful dissemination and application of research results for fostering innovation in bio-economy sectors and beyond. The strategy, its objectives, and action plan will be presented.

Keywords: bio-economy, communication, Europe 2020 Strategy, knowledge transfer.

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ICES CM 2010/R:21

Is fishery science too complicated to achieve Defra's long-term vision of sustainable fisheries?

Gurpreet Padda and Richard Pullen

Typically, the annual cyclical process of December Council involves "operational" stock assessment science by policy-makers. However, because the methods used have evolved over time, from single- and multispecies models to sophisticated ecosystem approaches, they can be interpreted in many different ways according to the target audience. The difficulties and subsequent scepticism arises when, within the current EU Common Fisheries Policy (CFP) framework, communicating complex scientific tools across to stakeholders is becoming an essential part of the decision-making process. Alongside, policy-makers are balancing short- to mid-term fishing effort regimes and total allowable catch and quota policy objectives. This paper explores how fishery scientists can communicate evidence that will allow Defra's policy-makers to better use the evidence presented to ensure that their longer term/reformed CFP vision of "ensuring fish stocks are within safe biological limits; ensure a prosperous and efficient fishing industry; recognition of the contribution of fishing to local communities; and fishery management integrated with marine conservation" is achievable.

Keywords: fisheries, models, policy, science communication, stock assessments.

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ICES CM 2010/R:22 Poster

Integrated science advice supporting living marine resource management: can we have it all?

S. A. Murawski

Management of living marine resources becomes ever more complex as the number of dimensions increases, especially in the crowded coastal zone. This increasing complexity gives rise to two fundamental problems that stretch our limited resources: (i) complex and synergistic effects between human-induced and other pressures and their impacts on biodiversity, and (ii) the increasing need to re-tailor data products and analyses to address longer lists of evolving demands. The need for more holistic analyses of marine ecosystems fuels the demand for more integrated assessments of ecosystems that can be developed around specific or general management questions. The trend to integrated ecosystem assessments also prescribes a path forward for formal adaptive management approaches under process and measurement uncertainty. However, IEAs are not required in all circumstances—and thus the conundrum of specific or generic assessments used to address the array of management issues. Addressing the longer list of demands for information requires efficient, flexible, and transparent data, modelling, visualization, validation, and valuation tools to efficiently address evolving demands. All these investments are at least an order of magnitude less expensive than basic data-gathering activities, and are thus advocated as a priority.

Keywords: data fusion, decision support tools, integrated ecosystem assessments.

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ICES CM 2010/R:23 Poster

Finding keys to sustainable fisheries: exploring the potential of using life cycle assessment to evaluate the performance of fishery management

Sara Hornborg, Frederike Ziegler, and Andreas Emanuelsson

Fisheries managers try to predict the biological effects of management measures in order to impede the unsustainable exploitation rate of global fish stocks. Nevertheless, the wider environmental implications of management decisions remain largely unknown. In part, this is because the tools for studying impacts on a broader level, such as life cycle assessment (LCA), are relatively new. LCA is an ISO standardized methodology to study the resource use and environmental impact of products and processes from cradle to grave. Earlier LCAs on seafood production have shown that the fishing phase dominates the environmental impact. Great differences can be seen from gear type and stock status; both factors strongly correlated to management. Trawling has considerably higher fuel consumption than gillnetting. Creeling, compared with conventional trawling, shows the same results—with the addition of much higher seabed impacts and discards. Different fishery managements, all aiming at decreasing fishing pressure, could contribute differently to climate change and other environmental issues. Two PhD projects will develop the LCA methodology and explore the potentials as a tool to evaluate the environmental performance of different measures in the Swedish fisheries. The case studies will aim to illustrate the environmental impacts of fishery management. The focus is on the biological impacts of selectivity measures (i.e. target stock selectivity and bycatch extraction) and effects from no-take zones. Close collaboration with stakeholders in Sweden and Norway will facilitate the project and ensure its results are applicable after completion of the study.

Keywords: climate change, fishery management, LCA, sustainable resource use.

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ICES CM 2010/R:26 Poster

Adaptive management of living marine resources by integrating different data sources and key ecological processes (ADMAR): a joint effort by IMR and CEES

Nils Olav Handegard, Nils Christian Stenseth, Dorothy Dankel, Joël M. Durant, Anne Maria Eikeset, Katja Enberg, Dag Øystein Hjermann, Geir Huse, Michael Pennington, Mette Skern-Mauritzen, Leif Christian Stige, Samuel Subbey, and Helge Vølstad

The Norwegian Ocean Resource Act (Havressursloven) of 2009 is a formal implementation of the ecosystem approach to Fisheries. This requires explicit management action towards data-rich stocks, as well as for data-poor stocks, including those of minor commercial importance. The ADMAR project is a partnership between CEES at the University of Oslo and the Institute of Marine Research designed to collaboratively address these challenges. The main objective of ADMAR is to develop an adaptive approach for providing the best possible advice for ecosystem-based management. This includes models to derive key ecosystem parameters, including their error structures, using survey data, fisheries statistics, life-history traits, multispecies considerations, etc. Further, we plan to combine this approach by developing ecosystem models that incorporate foodweb interactions and provide basic understanding of the ecosystem functioning. The goal of the project is to use these models to test ecosystem-based harvest control rules (eco-HCRs) for exploited stocks under varying amounts of information and under different ecological scenarios. In this paper, we describe some of the main principles of the ADMAR concept and illustrate our approach through examples that demonstrate some of the key features of the project. ADMAR is designed to synthesize the breadth of data already collected in Norway to develop more cost-effective ways of providing ecosystem-based advice to meet the needs outlined in the Norwegian Ocean Resource Act.

Keywords: ecosystem management, ecosystem modelling, ecosystem parameters, harvest control rules.

