BOOK OF ABSTRACTS

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Table of contents

Abstracts submitted to the 2011 Annual Science Conference by the deadline 15 April 2011

Theme Session A

Atlantic redfish and Pacific rockfish: comparing biology, ecology, assessment, and management strategies for *Sebastes* spp.

ICES CM 2011/A:01

Modelling the effect of climate variability on rockfish growth rates in the North Pacific: empirical evidence for biophysical coupling

Thomas E. Helser, Bryan A. Black, and Vanessa R. von Biela

Annual growth increment widths measured in marine organism hard structures provide an integrated measure of an animal's growth rate over its lifespan,. and when related to environmental variability, these reveal evidence of a biophysical response. Evidence of a functional response between climate variability and animal growth is strengthened when such a response is seen across diverse taxa under the influence of physical processes in a given ecosystem. In this study, we evaluated the functional response between short- and long-term climate variability on the growth rates of long-lived bivalves (*Panopea abrupta*) and two species of rockfish (*Sebastes* spp.) in the North Pacific Ocean. Exactly dated growth increment data spanning nearly 60 years were analysed using a non-linear Bayesian hierarchical growth model that included covariates such as age, annual sea surface temperature (SST), upwelling and the Pacific Decadal Oscillation (PDO). Both SST and PDO entered the model as covariates, explaining the significant variability of growth across both bivalves and rockfish. Once the effects of age on growth increment data were removed, growth variability correlated positively with SST on an interannual basis, whereas PDO accounted for longer term growth rate trends that were particularly evident between the 1940–1950 warm–cold and 1970–1985 cold–warm regime transitions. Accounting for PDO and SST greatly improved model skill in reconstructing climate conditions prior to the instrumental record. Our results indicate that biophysical coupling probably occurs at several temporal scales.

Keywords: Bayesian inference, climate change, fish growth, North Pacific.

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ICES CM 2011/A:02

Biology and fishery of red fish, *Sebastes oculatus*, around the Falkland Islands (Southwest Atlantic)

Alexander Arkhipin and Vladimir Laptikhovsky

Patagonian red fish (*Sebastes oculatus* Valenciennes, 1833) is a common near-bottom inhabitant of the Patagonian Shelf. It comprises a small (up to 50–100 kg per trawl) but valuable bycatch in the Falkland Islands bottom-trawl fishery. Little is yet known about its biology and ecology. The fish occurs mainly above the rocky grounds at 150–170 m depth. Occasionally, it is encountered both in shallow waters (70 m) and on the shelf break (300–350 m). Red fish is most abundant in waters of temperate origin to the northwest of the Falkland Islands, but penetrates also with shelf water mass to the coldest southeastern part of the shelf. *Sebastes oculatus* is a medium size fish with adults attaining 36–38 cm total length (total body weight 700–900 g). There is a slight sexual dimorphism in maximum sizes of adults, with females being larger (44 cm) than males (42 cm). Otolith counts have confirmed that red fish is a long-lived species, with maximum ages up to 30 years. Growth follows the von Bertalanffy growth curve, with growth rates being rather similar for both sexes. Taking into account the occurrence of ovoviviparous females, spawning takes place between

austral spring and autumn with two peaks (October–November and March–April). A possible role of *S. oculatus* in the ecosystem of the Patagonian Shelf is discussed.

Keywords: ecosystem, Falkland Islands, Patagonian red fish, *Sebastes oculatus*.

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ICES CM 2011/A:03

The influence of maternal age on fishery harvest reference points

Paul D. Spencer, Sarah B. M. Kraak, and Edward A. Trippel

Maternal effects, defined here as the reduction of larval viability with reduced spawner age, have been proposed as a feature of marine populations that motivate the conservation of age and size structure, and have been observed in both Atlantic cod (*Gadus morhua*) and Pacific rockfish (*Sebastes* spp.) stocks. In this study, we simulated "cod-like" and "rockfish-like" populations to explore how estimates of management reference points such as F_{msy} (the F level associated with maximum sustained yield) and F_{crash} (the F level where equilibrium yield is reduced to zero) may be affected by life-history pattern, recruitment variability, exploitation, and environmental variability. In these simulations, larval survival was dependent upon spawner age, and estimates of F_{msy} and F_{crash} were made using either total larvae (proportional to eggs and spawning-stock biomass) or viable larvae (i.e. larvae remaining after mortality dependent upon spawner age is applied) as measures of reproductive output. Over a range of harvest rates and levels of recruitment autocorrelation for each life-history type, estimates of F_{msy} obtained when using total larvae were similar to those obtained when using viable larvae. However, estimates of F_{crash} obtained when using total larvae were larger than those obtained when using viable larvae because of the reduced age of spawners and reduction in larval survival rates associated with the high fishing mortalities of F_{crash}. These results suggest that the potential for biased estimates of stock productivity is most pronounced at high fishing rates, and reinforces the desirability of maintaining harvest rates at or below F_{msy}.

Keywords: fishing reference points, maternal effects, rockfish.

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ICES CM 2011/A:04

Feeding of redfish, *Sebastes mentella*, in the Irminger Sea and adjacent waters—what data on diet indicate?

V. Dolgov, V. I. Popov, and A. Yu. Rolsky

Feeding intensity and feed composition of redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters in the late twentieth and the early twenty-first centuries were examined according to data from the qualitative and quantitative analysis of their diet. The paper presents analysis of interannual, local, and ontogenetic variabilities in the diet of this species as well as relations between the species' diet, food supply, and climate fluctuations. Information on the feeding patterns of redfish from different biotopes is also provided.

Keywords: biotope, diet, feeding, Irminger Sea, redfish.

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ICES CM 2011/A:05

Studies of biology and history of fisheries on *Sebastes mentella* in the Barents Sea and adjacent waters as a basis for future development of technical regulations for this stock

Konstantin V. Drevetnyak

Beaked redfish (*Sebastes mentella*) had attained commercial importance in the Barents Sea by 1952. During 1952–2002, the international fishery for beaked redfish in the Barents Sea ranged from 5400–276 000 t y^{-1}, with peaks in 1959 (65 300 t), 1976 (276 000 t), 1982 (113 000 t), and 1991 (49 000 t). Being a long-living and late-maturing species, the Barents Sea stock of *S. mentella* was depleted by unregulated fishery and bycatch of juveniles in other fisheries. In 2003, Russia and Norway prohibited directed fishery of *S. mentella* in the Barents Sea. Using PINRO data and survey scientific literature on the biology and fisheries of *S. mentella* in the Barents Sea and adjacent waters, the author suggests management measures for fishery on that species, including fishing seasons, areas and depths, minimum legal size (MLS), and optimum yield from stock.

Keywords: Barents Sea, biology, fishery, management, redfish.

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ICES CM 2011/A:06

Hybridization of redfish (genus *Sebastes*) in the Irminger Sea and its significance for studies of population structure of beaked redfish, *S. mentella*

Valentina S. Artamonova, Alexander A. Makhrov, Alexey Yu. Rolskiy, Yuri I. Bakay, and Victor I. Popov

Interspecific hybridization is common in many fish, including redfish of the genus *Sebastes*. Studies of this phenomenon are interesting in terms of evolutionary genetics as well as conservation genetics. Specimens that were morphologically intermediate between *S. mentella* and *S. marinus* were found as early as the 1960s, when investigations of *S. mentella* were initiated in the Irminger Sea. A large number of these hybrids (13.3%) in that area was revealed later by genetic analysis. We searched for *S. mentella* hybridized with *S. fasciatus* and *S. viviparus* in samples of redfish with external traits typical of *S. mentella*. The samples were collected in the Irminger Sea in 2007 ($n = 131$) and 2010 ($n = 72$). Hybrids were identified using *MDH-2** locus coding malate dehydrogenase. The samples contained hybrids with 0.0152 and 0.0138 frequency, respectively. It should be mentioned that the allele typical of *S. viviparus* and *S. fasciatus* had been observed already in samples of beaked redfish collected in different years and at different depths of the Irminger Sea. In 2000, its average frequency was 0.05 in samples taken at more than 500 m depth. The results from our investigations reveal that interspecific hybridization may have a strong impact on the genetic structure of *S. mentella* in the Irminger Sea, presumably being one of the main reasons why allele frequencies of a number of genes is different between samples collected at different depths. This should be taken into consideration in population structure studies.

Keywords: hybridization, interspecific population structure, Irminger Sea, *S. mentella*.

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ICES CM 2011/A:07   Withdrawn

ICES CM 2011/A:08

Feeding ecology of juvenile rockfish off Oregon and Washington: insights into life-history patterns based on stomach content and stable isotope analyses

Keith L. Bosley, Richard D. Brodeur, Todd W. Miller, Katelyn M. Bosley, Ahna Van Gaest, and Anna Elz

We examined the feeding habits of pelagic juvenile rockfish (*Sebastes* spp.) collected off Oregon and Washington during 2000, 2002, and 2006 using a combination of stomach content and stable isotope analyses. Species were identified using genetic techniques and the predominant species collected in all years were darkblotched (*S. crameri*), canary (*S. pinniger*), yellowtail (*S. flavidus*), and widow (*S. entomelas*) rockfish. Analysis of stomach contents by % number revealed that darkblotched rockfish expressed a high degree of variability of their diets, whereas canary, yellowtail, and widow rockfish had high dietary overlap, attributed to the common utilization of copepods and euphausiids. Less overlap in diets was observed among species when % wet weight was examined. Multivariate analysis of stomach content data (% wet weight) revealed significant differences in diet based on distance from shore where caught, fish size and species. Nitrogen stable isotope analyses revealed all rockfish were feeding at about the same trophic level within each year; however there was a 1.5‰ difference between years. Low (more negative) $\delta^{13}C$ values of rockfish were indicative of primary production from a more offshore origin, with widow consistently expressing the lowest values between years. Comprehensively, these results advance our understanding of some of the important environmental factors that affect young-of-the-year rockfish during their critical pelagic phase.

Keywords: carbon and nitrogen stable isotopes, feeding ecology, juvenile rockfish, stomach analysis.

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ICES CM 2011/A:09

Stochastic population dynamics of beaked redfish (*Sebastes mentella*)

Eirin Bjørkvoll, Vidar Grøtan, Sondre Aanes, Bernt-Erik Sæther, Steinar Engen, and Ronny Aanes

The beaked redfish in the Barents Sea is at historical low abundance levels as a result of previous overexploitation and is considered as vulnerable by the Norwegian red list. The management of the population is currently based on survey data that only indicate abundance trends, and no analytical assessment is done. Using a Bayesian modelling framework, we have fitted an age-structured stochastic population model to catch and survey data. The model accounts for observation errors, separates natural mortality from fishing mortality, estimates important population dynamical parameters, and provides age-specific estimates of abundances for ages 6–18 years between 1992 and 2009. Our results indicate that the population increased from 317 (95% CI 188,523) to 824 (316,1723) million individuals during 1992–1997, and gradually decreased to 227 (109,433) million individuals in 2009. The last strong cohorts were born in the late 1980s and early 1990s and the population have subsequently shifted the age distribution from being dominated by young individuals to being dominated by old individuals. Using estimated parameters, assuming no harvesting, generating recruits from a Ricker stock–recruitment curve, and conditioning on the current estimated age distribution, we constructed a population prediction interval by stochastic simulations of the adult population size 100 years forward in time. The population prediction interval indicates that the adult population is expected to decrease to a minimum of 83 (33,343) million individuals in 2014. If harvest is terminated, subsequent years are predicted to demonstrate an increase in adult abundance because of increased contribution to recruitment from the strong cohorts born in the late 1980s and early 1990s.

Keywords: none.

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ICES CM 2011/A:10   Withdrawn

ICES CM 2011/A:11

Assessment and status of the US Gulf of Maine–Georges Bank Acadian redfish stock

Timothy J. Miller and Steven X. Cadrin

From the 1930s through the 1970s, Acadian redfish supported a substantial domestic commercial fishery in the Gulf of Maine and on Georges Bank. Since the stock's collapse in the 1980s, there has been little targeted fishing effort. In 2001, the stock was determined to be overfished with a rebuilding plan begun in 2004 as part of Amendment 13 to the Multispecies Fisheries Management Plan. The last assessment of Acadian redfish in 2008 determined that the stock was still overfished although it was projected to be rebuilt with high probability in 2011 with current levels of fishing. Recovery was projected to occur more quickly than expected owing to healthy recruitment and lack of any significant fishing pressure for a protracted period of time. Preliminary results from the same model used in the most recent assessment, but updated with survey indices and catches through 2009, suggest that the stock has been recovering as predicted by the 2008 assessment.

Keywords: redfish, *Sebastes*, stock assessment.

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ICES CM 2011/A:12

The red- and rockfish around the world: a history of divergence

Fran Saborido-Rey

Sebastes is a fish genus comprising a large number of species, around 110, the majority of which live on either side of the North Pacific, the origin of the evolutionary radiation of the genus, where they are called rockfish. Four species spread into the North Atlantic, the first source of divergence, where they are known as redfish. Another few species managed to spread to the southern hemisphere. *Sebastes* have diverged to occupy a large variety of habitats but have maintained common features despite isolation: longevity, relatively low fecundity (but high lifetime reproduction), viviparism, and nearly identical morphologies. The adaptation to different ecosystems and species competition have led to *Sebastes* species evolving different productivities, distributions, and ecologies. They are therefore subject to recreational as well as commercial fishery in both oceans. This is a third source of divergence. Despite their importance, researchers from both oceans have shared very little knowledge, thus fostering even more divergence. How old are they? Do they migrate? Do they hybridize? Are they therefore different species? How many stocks are out there? What would be the optimum management strategy? Like the species they study, researchers have also diverged on these and another questions. Despite all of these divergences, however, much of the research conducted on *Sebastes* has followed similar methods. When research has varied, it has been of interest of researchers in both communities. Although *Sebastes* will continue to diverge, researchers try to find convergence in this theme session, as one thing seems to be common for all researchers: these are very particular species, with several unique biological and ecological features, difficult to assess and very complex to manage.

Keywords: rockfish, redfish, *Sebastes*.

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ICES CM 2011/A:13

Evaluating the role of predation by harbour seals and sea lions in the lack of recovery of British Columbia inside waters yelloweye rockfish

M. K. McAllister and K. L. Yamanaka

Many Pacific rockfish populations have undergone pronounced declines in the last several decades, apparently caused by episodic high fishing mortality rates. In contrast, some harbour seal and sea lion populations have demonstrated marked increases since the halting of culling and bounty programmes in Canada and the United States in the 1960s. Strait of Georgia harbour seals (*Phoca vitulina richardsi*), for example, have increased from about 3500 animals in the 1970s to about 42 000 animals. Diet studies indicate that rockfish form a relatively small fraction of the diet of British Columbia pinnipeds. The high annual rates of consumption, however (e.g. about 700 kg per harbour seal), and current high abundance of pinnipeds suggest that predation rates on British Columbia rockfish may have increased substantially and could be preventing recovery (i.e. the "predator pit hypothesis"). In this paper, I present an adaptation of a stock assessment model for British Columbia inside waters yelloweye rockfish (*Sebastes ruberrimus*) that accounts for variations in predation since the early 1900s and assess the potential impacts of fishing vs. pinnipeds on rockfish population recovery. With the recent increases in pinnipeds, the biomass of inside waters yelloweye rockfish consumed has increased approximately fivefold since the 1970s. In contrast, the total catch has dropped to very low levels in recent years. Bayes factors computed for the alternative hypotheses provide mild support for the predator pit hypothesis and indicate that further decline in rockfish populations may occur, even with a complete ban on fishing.

Keywords: Bayes factors, pinniped predation, rockfish, stock recovery.

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ICES CM 2011/A:14

Multidecadal growth increment chronologies for North Pacific and North Atlantic rockfish species

Bryan A. Black, Isaac D. Schroeder, William J. Sydeman, and Steven J. Bograd

Tree-ring (dendrochronology) techniques have been increasingly applied to develop environmentally sensitive growth chronologies from annual otolith increment widths of various rockfish (*Sebastes*) species. Final chronologies are multidecadal, exactly dated, and can be used to (i) describe long-term growth histories, (ii) determine the effects of climate on growth, and (iii) integrate with other biological time-series to quantify relationships across diverse taxa and ecosystems. In the California Current of the Northeast Pacific, splitnose and yelloweye rockfish chronologies span as many as 71 years and strongly relate to each other as well as other biological indicators, including records of seabird reproductive success. Synchrony across these diverse time-series is driven by their shared sensitivities to winter ocean conditions, and years with favourable climate (strong February and March upwelling) are characterized by robust rockfish growth, early seabird lay dates, and high fledgling success. These results provide long-term, corroborating evidence as to the importance of winter ocean conditions for ecosystem productivity. Similar approaches are also possible for Atlantic rockfish species. A 30-year Acadian redfish (*S. fasciatus*) chronology has recently been developed for the Gulf of Maine, which significantly ($p < 0.01$) correlates to climate indices, especially the Atlantic Multi-decadal Oscillation. These correlations indicate that cool conditions are associated with strong growth, consistent with species in the Pacific. Overall, chronology development could be more widely applied in the North Atlantic to better understand long-term rockfish growth patterns, their relationships to climate, and interactions with other biological components of the ecosystem.

Keywords: climate, North Atlantic, North Pacific, rockfish.

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ICES CM 2011/A:15

Monitoring beaked redfish in the North Atlantic: current challenges and future prospects

Benjamin Planque, Kristján Kristinsson, Alexey Astakhov, Yuri Bakay, Matthias Bernreuther, Eckhard Bethke, Konstantin Drevetnyak, Kjell Nedreaas, Jakup Reinert, Alexey Rolskiy, Thorsteinn Sigurdsson, and Christoph Stransky

Beaked redfish (*Sebastes mentella*) inhabit North Atlantic waters in the depth range 100–950 m, over the continental shelf, slope, and the open ocean and can be demersal or pelagic, at various stage of their life cycle. The geographical distribution of the species extends to most of the Atlantic waters from Newfoundland and the Labrador basin in the west to the Barents Sea in the east. The wide geographical distribution and large-scale migrations, associated with a deep distribution which complicates trawling and hydroacoustic measurements as well as problems with tagging makes it a particularly challenging species to observe with conventional research methods We review these key challenges and explore possibilities for the coordinated observation of *S. mentella* in the North Atlantic that would best contribute to the assessment and ecological research of this species.

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ICES CM 2011/A:16

Population structure of *Sebastes mentella* in the Norwegian Sea inferred from microsatellites

Torild Johansen, Tuula Skarstein, Jon-Ivar Westgaard, and Benjamin Planque

Beaked redfish (*Sebastes mentella*) is distributed over the whole North Atlantic, including shelf slope and open ocean waters. It is currently managed separately in the Irminger and Norwegian–Barents Sea regions and recent work in the Irminger region has revealed a complex stock structure consisting of three units: (i) shallow pelagic, (ii) deep-sea pelagic, and (iii) Iceland slope. It is currently believed that *S. mentella* in the Norwegian Sea constitutes one single population unit and is most similar to the shallow pelagic unit in the Irminger Sea. However, this is based on a very limited set of observations and only for shallow waters. In the present study we investigate the population structure in the Norwegian Sea for different areas (north, south, shelf, slope), for different depths and different seasons using data collected in 2006–2009 ($n = 2500$). We analyse data from 11 microsatellites and compare the results to age structure, size, and sex distribution. The results are used to reveal the population structure of *S. mentella* in the Norwegian Sea.

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ICES CM 2011/A:17

Recruitment of beaked redfish (*Sebastes mentella*) from the Greenland shelf into the pelagic of the Irminger Sea: Have we located the origin?

Matthias Bernreuther, Christoph Stransky, and Heino Fock

The Greenland shelf is a nursery ground for the different stocks of beaked redfish (*Sebastes mentella*) inhabiting the Irminger Sea and adjacent areas. To date, it is unclear where and how the recruitment of juvenile *S. mentella* into the Irminger Sea is taking place. We conducted a haul-based analysis of the length composition of *S. mentella* on the Greenland shelf and in the Irminger Sea, based on the annual German Greenland groundfish survey and the biannual international trawl/acoustic survey on pelagic redfish in the Irminger Sea. We were able to identify one area on the Greenland shelf with a high abundance and an increasing mean length over the past years. Here, we present the results of a fine-scale spatial analysis of potential recruitment pathways of juvenile *S. mentella* into the Irminger Sea and adjacent areas.

Keywords: beaked redfish, Greenland shelf, Irminger Sea, length-based, recruitment.

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ICES CM 2011/A:18

Growth and production of Pacific ocean perch (*Sebastes alutus*) in nursery habitats of the Gulf of Alaska

Christopher N. Rooper, Jennifer L. Boldt, Sonia Batten, and Christopher Gburski

Pacific ocean perch (POP, *Sebastes alutus*) are an important component of commercial groundfish fisheries in the western US and Alaska. They have an extended juvenile period (ages 1–5 years) where they occupy rocky nursery habitats on the continental shelf. The limited spatial extent of these nursery habitats may dampen POP recruitment variability of the Gulf of Alaska. We conducted field and modelling studies to examine POP nursery areas with the goal of providing a forecast of POP recruitment in the Gulf of Alaska that can be incorporated into the POP stock assessment and utilized to inform yield recommendations. We used information collected in field studies (e.g. underwater video) to predict where substantial areas of nursery habitat for juvenile POP exist in the Gulf of Alaska and estimate the expected total abundance of age 2–5 juvenile POP. Field study information also included estimates of POP growth and the environmental conditions in their nursery areas. These data were utilized in conjunction with bottom-water temperature and spring bloom timing to construct a bioenergetics model and estimate growth-rate potential of juvenile POP. When a single outlying recruitment year in 1986 (~4.5 times the average) was removed, growth-rate potential experienced by juvenile POP in nursery areas was significantly correlated with the recruitment time-series from the stock assessment. This research highlights the potential to predict recruitment using habitat-based methods and provides a potential mechanism for environmental correlations with population abundance trends.

Keywords: Alaska, bioenergetics, recruitment prediction, *Sebastes*.