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ICES CM 2010/R:27 Poster

Diversifying the uses of the Danish discard data collection programme

Jordan Feekings and Niels Madsen

In accordance with the EU Fisheries Data Collection Programme it is mandatory for each Member State to collect data on discards. Since 1995, DTU Aqua (formerly Danish Institute for Fisheries Research) and the Danish Fishers' Organization have cooperated to collect data on catches and discards. The programme covers all fisheries except the ones with very limited fishing effort and the ones with no discard, and aims at collecting all biological information from the catch on each haul, and in addition, vessel, gear, geographical, and environmental attributes. All data are inspected in cooperation with the fishers' organization to ensure that they are collected correctly, that there are no signs of error, and that they are representative for the fisheries investigated. Only objective criteria are used in the inspection (not the observed discard amounts). Currently in Denmark, these data are used very little for scientific analysis. Here we attempt to analyse the data and reveal the pitfalls and possible additional information that may improve the data quality and diversify its use into other fields of research.

Keywords: discards, discard data collection programme.

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ICES CM 2010/R:28 Poster

Survey-specific software saves time and increases data integrity

Tom Jaffarian and Kevin D. E. Stokesbury

Each layer of user interaction, from data collection to final analysis, adds time and error to the scientific process. Increased user speed introduces further error. As the demand to implement real-time fisheries data into management grows, so too does the risk of these errors. Survey-specific software can offset the error introduced by increasing processing speed. Directly handling GPS data, enforcing data-type constraints, enforcing non-nullable data fields, video metadata, timestamps, the compression of tasks requiring multiple commercial programmes into one place, and standardizing file names are all examples of how custom software can help streamline the sampling process. Automatic quality control filters and feedback systems further strengthen the reliability of the dataset. The SMAST video survey assesses the status of the US sea scallop resource with present annual landings worth US$350 million. This survey began as a simple quadrat count design with all the information entered by hand into Excel. However, demand for these data eventually surpassed processing limitations. To address this we integrated Microsoft's SQL Server relational database and a sampling framework coded in C# into the sampling and analysis design. We demonstrate significantly decreased processing times while maintaining a high level of data integrity through the implementation of this protocol.

Keywords: control, data, real-time, software.

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ICES CM 2010/R:29 Poster

North American Marine Protected Area Network (NAMPAN) condition assessment scorecard: improving collaboration, disseminating science information that stakeholders can understand, and encouraging ownership of marine resources in Canada, Mexico, and the United States

Robert J. Brock, , Flavio Chazaro, Joseph Uravitch, and Doug Yurick

As ocean currents and living marine resources do not recognize national boundaries, the peoples of North America share a common maritime heritage and are concerned about long-term

sustainability of the ecological services the sea provides us all. In order to set up a common framework among the three countries that can both clearly report complex monitoring of environmental conditions and convey in an easy to understand format the assessment of these conditions, the tri-national Commission for Environmental Cooperation (CEC) sponsored the development of ecological scorecard condition reports along the Pacific coast of North America in diverse biogeographical Marine Protected Areas (MPAs) ranging from southern Baja California to Vancouver Island. MPA experts from the three countries developed 14 standard questions about water quality, habitat, living marine resources, and human activities. In subsequent workshops, 10–25 experts familiar with select MPAs analysed existing monitoring data and assigned the ecosystem condition a value under each of the 14 questions, ranging from excellent to poor and a trend, whether the condition appears to be improving, stable, or declining. This scorecard process effectively summarizes large amounts of complex monitoring data through expert interpretation and synthesizes this information in a format that is easy to understand for a wide array of stakeholder groups such as citizens, communities, resource managers, and policy-makers. With the success of this Pacific pilot project, the ecological scorecard process will be expanded to the Atlantic coast of North America in the near future.

Keywords: convey science information, monitoring, MPAs.

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Theme Session S

Joint ICES/PICES Theme Sessions on "Responses to climate variability: comparison of northern hemisphere marine ecosystems"

ICES CM 2010/S:01

CAVIAR: climate variability of the Baltic Sea area

A. Lehmann, K. Getzlaff, H-H. Hinrichsen, and F. Köster

The warming trend for the entire globe (1850–2005) is 0.04°C per decade. A specific warming period started around 1980 and continues at least until 2005, with a temperature increase of about 0.17°C per decade. This trend is equally well evident for many areas on the globe, especially in the northern hemisphere in observations and climate simulations. For the Baltic Sea catchment, which lies between the maritime temperate and continental Subarctic climate zones, an even stronger warming of ca. 0.4°C per decade has appeared since 1980. The annual mean air temperature increased by ca. 1°C until 2004. A similar warming trend can be observed for the sea surface temperature of the Baltic Sea. Even the annual mean water temperatures averaged spatially and vertically for the deep basins of the Baltic Sea show similar trends. We provide a detailed analysis of the climate variability and associated changes in the Baltic Sea catchment area as well as in the Baltic Sea itself for the period 1958–2009, in which the recent acceleration of the climate warming happened. Changes in the atmospheric conditions cause corresponding changes in the Baltic Sea, not only for temperature and salinity but also for currents and circulation. These changes in the physical conditions have strong impact on the marine ecosystem structure and processes.

Keywords: Baltic Sea, climate variability, modelling.

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ICES CM 2010/S:02

Walleye pollock biomass dynamics in the Bering Sea: possibility of long-term forecasting

O. A. Bulatov and L. B. Klyashtorin

This study investigates relationships between climate variations and dynamics of walleye pollock biomass in the Bering Sea. A 100-year time-series of the major climate indices were examined: air temperature in the Arctic (Arctic d*T*), Pacific decadal oscillation (PDO), Aleutian Low Pressure Index (ALPI), and 150-year temperature time-series of temperature changes in Gulf of Alaska (GOA SST). In addition, a 100-year series of variations in the Total Solar Irradiance (TSI) index was examined. All climatic indices and TSI show common cyclic dynamics of 60–65 year periods with peaks in the 1940s and 2000s and minima in the 1960–1970s. The overall Bering Sea pollock biomass dynamics was assessed by three major fishing regions: Donut hole area (+ Bogosloff area), West and North Bering Sea, and East Bering Sea. Each region has its own characteristics of biomass dynamics, although a comparative analysis of walleye pollock biomass changes in the entire Bering Sea and climate indices reveals their similarity. The correlation can be seen between the total walleye pollock biomass dynamics and North Pacific climate indicators (PDO and ALPI). A historical maximum in walleye pollock total biomass was observed in the mid-1980s (32 million tons), which was followed by a notable decline in biomass. The authors suggested a stochastic model to estimate long-term changes in the total abundance of the Bering Sea pollock According to the model the downward trend in the total pollock biomass will continue up to historic minimum in 2020–2030.

Keywords: biomass, climate impacts, walleye pollock.

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ICES CM 2010/S:03

Comparison of the atmospheric forcing and oceanographic responses between the Labrador Sea and the Norwegian and Barents Seas

Ken Drinkwater, Eugene Colbourne, Harald Loeng, Svein Sundby, and Trond Kristiansen

The Labrador and Norwegian Seas lie within the Subarctic region on opposite sides of the North Atlantic, whereas the Barents Sea is one of the marginal seas comprising the Arctic continental shelf. Warm Atlantic inflow from the south into the Barents Sea results in the Barents Sea containing flora and fauna similar to that of several of the Subarctic regions farther to the south. A comparison of the mean and variability in the climate and physical oceanography between the Labrador Sea and the Norwegian/Barents seas regions was carried out. The previously reported out-of-phase relationships of air and sea temperatures and sea ice conditions was confirmed between the Labrador Sea and the Norwegian/Barents Seas regions from the 1950s until the mid-1990s owing to their opposite response to the variability in the large-scale atmospheric pressure patterns as reflected in the North Atlantic Oscillation (NAO) index. However, since the mid-1990s, air and sea temperatures have been in phase, generally showing strong warming and reduced ice coverage in both regions. The cause of this change is linked to changes in the spatial structure of the atmospheric pressure patterns and a generally weakening of the influence of the NAO pattern. The effect of these changes on the primary production and higher trophic levels will be discussed as well as their implications on making projections for both the climate and ecosystems in these regions under future climate change.

Keywords: climate, comparisons, NAO, physical oceanography.

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ICES CM 2010/S:04

Using production models as a tool to examine factors that influence productivity of marine systems: a comparative analysis among ten northern hemisphere ecosystems

Bernard A. Megrey, Jason S. Link, Thomas J. Miller, Tim Essington, R. Ian Perry, Alida Bundy, and Ken F. Drinkwater

The inherent complexity and large scale of marine ecosystems suggest that progress toward understanding how marine ecosystems influence and regulate patterns of fishery production requires a comparative approach. We present the results of an international workshop focused on applying various surplus production model configurations as a tool for ecosystem comparison with the goal to answer the question—how does ecosystem structure and function interact to support fishery production, and what processes amplify, dampen, or obstruct the production that ecosystems provide? Our workshop goal was to understand how multiple drivers of productivity in fishery ecosystems simultaneously interact to determine overall production levels. These drivers reflect the triad of factors influencing fishery production including fisheries, the environment, and trophodynamics. In this presentation, we describe a common methodological framework (i.e. surplus production models) that was applied across several levels of taxonomic aggregation, for several species, and communities from several marine ecosystems and examine model outputs from multiple production modelling packages. We estimate management-relevant metrics and ecosystem attributes and compare them across populations and ecosystems. We also describe the utility of applying surplus production models in single-species, multispecies, and aggregate species group frameworks. We conclude by elucidating challenges of fitting such modelling approaches to similar species or functional guilds in contrasting arrangements (different species within ecosystems and similar species between ecosystems) to better delineate what controls ecosystem fishery production. Implications of our results for future work relevant to operational oceanography, population, and community modelling, and ecosystem-based fishery management are discussed.

Keywords: comparative ecosystem analysis, ecosystem productivity, surplus production models.

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ICES CM 2010/S:05

Long-term variability in the fish populations in the Japan Sea, with special reference to the impact of the mid-1970s regime shift

Yongjun Tian and Hideaki Kidokoro

It is reported that a regime shift, characterized by an abrupt change from a cool to warm conditions, occurred in the Tsushima Warm Current (TWC) region in the Japan Sea in the late 1980s, and associated large changes in the TWC ecosystem. However, the impacts of the well-documented 1976/77 regime shift on fish populations in the Japan Sea are not well understood yet. Variation patterns in the fish community in the Japan Sea and its relations with environmental factors were examined using long-term fisheries and environmental data. Detailed analysis including PCA (principal component analysis) showed that fish populations from demersal to pelagic species changed abruptly during the early 1970s with increase in cold-water species such as walleye pollack and sardine, and decrease in warm-water species such as anchovy and horse mackerel, but no evident changes occurred in the mid-1970s. The variation pattern in the fish populations corresponded well with the winter and summer water temperature in the TWC. These results indicate the change in the early 1970s associated largely with the change in the summer water temperature, and the impact of the 1976/77 regime is not evident. It suggests the response pattern to the 1976/77 regime shift is different between the Japan Sea and central–eastern North Pacific.

Keywords: community, fish population, Japan Sea, regime shift, Tsushima Warm Current, water temperature.

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ICES CM 2010/S:06

Processes driving differences in major foodweb linkages of the Gulf of Alaska and eastern Bering Sea ecosystems: a conceptual view

Mary E. Hunsicker, Lorenzo Ciannelli, Kevin M. Bailey, and Stephani Zador

Key foodweb linkages and species dynamics can diverge in seemingly similar ecosystems owing to differences among physical and biological factors. The eastern Bering Sea (EBS) and western Gulf of Alaska (GOA) represent two such ecosystems. These systems are adjacent at similar latitudes, separated by the thin Alaska Peninsula; they are inhabited by similar species communities, and are affected by similar anthropogenic and large-scale forcing. However, population dynamics of some of the key species, specifically arrowtooth flounder (*Atheresthes stomias*) and walleye pollock (*Theragra chalcogramma*) are driven by the differences in their predation interactions among these regions. For example, cannibalism is the greatest source of predation on pollock in the EBS whereas predation by arrowtooth flounder is not so important. In the GOA, the roles are reversed, and predation by arrowtooth flounder exerts the highest source of predation mortality on juvenile pollock. These differences within the GOA and EBS foodwebs inspire questions about the causes and the consequences at the community level. Here, we present multiple hypotheses on possible local-scale abiotic and biotic processes that may have facilitated the divergence in these linkages. In support, we also evaluate the spatio-temporal distributions of arrowtooth flounder and pollock in the GOA and EBS systems and the physical and biological factors that facilitate overlapping distributions. We identify environmental conditions that generate strong overlaps between these species to improve our understanding and ability to predict how these important key trophic linkages may change under alternate climate scenarios.