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ICES CM 2011/A:19

Review of the fishery, biological research, assessment, and management of golden redfish (*Sebastes marinus*) in Icelandic waters

Kristján Kristinsson and Thorsteinn Sigurdsson

Golden redfish (*Sebastes marinus*) is one of the most important fishery resources in Icelandic waters. It has been exploited since the early 1920s, but it was not until after World War II that the fishery expanded. There were soon signs of overfishing as redfish species are in general vulnerable to overfishing. In large part, this vulnerability is a product of their life history, which is characterized by a long-lived, slow-growing, and late-maturing cycle. Available survey indices (since 1985) revealed a decline in stock size until the mid-1990s but a slow increase since then. Following various protection measures and a reduction in fishing effort since the mid-1990s the golden redfish stock is now considered within safe biological limits. Here, we review the golden redfish fishery, assessment, the status of the stock, advice, and management. We also review the protection measures taken to protect juvenile redfish, recent biological changes such as growth and maturity, and the relationship between golden redfish populations of Icelandic and East Greenland waters.

Keywords: advice, assessment, fishery, management, protection, *Sebastes marinus*.

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ICES CM 2011/A:20

Population characteristics of *Helicolenus dactylopertus* in the Azores

R. M. Higgins, A. I. Ferreira, and E. Isidro.

Bluemouth rockfish (*Helicolenus dactylopterus*) is a valued commercial species in the Azores. Captures of this species have been steadily declining over time. Knowing specific information about the population structure and separation of populations is essential in managing this resource. Here we explore age and growth of bluemouth ($n = 290$), with lengths ranging from 15 to 52.5 cm, using whole and sectioned otoliths. We compare the performance of various models (von Bertalanffy, Gompertz, and others) for explaining growth patterns. We also use otolith elemental composition derived through solution-based inductively coupled plasma mass spectroscopy (SBICPMS) as a tool to distinguish fish from different regions of the archipelago, under the influence of the North Atlantic Current, Azores Current, and, to some extent, the Mediterranean Water Plume.

Keywords: age, growth model, *Helicolenus dactylopterus*, otolith, trace element.

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ICES CM 2011/A:21   Withdrawn

ICES CM 2011/A:22

Refinements to the exponential model index of inshore rockfish abundance based on hook timers and ROV observations of longlines

Shannon G. Obradovich and Murdoch K. McAllister

Competition for hooks in longline surveys is an ubiquitous issue. In the inside waters of British Columbia, inshore rockfish relative abundance is currently indexed by a benthic longline survey. However, a non-target species, spiny dogfish (*Squalus acanthias*), comprises more than 90% of the catch by weight and is a major competitor for hooks. This confounds the use of traditional indices such as catch per unit of effort (cpue). An alternative to the assumption that population abundance is directly proportional to cpue is the exponential model using species-specific bait removal rates (λ_j) as an index of relative abundance that is unaffected by hook competition and gear saturation. To calculate λ_j we measured capture times for inshore rockfish and dogfish through the use of fish-triggered hook timers on the longline gear during the survey. We also conducted longline experiments where we simultaneously deployed a remotely operated vehicle (ROV) in order to repeatedly observe the longline during the soak time. These empirical observations are used to test the assumptions of the pelagic-derived exponential model and the appropriateness of its application to derive rockfish abundance indices from benthic longline data. The exponential model has been refined to account for the tendency for rockfish to be more responsive than dogfish at the start of the set. We demonstrate that improved accuracy in rockfish indices can be obtained from the refined version when dogfish density is high.

Keywords: exponential model, hook competition, rockfish.

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ICES CM 2011/A:23

Geographical and temporal variation of redfish (*Sebastes mentella*) microsatellite DNA in the Irminger Sea and adjacent waters

Daria A. Zelenina, Dmitry M. Schepetov, Alexander A. Volkov, Anna E. Barmintseva, Sergey P. Melnikov, and Nikolai S. Mugue

We have analysed 21 samples (total 514 fish) of *Sebastes mentella* collected in different years (2005, 2007, 2009) throughout the Irminger Sea from depths above and below 500 m and three samples (89 fish) from the open part of the Norwegian Sea. All samples were scored for ten microsatellite loci. Our data indicate the absence of significant genetic segregation based on microsatellite loci between "deep pelagic" and "oceanic" samples in the Irminger Sea. Samples taken from the same geographic area (but from different depths) in a number of cases manifest more genetic similarities compared with geographically distant samples from the same depth. In addition, no temporal stability was revealed, and the samples from the same area but taken in different years did not cluster together. The results clearly indicate that whereas pelagic *Sebastes mentella* has prominent polymorphism revealed by meristic, morphometric, and genetic data, neither geographical nor temporal stability in genetic structure from deep and shallow pelagic zones has been confirmed.

Keywords: genetic structure, Irminger Sea, *Sebastes mentella*.

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ICES CM 2011/A:24

Application of an adaptive acoustic/trawl survey to reduce uncertainty in rockfish biomass estimates

Dana H. Hanselman, Paul D. Spencer, Denise R. McKelvey, and Michael Martin

Survey biomass estimates of several Alaskan rockfish species have demonstrated large interannual variations that are not consistent with their longevity. These variations are attributed to "patchiness" of the spatial distribution of the population. We used a field study to evaluate the performance of an experimental survey design (Trawl and Acoustic Presence/Absence Survey, TAPAS) to reduce variability of estimated biomass for *Sebastes alutus*. The design is similar to double sampling and uses acoustic information to distinguish areas of higher and lower fish density. The objective was to assess whether or not using echosign data in real time to allocate an increased portion of the survey trawl effort to high-density patches can reduce biomass variability. An analysis of archived echosign data produced an algorithm for delineating a "patch". In 2009, we conducted a 12-day TAPAS survey in rockfish depths in the Eastern Gulf of Alaska to test the sampling design. Fifty-nine trawl hauls were completed, with 19 "patch" stations and 40 background stations. The design performed well logistically, and *S. alutus* comprised the majority of the catch. The resulting biomass estimates were less precise than simple random sampling. This was the result of weak relationships of density to echosign (Sv) and patch size, and the background variability encountered was relatively low. When the acoustic data were reanalysed with a higher Sv threshold, the design performed better than random sampling. Future improvements to the design include establishing a stronger link between echosign and density, and incorporating the design into a multispecies context.

Keywords: acoustics, rockfish, sampling design, *Sebastes*, trawl survey.

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ICES CM 2011/A:25

Biology of Acadian redfish and implications for optimum yield in a mixed-species fishery

Steven X. Cadrin

The New England fishery for Acadian redfish (*Sebastes fasciatus*) is managed as part of the mixed-species demersal fishery. The fishery was traditionally managed according to the status of principal groundfish species: Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinnus*), and yellowtail flounder (*Limanda ferruginea*), and recent management of each stock remains largely focused on gadoid and flatfish species. However, the life history of redfish differs from that of other species in the fishery in several important ways. The live-bearing reproductive strategy of redfish (ovovivipary) is associated with much lower fecundity than that of other gadoid and flatfish species and may involve depensatory forms of density-dependent stock–recruit relationships. Redfish have much greater longevity, lower natural mortality rate, and slower growth than other New England groundfish. Their morphology also confers size-selectivity patterns different to those of gadoids or flatfish. The life-history strategy of redfish makes it more vulnerable to overfishing and less resilient than other species in the fishery. Although the history of the New England redfish fishery includes serial depletions that are consistent with life-history expectations, recent stock rebuilding and strong recruitment offer prospects for a productive and sustainable fishery. Life-history information is considered in the overfishing limit (50% of maximum spawning potential compared with 40% for other groundfish), but the fishing mortality rate associated with overfishing is much less than that for other species. Therefore, mixed-species fishing effort is more likely to overfish redfish than other species. If redfish are targeted with smaller mesh that is commensurate with their relatively small size at maturity, then the opposite problem of incidental bycatch of immature sizes of other species (e.g. cod and pollock, *Pollachius virens*) should be considered. Based on the biology of redfish as compared with life histories of other New England groundfish and experience from other mixed-species demersal fisheries including *Sebastes* species, redfish should be selectively targeted and managed within sustainable catch limits to achieve optimum yield.

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ICES CM 2011/A:26 Poster

Feeding of three species from genus *Sebastes* in the Barents Sea

V. Dolgov and K. V. Drevetnyak

Qualitative and quantitative analysis was used to study feeding of three redfish species (*Sebastes mentella*, *S. marinus*, and *S. viviparus*) in the Barents Sea in 2002–2010. The analysis focuses on interannual, seasonal, spatial, and ontogenetic variations of feeding intensity and diet of those species, caused by differences in habitat preferences, spatial distribution, and length composition. In addition, feeding of *Sebastes mentella* was compared in the Barents Sea and the international waters of the Norwegian Sea.

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ICES CM 2011/A:27 Withdrawn

ICES CM 2011/A:28   Poster

Discrimination of the redfish (*Sebastes mentella*) stock components in the Irminger Sea and adjacent waters based on meristics, morphometry, and biological characteristics

K. Trella, M. Podolska, K. Nedrdeaas, and J. Janusz

The study material was collected in 2004 and 2005 during commercial cruises to the Irminger Sea on board the Polish vessel MT "Wiesbaden". The ichthyological studies of the pelagic *Sebastes mentella* include detailed biological analyses, length measurements, otolith collection for age determinations, and digital images of the redfish for meristic and morphometric characters analysis. Comparison of the pelagic redfish from the northeastern and southwestern areas of the Irminger Sea indicates that there are a number of differences, including differences in spatial and vertical distribution, ambient temperature, length and age composition and morphometric–meristic characteristics. Significant differences between fish samples from the northeastern fishing grounds at depths greater than 500 m and fish from the southwestern fishing grounds at depths shallower than 500 m were observed in the number of fin rays in the back part of the dorsal fin, in the pectoral fin, and in the number of gillrakers. The share of the "pelagic deep-sea" component in the northeastern area was nearly 92%, whereas the "oceanic" component dominated in the southwestern area and comprised more than 88% of the fish there. Cluster and principal component analyses suggest that the oceanic component is a more homogeneous group than the deep-sea component. The results support the management units recently advised and established by ICES.

Keywords: Irminger Sea, morphology, pelagic redfish, *Sebastes mentella*, stock components.

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ICES CM 2011/A:29   Poster

Cohort-specific mortality and growth-selective survival of juvenile black rockfish, *Sebastes cheni*: does habitat complexity decrease predation?

Yasuhiro Kamimura and Jun Shoji

Black rockfish (*Sebastes cheni*) is widely distributed in coastal waters of western North Pacific and is one of the most dominant species in seagrass (*Zostera marina*) and macroalgae (*Surgassum* spp.) beds in temperate waters of Japan. Juvenile rockfish migrate into macroalgae beds at ca. 20 mm in total length (TL) and grow up to ca. 50 mm TL in the Seto Inland Sea, southwestern Japan. Vegetation has been suggested to significantly influence abundance and early survival of several *Sebastes* species as they are highly dependent on substrates during the early life stages. In the present study, we tested the hypothesis that habitat complexity affects cohort-specific mortality rates and growth-selective survival of rockfish. Rockfish juveniles were collected in a macroalgae bed in the central Seto Inland Sea using a seine net at one- or two-week intervals from March to May in 2008. Water temperature, salinity, prey abundance, and vegetation were measured. Otolith microstructures were analysed to estimate extrusion date and growth trajectory of the juveniles. Extrusion date was used to divide the juveniles into three cohorts (A: 1–14 Jan to C: 29 Jan–11 Feb). Mortality coefficients were estimated for each cohort from the exponential decline of abundance after the date of migration (at 20 mm TL). Growth trajectory of each cohort was compared between individuals at post-migration period and those at 8–13 days after the migration period. In cohort C, which experienced a low abundance of macroalgae, the mortality coefficient was highest and positive selection for fast-growing individuals was most strong.

Keywords: macroalgae bed, *Sebastes cheni*, Seto Inland Sea in Japan, survival.

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ICES CM 2011/A:30   Poster

SNPfisk: Use of single nucleotide polymorphisms to improve fisheries management

Torild Johansen, Benjamin Planque, Lorenz Hauser, Steve Cadrin, Halvor Knutsen, Matthew Kent, Jon-Ivar Westgaard, and Sigbjørn Lien

To facilitate their management, fishery programmes usually regard "fish stocks" as being synonymous with "fish populations". The accuracy of this assumption has important implications for management success, and is frequently assessed by ecologists who investigate the distribution and movement of individuals within and between local populations and characterize "fish populations" as a type of demographic/geographic structure. Evolutionary biologists, however, think in terms of the spatial distribution of genetic variation within and between local populations (breeding units). Exploring genetic variation has revealed that in many cases marine fish species are differentiated into local populations although no physical dispersal barrier is present. Understanding how marine species are distributed and differentiated into populations is therefore best addressed by cooperation between ecologists and evolutionary biologists. Single nucleotide polymorphisms (SNP) are a new powerful tool for quantifying genetic variation. They are bi-allelic, abundant, and found in both coding and non-coding DNA regions, reflecting both neutral and selective markers. The binary nature of these markers makes it easy to compare results between laboratories and to establish genetic databases for fishery management. Technologies to interrogate large numbers of SNPs in individual samples is robust and accessible; however a prerequisite is the discovery and validation of many, distributed SNP markers. The SNPfisk project employs a proven combination of new technologies to build a library of species-specific SNP markers. SNPfisk focuses on redfish (*Sebastes* sp.), Greenland halibut (*Reinhardtius hippoglossoides*), and saithe (*Pollachius virens*).

Keywords: Greenland halibut, North Atlantic, redfish, saithe, stock identification.

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ICES CM 2011/A:31

Documenting the collective experience in the assessment and provision of management advice for data-poor *Sebastes* species on the Canadian Atlantic and Pacific coasts

Murdoch K. McAllister and Daniel Duplisea

Several *Sebastes* species in Canadian waters have been designated as endangered and threatened by the Canadian Committee on the Status of Endangered Wildlife. In most of these instances, there have been relatively sparse records of commercial and other harvests, a lack of reliable catch-age data, and imprecise time-series of data on relative abundance. It has thus not been possible to formulate plausible age-structured fishery assessment models. We document the collective experience in the application of Bayesian state-space surplus production models for the assessment and provision of fishery management advice for *Sebastes* populations on the Canadian Pacific and Atlantic coasts. These include British Columbia bocaccio, inside waters yelloweye rockfish, and two populations of quillback rockfish, two populations of Atlantic deep-water redfish, and three populations of Acadian redfish. Key advantages of this methodology are that it incorporates available population-specific and meta-population information on the factors that determine the maximum rate of population growth and can account for interannual variability of stock biomass owing to large recruitment fluctuations and the effects of time varying selectivity. The approach has provided credible fits to available abundance index data for all nine *Sebastes* populations and credible projections under a range of stock rebuilding policies. The framework has accommodated the imputation of poorly known bycatch in non-target fisheries, historical catches from recreational fisheries, poorly known stock structure in Acadian redfish, the impacts of harbour seal and sea lion predation on British Columbia yelloweye rockfish and the formulation of informative prior probability distributions for trawl survey catchability.

Keywords: Bayesian state-space surplus production, data poor, *Sebastes* species, threatened and endangered.

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ICES CM 2011/A:32   Poster

Cross-dating in a deep-sea species from Azores

A. I. Ferreira, R. M. Higgins, and E. Isidro

Bluemouth (*Helicolennus dactylopterus*) is an important demersal fishery resource in the Azores archipelago. High sensitivity of this species to exploitation is reflected by the decline of catch numbers in the artisanal fisheries. Ageing, through growth increment counts of otoliths, is a valuable tool for stock assessment and therefore for sustainable fishery management. We employed cross-dating, an increment verification technique commonly used by dendrochronologists, in an attempt to validate annual ring formation in sagittal otoliths. Cross-dating uses natural sources of variability to synchronize growth patterns across individual fish. Measuring growth increment widths in each transversal otolith section, we identified conspicuously wide and narrow rings or signature years. By controlling for age-related growth patterns, we attempted to establish a master chronology for bluemouth in Azorean waters.

Keywords: age validation, ageing, cross-dating, *Helicolenus dactylopterus*, master chronology, sclerochronology.

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ICES CM 2011/A:33   Poster

Depth goes the distance regarding *Sebastes mentella* genetic population structure across the North Atlantic

Alexandra Valentin, Cathrin Bunke, Don Power, Jochen H. Trautner, and Jean-Marie Sévigny

The genetic population structure of redfish (*Sebastes mentella*) was investigated at the scale of the North Atlantic (i.e. from Canada to Iceland). A total of 1189 individuals, representing 31 samples, were genotyped at eight microsatellite loci. An individual-based clustering method detected five genetic groups. Most individuals from a given sample were assigned to the same genetic group. Overall, the genetic groups segregated according to geography and/or depth, such as: (1) the St. Lawrence system in Canada, (2) Flemish Cap, (3) southeast of Iceland, (4) depth greater than 550 m—observed in Davis Strait, in the Labrador Sea, off northern Newfoundland Grand Bank, in the Irminger Sea, and southeast of Iceland, (5) depth shallower than 550 m—observed in the Labrador Sea, off northern Newfoundland Grand Bank, in the Irminger Sea, and in Greenland waters. Eastern Greenland comprised a mix of individuals with the genetic signature of groups 3, 4 or 5. The same overall geographic/depth structure was observed using F_{st} pairwise comparisons between samples and a neighbour-joining tree on genetic distances. This study (i) confirms the presence of local redfish populations in the St. Lawrence system, and on the Flemish Cap, (ii) supports the hypothesis of an Icelandic slope population, and (iii) suggests the presence of two genetic groups, which are separated by depth but exhibit only weak spatial structure across the North Atlantic. The present study provides the first evidence that depth accounts for genetic differentiation at a broader scale than the Irminger Sea, an observation supporting the hypothesis of incipient speciation.

Keywords: depth, North Atlantic, population structure, *Sebastes mentella*.

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ICES CM 2011/A:34   Withdrawn

ICES CM 2011/A:35   Poster

Species composition of historical cruitment pulses in the St. Lawrence system as revealed by the genetic analyses of archived otolilths

Alexandra Valentin, Don Power, and Jean-Marie Sévigny

Sebastes fasciatus and *S. mentella* were traditionally managed as one species in Atlantic Canada because of close morphological resemblance. In 1995, Unit 1 (Gulf of St. Lawrence) was placed under moratorium owing to stock collapse, whereas Unit 2 (Laurentian Channel) continues to support a fishery. From 1995, research efforts focused on the species identification and stock structure issues. It is now recognized that Units 1 and 2 correspond to (i) an area of introgressive hybridization between the two species and (ii) a single biological population of each species. In addition, redfish is characterized by extensive variability of recruitment with tractable pulses that generally occur at an interval of 5–12 years. However, strong recruitment has not been observed in Unit 1 since the beginning of the 1980s. Moreover, some year classes that appeared strong at young ages in research surveys subsequently disappeared before contributing to the fishery in Unit 1 and contributed only marginally in Unit 2. A recent genetic study based on DNA analyses of archived otoliths demonstrated that recruitment mechanisms are different between the two species. This study demonstrated that the last strong year class (i.e. y-c 1980) that has supported the fishery in Unit 1 belonged to *S. mentella* and expressed the genetic signature of Units 1 and 2. Strong year classes that have disappeared before contributing significantly to the fishery belonged to *S. fasciatus*. These year classes originated from the southern margin of the Grand Banks, suggesting possible interactions with other management units.

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Theme Session B

Ecological response of phytoplankton and other microbes to global change processes in ocean basins, shelf seas, and coastal zones

ICES CM 2011/B:01   Withdrawn

ICES CM 2011/B:02

Towards an ecological status report for phytoplankton and microbial plankton in the North Atlantic

William K. W. Li, Xosé Anxelu G. Morán, and Todd D. O'Brien

The ecological links between the physical environment of the ocean and the mid to upper trophic levels of pelagic foodwebs are the lower trophic levels comprising microbial primary producers (phytoplankton) and microbial secondary producers (bacterioplankton, heterotrophic protists). In the North Atlantic Ocean, standardized annual average anomalies of oceanic hydrography (WGOH) and of mesozooplankton (WGZE) derived from time-series observations at monitoring sites located across the entire basin provide long-term trends suitable for discerning climate variability and change. Here we (Working Group on Phytoplankton and Microbial Ecology, WGPME) describe work in progress aimed at establishing contemporaneous trends at similar scales of space and time for phytoplankton and other microbial plankton (and associated variables such as inorganic nutrients) with a view towards understanding climatic and anthropogenic signal propagation from the abiotic environment to higher trophic levels.

Keywords: ecological status, microbial plankton, phytoplankton, WGPME.

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ICES CM 2011/B:03

Enrichment of highly competitive omnivorous cercozoan nanoflagellates from coastal Baltic Sea waters

Kasia Piwosz and Jakob Pernthaler

Coastal waters are home to myriad microbes that are responsible for much of the metabolism of the ecosystem. However, this habitat is vulnerable to human impact and threatened by global changes. Therefore, it is crucial to understand processes and interspecies interactions within the microbial foodwebs because they control the occurrence and activity of the microorganisms. Free-living nano-sized flagellates are important bacterivores in aquatic habitats, but some forms can also be omnivorous (i.e. prey on both bacteria and eukaryotes). We followed the response of an uncultured group of omnivorous cercozoan nanoflagellates from the Novel Clade 2 (Cerc_BAL02) to experimental foodweb manipulation in samples from the Gulf of Gdańsk (southern Baltic Sea). Seawater was either prefiltered through 5 μm filters to exclude larger predators of nanoflagellates (P-treatment) or prefiltered and subsequently 1 : 10 diluted with sterile seawater (P+D-treatment) to stimulate the growth of both flagellates and bacteria. Initially, Cerc_BAL02 were rapidly enriched under both conditions. They clearly selected for eukaryotic prey but also readily ingested bacteria, and they were highly competitive at low concentrations of both food types. However, these omnivores were later only successful in the P+D-treatment, where they eventually represented almost one-fifth of all aplastidic nanoflagellates. By contrast, their numbers stagnated in the P-treatment, possibly as a result of top-down control by a concomitant bloom of other, unidentified flagellates. In analogy with observations about the enrichment of opportunistically growing bacteria in comparable experimental set-ups we suggest that the small numbers of

omnivorous Cerc_BAL02 flagellates in the waters of the Gulf of Gdańsk might be related to their vulnerability to grazing pressure.