Keywords: arrowtooth flounder, eastern Bering Sea, foodwebs, Gulf of Alaska, walleye pollock

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ICES CM 2010/S:07

Comparative analysis of zooplankton communities in the east and west coast of United States—biological response to large-scale driving forcing?

Hongsheng Bi, Bill Peterson, Cheryl Morgan, Jon Hare, and Joseph Kane

Zooplankton samples were collected in June 1998–2008 along the Washington and Oregon coast, the west coast of the United States, and May–June in 1977–1987 and 1992–2008 in Georges Bank, on the east coast of the USA. Although two systems are dramatically different, the west coast is a typical eastern boundary current system with strong upwelling and narrow shelf, and the east coast is a western boundary current system with a broader shelf, we examine how zooplankton communities respond to large-scale decadal variation in climate forcing. Non-metric multidimensional scaling (MDS) was applied on both datasets. Pacific decadal oscillation (PDO) and Atlantic multidecadal oscillation (AMO) were adopted as indicators for large-scale forcing in the two systems, respectively. Zooplankton communities in the west coast were consistent with PDO. When PDO was positive, there were more warm-water species and when PDO was negative, cold-water species were abundant. Zooplankton communities in the east coast did not display a consistent pattern with AMO, especially after 2000. We hypothesized that changes in zooplankton community structure in both coasts were associated with source water. On the west coast, when PDO was positive, more offshore water entered the coast and warm-water copepods were abundant, and when PDO was negative, more cold water came from Alaska coast and cold-water copepods were abundant. On the east coast, when more low-salinity water from north entered the coast, smaller copepods became more abundant.

Keywords: AMO, communities, multidimensional scaling, PDO, transports, zooplankton.

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ICES 2010/S:08

Interannual variability in the Northern California Current foodweb structure: inferred changes in energy flow pathways and system response to alternate forcing scenarios

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The Northern California Current (NCC) is a seasonally productive and open ecosystem. It is home to both a diverse endemic community and to seasonally transient species. Productivity and foodweb structure vary seasonally, interannually, and decadally owing to variability in the rate of nutrient input via coastal upwelling, forcing by climate-scale physical processes, and the abundance of migratory species entering the system. Important community structure changes observed between years include changes in the relative abundances of large jellyfish and small pelagic fish (anchovies, sardines) at intermediate trophic levels that form alternate energy transfer pathways linking lower to upper trophic levels. Annual plankton, fish, and seabird surveys provide information about pelagic community composition variability within the NCC. From these observations, interannual variability in trophic interactions and energy flow through the NCC system was inferred within a series of independent, mass-balanced foodweb models. Using these models, we quantified relative changes in energy transfer efficiency from bottom to top trophic levels, and we identified the relative importance of alternate energy transfer pathways at intermediate trophic levels. Alternate scenario investigations were used to analyse system sensitivity to variability in the strength of individual trophic linkages and system-wide response to changes in upwelling strength through time. Analysis of the range of ecosystem states observed interannually and system response to alternate forcing scenarios will improve our ability to predict NCC ecosystem response to environmental change and quantify trophic pressures acting upon individual species.

Keywords: foodweb model, interannual variability, northern California current, sensitivity, upwelling ecosystem.

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ICES CM 2010/S:09

How does exploitation of prey fish affect population growth rate in changing seas?

Joël M. Durant, Manuel Hidalgo, and Lorenzo Ciannelli

Population growth, hence the population's persistence, is affected by several factors such as climate, species interaction, and harvesting pressure the latter having been shown to make the marine populations more sensitive to climate forcing. Alternatively, age-truncated or juvenescent populations are a worldwide consequence of the protracted size-selective mortality of commercial fishing on the older and larger individuals. This process also increases a population's ability to directly respond to environmental fluctuations, emphasizing the importance of the interaction between fisheries, environment, and internal dynamics that produces complex synergic effects on the population dynamics of marine species. We used a comparative approach investigating commercially fished species on four different systems: the Norwegian Sea–Barents Sea (northeast Arctic cod), the Atlantic Ocean (European hake), the Mediterranean Sea (European hake), and the Bering Sea (pollock). Our objective was to address in a comparative way the ecological consequences of fishery effect on population properties (e.g. intrinsic growth rate) in relation to different environmental conditions (fishing intensity, climate, and prey abundance). For this, we have applied techniques based upon age-structured population matrices to analyse estimated stock sizes. By combining all sources of information, we investigated differences in the coupling between

life-history traits and population dynamics for all stocks that display different level of juvenescence. This study will advance our understanding of the underlying mechanisms behind the transitory relationships between climate and fish populations.

Keywords: Barents Sea, European hake (*Merluccius merluccius*), fisheries, Leslie matrix, Mediterranean Sea, northeast Arctic cod (*Gadus morhua*), Pollock (*Theragra chalcogramma*).

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ICES CM 2010/S:10

Eastern Scotian Shelf and Barents Sea intercomparison: climate fluctuations, human impact, and system resilience

Edda Johannesen, Mette Skern-Mauritzen, Randi Ingvaldsen, Jan Erik Stiansen, and Emma Orlova

Climate variation and overfishing of top predators have caused a restructuring of several formerly cod-dominated North Atlantic shelf ecosystems. The Barents Sea, currently holding the world's largest cod stock and having undergone significant demersal fish biomass fluctuations, has not experienced major ecosystem restructuring. In contrast, the collapse of eastern Scotian Shelf demersal fish stocks in the early 1990s led to a trophic cascade with a dramatic increase in forage fish and alternating responses at lower trophic levels. In the early 1990s, the Barents Sea had the lowest 5-year cod fishing mortality ($F = 0.45$) since the 1950s; whereas cod fishing mortality ($F = 0.96$) on the eastern Scotian Shelf was the highest on record. At the same time, a deepening of the Icelandic low-pressure system led to increased inflow of warm-water masses to the Barents Sea and colder water temperatures on the eastern Scotian Shelf. These interacting forces of ocean climate and fishing mortality led to diametrical responses: a rapid increase in Barents Sea cod biomass during the mid-1990s and a collapse of the eastern Scotian Shelf stocks. Evidence indicates that a predator-prey role reversal is an important factor in the lack of recovery of the eastern Scotian Shelf demersal stocks despite a nearly 20-year fishing moratorium. In the Barents Sea, a limited overlap between the distribution of forage fish and demersal fish larvae, and a directed forage fish fishery limits the potential for predator–prey role reversal.

Keywords: climate variation, ecosystem effects of fishing, spatial overlap, trophic regulation.

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ICES CM 2010/S:11

Regime shifts in marine and lake ecosystems: teleconnection patterns

Carola Wagner, Rita Adrian, Jürgen Alheit, Thorsten Blenckner, Stephanie E. Hampton, Franz Hölker, Douglas J. Beare, and Daniel E. Schindler

Climatically induced regime shifts in aquatic ecosystems can re-organize plankton communities and thus alter structural and functional system properties. These changes may be synchronized over large spatial scales and across different types of aquatic ecosystems. We studied the timing and type of long-term changes for several indicators of abiotic and biotic system components. The synchrony of regime shifts was analysed with regard to system type (marine, freshwater), season (spring, summer), and geographic location. We chose two marine systems (North Sea, Baltic Sea) and three lakes (Lake Erken, Lake Müggelsee, Lake Washington). We hypothesized coherent shifts of all physical system components in spring during the late 1980s in Europe—possibly synchronized by NAO dynamics—regardless of system type and location, but out of phase with the North American systems. Further, biological responses were expected to be less coherent but there were still obvious shifts in ecosystems. Responses of all system components are expected to be more variable during summer.

Keywords: climate variability, regime shifts.

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ICES CM 2010/S:12

Impact of the Atlantic multidecadal oscillation (AMO) on Northeast Atlantic ecosystems

Jürgen Alheit and Carola Wagner

The AMO is a mode of multidecadal climate variability whereby warm and cold periods alternate over large parts of the northern hemisphere. Anecdotal records since the late nineteenth century and long-term time-series since the early twentieth century indicate that multidecadal changes in sea surface temperature associated with the dynamics of the AMO have impacted on dynamics of zooplankton, intertidal benthos, and fish populations of Northeast Atlantic ecosystems. During the warm periods (i) in the late nineteenth century, (ii) from approximately 1930–1960, and (iii) since the 1990s, many zooplankton, benthos, and fish species have extended their northern boundaries. Southern species have been observed in the North and Baltic Seas during these times, but were not recorded in the intervening periods. Examples of these apparently climatically driven changes in species distribution and abundance will be presented and comparisons will be made to similar phenomena in the North Pacific.

Keywords: AMO, benthos, climate variability, fish, Northeast Atlantic, northern Pacific, zooplankton.

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ICES CM 2010/S:13

Contemporary ocean warming and freshwater conditions contribute to delay the completion of maturation in Atlantic salmon throughout the Norwegian range of distribution

Jaime Otero, Arne J. Jensen, Jan Henning L'Abée-Lund, Nils Chr. Stenseth, Geir O. Storvik, and Leif Asbjørn Vøllestad

The completion of maturation in Atlantic salmon (*Salmo salar*) depends on environmental conditions that affect both feeding opportunities and growth, which would provide sufficient lipid stores for reproduction. However, if the level of energy reserves of a given fish is below a certain genetic threshold at a critical decision time further gonadal development is arrested and full maturation postponed. This individual development pattern suggests that the proportion of fish maturing at a given sea age could vary from year to year according to the feeding opportunities in the oceanic migratory habitat, and the growth rate during freshwater residence that might be associated with growth at sea. In this study we show that sea age at maturity of adults caught in multiple Norwegian rivers has increased with increasing sea surface temperature (SST) experienced by the fish in autumn months during their first year at sea. Furthermore, freshwater conditions measured by river discharge during summer one year ahead of seaward migration is positively related to increasing sea age at maturity. This result is discussed within the broad changes occurring in the Northeast Atlantic pelagic foodweb, mostly related to the current ocean warming, and river conditions influencing growth rates.

Keywords: Atlantic salmon, *Salmo salar*, maturation, Norwegian rivers, sea surface temperature, run-off.

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ICES CM 2010/S:14

Climate variability drives anchovies and sardines into North and Baltic Seas

J. Alheit, C. Wagner, T. Pohlmann, M. Casini, A. Sell, and R. Vorberg

European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are southern, Lusitanian species needing warmer temperatures than boreal ones. After approximately 40 years of absence, they were observed again in increasing quantities in the North and Baltic Seas. Surprisingly, the population rise did not start in the late 1980s, when sea surface temperatures increased conspicuously in association with the increase of the NAO index. Instead, increasing numbers of eggs, larvae, juveniles, and adults of both species were recorded from the mid-1990s, indicating that temperature was not the only factor triggering their re-appearance and spawning in waters that are more northern. Apparently, climate variability drives anchovies and sardines into North and Baltic Seas. We will discuss which atmospheric (e.g. AMO, East Atlantic Pattern) and oceanographic (e.g. contraction of Subpolar gyre) drivers might be responsible for the occurrence of anchovies and sardines in North and Baltic Seas and other changes observed in plankton, intertidal benthos, and fish observed at the same time. Comparisons to similar northward migrations of anchovies and sardines in the North Pacific will be made.