Keywords: Baltic Sea, cercozoa, intra-guild predation, omnivory.

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ICES CM 2011/B:04

Coastal bacterioplankton in the southern Bay of Biscay: changes in abundance and cell size at seasonal and interannual scales

Xosé Anxelu G. Morán, Laura Díaz-Pérez, Enrique Nogueira, and Antonio Bode

Effects of global warming on the abundance and cellular properties of planktonic heterotrophic bacteria have been traditionally overlooked. We analyse here the temporal patterns in the distribution, abundance, and size of heterotrophic bacterioplankton after 9 years of monthly samplings in the southern Bay of Biscay continental shelf off Xixón and A Coruña (Spain). Total abundance ($0.2–1.5 \times 10^6$ cells mL^{-1}) exhibited a unimodal distribution in A Coruña, with maxima in August and minima in February, and a bimodal distribution in Xixón, with maxima in April and October and minima in January and July. The weak temperature-dependence in Xixón can be partly explained by summer resource limitation. We also examined the contribution of the two widespread groups detected by flow cytometry—bacteria with low and high nucleic acid content (LNA and HNA, respectively). HNA cells are usually larger and more dependent on phytoplankton than their LNA counterparts. The contribution of HNA cells exhibited a distinct seasonality in Xixón, with maxima (>80%) in April and minima in summer (~40%). Contrasting long-term trends in bacterial biomass were detected at the two sites, decreasing in A Coruña and increasing in Xixón, where the mean annual value was 50% higher by 2010. Although tight associations with warming are precluded by lack of extended records, we demonstrate that increases in abundance were accompanied by decreases in HNA cell size, as predicted by the temperature–size rule. Whether or not heterotrophic bacteria will become increasingly important in a warmer future has profound implications for biogeochemical carbon cycling in the oceans.

Keywords: bacterioplankton, North Atlantic, ocean warming, time-series.

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ICES CM 2011/B:05

Data archival mechanisms at the Alfred-Wegener Institute: examples from the Helgoland Roads long-term plankton monitoring site

Alexandra C. Kraberg, Merja Schlüter, and Karen H. Wiltshire

The Alfred-Wegener Institute (AWI) generates extensive, long-term biological and environmental data in different habitats from the Antarctic to Arctic. Importantly many long-term monitoring sites generate parallel datasets for plankton and benthos along with environmental data facilitating comparative analyses. An excellent example is Helgoland Roads. Since 1962 phytoplankton has been collected on a work-daily basis. In addition, inorganic nutrients, Secchi depth, temperature, and salinity are also determined. Since 1975, the phytoplankton dataseries has also been augmented by zooplankton counts. These long-term records demonstrate that surface water temperature has risen by 1.7°C, the water has become slightly more saline and the Secchi depth increased. These changes are also reflected in changes in the temporal dynamics of the plankton community. The diatom *Guinardia delicatula*, which used to be a typical summer species, is now appearing earlier in the year and into autumn, whereas the "winter species" *P. sulcata* is becoming more and more important. Some of these changes occurred very abruptly and provide evidence of a potential regime shift in the late 1970s. A third diatom, *Mediopyxis helysia*, unknown from Helgoland until recently, is now forming massive blooms, possibly influenced by the occurrence of

salinity anomalies. In this presentation we will summarize the results of the numerical analyses of the Helgoland Roads dataseries but will also describe the AWI data management strategy which ensures that these data are accessible to the scientific community at large, and facilitates that data for large-scale comparative analyses can easily be identified.

Keywords: none.

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ICES CM 2011/B:06

Effect of experimental additions of black carbon on nutrients elements and planktonic marine communities

Aurore Trottet, Xavier Mari, Eric Fouilland, Jean-Pascal Torreton, Thierry Bouvier, Corinne Bouvier, Chu Van Thuoc, Cao Thi Thu Trang, and Nghiem Ngoc Minh

Black carbon (BC) is a form of aerosol emitted as soot during biomass burning or coal and diesel combustion. BC is associated with other aerosols (sulfates, nitrates, organic acids, etc.) and contributes to global warming and climate change. Studies have also demonstrated that BC may alter sedimentation and microbial processes in the water column. The aim of this study was to determine the effect of different types of BC (diesel particulate matter, DPM; urban dust, UD; rice char, RC) on (i) the availability of dissolved nitrogen (DIN and DON) and organic carbon (DOC and POC) and (ii) the growth of cultivated phytoplanktonic key species and bacterial communities isolated from an anthropogenically perturbed area (Halong Bay). The availability of N and C was measured before and 24 h after the addition of different BC concentrations (1–10 mg l^{-1}) in nutrient-enriched artificial seawater. The effect of the same range of BC addition was also tested on the growth of phytoplanktonic species and bacterial communities using optical density increases over a few days. At 10 mg l^{-1}, a reduction of DIN availability was observed with DPM and RC addition. An increase of DIN availability was measured with UD addition. Significant growth inhibition (20–45% inhibition after 3 d) was observed after RC addition for two species of green algae (*Dunaliella tertiolecta*, *Nannochloris* sp.) and a member of the Cyanophyceae (from 1 mg l^{-1}). Significant growth inhibition was also observed after UD addition for green algae, whereas DPM addition seemed to have no effect on all species. These results demonstrate that BC affects nutrient concentrations and planktonic growth differently depending on its composition.

Keywords: bacterio-/phytoplankton, black carbon, Halong Bay, nutrient.

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ICES CM 2011/B:07

Effects of sewage effluent diversion on nutrient and phytoplankton dynamics in French Mediterranean lagoons: results from a ten-year survey

B. Bec, N. Malet, L. Dubroca, D. Munaron, A. Vaquer, and Y. Collos

Along the French Mediterranean coast, many lagoons are subjected to increasing anthropogenic pressure and appear to be particularly sensitive to climate change. Since 2001, the trophic state of seven lagoons has been followed based on monitoring of physical, chemical, and biological variables of the water column. Initially, summer phytoplankton chlorophyll *a* (Chl *a*) maxima reached 20–390 µg l^{-1} depending on the lagoon. In 2005, the installation of a 10-km offshore outfall system diverted secondarily treated waters from the sewage treatment plant of the Montpellier district (450 000 inhabitants) and led to a major decrease in nutrient input to the lagoons in the vicinity of the previous outfall. This anthropogenic decrease also corresponded to a natural decrease related to three consecutive dry years, limiting nutrient inputs from point and non-point sources. Total nitrogen (TN), phosphorus (TP), and suspended Chl *a* were used as integrating

variables allowing us to show an improvement in lagoon water quality. Five years after implementation of the outfall, summer concentrations of TN and TP were decreased by factors of 1.5 to 4, and Chl *a* concentrations were decreased by factors of 10–55, depending on the lagoon. In response to decreased anthropogenic inputs, the structure of the phytoplankton communities, in terms of pigment composition (diatoms, dinoflagellates, cyanobacteria), densities (pico- and nanoplankton), and diversity, has also changed. The Chl *a* decrease in particular was associated with a decrease in diatom pigment markers and an increase in dinoflagellate pigment markers.

Keywords: lagoons, Mediterranean, phytoplankton, water quality improvement.

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ICES CM 2011/B:08

Observed changes in the marine phytoplankton community in the northeast of Scotland over the last decade

Eileen Bresnan, Sarah L. Hughes, Sheila Fraser, Ana-Louisa Amorim, Kerry Smith, Pam Walsham, Lynda Webster, Barbara Berx, George Slesser, Jens Rasmussen, and Steve Hay

Marine Scotland—Science operate a long-term monitoring station 5 km offshore from Stonehaven in the northeast of Scotland (56°57.8′N 02°06.2′W). Temperature, salinity, nutrients, phytoplankton, and zooplankton are monitored on a weekly basis. A number of changes in the phytoplankton community have been observed since the time-series began in 1997. During the early part of the time-series the spring bloom was dominated by *Chaetoceros* species. Since 2001, very dense blooms of this genus are no longer observed and *Skeletonema* has become more abundant. From the beginning of the decade until 2004, chlorophyll *a* values during the spring bloom were reduced. During this time a change in the species dominating the summer *Dinophysis* population was also observed. This change occurred during a period when a negative anomaly was detected in the salinity data collected at the Stonehaven site and in offshore time-series operating in the North Atlantic and Fair Isle inflow. The influence of physical parameters on the phytoplankton community at this site will be discussed.

Keywords: dinoflagellates, northern North Sea, phytoplankton, spring bloom.

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ICES CM 2011/B:09

Comparison of temporal variations in chlorophyll *a* environmental parameters off the southeastern Black Sea coast during the periods 1993–1994 and 2001–2002

Ali Muzaffer Feyzioglu and Ulgen Kopuz

The Black Sea coastal ecosystem is very dynamic. During the last two decades, fisheries have been affected by regime shift, a changing ecosystem structure, and overfishing. As in all aquatic ecosystems, phytoplankton is an important factor in the Black Sea. A monitoring programme for phytoplankton biomass helps us to understand ecosystem dynamics by using bottom-up control models. In the present study we try to understand and compare phytoplankton biomass dynamics and responses to environmental parameters during the periods 1993–1994 and 2001–2002. For this purpose, the station was fixed 8 km from the coastline and water samples collected monthly. Our results showed that Secchi disc depth was greater in the 2001–2003 sampling period than that in the 1993–1994 sampling period. This increase demonstrated that light penetration increased but attenuation of light decreased. Chlorophyll *a* values, used as an indicator of phytoplankton biomass, were higher in 1993–1994 and decreased in the 2001–2002 samples. Diatom biomass decreased and species composition also changed in 2001–2002. In contrast, diversity of dinoflagellate species increased.

Keywords: Black Sea, chlorophyll *a*, phytoplankton.

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ICES CM 2011/B:10

Phytoplankton phenology in the Northwest Atlantic: observation and modelling

Rubao Ji

Growing evidence demonstrates that climate-related changes in forcing factors are driving shifts in plankton phenology (e.g. phytoplankton blooms). The objective of this study is to (i) quantify the spatial and interannual phytoplankton phenological variability on the Northwest Atlantic Shelf, with a focus on the Nova Scotian Shelf and Gulf of Maine region, using satellite ocean color data; (ii) identify dominant links to forcing through comparison with concurrent multi-platform ocean satellite and *in situ* survey datasets; and examine the processes and mechanisms controlling this variability by hypotheses testing using a state-of-the-art coupled biological–physical numerical model. The major local and external forcing factors include (i) the inflow of upstream shelf water of high latitude origin, (ii) penetration of offshore slope water, (iii) heat flux to the sea surface, and (iv) winds. The coupled model is used to examine the importance of bottom-up control (through changes in physical and nutrient environments) relative to top-down control (through changes in grazers), on phytoplankton phenology. The results suggest that among many forcing factors, freshening plays a major role in phytoplankton phenological variability on the Northwest Atlantic Shelf.

Keywords: modelling, Northwest Atlantic, observation, phenology, phytoplankton.

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ICES CM 2011/B:12

Changes in chlorophyll *a* concentrations in the Baltic Proper

Anetta Ameryk, Mariusz Zalewski, and Marianna Pastuszak

Apart from the light conditions, changes in nutrient concentrations and in temperature have crucial impact on phytoplankton growth. Relatively simple measurements of chlorophyll *a* concentrations provide information on phytoplankton biomass in water. Measurements of seasonal concentrations of chlorophyll *a*, nutrients, temperature, and some other environmental parameters were carried out in the southern Baltic Proper in 1977–2010; the region of study encompassed the Pomeranian Bay, the Bornholm Basin, the Gdańsk Basin (including the Gulf of Gdańsk), and the southern Gotland Basin. Over the first 15 years of the studies, measurements of chlorophyll *a* concentrations were carried out using spectrophotometers, whereas in subsequent years two parallel techniques were used: the spectrophotometric and the fluorometric one. The period of our studies was characterized by an increase in both the temperature and the nutrient concentrations in the Baltic surface waters, and that must have caused the observed increase in chlorophyll *a* concentrations. Heavy blue-green algae blooms recorded over recent years in the Baltic surface waters have resulted in an increase in chlorophyll *a* concentrations in the surface water layer. The estimations demonstrate that in the southern Baltic the increase amounted to ca. 2% annually over the last 15 years. The spring phytoplankton bloom is observed earlier in the western part of the region studied.

Keywords: Baltic Proper, chlorophyll *a*, nutrients, temperature.

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ICES CM 2011/B:14

Ecological changes in the Iceland Sea

Hafsteinn G. Gudfinnsson and Sólveig R. Ólafsdóttir

The Iceland Sea was sampled for hydrography, nutrients, and phytoplankton in nine cruises from February to November during the years 2006–2008. Concentration of nutrients prior to the growth season is dependent on the mixed-layer depth in winter and becomes highest at the end of the winter mixing (March–April). Differences in the nutrient budget were found east and west of the Kolbeinsey Ridge, with lower silicate concentrations on the eastern side in general. This leads to an early silicate depletion after the spring diatom bloom. Nitrates and phosphates were found in low concentrations in the euphotic zone on the eastern side of the ridge in July 2006 and August 2007 but were exhausted at the same time in the western part. In contrast, these two were totally exhausted in the whole Iceland Sea in August 2008. Phytoplankton growth starts in April within a deep mixed layer (100 m). The spring bloom maximum was found in late May 2006 with phytoplankton spread only within the stratified layer. Phytoplankton biomass and production decreases in summer as the stratified layer gets stronger and shallower and nutrients are strongly reduced or exhausted. Diatoms seem to be the main producers in spring but small flagellates seem to be very important in the ecosystem throughout the growth season, as well as dinoflagellates. The mean daily primary production at the 69°N transect varied between 0.2 and 1.1 g m^{-2} d^{-1} through the growth season. Primary production in late summer is probably based on regenerated nutrients.

Keywords: Iceland Sea, nutrients, phytoplankton biomass, primary production.

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ICES CM 2011/B:15

Use of phytoplankton for the monitoring and assessment of ecological status of the Russian parts of the Curonian and Vistula Lagoons (Baltic Sea)

Olga Dmitrieva

On basis of recent developments, phytoplankton was used to assess of ecological status of two different water bodies according to the European Water Framework Directive (WFD, 2000/60/ES). The data were collected during a monitoring study carried out on the ten monitoring stations in coastal lagoons of the southeastern Baltic (Curonian and Vistula Lagoons). The data were sampled monthly from April to November in 2002–2010. The abundance data of indicator species and different characteristics of assemblages (diversity of algae and species richness, biomass, and abundance of different phytoplankton functional groups) were analysed on the basis of spatial and temporal gradients. Results revealed differentiation in the ecological status of the lagoons as assessed by the phytoplankton indicators, which reflects the environmental condition of the ecosystems and their responses to anthropogenic pollution and eutrophication.

Keywords: Curonian and Vistula Lagoons, ecological quality assessment, indicator species, phytoplankton, Water Framework Directive.

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ICES CM 2011/B:16

Heterotrophic nanoflagellate and bacteria dynamics in the southeastern Black Sea during late spring 2010

Ulgen Kopuz, Ali Muzaffer Feyzioglu, and Ertugrul Agirbas

Heterotrophic nanoflagellates (HNF) and heterotrophic bacteria (HB) are major components of the microbial loop in the marine ecosystem. However, little is known about their dynamics and contribution to carbon cycling of the Black Sea ecosystem. To improve our understanding, temporal and spatial changes in abundance and biomass of HNF and HB together with environmental variables were monitored monthly in the southeastern Black Sea during late spring 2010. Seawater samples were taken at 10-m intervals from the surface to 60-m depth at two stations located in neritic and oceanic waters. A Nikon E 600 epifluorescence microscope and image analysis system were used to estimate cell numbers and carbon biomass of HNF and HB. According to our results, HNF and HB abundances range from 3.16×10^2 cells ml^{-1} to 14.08×10^3 cells ml^{-1} and 1.12×10^6 cells ml^{-1} to 3.62×10^6 cells ml^{-1}, respectively. Although the maximum cell number of HNF was present in coastal surface waters in May, the maximum abundance of HB was found above the thermocline in stratified waters in June during the sampling period.

Keywords: heterotrophic bacteria, heterotrophic nanoflagellates, Black Sea.

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ICES CM 2011/B:17

Mesoscale variability of chlorophyll *a* in North Sea coastal waters

Anouk N. Blauw, Elisa Benincà, Remi W. P. M. Laane, Naomi Greenwood, and Jef Huisman

Phytoplankton variability is mostly analysed on seasonal and decadal time-scales. Variability at shorter time-scales is typically regarded as noise in such analyses. Algal bloom phenomena often develop at shorter time-scales. Better understanding of short-term phytoplankton variability is needed both to reduce the noise in seasonal and trend analyses and to predict blooms. We have analysed variability at time-scales shorter than a month in time-series of chlorophyll *a*, suspended particulate matter, salinity, and temperature from four mooring sites in the North Sea. The dataseries cover several years at an hourly resolution. We used wavelet analysis to characterize time-scales of variability and correlations between variables. We compared how time-scales and correlations change with the seasons and between sites. Turbulent mixing by tides and wind appears to be the dominant factor controlling mesoscale variability for all four variables. Dominant time-scales of chlorophyll *a* variability are 6 h, 12 h, and 15 d in our data, which correspond to the time-scales of tides. Most of the time chlorophyll *a* variability is positively correlated with variability of suspended matter concentrations. This suggests that sinking and vertical mixing have a stronger effect on phytoplankton variability than light limitation of growth rates, except during the start of the spring bloom.

Keywords: chlorophyll *a*, North Sea, variability.

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ICES CM 2011/B:18

Microbial dynamics and response to a changing polar ocean climate

Richard. B. Rivkin, Kimberley Keats, and Michelle Hale

Marine heterotrophic microbes (i.e. prokaryotic bacteria and eukaryotic protozoa) dominate the fluxes of organic carbon in the upper ocean, where they typically remineralize >75% of primary production back to CO_2. Although these small organisms and their interactions have been well

studied in low latitudes, there is far less known about their distribution, community structure, activity and foodweb interactions, and their impact on upper open biogeochemistry in high latitudes. Despite the low temperatures, microbial processes are highly active and the rates of growth and elemental transformations are similar to those in lower latitudes. Profound climate changes are predicted for high-latitude regions. These include altered temperatures, ice cover, mixing and nutrient supply. These changes will influence the distribution of ice, physiochemical, biological, and foodweb properties. In the present study, we report on decade-scale field measurements in the eastern Canadian Arctic, and a meta-analysis of a large database on heterotrophic microbes from polar oceans. Using the results, and conceptual and analytical models, we examine the influence of predicted changes in the climate in polar regions on microbial activity, their mediation of upper ocean biogeochemistry, and potential feedbacks on the cycling and flux of climate active properties.

Keywords: bacteria, biogeochemistry, climate, foodwebs, microbial dynamics, nutrients.

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ICES CM 2011/B:19

Factors controlling the onset of spring blooms in the German Bight 2002–2005: light, wind, and stratification

Tian Tian, Jian Su, Goetz Floeser, Karen Wiltshire, and Kai Wirtz

Our quantitative understanding of the strong spatial and temporal variability of coastal algal spring blooms is currently limited by the presence of changing physical forcing factors (e.g. tides, wind, precipitation, and river run-off) on various spatio-temporal scales. In this study, we reconstructed the spring bloom dynamics of a shallow coastal marine ecosystem from 2002 to 2005 by combining three continuous time-series along a nearshore to offshore transect in the German Bight (GB). Nearshore, the timing and magnitude of the bloom remained nearly constant between years. At locations further offshore, bloom onset was related to water provenance, as expressed by salinity and the position of the tidal front. There, we could distinguish two regimes: (i) Under prevalence of turbid coastal waters, the bloom started early before stratification; Chl : C ratios increased with increasing mean water column irradiance, I_m. (ii) If the transitional water originated from the open North Sea, the bloom followed the stratification in late spring and depended less on I_m; the Chl : C ratio was inversely related to I_m and fluctuated widely. In both cases, we found a striking coincidence of wind-slack events (below 5 m s^{-1}) and bloom onset. In particular, a biweekly period with low wind below 5 m s^{-1} on average favoured the formation of a pronounced bloom. Our study demonstrates the critical role of mesoscale spatial variations (i.e. lateral mixing and stratification) for coastal plankton dynamics in winter–spring.

Keywords: Helgoland Roads, nearshore–offshore gradient, spring bloom, tidal front, turbidity, wind.

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ICES CM 2011/B:20   Poster

Changes in the phytoplankton of Vyborg Bay (eastern Gulf of Finland) in the area of Port Vysotsk construction

Olga B. Maximova

Phytoplankton is one of the most important indicators of ecological status of a water body. In recent decades, active hydroengineering works have been carried out in Vyborg Bay. During the first period of work in 1997–1999, phytoplankton quantitative development in the water area near the construction of Port Vysotsk corresponded with levels in the mesotrophic water body. Phytoplankton abundance varied from 39 to 79 million cells l^{-1} and biomass was 2–4 g m^{-3}. Blue-green algae constituted the major (50%) portion of biomass. Chlorophyll *a* concentration was 8–

9 mg m^{-3}. In 2008–2010 in this area phytoplankton abundance varied from 70 to 193 million cells l^{-1} and biomass was 5–10 g m^{-3}. The blue-green algae constituted ca. 80% of total biomass. The freshwater green algae *Dictyosphaerium pulchellum*, *Sphaerocystis schroederi*, and *Tetraedron* spp. had disappeared. Chlorophyll *a* concentration was in the range 15–30 mg m^{-3}. Thus, in recent decades the phytoplankton development in the study area increased to eutrophic levels. This increase was accompanied by an enhancement of the role of blue-green algae, while the role of freshwater green algae declined. These changes in phytoplankton were probably caused by natural factors (more intensive inflow of salt- and nutrient-rich deep waters from western Gulf of Finland) as well as by anthropogenic impacts mainly connected with additional nutrient supply from the bottom during hydroengineering works.

Keywords: Baltic Sea, eutrophication, hydroengineering works, phytoplankton.