Keywords: anchovies, climate variability, North Sea, sardines.

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ICES CM 2010/S:15

Changing states of North Atlantic large marine ecosystems

Kenneth Sherman, Kevin Friedland, John O'Reilly, and Kimberly Hyde

Effects of climate forcing are examined for 15 large marine ecosystems (LMEs) bordering the North Atlantic basin. Trends in multidecadal time-series data of temperature, chlorophyll, primary productivity, nutrients, and fish and fishery yields, differed among these LMEs. Responses to climate warming varied between northwestern and northeastern Atlantic LMEs, with warming rates influencing changes in Northeast Atlantic LME plankton production and fishery yields more directly than in LMEs of the Northwest Atlantic, where warming rates are lower. In contrast, negative effects of nutrient over-enrichment in relation to harmful algal blooms and hypoxic conditions were greater in the Northwest Atlantic LMEs. Forecasts suggest significant increases in nutrient over-enrichment of North Atlantic LMEs by 2050. Fishery time-series analyses suggest increases in fishery yields for Subarctic LMEs, and declines in LMEs of more southerly latitudes.

Keywords: climate effects, fishery yield, large marine ecosystems (LMEs), North Atlantic, nutrient overenrichment.

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ICES CM 2010/S:16

English Channel cuttlefish (*Sepia officinalis*) stock structure in the reproduction period

Michaël Gras, Olivier Goetz, Jehane Lepoittevin, and Jean-Paul Robin

Sepia officinalis is distributed from the West African coast to the North Sea and throughout the Mediterranean Sea. It is a semelparous species with a lifespan that varies between 12 and 24 months (from the south to the north of its distribution range). The migratory cycle of the English Channel population is now well known and coastal reproduction has been described in French waters (1989) as well as in English waters (1999). Spawning occurs inshore during the spring season on both sides of the English Channel. In the context of the global warming and in a species whose the life cycle can change in relation with temperature, updated information about sexual maturity is desirable. During the spring phase, the population is exploited by several métiers,

including traps and otter trawls. A series of samples have been collected and analysed for biometric data and sexual maturity using a macroscopic key to determine the maturation stage. The different cohorts were identified with length–frequency data and size-at-maturity ogives were determined on a subsample of specimens. In addition to biological parameters, this work provides information about spatial and métiers-based differences in catch composition. Such elements are collected in order to develop a biomass model for the assessment of this stock.

Keywords: English Channel, global warming, life cycle, maturation, *Sepia officinalis*.

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ICES CM 2010/S:18

Bottoms up: potential effects of environmental forcing on apex predators in the Gulf of Maine

Walter J. Golet, Jason Stockwell, Graham Sherwood, Andrew Pershing, Jeffrey Runge, and Molly Lutcavage

The Gulf of Maine, a highly productive shelf region in the Northwest Atlantic, supports a large biomass of energetically rich prey species such as Atlantic herring, Atlantic mackerel, and the copepod *Calanus finmarchicus*. Seabirds, marine mammals, and large pelagic fish migrate seasonally to this region where consumption of this prey base yields rapid accumulation of lipid stores used for reproduction and migration. Oceanographic data indicate the Gulf of Maine has experienced a pronounced shift in salinity, primary and secondary productivity during the mid-1990s. Generalized additive models suggest these oceanographic shifts may have contributed to significant changes in Atlantic herring and tuna condition and lipid energy stores during the previous decade. For example, medium and giant size classes of bluefin tuna experienced a 5–25% decline in summer body weight between the early 1980s and late 1990s. Such reductions to key energy stores have the potential to severely alter migration and reproductive patterns of highly mobile species and highlight the importance of understanding and incorporating the effect of bottom–up forcing in fishery management.

Keywords: bluefin tuna, condition, herring, lipid.

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ICES CM 2010/S:19

Repeated observations of abrupt and persistent recruitment collapses in gadoids—a potential scenario in relation to climate change?

Tore Johannessen

Management, surveillance, and studies of ecosystems and their constituent species are generally based on the assumption of simple dose–response relationships. Gradual environmental changes or perturbations are expected to cause corresponding changes in the abundance of affected species. However, a unique time-series (since 1919) of 0-group gadoid abundance data from the Norwegian Skagerrak coast shows repeated incidents of abrupt and persistent recruitment collapses in gadoid fish. It is proposed that the recruitment collapses are caused by gradually increasing nutrient loads, which result in abrupt changes in the planktonic community and thereby reduced food variability for the 0-group gadoids. The results suggest that: (i) there are alternative stable states with different environmental optima in marine ecosystems; (ii) the change from one stable state to another appears as a catastrophic shift; (iii) different stable states may persist under overlapping environmental conditions, suggesting that marine ecosystems are highly resilient; and (iv) the eutrophication-induced shifts are linked to increasing turnover rates in the algal community with increasing primary productivity. This favours small, fast-growing algal species, which are then grazed by smaller herbivorous zooplankton. The fact that marine ecosystems may not respond in a

gradual dose–response manner, but shift abruptly between alternative stable states seriously challenges our present approach of managing ecosystems and their constituent species, and the way we monitor potential impact of environmental changes. This is of particular concern with the prospect of global warming.

Keywords: climate change, ecology, eutrophication, recruitment, regime shifts.