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ICES CM 2011/B:21   Poster

Semi-decade dynamic of the summer phytoplankton community from the southern Baltic Proper

Janina Kownacka and Sławomira Gromisz

Phytoplankton samples were collected in summer 2005–2010 during research cruises of the RV "Baltica" in the southern Baltic Proper with the aim of investigating changes in the summer phytoplankton community in connection with environmental factors. The similarity of taxonomic composition between samples was estimated by hierarchical agglomerative clustering analysis according to the Bray–Curtis measure of similarity using PRIMER v.6 software. Two groups of samples were identified at a similarity level of 40%. The first group included 84% of the stations and was characterized by dominance of nanoplanktonic flagellates (cryptophytes, *Pyramimonas* spp., unidentified flagellates), diatoms (*Actinocyclus octonarius*, *Chaetoceros danicus*), and *Mesodinium rubrum*. Mean phytoplankton biomass was 360 µg l^{-1}, with maximum of 831 and minimum of 97 µg l^{-1}. Water temperature ranged from 14.4°C to 20.5°C. The second group consisted of all samples from July 2005 and samples from the Gdańsk Basin collected in August 2010. In this case water temperature was generally higher, ranging from 16.6°C to 23.3°C. Blue-green algae, such as *Aphanizomenon* sp. and *Nodularia spumigena*, dominated the phytoplankton community. The mean biomass value for this group was 765 µg l^{-1}, with the highest biomass value of 2581 µg l^{-1}, which was also the highest found in all investigated material. Aggregation of 84% samples from five years of investigations into one group with high taxonomic similarity suggests that the summer phytoplankton community was homogeneous and "conservative" over a large area of the Baltic Proper, and in the period of last semi-decade seemed to be unaffected by the ongoing global changes.

Keywords: biomass, clustering analysis, phytoplankton, southern Baltic, summer community.

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ICES CM 2011/B:22   Poster

Chromatic adaptation in three Baltic picocyanobacteria of the genus *Synechococcus*

Sabina Jodłowska

Experiments were carried out on three different picocyanobacterial strains from the genus *Synechococcus*: BA-120, BA-132, and BA-124. The strains were isolated from the coastal part of the Gulf of Gdańsk (southern Baltic) and are maintained as unialgal cultures in the Culture Collection of Baltic Algae at the Institute of Oceanography in Gdynia (http://ocean.ug.edu.pl/~ccba/). The *Synechococcus* strains were exposed to light from different parts of the spectrum: red, green, blue, and white. To determine the capacity of the investigated strains for chromatic adaptation the

concentration of photosynthetic pigments and photosynthetic activity were analysed. Chlorophyll *a*, carotenoid, and phycobilin concentrations were determined spectrophotometrically and the composition of carotenoids was analysed by HPLC. The measurements of photosynthesis rate were conducted using a Clark oxygen electrode, and chlorophyll fluorescence was measured using pulse amplitude modulation (PAM). Photosynthetic activity was characterized by the course of photosynthetic light–response curves (P–E), which produce the compensation (P_c) and saturation irradiances (E_k), the initial slope of photosynthetic curves (α), maximum rate of photosynthesis (P_{max}), and dark respiration (R). The values of the chosen fluorescence parameters were also analysed. F_v/F_m (maximum PSII quantum efficiency) and Φ_{PSII} (effective PSII quantum efficiency) provide additional information concerning the photosynthetic apparatus. Each of the strains indicated the best growth and the best photosynthetic activity in full spectrum light. However, when different ranges of the light spectrum were compared, BA-120 and BA-132 (both phycoerythrin-rich) strains exhibited favourable growth in green light, whereas for BA-124 (phycocyanin-rich) red light was better for growth.

Keywords: Baltic, chromatic adaptation, picocyanobacteria, *Synechococcus.*

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ICES CM 2011/B:23   Poster

A study of toxic effect of five ionic liquids on Baltic microalgae

Małgorzata Chobot and Adam Latała

Ionic liquids are gaining attention as a new class of solvents in different chemical processes. Although their physical and chemical properties are promising for industry, however, because of their high stability and solubility in water, they can become persistent pollutants. The role of algae in aquatic environment is fundamental. In addition, primary producers are very sensitive to chemical compounds. In this study we investigated whether or not anions of imidazolium-based ionic liquids have a toxic effect on algae strains. Three species were tested: a green alga (*Chlorella vulgaris*), a diatom (*Skeletonema marinoi*), and a cyanobacterium (*Synechococcus* sp.). Measurements of growth in different concentration of toxicants were made. The results demonstrate that all the analysed ionic liquids are toxic below 100 mg l^{-1}. The EC$_{50}$ values were estimated. The most sensitive were the diatom and cyanobacterium species. This indicates that the ionic liquids tested are potentially dangerous to aquatic organisms.

Keywords: Baltic microalgae, cyanobacteria, growth inhibition toxicity tests, ionic liquids.

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ICES CM 2011/B:24   Poster

The toxic effect of nanosilver on Baltic green algae, *Chlorella vulgaris*, and cyanobacteria, *Synechococcus* sp.

Marta Brucka and Adam Latała

For many years, silver has been extensively used for its antibacterial effects. Nowadays, with the development of nanotechnology, silver in the form of nanosilver is being widely used in industry in many products for everyday use. With this huge interest, nanosilver will eventually appear in reservoirs, hence it is important to assess the effect of this compound on marine microalgae. In this study growth measurements and modulated pulse amplitude modulation (PAM) fluorometry were used to investigate the toxic effect of nanosilver on Baltic green algae (*Chlorella vulgaris*) and cyanobacteria (*Synechococcus* sp.). The number of cells and fluorescence parameters were analysed after algae were treated with various concentrations of nanosilver and after different cultivation periods (2 h, 72 h, and one week). Nanosilver significantly influenced the fluorescence and cell numbers of analysed species. The most useful fluorescent parameter for toxicity estimation of

nanosilver was F_0 (fluorescence minimal). It is possible that the dissipation of light caused by nanosilver is the main reason for growth inhibition. This study demonstrated that the picocyanobacteria *Synechococcus* sp. was more sensitive to the influence of nanosilver than the green algae *C. vulgaris*. For *C. vulgaris* after 7 d the highest applied concentration (10 µM) caused a decrease of F_0 to 20%, whereas for *Synechococcus* sp. it fell to 12% compared with control. The values of the examined parameters depended on the concentration of nanosilver used and the length of exposure. The observed drop in the parameter values provides information about the stressful effect of toxicant on plants.

Keywords: Baltic microalgae, chlorophyll *a* fluorescence, cyanobacteria, nanosilver.

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ICES CM 2011/B:25   Poster

Temperature and light effects on photosynthesis and respiration—implications for phytoplankton survival during deep convection

Bettina Walter, Janna Peters, Justus van Beusekom, and Michael St John

The winter in the North Atlantic is dominated by deep convection, during which phytoplankton cells are exposed to short, ephemeral intervals of light coupled with low temperatures. Photosynthesis as well as dark respiration are both temperature dependent and their ratio largely determines the survival of phytoplankton cells. An increase of water temperature caused by climate change will affect the deep convection by decreasing the depth of the mixed layer as well as increasing water temperatures within the mixed layer. In order to better understand the effect of temperature increases on phytoplankton survival, deep convection was simulated in laboratory experiments by culturing algae under different light–dark cycles and temperatures. Continuous oxygen measurements of diatom monocultures were used to determine the compensation depth (where net oxygen production is zero) at different temperatures and under different light–dark cycles. Our first results indicate that photosynthesis is more sensitive to changes in temperature than dark respiration. This indicates that an increase in water temperature could support phytoplankton growth during winter and hence lead to a larger standing stock of phytoplankton that ultimately drives the spring bloom. Furthermore, following this approach we assessed the potential for acclimatization by phytoplankton to low temperatures and long periods of darkness. Our results illustrate that although phytoplankton growth rates acclimatized after a few days, no signal was detectable in oxygen production or consumption.

Keywords: deep convection, North Atlantic, photosynthesis and respiration, temperature.

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ICES CM 2011/B:26   Poster

Shift in the dominant cyanobacteria species complex in the Curonian Lagoon, Baltic Sea in the 2000s

Evgenia Lange

The Curonian Lagoon is a coastal waterbody known to have the highest level of trophic state in the Baltic Sea. The phytoplankton in the Russian part of the lagoon was studied at 15 standard stations as part of the AB IORAS monitoring programme in 2001 and 2005–2010. The structural characteristics of the summer phytoplankton have changed markedly in the 2000s. These changes are primarily in the composition of the dominant species complex, an increase in the frequency and duration of algal blooms of the potentially toxic cyanobacteria genera *Aphanizomenon*, *Anabaena*, *Microcystis*, *Planktothrix*, and *Woronichinia*. Earlier, the cyanobacteria *Aphanizomenon flos-aquae*, often together with *Microcystis aeruginosa*, had prevailed in the summer–autumn period, but now

Planktothix agardhii periodically becomes a major dominant species. In 2007 it made up ca. 50% of phytoplankton biomass, whereas *Aph. flos-aquae* was less than 1%, although temperature conditions were favourable to its vegetation. For comparison, during mass development of *Aph. flos-aquae* in 2001 and 2002, when zones of hyperbloom were formed all over the bay, including the Lithuanian area, the phytoplankton biomass exceeded $1000 \, g \, m^{-3}$. *P. agardhii* is known to be able to displace other cyanobacteria, including *Aph. flos-aquae*. Its vegetative growth does not depend on TN : TP ratio, but the development of N_2-fixing *Aph. flos-aquae* reaches the highest biomass values only when TN : TP < 16 : 1. Studies of winter phytoplankton of the Curonian Bay in the freezing-over period in February 2010 revealed development of *P. agardhii* occurring everywhere, whereas there were almost no *Aph. flos-aquae* in samples. This indicates the perennial character of *P. agardhii* vegetation at present. In the hypertrophic Curonian Lagoon mass development of potentially toxic cyanobacteria is a risk factor for the stability of the whole water ecosystem.

Keywords: algae bloom, Baltic Sea, coastal lagoon, cyanobacteria, *Planktothrix agardhii*.

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ICES CM 2011/B:27   Withdrawn

Theme Session C

Harmful algal blooms in the Baltic Sea

ICES CM 2011/C:01

Toxic effect of harmful algae on zooplankton in the Curonian Lagoon (Baltic Sea)

Anna Semenova and Olga Dmitrieva

The Curonian Lagoon is the largest freshwater coastal lagoon in the Baltic Sea. Phytoplankton and zooplankton samples were taken every month from March till November at 5–6 stations in 2007–2010. To distinguish between live and dead organisms zooplankton samples were stained using aniline blue. Dead organisms have been found in populations of all dominating zooplankton species. Both during the period of mass development of harmful cyanobacteria and subsequently, in July–October 2008–2010, the percentage of dead organisms from abundance and biomass measurements of zooplankton increased 5–13 times (up to 8.3–19.4%) compared with the percentage of dead organisms in July–October 2007 (1.5–1.8%), when the biomass of cyanobacteria was very low. The sensitivity of zooplankton taxonomic groups to "blooms" of cyanobacteria and the influence of toxins (according to the increasing proportion of dead organisms in periods of mass developing cyanobacteria) increased in the following order: Cyclopoida→Calanoida→Rotifera→Cladocera. The lowest percentage of dead organisms was observed at the station in which organic pollution, eutrophication, and biomass of harmful cyanobacteria (especially *Microcystis* spp.) were at lower levels. One of the main possible reasons for the increasing proportion of dead organisms in the zooplankton is the influence of toxins from *Microcystis* spp. We obtained a significant correlation between the proportion of dead organisms in the zooplankton and the biomass of toxic *Microcystis* spp. ($r = 0.62$–0.81). Green algae can presumably compensate for the negative effect of cyanobacteria, because the correlation between the proportion of Chlorophyta in the total biomass of phytoplankton and the proportion of dead organisms in the zooplankton was negative ($r = -0.51$–0.60). Thus, the proportion of dead organisms in the zooplankton is a sensitive indicator to determine the influence of harmful algae.

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ICES CM 2011/C:02

The effects of the 2010 Vistula River spring flood in the Gulf of Gdañsk measured by the FerryBox system on the Gdynia–Karlskrona ferry

Elżbieta Łysiak-Pastuszak, Wojciech Kraœeniewski, Katarzyna Sutryk, Hanna Mazur-Marzec, Łukasz Lewandowski, and Włodzimierz Krzymiński

A catastrophic flood event occurred in the Vistula River catchment area in spring 2010. The flood water discharged in several crests into the Gulf of Gdañsk in late May and June. The impact of the flood on the environment of the Gulf of Gdañsk was scrutinized to a very limited extent in the routine monitoring activities of the Institute of Meteorology and Water Management (IMWM), but observations from the FerryBox system operating (since 2007) on a Stena Line ferry commuting daily between Gdynia (Poland) and Karlskrona (Sweden) provided a large amount of information on the response of the phytoplankton community to the additional supply of nutrients. The measurements carried out online by Blue Box revealed a rapid increase in seawater fluorescence/chlorophyll *a* around the beginning of June after the first flood crest discharged on 25 May. In addition to Blue Box autonomous measurements, discrete water samples were collected at predefined geographical locations along the ferry route. Discrete samples were subject to determination of various chemical (nutrients) and biological (chlorophyll *a*) constituents, including phytoplankton species structure (abundance and biomass) and algal toxins (hepatotoxins—

nodularin, microcystin, and neurotoxins (BMMA and anatoxin-a)). Community structure analyses revealed the presence of the potentially toxic species *Aphanizomenon flos-aquae*, *Nodularia spumigena*, and *Anabaena* cf. *torulosa*, though the dominating phytoplankton group was non-def. Unicell and regarding the species—*Eutreptiella* sp. (Euglenophyceae) within the Gulf of Gdañsk whereas diatoms, especially *Chaetoceros simplex*, were abundant in the offshore area along the ferry route. Nodularin concentrations of 0.1–0.2 μl l^{-1} were detected in the Gulf of Gdañsk on 8 and 22 June 2010.

Keywords: algal toxins, FerryBox, Gulf of Gdañsk (Baltic Sea), phytoplankton bloom.

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ICES CM 2011/C:03

The extensive bloom of the alternate stage *Chrysochromulina polylepis* in the Baltic Sea during winter and spring 2007–2008

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During autumn 2007, an unusual increase in a species belonging to the genus *Chrysochromulina* was observed within the national Baltic Sea monitoring programmes. Electron microscopic examination of the blooming species revealed two types of flat scales: small and large scales that resembled those of the alternate stage of C. *polylepis*, but no spine-bearing scales were found. The partial 18S rDNA sequences from the Baltic Sea samples which clustered with C. *polylepis* sequences differed in 0–7 bp ($n = 20$, ca. 1500 bp), corresponding to variability of 0–0.5%. These environmental sequences differed by 1.1–7.1% to other available Prymnesiaceae sequences. Hence, the 18S rDNA sequence data verified the species identification as *C. polylepis*, known to be a HAB species. The number of C. *polylepis* started to increase in October 2007, and at most it accounted for over 80% of the total phytoplankton biovolume in December–January. The species reached bloom concentrations (>1 × 10^6 cells l^{-1}) from March to May 2008 and was observed in the whole Baltic Sea, except the Bothnian Bay, the Gulf of Riga, and the Kattegat. During February–April 2008, 70% of the cells were over 10 μm long. In May, the abundance of 6–10 μm cells increased to 54%, and 4–6 μm cells to 13%. There were no toxic effects of the bloom observed. The mildest ever recorded winter 2007–2008, together with higher than normal salinity in the Baltic Sea, is the hypothesized explanation for the extensive bloom.

Keywords: 18S rDNA, Baltic Sea, *Chrysochromulina polylepis* alternate stage, *Chrysochromulina polylepis* bloom, winter.

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Effects of increased temperature and pCO$_2$ on growth and toxicity of a northern Baltic *Alexandrium ostenfeldii* population

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Dense localized blooms of the toxic dinoflagellate *Alexandrium ostenfeldii* are a recent phenomenon in the low-salinity waters of the Baltic Sea. Proliferation of the species is particularly pronounced at high summer surface temperatures, suggesting that global warming might be one of the factors that promote the expansion of the blooms here. The aim of the present study was to investigate the direct effects of increased temperature and pCO$_2$—as predicted consequences of global change—on a set of strains representing a population of *A. ostenfeldii* from the Åland archipelago in the northern Baltic Sea. Acclimated batch cultures of each isolate were incubated in triplicates for 5–10

generations in a factorial set-up at 20 and 24°C and 385 and 750 ppm applied pCO_2, respectively. Growth was monitored throughout the experiment by measuring chlorophyll *a* fluorescence. Maximum growth rates, calculated from individual growth curves as well as paralytic shellfish poisoning (PSP) toxin concentrations and composition measured for *A. ostenfeldii* at the end of the experiment were determined as response variables. Although increased pCO_2 did not affect the growth of *A. ostenfeldii*, increased temperature significantly enhanced the overall growth of the population, despite notable variability of strain-specific response patterns. The experimental manipulations only affected the total cellular toxin concentrations of a few strains, but consistently altered toxin composition, resulting in an overall promotion of particularly toxic saxitoxin in relation to the other toxin derivatives. Together, these results suggest that future climatic conditions may favour the formation of toxic *A. ostenfeldii* blooms and amplify the potential harmful effects of the toxins.

Keywords: *Alexandrium ostenfeldii*, climate change, phenotypic variability, toxicity.

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PST production of the bloom-forming dinoflagellate *Alexandrium ostenfeldii* in the Baltic Sea and bioaccumulation of the toxins

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The dinoflagellate *Alexandrium ostenfeldii* has started to form late-summer blooms in coastal areas around the Baltic Sea during the last decade. Globally, the species produces spirolides (SPXs) and paralytic shellfish toxins (PSTs), such as gonyautoxins (GTXs) and saxitoxin (STX). In the Baltic, PSTs are produced by *A. ostenfeldii* populations originating in the Finnish, Swedish, and Polish coasts and the Danish Straits, but apparently not further into the North Sea. Outside the Baltic Sea, except for New Zealand, the species primarily produces SPXs but not PSTs. In the Åland archipelago, northern Baltic Sea, PST production by *A. ostenfeldii* was confirmed both in cultured strains isolated from the area and in the field, matching the occurrence of *A. ostenfeldii* cells in the water. Although the PST profile (GTX2, GTX3, STX) seems to be stable in the Baltic strains studied so far, the concentrations of the toxin variants produced by the different strains varies, both within the Åland bloom site and between the different Baltic *A. ostenfeldii* populations. In addition to water samples, PSTs were detected in size-fractioned plankton, moon jelly (*Aurelia aurita*), mussels (*Macoma balthica, Cerastoderma* spp., *Mytilus edulis*), and fish viscera (*Perca fluviatilis, Rutilus rutilus, Alburnus alburnus*) in July–September 2010. PST concentrations in mussel tissue exceeded the WHO safety guidelines for shellfish consumption (80 µg 100 g^{-1}). This is the first evidence of PSTs in Baltic Sea fauna, and indicates that the toxins may bioaccumulate.

Keywords: *Alexandrium ostenfeldii*, Baltic Sea, dinoflagellates, PSP.

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ICES CM 2011/C:06

Cyanobacterial blooms, cyanotoxin production and its bioaccumulation in the southern Baltic Sea

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In this study, cyanobacteria structure and abundance in the Gulf of Gdańsk and the Baltic Proper were examined. The diversity of toxin-producing *Nodularia spumigena* was determined based on the profile of peptides produced by the cyanobacterium. In addition, nodularin concentrations in water, seston, fish, and soft tissues of blue mussels were measured by LC-MS/MS. The results of the studies conducted in 2008–2010 were compared with the data collected in previous years. Our

studies revealed the presence of different *N. spumigena* chemotypes in the Baltic Sea. In general, in the past three years *N. spumigena* biomass has decreased. In the Baltic Proper its maximal value dropped from 1782.86 µg l^{-1} in 2008 to 160 µg l^{-1} in 2010. The biomass of *Synechococcus* spp. started to decline before the peak of *N. spumigena* development, which in turn was followed by the increase in nutrient concentrations. This observation is contradictory to earlier findings indicating a stimulatory effect of N-fixing *N. spumigena* on picocyanobacterium growth. As a consequence of the lesser abundance of *N. spumigena*, nodularin concentrations in all analysed samples were also lower than in previous years. In phytoplankton samples from the Baltic Proper nodularin never exceeded 4 µg l^{-1}. The concentration of the toxin in soft tissues of *Mytilus edulis* was correlated with *N. spumigena* biomass and during cyanobacteria bloom it reached a maximum value of ca. 150 ng g^{-1} dry weight.

Keywords: chemotaxonomy, cyanobacteria, nodularin, southern Baltic Sea.

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ICES CM 2011/C:07

Genetic structure of the toxic dinoflagellate *Alexandrium ostenfeldii* in the Baltic Sea

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The toxic dinoflagellate *Alexandrium ostenfeldii* (Paulsen) Balech and Tangen has recently started to form dense localized blooms in the central and northern parts of the Baltic Sea. To better understand the present expansion of the species in the Baltic Sea, we analysed the genetic structure and gene flow among different spatially and temporally separated populations using 1177 polymorphic amplified fragment length polymorphism (AFLP) markers. Fragment analyses revealed high genetic variability within all examined populations. Spatial populations were significantly differentiated from each other with the highest level of differentiation measured between the southern and northern populations. Such clear geographic structure suggests some degree of local adaptation despite the relatively low level of genetic difference and apparent gene flow among the populations. Cyst and bloom populations from the same location displayed nearly equal genetic structures. The high genetic diversity of the bloom population was unexpected because cyst populations are usually considered to be genetic reservoirs and more diverse than fast-growing bloom populations. We conclude that sexuality in bloom populations might play a more important role than previously thought in maintaining the genetic diversity of the population.

Keywords: AFLP, *Alexandrium ostenfeldii*, genetic structure.