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ICES CM 2010/S:20

Comparison of the effects of climate variations on pelagic ocean habitats and their potential role in structuring the forage fish distributions in the Bering Sea and Gulf of Alaska

Anne B. Hollowed, Steven Barbeaux, Ned Cokelet, Stan Kotwicki, Patrick Ressler, and Christopher Wilson

Theoretical ecology suggests that competition between species and predator–prey interactions are modulated by the quality and quantity of suitable habitat. This paper examines whether climate variations influence the boundaries of suitable pelagic habitat, and whether these changes effect the spatial distribution and interactions between key fish species in the Bering Sea and Gulf of Alaska. The study focuses on the summer distributions of forage fish (age-0 and age-1 walleye pollock (*Theragra chalcogramma*), and capelin (*Mallotus villous*). Forage fish distributions were collected during summer acoustic and bottom-trawl surveys conducted as part of the NOAA groundfish trawl and acoustic surveys in the Bering Sea in 2003–2008, and the NOAA Fishery Interaction Team experiments in the Gulf of Alaska conducted in 2000–2006. We compare the responses of age-0 and age-1 walleye pollock, and capelin to climate induced shifts in pelagic habitats in the Bering Sea and Gulf of Alaska ecosystems. Habitat boundaries are defined using key explanatory variables including: forage fish density, predator distribution, depth, bottom temperature, surface temperature, and surface chlorophyll *a*. General additive models are developed to predict the spatial distribution of age-0 pollock, age-1 pollock, and capelin in both regions. Comparison of the responses of three classes of forage fish in different ecosystems helps to better understand their expected responses to climate forcing. A framework is presented for integrating the relationships between climate variability, pelagic ocean habitats, and forage fish distributions into stock assessment models to permit forecasting.

Keywords: climate variability, Bering Sea, Gulf of Alaska, forage fish.

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ICES CM 2010/S:21 Poster

Oscillations of abundance in North Atlantic fish in 1977–2010 compared with synchronous changes of commercially important species in other parts of the world ocean owing to global climatic variability

Feodor Litvinov, Nikolay Timoshenko, and Pavel Chernyshkov

Prediction of changes in the quantitative parameters (total biomass, recruitment, spawning biomass, etc.) of commercially important species is one of the most important tasks to be resolved by ICES and PICES, being the general basis for fishery management. Those parameters undergo various oscillations of the different amplitudes: quasi-periodical, synchronous, asynchronous, etc. Possibility of forecast strongly depends on general knowledge of a certain species' biology, its ecology, longevity, etc. and these factors differ significantly from species to species. Some severe oscillations cannot easily be derived from available data on environment and life history, but prediction with a certain accuracy is allowed, based on analogous changes in other species. Such species with analogous oscillations may be neighbouring fish of similar ecology or may be very distant organisms, spatially and taxonomically. The present paper presents analysis oscillation in

blue whiting, northern mackerel, and Norwegian herring compared with Antarctic krill, pink salmon, and Chilean Jack mackerel. Significant similarities in oscillations were revealed, including opposite-directed, long-period, and short-period ones, caused most probably by synchronous changes in global processes in the ocean and atmosphere that are not perceived yet, but may be traced in integral indicators: living organisms. The synchrony revealed may be used for prediction of quantitative changes in commercially important species in North Atlantic, and other parts of the world ocean as well.

Keywords: Antarctic krill, Atlantic and Pacific fish, biomass oscillations, environmental background, quantitative changes.

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Relationships between climate/environmental factors and Pacific cod (*Gadus macrocephalus*) catch in the southwestern East/Japan Sea

Sangdeok Chung and Suam Kim

This paper investigates the habitat characteristics of Pacific cod (*Gadus macrocephalus*) and the relationship between Pacific cod catch and environmental parameters in the southwestern Japan/East Sea. The highest catch of Pacific cod occurred in the seawater temperature range of 2–4°C and salinity range of 33.8–34.0 PSU at 100 m. The cross-correlation function (CCF) analysis indicated that there is a significant negative correlation ($r = –0.380$, $p < 0.05$) between Pacific cod catch and seawater temperature at 75 m in spawning area with a time-lag of 5 years. Furthermore, annual catch of Pacific cod has a significant correlation with zooplankton biomass in coastal nursery areas with a time-lag: i.e. $r = 0.452$ and $r = 0.421$ for total zooplankton in June of 5 years ago, and euphausiids in February of 4 years ago, respectively. Also, total cod catch was negatively correlated with winter Arctic Oscillation Index (AOI), and the highest correlation ($r = –0.500$) was shown with a time-lag of 4 years. This might explain that both biotic and abiotic environmental factors during early life stages have significant influence on cod recruitment after 4–5 years.

Keywords: climate, environmental conditions, Korean waters, Pacific cod.

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Are there evidences of environmental-driven fluctuations in landings from the Portuguese trawl crustacean fishery?

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Crustaceans are a highly valuable component of the Portuguese continental bottom-trawling fisheries, being currently targeted by ca. 30 vessels operating mainly off the south coast and, to a lesser extent, the southwestern one, at depths ranging from ca. 150 to more than 600 m. The main target species are the Norway lobster (*Nephrops norvegicus*), a benthic burrowing species, and the deep-water rose shrimp (*Parapenaeus longirostris*). During a 23-year period (from 1986 to 2008), landings of both species fluctuated greatly, particularly rose shrimp (e.g. increase from 800 to 2000 tons between 1998 and 1999; decrease from 1000 to ca. 140 tons between 2003 and 2004). The fact that these species are often captured during the same fishing trip makes it difficult to allocate the fishing effort for each of them, thus preventing the correct estimation of catch per unit of effort. Furthermore, rose shrimp is a pivotal species because fishers reorient their effort towards Norway lobster depending upon fluctuations in the shrimp abundance. The latter fact adds a further level of complexity when trying to disentangle fishery-induced from environmental-induced fluctuations in landings. We examined the relationship between Norway lobster and rose shrimp

landings from 1986 until 2008, assumed as a proxy of abundance, with environmental variables such as the eastern Atlantic and upwelling indices, regional average sea surface temperature and rainfall, and river hydrologic regime, by estimating maximum cross-correlation (and associate time-lags) among them. Preliminary results for Norway lobster led us to use a time-series of spawning-stock biomass of recruitment in place of landings. Both species displayed a significant positive correlation at different lags with the eastern Atlantic index. Good recruitment years seem to be associated with dryer, warmer conditions associated with higher values of EA. Water temperature may also be associated with species abundance, but with an opposite impact, positive correlation for the rose shrimp and negative for the Norway lobster. This may be related to the fact that the Portuguese coast is approximately the northern limit of the former species and the southern limit of the latter.

Keywords: deep-water rose shrimp, environmental variables, landings, Norway lobster, Portugal, spawning-stock biomass of recruitment, time-series.

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ICEM CM 2010/S:24 Poster

Comparing trophic structure and diversity in northern ecosystems using stable isotope data

Silje Ramsvatn, Torstein Pedersen, and Einar M. Nilssen

Change in trophic level of catches has become a key indicator of fishery impact, ecosystem structure, and health. Whether because of fishing pressure, climate change, or other sources of physical or biological changes in an ecosystem, we propose to use isotope metrics in comparing key species and functional groups in ecosystems across the northern hemisphere. Layman *et al.* (2007) suggested an interesting approach for using stable isotopes in community-wide measures to represent a species trophic role, and they also presented a possible way of quantitatively measuring ecosystem structure and dynamics. By making a bi-plot of $\delta^{13}C$–$\delta^{15}N$ they proposed using this to measure, for example, niche diversity and trophic redundancy. As a case study, we attempt to use this approach to compare northern ecosystems in Norway with Canadian Gulf of St Lawrence using stable isotope data. The systems exhibit similar physical and biological properties in being northern estuarine systems and share many of the same species, but have been under different stress from fishing pressure and other perturbations. Recently sampled stable isotope data from a Norwegian outer fjord system (Ullsfjord) were compared with published data from inner fjord systems and from Atlantic Canadian systems.

Keywords: diversity, ecosystem change, niche, stable isotopes, trophic redundancy.

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Comparing long-term changes in primary and secondary production in the North and Baltic seas: a modelling study

Dhanya Pushpadas, Ute Daewel, Corinna Schrum, and Sturla Winger Svendsen

Although the North Sea and Baltic Sea are located side by side and hence exposed to almost the same climatic conditions, their respective ecosystems are very different in terms of both physical and biological characteristics. Although the North Sea is an open system characterized by strong tides and a pronounced frontal system, the Baltic Sea ecosystem is almost enclosed and influenced by freshwater run-offs, creating a permanent halocline. Here we applied a three-dimensional ecosystem model (ECOSMO) simultaneously to both systems in order to identify interannual variability and long-term trends in primary and secondary production with a special focus on climatic impacts. Therefore, we present results from a 60-year (1948–2007) hindcast simulation and analysed both primary and secondary production with respect to specific climatic variables (e.g.

windstress, 2 m air temperature, short-wave radiation). Previously performed scenario tests indicated that specifically changes in short-wave radiation determine spatial and temporal variability in North Sea production, depicting a rather direct source for variability. For the Baltic Sea, we expect both direct impacts of climatic forcing on primary and secondary production via, for example, solar radiation, or vertical mixing, as well as indirect impacts such as climatically triggered nutrient infusions from the North Sea, influencing nutrient availability and hence primary production. Comparing these two, similarly located ecosystems, raises not only the opportunity to identify climatic impacts on ecosystem dynamics, but to highlight the interactions with other environmental conditions such as bottom topography, tides, and exchange with other ecosystems.

Keywords: Baltic Sea, climate variability, ecosystem modelling, North Sea, primary production, secondary production.

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Environmental effects on ocean entry of Atlantic salmon (*Salmo salar*) smolt across its range of distribution

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The smolt transformation process is the change in morphology, physiology, and behaviour that Atlantic salmon (*Salmo salar*) parr undergo before migrating to sea in spring. Temperature and photoperiod are the primary environmental cues regulating this process. Previous studies have identified water temperature and water flow as the main factors controlling the smolt downstream migration. These factors vary with geographical location and habitat characteristics, suggesting that the pattern of downstream migration could differ within and among rivers. Survival appears to be dependent on a precise alignment with "optimal" conditions when entering the sea, thus making timing of smolt descent a critical life-history event. Moreover, there is heritability for timing of smolt migration. However, the importance of genes and environmental conditions might be spatio-temporal dependent, allowing for local adaptation and evolution. Whereas most of the previous research has focused on analysing single or only a few populations, here we present a meta-analysis that compiles information on downstream smolt migration covering much of the distributional range of this species within the North Atlantic basin. Using different modelling approaches and population-specific sampling, we aim at exploring how local environmental conditions affect the spatio-temporal patterns of Atlantic salmon smolt run.

Keywords: Atlantic salmon, *Salmo salar*, North Atlantic basin, river temperature, run-off, sea surface temperature, smolting.

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ICES CM 2010/S:27 Poster

Monitoring and Evaluation of Spatially Managed Areas (MESMA)

Anke Weber Smit

The seas around Europe are home to an exceptionally wide range of marine habitats, which must also support a variety of marine industries. "Multiple use" can cause problems between various user groups, between economic interests and conservation requirements, and there is also a greater potential for degradation of the marine ecosystems themselves. This combination increases future challenges for marine environmental managers. The increasing pressures upon the European seas and coastal areas call for a well-planned approach for their continued spatial development. The

challenge for marine spatial management is to find an optimal balance between the competing demands of economic use, ecological development, and nature conservation, while at the same time maintaining sensitivity towards traditional practices. MESMA is an EU 7th framework project on Monitoring and Evaluation of Spatially Managed Areas. The project was started in November 2009 and will last till November 2013. MESMA operates on a local, national, and European scale. Within MESMA, 19 partners from 12 countries will evaluate cross-border pan-European comparison of spatial management. We base our research on existing data of nine case studies. The project focuses on marine spatial planning and produces integrated management tools (concepts, models, and guidelines) for monitoring, evaluation, and implementation of spatially managed areas (SMAs). Within MESMA we will involve the stakeholders essential to the effectiveness of SMAs, assess the conflicts generated by SMA, and identify tools for "good practice" management. Beneficiaries of the results will be governments, local authorities, stakeholders, and managerial bodies for planning and decision-making.

Keywords: European Union, Marine Strategy Framework, 7th Framework Programme, spatial management, spatially managed areas.

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