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ICES CM 2011/C:08

Eutrophication and harmful algal blooms in the Curonian Lagoon of the Baltic Sea

Sergey Aleksandrov

The Curonian Lagoon is the largest coastal lagoon of the Baltic Sea, relating to the most highly productive water bodies of Europe. Hydrobiological and chemical monitoring (nutrients, primary production, chlorophyll, and others) was carried out monthly from 1991 to 2010 at 10–12 stations. According to the trophic classification, the Curonian Lagoon may be considered a hypertrophic water body. The initial reason for its hypertrophic state and harmful algal blooms was intensive external nutrient loading in the twentieth century. Multiple reductions of nutrient loading in the 1990s–2000s did not result in considerable improvement. In the Curonian Lagoon, unlike many inland and coastal marine waters, eutrophication has continued, which is reflected primarily in the abundance and production of algae. A possible reason for this ongoing eutrophication is a warming climate (increase in the number of "warm" summers), which in combination with several

other factors (freshwater, slow water exchange, and high nutrient concentrations), stimulates summer "blooming" of cyanobacteria. In the 1990s-2000s "hyperblooms" of cyanobacteria (*Aphanizomenon flos-aquae*, *Microcystis aeruginosa*) were observed more frequently, and the phytoplankton production increased by 60% over 30 years (from 300 to 500 $\text{g C m}^{-2}\text{y}^{-1}$). Phytoplankton production exceeds mineralization of organic matter of 70%. Such a ratio results in the accumulation of organic matter in water and sediments and further eutrophication. Hyperblooms of cyanobacteria have seriously affected the ecosystem of the Curonian Lagoon, leading to the deterioration of water chemical parameters, oxygen deficiency, death of fish in the coastal zone, pollution with cyanobacteria toxins, and symptoms of exposure at different trophic levels (including zooplankton and fish).

Keywords: climate change, Curonian Lagoon, eutrophication, hyperblooms.

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ICES CM 2011/C:09

Overview of harmful algal blooms in the Baltic Sea

Bengt Karlson and Emil Vahtera

Harmful algal blooms have effects on the whole ecosystem of the Baltic Sea. Blooms of nitrogen-fixing cyanobacteria that form surface accumulations have been a recurrent phenomenon. These blooms, which include the toxic species *Nodularia spumigena*, are of great concern to the public and affect tourism in the region in summer. A new phenomenon in the Baltic in recent years is small-scale blooms of the dinoflagellate *Alexandrium ostenfeldii*, which has been demonstrated to produce paralytic shellfish toxins (PST) in the archipelago of Åland. Other toxin-producing dinoflagellates in the Baltic include the genus *Dinophysis*. The fish-killing species *Pseudochattonella farcimen* (Dictyochophyceae) has also been observed in the southern Baltic Proper during the last few years. The first bloom of the genus *Pseudochattonella* in the area was observed in the eastern North Sea–Skagerrak–Kattegat in 1998, where it has subsequently become established. It has affected fish farms in the Danish part of the Kattegat on a few occasions. During the bloom in spring 2011 cell numbers of 70 million l^{-1} were observed. In 2008 and 2009 persistent winter blooms of the harmful species *Chrysochromulina polylepis* (Haptophyta) were observed in the Baltic Proper. No harmful effects were reported. *Prymnesium* sp. has caused fish kills (e.g. in Kyrkfjärden near Stockholm in 1991–1992).

Keywords: Baltic Sea, harmful algae, phytoplankton.

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ICES CM 2011/C:10   Poster

Cyanobacterial neurotoxins in the ecosystem of the Gulf of Gdañsk (Baltic Proper)

Agata Błaszczyk and Hanna Mazur-Marzec

Cyanobacterial neurotoxins, including anatoxins and saxitoxins, constitute one of the most harmful substances synthesized by living organisms. They are produced by cyanobacteria inhabiting all ecological niches. Recently, the neurotoxic amino acid α-*N*-methylamino-L-alanine (BMAA) has been reported to be produced by diverse cyanobacterial taxa. Although controversial, accumulated evidence suggests a link between BMAA and the development of neurological diseases in humans. In the current study, the presence of neurotoxins in bloom samples and isolated strains of cyanobacteria, as well as in soft tissues of blue mussels and fish from brackish Baltic waters were examined. The toxins were analysed by HPLC and LC-MS/MS techniques. Biological activity of BMAA was tested using mouse hippocampus cell lines and three aquatic invertebrates: *Artemia franciscana*, *Thamnocephalus platyurus*, and *Daphnia magna*. Anatoxin-a was detected in 1 out of 27 analysed bloom samples and in 2 isolated strains belonging to the genus *Anabaena*. In this work, the

production of anatoxin-a by the Baltic cyanobacteria was confirmed by LC-MS/MS for the first time. Saxitoxins were not detected in any of the analysed samples. The neurotoxin BMAA was found in 16% field samples, including those containing *Anabaena* and *Nodularia* genera, yet in trace amounts only. The analyses of fish and blue mussel tissues did not reveal the presence of the neurotoxic amino acid. The toxicological tests indicated a moderate effect of BMAA, but only in samples where the concentration of the toxin was higher than 2–3 mM.

Keywords: anatoxin-a, cyanobacteria, Gulf of Gdañsk, α-*N*-methylamino-L-alanine (BMAA).

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ICES CM 2011/C:11   Poster

The role of cyanobacterial peptides in the interactions among microorganisms in the southern Baltic

Anna Toruńska, Monika Błońska, Ewa Kotlarska, Przemysław Kowal, and Hanna Mazur-Marzec

Microorganisms rarely grow individually under natural conditions. They usually form complex multispecies communities. Cyanobacterial blooms are often colonized by heterotrophic bacteria, diatoms, and other protists. All of these microorganisms produce and release compounds that might take part in inter- and intraspecies interactions and shape the structure of the microbial communities. The ecological role of cyanobacterial secondary metabolites, including toxins, remains unexplained. In the present studies, the interactions among the main Baltic bloom-forming cyanobacteria (*Nodularia spumigena*, *Aphanizomenon flos-aquae*, *Anabaena* sp., and *Synechocystis salina*) and coexisting bacteria, were investigated. The results revealed significant activity of intracellular and extracellular compounds produced by *Nostoc* sp. and *Anabaena* sp. towards *N. spumigena* growth. On the other hand, *N. spumigena* (cell extract) clearly inhibited the growth of *Aph. flos-aquae*. Changes in microbial community during the cyanobacterial bloom as well as the biodiversity of bacteria accompanying cyanobacteria were screened by denaturing gradient gel electrophoresis (DGGE). Fifty-six strains of bacteria living on the filaments of the Baltic cyanobacteria were isolated and identified based on 16S rDNA sequence. In addition, the capacity of the Baltic bacteria to degrade oligopeptides produced by *N. spumigena* (including hepatotoxic nodularin) was investigated. Such an activity was found in sediments during all vegetation seasons; the compounds had been degraded within 5–15 days. In addition, an attempt to isolate and identify individual bacterial strains capable of degrading the compounds was made. The biodegradation products were characterized by LC-MS/MS.

Keywords: Baltic bacteria, biodegradation, cyanobacteria, nodularin.

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ICES CM 2011/C:12   Poster

Applying *in situ* measurement to monitoring blue-green algae in the coastal zone

Katarzyna Bucholc, Małgorzata Szymczak-Żyła, Ludwik Lubecki, Przemysław Makuch, and Grażyna Kowalewska

One of the main tasks of the Institute of Oceanology at the Polish Academy of Sciences (IOPAS) within the framework of the WAB Project (Wetlands, Algae and Biogas—a southern Baltic Eutrophication Counteract Project, South Baltic Cross-Border Co-operation Programme 2007–2013) is to set up an *in situ* eutrophication monitoring station in Sopot (Poland, southern Baltic). The station will consist of a multiparameter water quality sonde (water temperature, salinity, dissolved oxygen, turbidity, ORP/pH, chlorophyll, phycocyanin), meteorological station (air temperature, humidity, pressure, solar radiation, wet precipitation, wind direction, velocity), and infrastructure for data transmission, storage, and processing. The *in situ* monitoring will be carried on day and night at short time intervals at one site located in the middle of the beach, and the data registered

by the system will be transferred to the laboratory. In case of changes in phycocyanin and chlorophyll contents registered by the system, samples of water will be collected. Correlation of such a dataset with the environmental conditions will provide the more reliable information needed to identify the factors responsible for blue-green algae blooms at the beach.

Keywords: blooms, blue-green algae, *in situ* monitoring, phycocyanin.

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ICES CM 2011/C:13　　Poster

Histopathological changes in the liver of the round goby (*Neogobius melanostomus*) after treating with nodularin extracts

Ilona Złoch, Marta Jaroszewska, and Mariusz R. Sapota

The adult males of the round goby (caught in the Gulf of Gdańsk) were treated with different doses of nodularin extract (from cells of *N. spumigena*)—50, 500, 1000 µg dm^{-3}. After treatment, both the experimental and control fish were sacrificed. Tissues were removed and fixed in aqueous Bouin's fluid or 10% buffered formalin. After fixation for 24–30 h, tissues were dehydrated through a graded series of ethanol, cleared in xylene, and infiltrated in the paraffin. Sections 5 µm thick were prepared from paraffin blocks by using a rotary microtome. These sections were then stained with Haematoxylin–Eosin and AB/PAS. Histopathological lesions were examined and photographed using an Olympus photomicroscope. In the control group, the liver exhibited a normal architecture and there were no pathological abnormalities, with hepatocytes presenting a homogeneous cytoplasm and a large central or subcentral spherical nucleus. The results revealed that the histopathological changes in the liver were mainly represented by parenchymatous degeneration of hepatocytes with mild necrosis, severe congestion and haemorrhage. The hepatic parenchyma of fish exposed to nodularin exhibited an increase in cytoplasmatic vacuolation. These changes were not dose dependent but varied significantly in time.

Keywords: Gulf of Gdańsk, histopathological changes, nodularin, round goby.

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ICES CM 2011/C:14　　Poster

Harmful algal blooms on inshore fish nursery grounds of the Gulf of Gdańsk

Anna J. Pawelec, Justyna Kobos, and Mariusz R. Sapota

Shallow inshore waters of the Gulf of Gdańsk (down to 1 m depth) are inhabited mainly by marine fish. During a year the appearance of 13 marine, 3 freshwater, and 1 anadromous fish species was noticed. In the summer, when algal blooms are observed, the highest fish numbers were usually caught (up to 27 individuals m^{-2}). These were mostly young individuals of gobies, small sandeel, flounder, three spine stickleback, and occasionally young herring. Studies of blooms reveal that the highest biomass accumulation of *Nodularia spumigena* is very often observed in the shallowest gulf area. Laboratory investigations of the effects of high concentrations of *N. spumigena* on some fish species found that it had a negative influence on the condition and mortality of organisms. Fish are able to abandon regions in which adverse environmental conditions occur, so what is happening during blooms in natural conditions? Does the bloom occurrence have an impact on fish abundance in the shallow zone? In our presentation we address the question of whether the presence of blooms decreases the number of fish in the area or whether they did not respond and escape.

Keywords: abundance, fish, harmful algal blooms, shallow waters.

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ICES CM 2011/C:15   Poster

Allelopathic effects of the cyanobacteria *Nodularia spumigena* on green algae *Chlorella vulgaris* and *Oocystis submarina*

Sylwia Śliwińska and Adam Latała

Allelopathic interactions can occur in all aquatic habitats, but the influence of abiotic factors on the allelopathic effects of cyanobacteria are in many cases unknown. In this study we investigated the influence of allelopathic compounds on the growth, chlorophyll fluorescence, and performance of photosynthesis of two phytoplankton species: *Chlorella vulgaris* and *Oocystis submarina* by addition of cell-free filtrate of *Nodularia spumigena* cultures grown at different temperatures (15, 20, and 25°C). The examined strains were isolated from the Baltic Sea and are maintained as unialgal cultures in the Culture Collection of Baltic Algae (CCBA; http://ocean.ug.edu.pl/~ccba/). To determine the effect of the investigated factors and their interaction with the allelopathy activity of the examined strains, one-way analysis of variance ANOVA was carried out. The rate of photosynthesis was measured using a Clark oxygen electrode and chlorophyll fluorescence was measured fluorometrically using pulse amplitude modulation (PAM). High temperature affected the donor species by increasing its production of allelochemicals. The greatest decrease in growth, chlorophyll fluorescence, and photosynthetic light response curves for the analysed green algae were observed after the addition of cell-free filtrate obtained from *Nodularia spumigena* grown at 25°C. *C. vulgaris* was more sensitive to the influence of cell-free filtrate than *O. submarina*. On the seventh day of the experiment the response of *C. vulgaris* dropped to 78% and *O. submarina* to 89%. These findings suggest that *Nodularia spumigena* may reveal allelopatic activity and that the production of allelopathic substances is influenced by temperature.

Keywords: allelopathy, Baltic Sea, cyanobacteria, green algae.

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ICES CM 2011/C:16   Poster

Will the Baltic Proper get more toxic with less nitrogen? A multifactorial study on the production of the cyanotoxin nodularin

A. Wulff, B. Pattanaik, M. Y. Roleda, K. Garde, and M. Mohlin

Summer blooms in the Baltic Sea are dominated by the cyanobacteria *Nodularia spumigena* and *Aphanizomenon* sp. During the blooms, *N. spumigena* is concentrated at the water surface and exposed to high levels of both photosynthetic active radiation and ultraviolet radiation. *N. spumigena* produces nodularin, a hepatotoxin lethal to wild and domestic animals. It has been suggested that the accumulation of nodularin within the cell and the release from the cell are affected by different environmental factors. In this study, we expected that interaction of ambient radiation, nutrient limitation, and the presence and absence of *Aphanizomenon* sp. would affect the accumulation and release of nodularin. One laboratory experiment and two outdoor experiments were performed to investigate the interaction of two radiation treatments (PAR and PAR + UV-A + UV-B); three nutrient treatments (nutrient replete, nitrogen limited, and phosphorus limited), and the presence/absence of *Aphanizomenon* sp. on intracellular as well as extracellular nodularin concentrations in *N. spumigena*. The effect of *N. spumigena* on the specific growth rate of the coexisting *Aphanizomenon* sp. was investigated. Significant interaction effects were found between the factors investigated. In all three experiments, the lowest intracellular nodularin concentrations were found under phosphorus limitation. The highest intra- and extracellular nodularin concentrations were observed under nitrogen limitation when shielded from UVR. The presence of *N. spumigena* had no significant effect on the specific growth rate of *Aphanizomenon* sp. We conclude that although nodularin accumulation and release depend on different environmental conditions, it did not affect the coexisting species *Aphanizomenon* sp.

Keywords: Baltic Sea, cyanobacteria, *Nodularia spumigena*, nodularin, nutrient, UV radiation.

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ICES CM 2011/C:17   Poster

Monitoring of harmful algal blooms in the Baltic Sea using a combination of ship sampling and remote sensing

Bengt Karlson, Cia Hultcrantz, Marie Johansen, Martin Hansson, Ann-Turi Skjevik, and Jörgen Öberg

The oceanographic departments of the Swedish Meteorological and Hydrological Institute (SMHI) provide operational services for monitoring of algal blooms in general and harmful algal blooms (HABs) in particular. Water samples are collected during cruises with research vessels as part of the national marine monitoring programme. A new tool for the SMHI is the FerryBox system on the MV "TransPaper" which is operated in conjunction with the Finnish Environment Institute. The Gothenburg–Kemi–Oulo–Lübeck–Gothenburg route is operated every week. This provides real-time data on chlorophyll and phycocyanine fluorescence, proxies for the biomass of total phytoplankton and the biomass of certain cyanobacteria. Every other week automated water samples for microscopic phytoplankton analysis are taken at a handful of stations. This provides information about species composition and identification of HAB species. After every cruise the publication AlgaWare is published on www.smhi.se. It contains up-to-date information about the algal situation. Satellite monitoring of surface accumulations of cyanobacteria in the Baltic and algal blooms in general are carried out using the Baltic Algae Watch System (BAWS) with information from MERIS (EnviSAT) and MODIS (Aqua).

Keywords: Baltic Sea, FerryBox, harmful algae, monitoring, phytoplankton, remote sensing.

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ICES CM 2011/C:18   Poster

Cyanobacteria blooms and fish, invertebrate, and bird kills in the Curonian Lagoon, Baltic Sea

Elena Ezhova and Eugenia Lange

The Curonian Lagoon is often cited as the largest Baltic lagoon with the highest level of primary production. Its trophic state is estimated to be hypertrophic during the 2000s. From the late 1990s an increase in the frequency and duration of extreme phytoplankton summer blooms has been recorded, with phytoplankton biomass reaching 1000 g m^{-3} in areas of hyperbloom. In the Curonian Lagoon the bloom-forming algae are potentially toxic cyanobacteria of the genera *Aphanizomemon*, *Anabaena*, *Microcystis*, *Planktotrix*, and *Woronichinia*. It has been noticed that, together with increase of frequency of warm years, cyanobacteria blooms have begun to last for several months of the year, from early July until the end of November, with different species dominating through the year. In 2009 an extreme bloom of *Aphanizomenon flos-aquae* occurred until the end of November; *Microcystis aeruginosa*, *M. wesenbergii*, and *M. viridis* formed a bloom from early July 2010, coming to a hyperbloom level in August. The next wave of blooming occurred in late autumn, until November again. Midsummer mass fish kills have been regular events in the lagoon in the last decade; this is usually explained as being a consequence of eutrophication, connected with oxygen deficiency. In 2009–2010 mass fish kills (numerous species), invertebrate kills (Lymnaeidae, Planorbidae, others), and bird deaths (fish-eating species) occurred repeatedly from May until November, when any oxygen deficiency was measured. The results of coastal zone monitoring (2007–2010), including hydrochemical parameters, sampling of zoobenthos, zooplankton, phytoplankton, analysis of dead fish, and algal phytomass on toxins, have led us to assume that cyanobacterian toxins are the main reason for this mass animal mortality.

Keywords: Curonian Lagoon, cyanobacterian toxins, fish kills, invertebrate deaths.

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ICES CM 2011/C:19   Poster

The use of *in situ* phycocyanin fluorescence as a proxy for estimating cyanobacteria biomass in the Baltic Sea

Kevin Vikström, Angela Wulff, Seppo Kaitala, Jukka Seppälä, and Bengt Karlson

Cyanobacteria are an important part of the phytoplankton community in the Baltic Sea. Picoplanktonic cyanobacteria of *Synechococcus* type are the most abundant, whereas filamentous or colony-forming species may be prominent when forming surface scums. Important genera are *Aphanizomenon*, *Dolichospermum*, and *Nodularia*. *Nodularia spumigena* produces the toxin nodularin and other cyanobacteria species produce microcystins. To produce early warnings of blooms of cyanobacteria, automated systems are used (e.g. FerryBox) and instrumented oceanographic buoys. A proxy for cyanobacteria biomass is the fluorescence from the pigment phycocyanin. In this ongoing study different types of phycocyanin fluorometers are compared and the effect of photoquenching (i.e. irradiance on the fluorescence signal) is investigated. Data from work with cultures and field data will be presented.

Keywords: Baltic Sea, blue-green algae, cyanobacteria, FerryBox, fluorescence, monitoring, phycocyanin, phytoplankton.

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Theme Session D

Linking the history to the present: understanding the history of fish, fisheries, and management

ICES CM 2011/D:01

Regional depletion of haddock and pollack during the last century in the Kattegat–Skagerrak

Massimiliano Cardinale, Henrik Svedäng, Valerio Bartolino, Luigi Maiorano, Michele Casini, and Hans Linderholm

Since 1960s, it is estimated that 90% of more of the biomass of large predatory fish has been lost and, seen over longer periods of time, a new era of depleted seas is emerging as a result of protracted and massive exploitation. Here we demonstrate, by reconstructing centennial time-series of stock, spatio-temporal dynamics, and commercial landings, the long-term erosion of the spatial structure that has resulted in regional depletion of haddock and pollack in the Kattegat–Skagerrak area. The erosion of the spatial structure occurred in parallel with the development of the industrial fisheries and the peak in landings was followed by a decline in adult biomass and individual size. No common response of adult biomass of haddock and pollack to sea surface temperature (SST) was found, and the decline and loss of adult aggregations of haddock in the Kattegat and eastern Skagerrak and of pollack in the entire area occurred several decades before the observed increase of SST in the area. These results illustrate the hazardous consequences of prolonged overfishing on the spatial structure of commercially exploited population. In addition, the continuation of the commercial fishery at "sustainable" levels adjusted to the present stock productivity might hinder the recovery of depleted stocks for a long period of time.

Keywords: Atlantic gadoids, historical data, regional depletion, spatial stock structure.

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ICES CM 2011/D:02

Movement modelling in stock assessment: from Beverton and Holt and back again

Daniel R. Goethel and Steven X. Cadrin

In the computer age of modern fishery science, it is difficult to imagine working on today's models by hand. This is especially true in stock assessment where a laptop computer has become the only tool most assessment scientists ever use. However, Beverton and Holt developed the foundations for much of fishery science in their 1957 "fishery bible" using little more than slide rules and adding machines. As models grow in complexity, it becomes easy to forget their origins and basic assumptions. On the forefront of assessment science is the use of tag-integrated models, which allow fish movement between subpopulations by including tagging data within the objective function. Although current tag-integrated models are more complex than could ever be imagined 60 years ago, it is important to remember that the basis for these models were first developed by Beverton and Holt in their seminal work. A review of Beverton and Holt's original movement models demonstrates that the assumptions are essential to the successful application of their models. Although these models were largely forgotten in stock assessment, advances in computing power, data collection techniques, and cooperative research have led to a resurgence of movement models and the successful application of tag-integrated models. In today's world of instant computing it is often easy to take for granted what one's predecessors have accomplished, not only undervaluing their work but also overlooking important lessons learned along the way.

Keywords: Beverton and Holt, movement models, tagging models, tag-integrated models.

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ICES CM 2011/D:03

The post-war evolution of the Norwegian longline fishery for ling and tusk

Kristin Helle and Michael Pennington

Ling and tusk have been fished by Norway for centuries, and the yearly total landings have been recorded since 1896. The major catches are taken by longlines; both species are targeted, but are also caught as bycatch. The landings statistics for ling and tusk reflect the state of the stock, but also to a large extent the amount landed depends on the size of the fleet and variable fishery regulations. The early data before World War II are doubtful; however after the war the landings statistics are more reliable. Fishing was minimal during the war; consequently, the post-war stocks of ling and tusk were abundant, and as a result the landings of ling and tusk were considerably larger after 1945 than the average annual pre-war landings. Immediately after the war, the fleet consisted of small, wooden boats with limited range and little storage capacity. During the 1960s the fleet gradually shifted to larger steel boats that had greater range and capacity. In 1977 automatic baiting machines were introduced and by the end of the 1980s, ca. 95% of the boats had converted to autolines. From the introduction of the autoline until 2000 the number of longliners increased until the fishing pressure became so great that regulations were implemented to reduce the longline fleet from 72 boats in 2000 to 35 boats in 2010.

Keywords: autolines, ling, Norwegian longline fleet, tusk.

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ICES CM 2011/D:04

Long-term trends in the population dynamics of northwestern Ireland herring revealed by data archaeology

Maurice Clarke

Herring populations to the northwest of Ireland are considered to constitute a single stock. They consist of a diverse array of autumn-, winter-, and spring-spawning components which have been subject to large catches in the past. Landings peaked at 50 000 t in 1987 and have demonstrated a slow decline since, as two dominant year classes, born in the 1980s, declined. No strong year classes have appeared since, and the stock is now outside safe biological limits. The time-series of data available for stock assessment only covered the period 1970–present, although routine sampling began after the end of World War I. In order to examine the stock trajectories over time, all catch-at-age data for the period 1921–1970 were compiled and analysed. The study revealed large fluctuations in the size of the stock and its productivity over time. Periods of very high recruitment never lasted more than 10 years and were observed at roughly 20- to 40-year intervals. Interspersed with this were long intervals of poor recruitment. Further historical analyses of eighteenth and nineteenth century records confirm this general periodicity. Overall results were examined in the context of time-series of environmental data. The study can provide a basis for development of a long-term management plan for the stock, using management strategy evaluation (MSE). The implications of this work for the rational management of this stock for the future are discussed.

Keywords: catch-at-age, herring, historical analyses, northwest Ireland, productivity.

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ICES CM 2011/D:05

The relative roles of fishing and biological productivity in fish stock dynamics: history can help to understand the present and design the future

Margit Eero

A major task for fishery management is to ensure that the harvest is taken sustainably, facilitating, among other things, the recovery of depleted fish stocks and maintaining populations at healthy levels. The main instrument for regulating the harvest of commercially exploited fish stocks in North Atlantic is annual total allowable catch (TAC), corresponding to a certain level of fishing mortality. This paper analyses historically observed trends in biomass of assessed fish stocks in the North Atlantic, focusing on the relative importance of the level of fishing mortality vs. stock productivity for determining trends in biomass. The results demonstrate that temporal variations in production rates have largely determined the observed declines and increases in fish biomass, whereas fishing mortality alone has generally had only a limited connection to biomass trends. The importance of relative production rate for stock recovery is confirmed by a recent example of stock recovery in the eastern Baltic cod. The biomass of this stock rapidly increased in recent years, largely as a result of a temporarily high production rate, whereas similar positive developments have not been observed for any other depleted North Atlantic cod stocks in recent decades, despite large reductions in TACs. Long time-series can help to understand changes in stock productivity, a major parameter driving changes in fish biomass. Furthermore, learning from historical patterns of drivers of stock dynamics could help us to design management frameworks that would have a greater chance of being successful in rebuilding depleted populations, which are not favoured by biological processes.

Keywords: fish biomass, fishing mortality, North Atlantic, stock productivity.

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ICES CM 2011/D:06

Cod behaves in mysterious ways: shifting distribution in the North Sea during the last century

Georg H. Engelhard, David A. Righton, Tina K. Kerby, and John K. Pinnegar

The distribution of cod within the North Sea has exhibited major shifts over the course of the last century. This has become evident from an analysis of almost 100 years of British commercial fisheries data, digitized from the Cefas archives. Combined with contemporary fisheries data, these span the period 1913–2010 (excepting both World Wars), at the spatially detailed level of the ICES rectangle (0.5° latitude, 1° longitude). New analysis of old data reveals that during most of the twentieth century, North Sea cod distribution was very different from that in the most recent period (2000–2010). Whereas historically, densities of cod catches were especially concentrated in the central and northwestern North Sea, they are currently concentrated in the northern- and northeasternmost part of the North Sea. We attempt to reveal the extent to which climate, fishing, or both have contributed to the recent shift in distribution.

Keywords: climate, cod, distribution shift, North Sea.

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ICES CM 2011/D:07

Herring in the Celtic Sea: a history of life on the edge

Deirdre Lynch, Jim Wilson, and Maurice Clarke

The most southern and western herring populations in Europe occur in the Celtic Sea, south of Ireland. These populations are considered to comprise a single stock, although they consist of both

autumn and winter spawning components. The herring fishery in this area has been commercially important for many years. Biological sampling has been conducted since the 1920s and routinely since 1958. This study collated and analysed these long-term data. Overall results were examined in the context of time-series of environmental data and population scale indices of population status. Size-at-age was low in the 1920s and 1950s, but increased to a peak in the 1970s before declining strongly until recently. Currently, growth is increasing again. Condition factors over time declined, whereas growth rates were greater in the 1960s and 1970s than in the 1980s and 1990s. Further analyses suggest that these changes are influenced by environmental factors, especially the North Atlantic Oscillation, sea surface temperature, and the abundance of *Calanus* copepods. The implications of this work for the rational management of this stock for the future are discussed.

Keywords: Celtic Sea, condition, herring, historical analyses, size-at-age.

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ICES CM 2011/D:08

Investigating key drivers of trends in Atlantic herring biology using over a half century of highly resolved catch data

Harma Clémentine, Minto Cóilín, Clarke Maurice, and Brophy Deirdre

Identifying the factor(s) that drive trends in population dynamics and stock structure is difficult and presents a challenge for fishery management. Long-term changes in key biological parameters of Atlantic herring populations around Ireland have recently raised concern about the state of the stocks which constitute a primary resource for the fishing industry of the country. Although spawning stock composition has changed during the same period, this does not explain the observed biological trends. The present study investigates temporal trends in the biology of Irish herring populations in relation to local and global environmental drivers, and to fishing activities. Biological data of herring around Ireland have been collected in a consistent way from 1958 to the present; this constitutes an exceptional and highly valuable time-series of fisheries data. Environmental time-series have been gathered from different sources and include both local variables and global climate indices. Measurements of fishing pressure were derived from stock assessment reports. The effect of these variables on size-at-age was investigated using cross-correlation and time-series modelling approaches. The nature of this long-term dataset provides a unique opportunity to explore the relationships between biological, environmental and fishery datasets within a statistical modelling framework. The results obtained are discussed in the context of the management of herring fisheries.

Keywords: Ireland, herring, time-series analysis.

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ICES CM 2011/D:09

Long-term (1920–2010) changes in the structures of the Polish long-distance and Baltic Sea fisheries—an effect of mutual concurrence or a decree of the fate?

Wlodzimierz Grygiel, Kordian Trella, and Emil Kuzebski

This study reflects the long-term (1920–2010) changes in the structures of the Polish long-distance and Baltic Sea fisheries, considered in light of variation in the state's economic system. The species composition of annual landings, technical support, and employment in the fisheries is analysed. Development of the Baltic fishery was initiated after World War I, with the logistical and technical support of the government. In 1920, the Polish fishing fleet operated in the Baltic Sea only and was composed of 55 motor-cutters, 16 sail-cutters, and 800 smaller boats, managed by private owners, locally associated in the Kashubian Maszoperia. At that time 1086 fishers were active and annual landings were 800 tons, with sprat, flatfish, and herring dominant. In 1931, eight Polish vessels

operated outside the Baltic for the first time. From 1947, the Baltic fishery was conducted by cooperative, private, and state fleets. Dynamic development of the long-distance fishery, which was steered by the state, started in 1960 and over the next 30 years dominated the Baltic fishery. The historically highest landing (816.7×10^3 tons) of marine species was recorded in 1975, of which 74% originated from 130 vessels operating outside the Baltic. In 1999, total landings decreased by about four times and only 42% was achieved outside the Baltic. In the 1990s the process of privatization of the Polish fishing fleet started. At the beginning of the 2000s, a gradual collapse of the long-distance fishery (in 2010 four vessels remained) was observed. In 2004–2010, 501 (38%) Polish vessels were removed from the Baltic fishery, and annual landings decreased by 28%.

Keywords: long-distance and Baltic fishery, Poland.

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ICES CM 2011/D:10

The history of exploitation of Northeast Atlantic fish stocks in the past half century highlights the need to protect immature fish

P. Vasilakopoulos, F. G. O'Neill, and C. T. Marshall

Exploitation rate, as described by average fishing mortality, has been the main focus of management of ICES stocks in the past half century and its negative impact on stock status is well documented. This is not the case for exploitation pattern (i.e. the proportional exploitation of immature fish), despite the expected benefits from allowing fish to spawn before they are caught ("spawn-at-least-once" principle). In this study a meta-analysis of time-series of stock status, exploitation rate, and exploitation pattern was performed to evaluate their trends in the last 60 years. The analysis was based on data for 38 ICES stocks including demersal roundfish, flatfish, and pelagic species. Periods of high exploitation in conjunction with exploitation of a large proportion of immature fish are associated with rapidly declining trends in stock status, whereas stocks tend to remain within precautionary limits when exploited at low rates with exploitation patterns resulting in the capture of fewer immature fish. Moreover, stocks appear to be able to endure higher levels of exploitation when the proportional exploitation of immature fish is low and vice versa. The results indicate that although exploitation rate appears to be the leading factor that has shaped stock status in the past, exploitation pattern also plays an important role in sustainability. Hence it would be beneficial to monitor the maturity stage of the fish caught and to include exploitation pattern limits in fishery advice in future.

Keywords: exploitation rate, exploitation pattern, meta-analysis, Northeast Atlantic.

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ICES CM 2011/D:11

Long-term (1781–2010) eel fishery in the coastal lagoon of Comacchio (northern Italy) and use of a new index for fish evaluation

Federico Brunelli and Elena Fabbri

The European eel (*Anguilla anguilla* L.) is an endangered species with an important role in the local economies of coastal lagoons. Evaluation of its health is of crucial interest both for fisheries' managers and for conservationists. In the lagoon of Comacchio, northern Italy, trends in the eel fishery have been noted since 1781. A sharp decline has been registered since the 1950s and habitat loss would appear to be the most important factor in this stock collapse. Furthermore, a decline in the economic importance of the fishery has led to a lack of funds for restocking, which constitutes a further threat for the conservation of eels in this region. The eel fishery in Comacchio is carried out in autumn using the *lavoriero*, V-shaped permanent trapping weirs located in the canal connecting the lagoon to the sea. Because *lavoriero* capture the fish during their reproductive migration, we

report a large dominance of mature females. A Sustainable Eel Fishery Index (SEELF) for the evaluation of fish condition has been designed using body indices, internal indices, and blood parameters. The SEELF Index has been calculated for a 5-year sample (as a synthetic parameter for the analysis of the historical trend), to reveal whether or not good fishery practices are being respected. Furthermore, mature female eels migrating towards the open sea from the Comacchio lagoon are less than 10 years old, are not affected by *Anguillicola crassus*, and, according to biomarker analyses, are not affected by pollution. Thus, we argue that this lagoon is a suitable environment for restocking and for the application of an efficient eel management plan.

Keywords: eel fishery, *Anguilla anguilla*, coastal lagoon, northern Italy.

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ICES CM 2011/D:12

Changes in marine communities of the northern Adriatic Sea (Mediterranean) over the past six decades (1945–2008): insights from fishery landings

Tomaso Fortibuoni, Simone Libralato, Cosimo Solidoro, Otello Giovanardi, and Saša Raicevich

Time-series of fishery-dependent data (such as landings), if detailed, corrected, and disaggregated, can provide a basis for describing changes in a marine community and calculating insightful ecological indicators (e.g. trophodynamic indicators). Long-term changes in the fish community were described in the northern Adriatic Sea through landings data time-series from over 60 years (1945–2008) in the main fish market of the area (Chioggia) by applying a set of indicators. Although fishing capacity increased during the whole period, total catch and the fishing-in-balance index sharply increased between 1945 and 1985, and then dramatically declined. No significant trend was observed for the mean trophic level, even applying a cut-off level of 3.25 TL. However, the elasmobranch–teleost ratio and the mean maximum length of the catch significantly declined, from a value of 0.10 (1945) to 0.004 (2008) and from approximately 43 cm (1945) to 22 cm (2008), respectively. The fishing-in-balance index captured not only the historical expansion of the fishery in the area that started after the World War II, but also its collapse in the 1980s, suggesting that this expansion met its natural limits (unbalanced fishery). Conversely, the relative stability of the mean trophic level of the catch hardly reflects massive changes in the system, which in turn are highlighted by the dramatic decline of elasmobranchs and by the change of catches towards smaller species. Overall, indicators applied on detailed and disaggregated landings proved to be useful in highlighting important changes that have occurred in the marine community in the last 60 years in the northern Adriatic Sea.

Keywords: landings, northern Adriatic Sea, trophodynamic indicators, unbalanced fishery.

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ICES CM 2011/D:13

Historical spatio-temporal dynamics of eastern North Sea cod

Valerio Bartolino, Massimiliano Cardinale, Hans W. Linderholm, and Anders Grimwall

The identification of historical baselines for marine ecosystems is a fundamental prerequisite for defining their sustainable management and conservation. Recent analyses of historical data of fish abundance and distribution have demonstrated promising potentialities, but pose numerous difficulties such as fragmentation and inhomogeneities in the amount of available information in space and time. Using mixed-effects models in a multiscale analysis we identified an appropriate spatio-temporal scale for investigation of a high-quality spatially explicit historical dataset, and we reconstructed the long-term spatial dynamics of cod (*Gadus morhua*) in the Kattegat–Skagerrak through the twentieth century, since the start of the industrial fishery in the area. In the broad scale

of our investigation, we identified a northern and southern main aggregation of adult cod in the study area, characterized by largely independent spatial dynamics. From the 1960s we observed a progressive contraction of the population, up to a historical minimum in the 1990s when only 20% of the estimated early century cod biomass was left. We found a relationship between adult cod seasonality and water temperature, which may indicate a possible anticipation of the time of spawning aggregation related to a warming environment, but its effects and consequences at the population level were not identified. In contrast, we found that the collapse of the cod population in the area matched the peak in landings, and anticipated the warming trend by at least two decades. Our results confirm the major role played by the fisheries in the decrease of local abundances and the disappearance of local adult cod aggregations.

Keywords: cod, eastern North Sea, historical spatial distribution, scale.

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ICES CM 2011/D:14 Withdrawn

ICES CM 2011/D:15

Lost migratory forage species and consequences on the function and structure of ecosystems

A. Jordaan, C. J. Hall, M. A. Nuttall, R. M. Cerrato, and M. G. Frisk

The current dogma suggests the removal of apex predators has fundamentally altered ecological systems through trophic cascading effects. We will demonstrate, using alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and Atlantic menhaden (*Brevoortia tyrannus*), how migratory forage species declines have also potentially affected ecological functioning. Alewife and blueback herring are anadromous species that have undergone century-long declines caused by damming of waterways that reduced available habitat 95% by 1850. The loss of these species eliminated substantial fluxes of marine-derived nutrients into terrestrial landscapes and a forage species for many piscivorous species. Atlantic menhaden sustained fisheries and processing plants that extended throughout the northeastern United States in the late 1800s. The current reduction in age structure and population size has eliminated the species from many of its original habitats. For example, coastal lagoons on Long Island, NY, have seen the complete loss of menhaden. The result is the loss of an effective plankivore, forage fish, and consequently an efficient energetic transfer of low trophic level energy to higher trophic levels. The losses of these species from foodwebs, in many cases prior to the development of the sciences of fishery management and ecology, has far-reaching consequences for ecosystem connectivity and trophic functioning. The possible consequences for current management will be emphasized.

Keywords: ecological connectivity, historical ecology, menhaden, river herring.

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ICES CM 2011/D:16 Poster

Great Britain's role in North Sea demersal fisheries: a long-term perspective over the past century

Tina K. Kerby, William W. L. Cheung, and Georg H. Engelhard

This study compiles 100 years of North Sea demersal fish landings, focusing on Great Britain and placing them in historical context in terms of events and political, technological, and economical drivers that influenced British demersal fisheries. In the early twentieth century, aided by technological advances, Great Britain had unchallenged dominance in North Sea fisheries. Since then, the two World Wars and other political developments have had a massive impact on British

fisheries. Between the 1920s and 1960s, English fishing ports shifted their interests away from the North Sea towards highly profitable distant waters. Meanwhile, especially in the 1960s, other European countries expanded their fisheries within the North Sea, undermining Britain's lead. Scotland retained its fleet mainly in the North Sea, benefiting from this in the 1970s and 1980s. First, the assertion of 200 nautical mile Exclusive Economic Zones made the distant waters inaccessible to English fleets at a time when England's fisheries were highly dependent on them. Second, the relatively low activity in the North Sea by the English compared with the Scottish fleet coincided with the establishment of the Common Fisheries Policy. This had implications when total allowable catches were first implemented because quota allocations to countries were based on their recent fish catches from the North Sea. After the loss of fishing opportunities in distant waters, the North Sea is once more an important fishing ground for Britain, just as in the early twentieth century, however, the emphasis of fisheries has shifted from England to Scotland.

Keywords: Common Fisheries Policy, demersal fisheries, historical perspective, North Sea.

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ICES CM 2011/D:17   Poster

Long-term dynamics of river lamprey fishery in Latvia

Jānis Birzaks, Kaspars Abersons, and Tatjana Baranova

River lamprey (*Lampetra fluviatilis*) is one of the most significant species in Latvian inland fisheries. The importance of river lamprey is still increasing because of its stable and high market price and demand. Fishing of river lamprey in Latvia is mostly carried out with different types of fykenets. In the River Daugava, drifting trammelnets are used as well as the traditional river lamprey fish basket weirs in several rivers. In 1945, regular river lamprey landing data collection was started in Latvia. The most significant changes in annual landings are recorded from the 1960s and 1970s. A continual increase in landings reached its peak in 1971 and 1973 (410 and 386 tons). In the mid-1970s annual landings decreased rapidly and by 1980 had dropped to only 8 tons. The lowest landings have corresponded with a period of increased cod stock in the Baltic Sea and the years following the building of a hydroelectric power dam 30 km from the mouth of the Daugava, the biggest river flowing into the Gulf of Riga. In the early 1980s new management approaches were implemented to preserve river lamprey resources. First, fishing regulations were restricted by decreasing of fishing effort (e.g. shortening of season and decreasing the numbers of allowable gear). In addition, artificial propagation of river lamprey was started. In recent years, 15–20 million river lamprey larvae have been restocked annually. In the last decade landings have become stable and now fluctuate from 73 to 135 tons per year.

Keywords: landing dynamics, Latvia, river lamprey.

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Theme Session E

Upwelling events, coastal–offshore exchange and links to biogeochemical processes in various parts of the oceans

ICES CM 2011/E:01

Subantarctic and temperate marine fauna links with oceanographic fronts on the Patagonian Shelf break and slope (Southwest Atlantic)

A. Arkhipkin, P. Brickle, and V. Laptikhovsky

One of the main oceanographic features in the Southwest Atlantic is the transport of cold waters of Subantarctic origin along the Patagonian slope to temperate latitudes (40–42°S) by the Falkland Current. Originating in the Antarctic Circumpolar Current in the Drake Passage, the current splits into two main northward-flowing streams, deviating at the Falkland Islands both west and east. The strongest eastern branch meanders onto the shelf to the south of Beauchene Island and northeast of the Falkland Islands and creates two major frontal zones with strong upwellings of Subantarctic Superficial Water Mass (SASW). Extension of the SASW to the shelf break and its mixture with shelf waters creates quasi-stationary areas of high productivity, identified by higher concentrations of chlorophyll *a*. Subantarctic fish (southern blue whiting) use these areas as their feeding and spawning grounds. Deep-water toothfish and squid (*Onykia ingens*) use them as pathways to migrate from the shelf to deep-water habitats. Cold-water squid (*Loligo gahi*) feed on plankton aggregations in both frontal zones. Temperate fish (hoki, rock cod) and squid (*Illex argentinus*) feed only in the northern frontal zone where the mixture with temperate shelf waters is the strongest. Scallops (*Zygochlamis patagonica*) form dense aggregations near both frontal zones to feed on phytoplankton. The presence of the two quasi-stationary fronts between the deep-water Falkland Current and shelf waters plays an important role in distribution, migration, and spawning of marine fauna that use them in accordance with their Subantarctic and temperate habitats.

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ICES CM 2011/E:02

A statistical approach on upwelling in the Baltic Sea based on the analysis of satellite data for 1990–2009

Andreas Lehmann, Kai Myrberg, and Katharina Höflich

A statistical analysis of Baltic Sea upwelling has been carried out for the first time for the entire sea area, based on infrared satellite observations for 1990–2009. Weekly surface sea temperature (SST) maps of NOAA/AVHRR satellite data (May until September) were used to evaluate the frequency of upwelling. The results obtained were analysed and compared with earlier studies, including both measurements and modelling, with an excellent fit. Our study allows us to evaluate the most intensive upwelling areas in the entire Baltic Sea. According to the analysis, the most common upwelling regions were on the Swedish south and west coasts (Gotland southern tip; frequency 15–25%) and the Finnish coast of the Gulf of Finland (frequency 10–15%). On the Polish and German coasts, Baltic east coast, and Estonian coast of the Gulf of Finland upwelling frequency was close to 10%. On the Finnish coast of the Gulf of Bothnia values of 10–15% were found, as on the Swedish coast of the Bothnian Bay; otherwise upwelling frequency was not more than 10% there. The Gulf of Finland and the Bothnian Sea as well as the southwestern Baltic Sea were areas where upwelling

can take place nearly everywhere for some time. In other areas, upwelling typically extended some 10–20 km from the coast to offshore. The trend of upwelling frequency over a 20-year period reveals an increase along the Swedish coast and a decrease along the Estonian coast in the Gulf of Finland, especially pronounced in August/September. However, the trends were only significant along the Swedish coast. In addition, we analysed surface wind data (10 m) along the coastline of the Baltic Sea taken from the Swedish Meteorological and Hydrological Institute (SMHI) meteorological database. Wind components parallel with the coast have been further discriminated into favourable and unfavourable winds forcing upwelling. The obtained frequencies of upwelling favourable winds fit very well with the observed upwelling frequencies derived from the satellite SST maps. It can be concluded that our analysis can be used in many scientific studies as background information as well as in various practical applications where detailed knowledge of the spatial-temporal variability of upwelling in the Baltic Sea is relevant.

Keywords: Baltic Sea, satellite data, statistics, upwelling.

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ICES CM 2011/E:03

The Orange Banks: topographic setting and mid-shelf hydrographic conditions at the northern extremity of the southern Benguela upwelling regime

Marek Ostrowski, Frank Shillington, and Marek Lipinski

The Orange Banks is a coastal offset at the maritime border between Namibia and South Africa. Its bathymetric profile is characterized by a steady descent from the coastline towards a 90-km-wide, flat central plateau between 170 and 190 m depth, terminating with a steep underwater cliff that falls 200 m down vertically to the continental slope. We investigate flow patterns and structure of the water column over the central plateau and outer slope area based on a 10-year time-series of surveys during February and employ a Regional Ocean Modelling System (ROMS) model, as well as remote sensing to understand their seasonal cycles. In February, upwelling is vigorous in the southern Benguela. The upwelling-inducted equatorward jet over the bank is strongly controlled by topography; it veers towards the seaward edge, weakens, and eventually ceases along the northwestern boundary of the bank. Despite strong wind periods, the interior water column remains relatively well stratified with the stability increasing towards the northern boundary. Although the steep outer slope inhibits development of local upwelling, a relatively oxygen-rich central water mass of upwelling origin dominates the bottom layers. The origin of this water mass can be tracked to the Namaqua upwelling cell located to the south of the bank. The concomitant results of trawl sampling point to the bank as a major nursery ground of *Merluccius paradoxus* in the Benguela. Our analysis indicates that the region has a unique combination of favourable bathymetric and environmental conditions for retention of *M. paradoxus* larvae and/or early juveniles in this area.

Keywords: ADCP, Benguela, coastal jet, hypoxia, retention, ROMs, topographic steering, upwelling.

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ICES CM 2011/E:04

Wind curl-driven upwelling: the example of the Benguela system

Wolfgang Fennel

Divergences of Ekman transports, which play a key role in driving ocean upwelling, exist near coastal boundaries, where alongshore winds, with the coast to the right/left in the northern/southern hemisphere, reach the coasts. This setting produces extreme divergences (delta functions) of the Ekman transports. Similar situations can be found at ice-edges. However, because of the waveguide properties of coastal boundaries, the upwelling is significantly reduced by Kelvin

waves or more general coastal trapped waves. Divergences of Ekman transports can also be caused by windstress curls, which constitute structures of windfields that are independent of coastal boundaries. Studies of the oceanic responses to windstress curls have been restricted by the lack of robust, coherent wind observations. With the new generation of sensors on the QuickSCAT satellite it is now possible to map spatial wind patterns and, in particular, wind curls and their variations in time. This gives new opportunities for theoretical studies to reach a better understanding of how upwelling and coastal currents are structured by the spatial shape of the forcing fields. This paper considers such problems for the example of the Benguela upwelling system.

Keywords: Benguela upwelling system, Kelvin waves, upwelling, wind curl.

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ICES CM 2011/E:05

Modelling the interannual variability of ocean circulation and marine ecosystem in the Canarian upwelling system

Vladimir Ryabchenko, Victor Gorchakov, Nikolay Diansky, Anton Dvornikov, and Svetlana Pugalova

A three-dimensional eco-hydrodynamical model of high resolution is applied to simulate the seasonal and interannual variability of ocean circulation and marine ecosystems in the Central–Eastern basin of the North Atlantic (CENA) including the Canarian upwelling system. Simulated temperature and salinity fields agree well with satellite and expeditionary observations in the period 1998–2006. According to model results and observations, in winter, "spots" of maximal phytoplankton biomass are often located in upwelling zones in the open ocean on the periphery of cyclonic eddies rather than in the coastal upwelling zones. In summer, when phytoplankton biomass reaches maximal values, maxima of phytoplankton are located in the coastal upwelling zones. Simulated surface phytoplankton distributions are in qualitative agreement with surface distributions of chlorophyll *a* derived from satellite data. Interannual changes in mean annual temperatures averaged over CENA region for the period from 2000 to 2006 amounted to 0.9°C and 1.0°C for the model and satellite data, respectively. Similar changes in primary production for the period from 1998 to 2006 amounted to +60, –100, and 50 mg C m^{-2} d^{-1} (+6, –13, and +12% of its mean annual values), respectively, according to the model results, satellite-derived estimate based on the Epply version of standard evaluation method, and satellite-derived estimate based on carbon method. Despite the existing quantitative divergences between model results and satellite data, the spatial distributions during the various periods of an annual cycle were similar. Results of sensitivity studies are also presented.

Keywords: Canarian upwelling, circulation, ecosystem.

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ICES CM 2011/E:06

The influence of meteorological variation on the upwelling system off eastern Hainan during summer 2007–2008

J. Su, J. Wang, T. Pohlmann, and D. F. Xu

The influence of meteorological variation (i.e. typhoon and precipitation events) on the coastal upwelling off eastern Hainan Island was studied based on observations taken during two upwelling seasons. The observations were made in August 2007 and July 2008. We found that, in principle, similar structure of sea surface temperature and bottom temperature prevailed in both observational periods, providing evidence that upwelling events occur frequently during the summer monsoon along the eastern Hainan shelf. Based on a simple momentum balance theory, we studied the balances between momentum fluxes, windstress, and bottom stress. The results

demonstrated that the Burger number $S \approx 1$, indicating that the cross-shelf momentum flux divergence was balanced by the windstress and the onshore return flow occurred in the interior of the water column. Hence, a conceptual model of the upwelling structure was built for further understanding of upwelling events. In addition, it was also observed that variations in the strength of upwelling are controlled by storm events (i.e. strong northerly winds change the structure of the thermocline on the shelf significantly). The strong mixing caused by wind reduces the strength of the thermocline, in particular in coastal seas. Based on our conceptual model, a frontal zone between mixed coastal water and offshore water develops which destabilizes the water column and hence decreases the upwelling strength. Freshwater from the two main rivers in Wenchang Bay are confined to the coastal area less than 20–30 m deep, as confirmed by our water mass analysis. Freshwater discharge stabilized the water column, inhibiting the upwelling as revealed by the potential energy calculation. Consequently, estuarine water only inhibits the upwelling in the near coastal area. Therefore, it can be concluded that estuarine water does not have a significant impact on upwelling strength on the shelf

Keywords: none.

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ICES CM 2011/E:07

Mesofauna inhabiting algae in the tidal zone of the Barents Sea

Izabella Olejniczak, Paweł Boniecki, Anita Kaliszewicz, and Ninel Panteleeva

One of the most important problems in ecosystem functioning is the role of invertebrates, especially mesofauna, in mineralization and humification of organic matter. Although the role of mesofauna is well known in the case of the soil system, our knowledge of the role of mesofauna inhabiting algae is still scarce, especially in the polar and subpolar regions. The aim of this study was to determine communities of mesofauna inhabiting algae in the tidal zone and the rate of the algae colonization by mesofauna. Our study was conducted near the field station of Murmansk Marine Biological Institute, in the Barents Sea in four bays: Zelenetskaya, Plohiye Tschevry, Yarnyshnaya, and Medvezhia. The material was collected using frames of 100 cm^2 in area. Samples were taken in zones of the "fresh" algae (FA), "old" algae (OA), and tundra (T). We also conducted an experiment in which we exposed "fresh" algae (FA) (100 cm^2) to mesofauna on stones, "old" algae (OA), and tundra (T). Although we noticed variability in mesofauna densities in sampling plots in different bays, in general we did not find significant differences between mesofauna densities on "old" algae and tundra. Densities of *Collembola* and *Acarina* were significantly lower in the FA zone (*Collembola* $p = 0.001$; *Acarina* $p = 0.0001$). Colonization of exposed "fresh" algae was different in the tundra and in the tidal zone. In the tundra *Collembola* colonized algae faster than *Acarina*, but in the tidal zone it was slower.

Keywords: *Acarina*, algae, Barents Sea, *Collembola*.

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ICES CM 2011/E:08   Poster

Time persistence of thermal fronts in the surface waters of the southern Baltic Sea

Lena Szymanek and Katarzyna Bradtke

Frontal zones with strong gradients are characteristic of surface water temperature (SST) fields in the sea. They may be connected with either stable mesoscale structures (influenced by bathymetry) or episodic phenomena (e.g. coastal upwelling or large riverine inflow). Spatial distribution of SST in the Baltic Sea depends primarily on light conditions and dynamic processes causing a local advection of different water types, so the second type of front is more likely to occur. High variability of the front's position and strength in time and space is expected because of the episodic

character and high dynamic of the phenomena they are connected with. We aimed to investigate the time persistence (stability) and repeatability of localization and strength of the thermal frontal zones in the southern Baltic Sea. We used all seasons advanced very high resolution radiometry (AVHRR) and moderate resolution imaging spectroradiometry (MODIS) imagery collected into the time-series. To determine the front location on one scene we used the maximum gradient in all directions detection method and for mean position for one day the composite front map approach. For detected fronts we performed spatio-temporal persistence and strength analysis. As was expected, we observed mainly the second type of front, a result of coastal offshore exchange processes. Upwelling thermal fronts were characterized by the greatest spatio-temporal stability and strength. These fronts were usually a sufficient and stable barrier to prevent the waters of different properties from mixing so they could have major influence on the transport of water masses and all substances that are suspended or dissolved in the sea.

Keywords: southern Baltic Sea, SST, stability, thermal front, upwelling.

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ICES CM 2011/E:09

Fluxes of particulate organic carbon and nitrogen in the Gulf of Gdańsk

D. Burska, D. Pryputniewicz–Flis, and Z. Witek

Suspended matter (SPM), particulate organic carbon (POC), and nitrogen (PON) concentrations and fluxes were measured during spring (22 March–6 April 2001) and summer (31 August–19 October 2000 and 17–25 June 2002) in the Gulf of Gdańsk. Comparison of results from selected regions (Vistula mouth, Puck Bay, Gdańsk Deep) provides information on interactions between coastal and open sea area zone. The measurements were carried out during the research cruises on board the "Baltica" vessel. The water samples from the water column were taken with a rosette sampler and measurements of water temperature, conductivity, and depth were done with a conductivity, temperature, depth (CTD) profiler. The organic matter fluxes at each water level were measured with cylindrical sediment traps. Sediment traps were located at depths which reflected density stratification of the water column. SPM, POC, and PON flux values ranged widely, from 93 to 13 751 mg SPM m^{-2} d^{-1}, from 21 to 678 mg POC m^{-2} d^{-1}, and 2.6 to 88.5 mg PON m^{-2} d^{-1}, respectively. The highest fluxes were observed during September 2000. Changes of organic matter participation in suspended material indicate qualitative differences between periods of measurements. The mean POC % values ranged from 17% in April 2001 to 37% in June 2002. Horizontal distribution of SPM, POC, and PON fluxes was influenced by a Vistula River inflow to the Gulf of Gdańsk. High levels of SPM fluxes with low participation of organic matter were connected with the appearance of suspended matter transported by river.

Keywords: POC, PON, flux, SPM.

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Theme Session F

Applications of optical and image-based technologies in the ecosystem approach to fisheries management

ICES CM 2011/F:01

Using optical flow techniques on acoustic multibeam data

Nils Olav Handegard, Kevin Boswell, Simon Leblanc, Dag Tjøstheim, and Iain Couzin

Techniques for automated analysis of data from optical imaging systems have evolved rapidly in recent years, and in this paper we demonstrate how optical flow techniques can be applied to acoustic multibeam sonar data. Traditionally, single target tracking methods have been used to obtain behavioural information from acoustic data. This process involves detecting single targets, forming tracks by associating targets, and estimating trajectory information such as speed, orientation, etc. However, with increasing fish density, these techniques become more challenging as detecting, resolving, and associating single targets becomes increasingly difficult. Within optics, optical flow algorithms are more common, and here we show how optical flow techniques can be used to resolve internal fish flow, structure, and responses in densely schooling fish. Wavelet noise filters were applied to the sonar images prior to a standard optical flow technique, and subsequently a detection algorithm was used to identify pixels containing schooling fish. Several estimators on school characteristics are used on the resulting flowfield, including behavioural correlations, polarization, etc. Finally, an alpha shape algorithm is used to define the outline of the schools, determining global properties such as shape, size, and perimeter length. We show how the set-up can be used for studying collective behaviour.

Keywords: collective behaviour, fish behaviour, multibeam sonar, optical flow.

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ICES CM 2011/F:02   Withdrawn

ICES CM 2011/F:03

Towed underwater television towards the quantification of Norway lobster, squat lobsters, and sea pens in the Adriatic Sea

M. Martinelli, E. B. Morello, I. Isajlovic, A. Belardinelli, A. Lucchetti, R. J. A. Atkinson, A. Santojanni, N. Vrgoc, and E. Arneri

Norway lobster (*Nephrops norvegicus*) is of great commercial importance throughout the Northeast Atlantic and Mediterranean, where it lives in burrows within muddy sediments. In several European countries it is assessed using towed underwater TV techniques. This method is particularly suited to *Nephrops* because the application of normal fishery-dependent stock-assessment methods is not applicable to this species for a number of reasons. The TV methodology relies on the visual assessment of a known surface area of seabed. The number of *Nephrops* burrows, whose features are distinct, can be counted and their inhabitants quantified. It follows that, in theory, the same can be done for other organisms or key ecological features which appear on the footage. In this study we report the results of two underwater TV surveys (2009 and 2010) carried out jointly by Italy and Croatia in the Pomo pit, an area of the Adriatic Sea important for its *Nephrops* fishery and its hake nursery grounds. The footage we obtained allowed us to quantify the density and biomass of *Nephrops* in the area and gain estimates of the abundances of: (i) the squat lobster (*Munida rutllanti*) a newcomer to the area, recently reported to have substituted the established *Munida intermedia* and (ii) the sea pen (*Funiculina quadrangularis*), whose assessment by means of underwater TV has recently been the object of OSPAR attention. The concurrent

quantification of trawling activity from the footage has allowed us to place our results in the context of an ecosystem approach to fisheries management.

Keywords: Adriatic Sea, Norway lobster, squat lobster, towed underwater TV.

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ICES CM 2011/F:04

Refining an optical tool for investigating spatial and substock structure in marine fish populations

S. M. Bierman, H. M. J. van Overzee, M. Dickey-Collas, and C. J. G. van Damme

Northeast Atlantic herring (*Clupea harengus*) consists of a complex mixture of spawning components. Each spawning component has its own spawning ground to which it returns during its own specific spawning period. An important management objective is to preserve the diversity of these spawning components. However, at present it is not possible to monitor trajectories of the subcomponents independently to provide information for management. The difference in spawning time and location between the different components results in the larvae experiencing different environmental conditions during their development which in turn may influence the shape of the otolith. We have developed an optical technique to distinguish between the spawner types by using otolith shape. Image analysis software has been developed to generate, automatically for large numbers of images, elliptical Fourier descriptors as well as distances and angles between four landmarks on each otolith. These shape measurements can be used to discriminate between spawning components. Otolith shape analysis is a low-cost, fast, and efficient method to determine stock identity. The analysis software is open source and freely available. Also, this is a non-destructive method, maintaining the otolith intact for future investigation. The results demonstrate that the Fourier descriptors, as well as the landmarks, are effective in differentiating between some of the types of spawning components. This methodology can therefore be used to determine the share of the different spawning components in the catch over time (and may have potential uses with other species).

Keywords: Atlantic herring (*Clupea harengus*), otolith shape analysis, stock discrimination.

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ICES CM 2011/F:05

Integrating benthic surveys and community analysis through image management: a case study from a biodiversity special area in the Lower St. Lawrence Estuary, Québec, Canada

Claude Nozères, Lizon Provencher, François Roy, and Jean-Sébastien Lauzon-Guay

The Manicouagan peninsula in the lower St. Lawrence Estuary is under consideration as a marine conservation zone, notable for its rich productivity and species diversity. To assist with the evaluation of habitats, consumer-level cameras and image management software were used to make data from different surveys readily available for ecological analyses. Surveys of habitats from sand shoals to the deep-water channel were conducted at stations at depths from 5 to 320 m using both physical sampling and a towed camera sled. An image catalogue database was used to compile field photos of grab and dredge samples (infauna) with laboratory images (conserved specimens) and the underwater tow photos (epifauna and demersal species). Software tools were used to leverage photo metadata and embed record information, including date, station, coordinates, and taxonomic names into the catalogue. Browsing images and filtering for metadata proved to be an efficient means for validating identification and location data. Catalogue records were exported for archiving to a network geodatabase, and subsequently used in analyses of community composition. Multivariate analyses performed with data from underwater photos and benthic grabs suggested similar zones of communities, even as the groups of species used in the

classifications differed between the two methods. Underwater photo surveys in conjunction with image cataloguing tools are suggested as a low-cost complement to physical sampling for the investigation of benthic habitats and their communities while greatly expanding the total area sampled.

Keywords: benthos, habitat classification, imaging, St. Lawrence Estuary.

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ICES CM 2011/F:06

Autonomous underwater vehicle (AUV)-based camera and sidescan sonar assessments of scallop grounds in western Iceland

Warsha Singh, Erla B. Ornolfsdottir, and Gunnar Stefansson

Underwater robots, such as autonomous underwater vehicles (AUVs) equipped with digital and acoustic imaging capabilities, offer a new platform for fishery studies with some known benefits over conventional methods. The proposed approach here was to investigate the use of this survey technique for macrobenthic organisms, specifically the Iceland scallop (*Chlamys islandica*). A pilot survey in Breidafjordur, western Iceland, was conducted in September 2010, where ten sites were surveyed. Sample locations were previously known scallop dredging sites, with one exception. Two to four parallel transects, 30–50 m apart, were taken at each site, sampling between 400–800 m in length. The AUV was programmed to bottom-track either at 2.0 or 2.5 m from the seabed. Photos taken from a downward-facing camera at 2.0 m from the bottom covered approximately 3 m^2 of ground area. High- and low-frequency sidescan sonar images were also taken at 10 m and 30 m range, respectively. Image-enhancement techniques were used to identify and count scallops from the digital photos. Other organisms, such as the common whelk and sea urchins, were also quantifiable. Maps of sidescan sonar images revealed the substrate type at the scallop grounds. Furthermore, it was apparent that higher quality photos were obtained at 2 m from the bottom, where organisms could be identified without difficulty. The imminent objectives are to obtain population density estimates of the scallops within a defined area and relate the distribution and population density to habitat type.

Keywords: AUV, digital photos, sidescan sonar, western Iceland.

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ICES CM 2011/F:07

In situ measurements of the individual acoustic backscatter of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*), with concurrent optical identification

Mathieu Doray, Laurent Berger, Jean Yves Coail, Jean Philippe Vacherot, Gérard Bavouzet, and Pierre Petitgas

Knowledge of the acoustic response of a single fish (or target strength, TS) is of prime importance for acoustic target classification and abundance estimation. TS is a stochastic variable which varies in the wild in response to changes in physical (tilt angle, depth) or biological (physiology) single-fish attributes. The first requirement in making sound TS measurements is to accurately identify the species comprising the fish targets. Fish target identification is usually carried out by fishing. The comparison between fishing and acoustic data may be biased by the large differences in sampling volume and selectivity between acoustic and fishing devices. Optical systems can improve target identification by providing images of the fish simultaneously ensonified by the echosounder. We used Ifremer's towed body "EROC", fitted with an optical–acoustic system, to conduct *in situ* TS measurements of Biscay anchovy and sardine, with concurrent optical identification. The towed body was equipped with a Simrad EK60 200 kHz split-beam echosounder and a low-light black and white still camera. Combined optical–acoustic observations were made at

various depths (10–100 m) during day and night, with or without concurrent pelagic trawling, to devise the most efficient way of measuring TS of optically identified small pelagic fish.

Keywords: anchovy, echosounder, sardine, target identification, target strength, video camera.

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ICES CM 2011/F:08

Surveying sparsely distributed fish in large closed areas: a visual technique

Paul Fernandes, Lorenzo Scala, Neil Collie, Michael Stewart, and Fiona McIntyre

The number and area of protected seas is set to increase under various international commitments. Owing to the destructive nature of traditional fish sampling methods, such as bottom trawling, new methods are required to survey in these areas. Visual surveys allow for non-invasive sampling in these areas, but typically they are conducted in shallow waters and cover short distances. Some of the protected areas are distant, very large, and in deep waters, such as those around the Rockall plateau, west of Scotland, closed to protect habitats of the deep-water coral *Lophelia pertusa*. Marine Scotland Science has developed visual survey methods to estimate the abundance of anglerfish (*Lophius piscatorius*), a valuable commercial fish species which is sparsely distributed in and around these closed areas. A towed video chariot was developed equipped with lights to allow visual surveying at depths of over 300 m and speeds of up to 5 knots. This paper describes the visual survey methods employed to survey anglerfish and reports on some of the results obtained to date. Estimates of anglerfish density are comparable with those obtained from traditional trawling methods. The visual method has the additional benefit of providing information on the abundance and distribution of other marine fauna such as the deep-water corals. The latter application is in development and will require some image analysis techniques to quantify the area occupied by the coral. These and other potential improvements are discussed in the light of future work to develop effective optical technologies for surveying marine fauna.

Keywords: anglerfish, deep-water coral, Rockall, visual surveys.

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ICES CM 2011/F:09

Using underwater video cameras and stereo image analysis to ground-truth acoustic surveys of rockfish

Christopher Rooper, Kresimir Williams, Jerry Hoff, and Alex DeRobertis

For those marine fish species with specific habitat preferences, a habitat-based assessment may provide an alternative to traditional surveys. We conducted a habitat-based acoustic and stereo-camera stock assessment survey for rockfish on a rocky ridge habitat in the eastern Bering Sea. Underwater video was used to identify habitat types and fish species observed on the rocky ridge. Stereo image analysis was used to estimate fish lengths. Mean biomass of adult rockfish (mostly northern rockfish) estimated using acoustics and the species and length information from the underwater video was 15 447 t. The biomass of juvenile fish (mostly Pacific ocean perch) was estimated to be 916 t. Sources of error were observed both in the length measurements (when compared with calibration data) and the ability to identify some cryptic rockfish species. The estimated error rates for measuring fish lengths were up to 5.5% on targets of known size. Less than 1% of the adult rockfish were not identified to species, whereas most of the smaller juvenile fish could not be identified to species. The advantages of using optical methods for this survey were realized in the ability to observe fish without capturing and killing the organisms or damaging their habitat, as well as being able to collect information from rocky areas where bottom trawling or pelagic trawling could not be persecuted successfully. Use of similar survey methods on a larger scale may improve assessment of rockfish not only in Alaska, but throughout their range where fishery-independent biomass estimates have been difficult to obtain.

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ICES CM 2011/F:10

The use of use of CCTV for monitoring commercial fisheries

Howard I. McElderry

Over the past decade, technology-based fisheries monitoring, or electronic monitoring (EM), has become a cost-effective solution to monitoring commercial fishing operations. EM records sensor and image data from active fishing vessels and thus can be used to provide 100% monitoring of catch and fishing activity. A number of pilot studies have been carried out to test the efficacy of this technology, spanning diverse geographies, fisheries, fishing vessels and gears, and monitoring issues. In a small but growing number of fisheries, EM is being implemented as a routine monitoring tool. The efficacy of using CCTV imagery for catch monitoring is dependent upon many factors and, with appropriate support by vessel crew, can be successfully used in a variety of fishing methods. EM technology will increasingly become part of the fishery monitoring "toolbox", providing monitoring in situations not suited for observers, or in placements on vessels with observers, recognizing that it may be impossible for an observer to simultaneously monitor different parts of a fishing vessel. A significant advancement resulting from EM technology is its use as an audit tool to increase the veracity of self-reported fishing logbook data. This capability, widely used in British Columbia groundfish fisheries, encourages industry involvement in data collection activities, allows for estimation of the accuracy of self-reported data, and allows the creation of fully documented fisheries more efficiently than is possible with an observer programme.

Keywords: bycatch, catch monitoring, CCTV, discards, electronic monitoring, observer programmes, self-reported data, vessel logbooks.

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ICES CM 2011/F:11　　Poster

Agreement of net and acoustical methods for surveying euphausiids using a net-based LED strobe light system.

Peter H. Wiebe, Gareth L. Lawson, Andone C. Lavery, Nancy J. Copley, Erich Horgan, and Albert Bradley

Euphausiids are well known for their ability to avoid capture by standard oceanographic plankton nets. During a study of euphausiid/herring interactions in Franklin Basin (Gulf of Maine), MOCNESS tows were made at night and during daylight to provide ground-truth for acoustic surveying of the euphausiids and fish. A 1-m^2 MOCNESS was equipped with an LED-based strobe light with peak output between 490 and 520 nm that filled a region in front of the net with light several orders higher than normal. Concurrent acoustic data were collected at 43, 120, 200, and 420 kHz. To evaluate its efficacy in increasing euphausiid capture, two horizontal tows were done at a site where euphausiids (mostly *Meganyctiphanes norvegica*) were present. During each tow (60–75 m at night; 160–190 m during daylight), four of the eight nets sampled with the strobe flashing and four sampled with the strobe off, in a random sequence. There was a significant increase in biovolume catch of zooplankton when the strobe light was activated with total displacement volume increased by a factor of 2.2 at night and by a factor of 5.5 during the day. This was due largely to a higher abundance of euphausiids between 10 and 35 mm during the night (factor of 4.5) and during the day (factor of 11.0). Euphausiids caught with the strobe light on accounted for most of the observed volume backscattering at 43 and 120 kHz, whereas those caught with the strobe light off did not. In addition, with the strobe light on the abundance of euphausiids collected by the nets matched the acoustically estimated abundances.

Keywords: acoustics, avoidance, euphausiids, krill, strobe light, zooplankton.

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ICES CM 2011/F:12   Poster

Investigating mesoscale eddies in the California System as a survivor habitat for small pelagic fish larvae

Karen Nieto, Sam McClatchie, and Ed Weber

The importance of eddies as a survivor habitat for sardine in the California Current System (CCS) has been recognized for a decade. However, there are no studies applying the improved remote-sensing techniques now available to quantify how mesoscale eddies affect the distribution and abundance of pelagic fish larvae. Eddies can have positive and negative effects on fish recruitment. Positive effects include enhancement of production, providing food for larval growth. Negative effects include advective transport away from favourable areas for recruitment. We focus on the unproven hypothesis that cyclonic eddies enhance the recruitment of small pelagic fish in the CCS. We used automatic detection of eddies based on the Okubo–Weiss parameter applied to the weekly satellite altimetry data at 0.25° resolution, computed from a merged altimeter distributed by Aviso. We classified the cyclonic and anticyclonic eddies and indexed production inside the eddies using chlorophyll pigment from the MODIS-Aqua satellite. We also created a tracking algorithm to determine the westward propagation rate of the eddies. We used information over the years 1997 to 2010 for the area between 19–43°N and 109–133°W. We compared the abundance and size distributions of sardine and anchovy larvae inside and outside eddies with and without enriched production to test for positive effects on larval survival. We also quantified the abundance of sardine and anchovy larvae inside and outside eddies, and estimated loss of larvae to less productive offshore water to test for negative effects owing to advection.

Keywords: California System, eddies, mesoscale, remote sensing, small pelagic fish.

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Theme Session G

Habitat modelling and mapping for better assessment and monitoring of our seas

ICES CM 2011/G:01

Spatio-temporal variation in the distribution of gadoid fish (family Gadidae) in relation to the installation history of offshore artificial structures in the North Sea

Toyonobu Fujii

There are no less than 500 offshore installations extracting oil and gas from the continental shelf in the North Sea. Initially, marine policy issues surrounding the offshore activities were focused primarily upon the effects of new production facilities on fish stocks and fisheries because they could generate negative externalities, either by increasing local pollution levels or by making considerable fishing areas inaccessible for fishing vessels. However, recent studies have suggested that the presence of physical structures of offshore platforms may in fact have beneficial effects for fisheries because they may serve as artificial reefs that attract marine life and increase the number of economically important fish and invertebrates around the structures. The aim of this presentation is to assess the potential value of existing offshore platforms as reef habitat and thereby advance research in the field of habitat utilization by marine fish. Many species belonging to the fish family Gadidae have been shown to exhibit enhanced abundance around offshore structures in the North Sea, and hence changes in the distributions of these fish in the past 25 years have been mapped and analysed in relation to key environmental variables such as temperature, salinity, depth, and slope, as well as the installation history of offshore artificial structures using GIS applications. Results from the statistical analysis demonstrated there are significant influences of the presence of the offshore structures on the distribution of certain gadoids of particular age classes, and implications for the marine spatial management of the seabed will be presented.

Keywords: fish habitat utilization, Gadidae, offshore platforms, North Sea.

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ICES CM 2011/G:02

Predicting the spatial presence of the youngest stages of sea-spawning whitefish (*Coregonus lavaretus* L. s.l.) larvae with an additive Gaussian process model

Jarno Vanhatalo, Lari Veneranta, and Richard Hudd

We present a novel statistical method to (i) predict the spatial presence/absence pattern of sea-spawning whitefish larvae in the Gulf of Bothnia (GoB), Baltic Sea and (ii) identify the environmental variables that best describe the presence/absence. A generalized Gaussian process (GP) model with additive spatial and non-linear predictor components is constructed to model the data. A full Bayesian analysis is conducted and the probability of the presence of larval whitefish is predicted for the entire shoreline of the GoB in a 300-m resolution. The predictors comprise various geoprocessed environmental variables. The importance of the environmental variables to the predictions are examined with an average predictive comparison technique. The data comprise 575 sampling stations located to the Finnish and Swedish shorelines of the GoB. Larval data are collected with beach-seine and a Gulf Olympia sampler. Results reveal that the most important variables are depth, shore and bottom profile, distance to sandy and shallow shore (20-m contour line), and the length of ice in winter. The GP is a non-linear model capable of modelling interactions between explanatory variables and the results indicate that the predictive effects of environmental variables are non-linear and contain interactions. The additive GP model can be used to construct a spatial predictive map that indicates the most important early stage larval areas of sea-spawning whitefish in the GoB.

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ICES CM 2011/G:03

Using the EUNIS habitat classification system in broadscale regional mapping: some problems and potential solutions from case studies in the English Channel

Roger Coggan, Ceri James, Bryony Pearce, and Jennifer Plim

The EUNIS (European Nature Information System) habitat classification system provides a standard for recording European marine habitats and biotopes. Its hierarchical structure introduces physical, environmental, and biological parameters at different levels, making it attractive for use in broadscale predictive mapping. We have developed a modelled EUNIS map for an area of 12 755 km^2 in the eastern English Channel, but in doing so met two difficulties which stem from the structure of the EUNIS classification system. First, it includes only two major substrate classes, "rock" and "sediment", so provides no solution for areas where rock is covered by a thin (<1.0 m) sediment layer. Acoustic surveys indicate such areas as rock but grab surveys show them as sediment, and the communities they support can be distinct from those in pure rock or sediment habitats. Second, there is an inconsistency in the level at which EUNIS introduces biological zones into the hierarchy. The littoral, infralittoral, and circalittoral zones are introduced at EUNIS level 2 for both rock and sediment habitats, but the deep-circalittoral is introduced at level 4, and then only for sediment habitats. As a result, broadscale maps classified at EUNIS levels 2 or 3 are frequently invalid, as they cannot discriminate the deep circalittoral from the circalittoral, something that is important when considering habitat sensitivity to disturbance. Through our case study we offer solutions to these problems through modifications to the EUNIS system, introducing a new substrate class of "rock and thin sediment" and allowing biological zones to be represented equitably.

Keywords: biological zone, English Channel, habitat mapping, thin sediment.

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ICES CM 2011/G:04

Acoustic studies of benthic habitats in south Baltic Sea using parametric signal processing technique for single-beam and multibeam echosounders and sidescan sonar data

Jaroslaw Tegowski, Natalia Gorska, Jaroslaw Nowak, Aleksandra Kruss, Mateusz Moskalik, and Kazimierz Szefler

The results of a study on the development of efficient and reliable acoustic techniques for the classification and monitoring of Baltic seabed habitats are presented. The comprehensive acoustic, geological, and biological investigations were performed in several areas of size up to 10 × 20 km and 220 × 1 km (narrow euphotic zone) located in the southern Baltic Sea, characterized by diversified types of sediments, geomorphological forms, and benthic habitats. We used multibeam and single-beam echosounders, sidescan sonar, a sub-bottom profiler, and a van Veen sediment sampler. Such an extensive data collection needs an efficient and fast seabed classification system, which was created and tested during this research. The basis of the system is a parametric approach to acoustic registrations. Computed spectral, wavelet, statistical, and fractal features of echo signals were the input to fuzzy clustering classification and neural network classification algorithms, which produced maps containing morphologically classified seabed areas. All of the seabed segmentation schemes have many promising features which allow them to be applied to the extraction of morphological forms of seabed and habitats. The correctness of the method was verified by the results of underwater video recordings conducted from an underwater vehicle, sedimentological analyses, and biological samples taken *in situ*.

Keywords: habitat mapping, seabed classification methodology, south Baltic Sea.

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ICES CM 2011/G:05

Rationalizing seabed sediment classification to promote consistency in biotope classification and improve accuracy in predictive biotope mapping

Bryony Pearce, Ceri James, Roger Coggan, Caroline Chambers, Jacqueline Hill, and David Tappin

The relationship between the distribution of benthic marine fauna and different aspects of the physical environment has been a key topic of research for many years. The nature of seabed sediments is one of the main drivers determining benthic community composition, so the way in which sediment deposits are classified is of fundamental importance in biotope classification and predictive mapping. The EUNIS (European Nature Information System) habitat classification scheme splits sediment deposits into four broad classes, namely "mud and sandy mud", "sand and muddy sand", "coarse", and "mixed" sediment. However, there is no practical guidance supplied with the EUNIS scheme on how these sediment categories should be applied to empirical or modelled sediment data, leading to inconsistent biotope designations. A segmentation of the Folk triangle, which provides a useful translation between existing Folk maps and EUNIS habitats, was developed in the MESH project (Mapping European Seabed Habitats). However, this categorization has been demonstrated to result in a poor match between modelled and observed biotopes. Many of the difficulties in using this classification scheme have arisen because it, counter-intuitively, places some sand habitats into the coarse sediment category and because the splits between "mud" and "muddy sand" and between "sand" and "muddy sand" have not been defined. During the course of two regional seabed-mapping projects in the UK we investigated alternative ways of segmenting the Folk triangle and propose a refined segmentation that better reflects the relationship between sediment class and species distributions and which facilitates habitat modelling using the EUNIS habitat classification scheme.

Keywords: biotope modelling, Folk, habitat mapping, sediment classification.

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ICES CM 2011/G:06

Exploring patterns of compositional change along environmental gradients, and mapping expected patterns of biodiversity composition at regional scale

C. Roland Pitcher, Nick Ellis, Peter Lawton, Stephen Smith, Chi-Lin Wei, Lew Incze, Michelle Greenlaw, Jess Sameoto, Nick Wolff, and Paul Snelgrove.

Environmental variables are increasingly used as indirect surrogates for mapping biodiversity patterns for planning and management applications because species survey data are scant, especially in the marine realm. However, environmental variables are measured on arbitrary scales unlikely to be directly relevant to biology. To make the connection, knowledge of the relationships between biological patterns and environmental variables is essential. We quantified these relationships by applying a novel analysis approach, "Gradient Forest", to examine the extent to which these variables predicted biological patterns and to explore the shapes and magnitude of multiple species responses representing patterns of biodiversity composition change along gradients of >30 environmental variables. These responses were compared for trawl, benthic sled, and grab surveys from three mesoscale regions: tropical Australia, deep Gulf of Mexico, and temperate Gulf of Maine. Typically, the environmental variables predicted an average of 13–35% of the variation in biological patterns. Important predictors differed among regions and biota, and included depth, salinity, temperature, sediment composition, and current stress. The shapes of responses also differed and were non-linear, often with thresholds indicative of step changes in composition. Within regions, Gradient Forest allowed integration of responses across multiple disparate surveys that used different sampling devices. This information contributes to our

understanding of the environmental drivers of patterns of beta diversity at mesoscales, and "biologically informed" transformations of the more readily available environmental data can be applied to provide predictive maps of patterns of biodiversity composition in a way that better reflects biological patterns than uninformed environmental variables alone.

Keywords: beta diversity prediction and mapping, Great Barrier Reef, Gulf of Maine, Gulf of Mexico.

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ICES CM 2011/G:07

Habitat suitability modelling as a tool in the Norwegian programme for mapping of marine habitats

Trine Bekkby, Eli Rinde, Heidi Olsen, Reidulv Bøe, Henning Steen, Nina M. Jørgensen, and Frithjof Moy

There is a growing pressure on coastal ecosystems from climate change and a diverse range of human activities. To develop effective marine spatial plans and achieve knowledge-based management decisions, managers and policy-makers need information (i.e. maps) on where different habitats are found. This information has been lacking in the marine environment in Norway for years, but in 2003, a national programme for mapping and monitoring of marine biodiversity started sampling and integrating data on habitat and species distribution. The Norwegian coast is long and complex, and mapping all of the habitats in all areas is an enormous task. Consequently, spatial predictive modelling based on statistical analyses of field-sampled data was developed as a tool. The methodology includes collaboration between physical oceanographers, marine ecologists and geologists, statisticians, and modellers, including GIS experts. This presentation will introduce the methods developed, the habitats modelled, and the lessons learned from doing such modelling at the national scale.

Keywords: habitat suitability modelling, marine, marine spatial planning, Norway.

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ICES CM 2011/G:08

Nature Index of Norway—spatial predictive modelling of soft sediment reference conditions along the Norwegian coast

Hege Gundersen, Trine Bekkby, Karl Norling, Eivind Oug, Brage Rygg, and Mats Walday

Soft sediments cover most of the ocean seabed and often contain benthic communities with high biological diversity. Sediment-dwelling organisms depend on the substrate that they are attached to or live in, and species composition varies with sediment type. Macrofauna composition and diversity in soft sediments are commonly used as "health indicators" in various pollution monitoring programmes worldwide, and this fauna component has also been selected as one of the main quality elements in the EU Water Directive. Several areas diverge from the reference condition, and spatial predictive modelling is an essential tool to get spatial maps of reference condition in soft sediments and to find areas in which actions have to be taken to gain good environmental status according to the directive. The presentation demonstrates how we have integrated GIS models on geophysical variables (such as depth, slope, wave exposure, and terrain structures) and different infauna indices developed based on data collected for over 30 years. We focus on the quality index NQI, an index intercalibrated within the EU. The model selection technique Akaike Information Criterion (AIC) was used to select the best statistical model from a set of candidate generalized additive model (GAM) models, which were also used to develop a spatial predictive NQI model for the Norwegian coast. The method and results from this study are considered a great improvement over earlier approaches, in which the same reference value was used in all regions and water types in Norway.

ICES CM 2011/G:09

Classification and mapping of macrobenthic communities as a tool for assessing the biological value and sensitivity of the benthic habitats in the Polish EEZ, southern Baltic Sea

J. Warzocha, S. Gromisz, L., Szymanek, and A. Drgas

In 2007–2008 a project on habitat mapping in the Polish marine areas was carried out by the Polish Research Institute Partnership in cooperation with the Norwegian Institute for Water Research. The product of the project was a set of GIS-based maps of marine habitats, including distribution maps of individual macrobenthic species. This paper presents the results of the next series of studies, aimed at characterization of macrofauna communities using multivariate methods. Data collected by the Sea Fisheries Institute in Gdynia were included in our analysis. Based on macrozoobenthos samples collected in the summer seasons of 2000–2007, the groups of species and stations were set off and characterized. The combination of abiotic variables which best explained the structure and distribution of faunal groupings consisted of depth + salinity, silt content + temperature and oxygen in the deep-bottom habitats. The sediment grain size and organic matter content were not important in discriminating between the groupings. Long-term changes in the macrofauna were studied by comparing datasets from the 1960s, 1980s, and 2000s. The composition of macrofauna and spatial distribution patterns of several species, especially in the deep-bottom habitat, have changed. However, in the open sea area covered by sandy sediments, the comparisons of structure and distribution of assemblages failed to reveal any statistically significant differences. The limitation of the usefulness of historical data, mainly because of the impact of different methods used for sampling and analyses today, is also discussed.

Keywords: habitat mapping, macrozoobenthos, southern Baltic Sea.

ICES CM 2011/G:10

A methodology to map the extent of the seabed significantly affected by bottom trawling

Markus Diesing, John Aldridge, and David Stephens

Seabed disturbance by bottom-towed fishing gear is recognized as the most widespread impact that humans have on the seabed in the North Sea and English Channel. Consequently, information on the extent and significance of such disturbance is fundamental to progressing an assessment of sensitivity of seabed sediments. In addition to this, the Marine Strategy Framework Directive's (MSFD) indicator 6.1.2 requires an assessment of the "Extent of the seabed significantly affected by human activities for the different substrate types". Here we present a methodology for making such an assessment in a case study for the English Channel. Based on Vessel Monitoring System (VMS) data from relevant UK and foreign vessels deploying bottom-towed fishing gear, we estimate the intensity of bottom trawling on the seabed. This is then related to the intensity of natural disturbance on the seabed caused by waves and tidal currents, which is derived from hydrodynamic model outputs. We make the assumption that significant bottom-trawling impact is experienced where the intensity of bottom trawling is larger than that of natural disturbance. In this way, we are able to map the relative proportions of fishing impact in relation to natural seabed disturbance. We assess significant fishing impacts for different substrate types and EUNIS (European Nature Information System) habitats. Our proposed methodology, as exemplified for the English Channel, should be applicable to other marine regions and could serve as a template for an assessment of descriptor 6 (seabed integrity) of the MSFD.

Keywords: English Channel, fishing pressure, natural disturbance, seabed integrity.

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ICES CM 2011/G:11

Geostatistical modelling of surficial sediment composition in the North Sea and English Channel: using historical data to improve confidence in seabed habitat maps

David Stephens, Roger Coggan, and Markus Diesing

This study aims to make the best use of historical data while addressing the need for a quantitative, repeatable procedure for the mapping of sediment composition over the UK areas of the North Sea and English Channel. The traditional approach has been qualitative, using expert interpretation to draw contours around point samples and so segment the seabed into polygons representing different substrate types. The variability of sampling density of the observations and subsequent variability in confidence of the interpretation are usually not provided to the users of the resulting mapped layers, therefore they have no way of judging the confidence they should have in it; they just assume that "the map is correct". An additional hurdle is that the output map often has a classification system applied (e.g. the Folk classification of sediment types) and this may not be fit for purpose for all end-users; a classification scheme that makes sense to a geologist may have little relevance to the biologist. Our objective was to use a database of historical samples obtained from the BGS (British Geological Survey) to model the spatial distribution of surficial sediment composition in a way that does not impose these constraints and permits the output of "bespoke" maps, classified according to the needs of the end-user. We achieved this using spatial prediction, specifically "Kriging with external drift" (KED). Using a digital elevation model of the seabed as the "external drift" significantly improves the outputs compared with ordinary Kriging (OK).

Keywords: Kriging, habitat mapping, North Sea, surficial sediments.

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ICES CM 2011/G:12

Quantification and prediction of the impact of fishing on epifaunal communities from a benthic photographic survey

G. I. Lambert, S. Jennings, M. J. Kaiser, H. Hinz, and J. G. Hiddink

There is a gap in the literature regarding the assessment of fishing impacts on benthic habitat-forming species. Here, based on an analysis of the impacts of the scallop dredge fleet around the Isle of Man, Irish Sea, we demonstrate how fishing and the physical environment act to determine the biomass and size composition of emergent epifauna. The epifauna create a habitat structure that is used by juvenile scallops and other species, thus providing an important ecosystem service. Epifauna were identified and quantified using still photographs taken during an extensive survey of the Isle of Man's territorial waters. On hard substrata, the effect of tidal velocity on total biomass (g m^{-2}) and maximum size (g) of the largest organism encountered in each taxon was positive, whereas wave stress and fishing frequency had a negative impact. We used the results to predict the distribution of biomass and maximum size and to quantify the total effects of fishing. Fishing frequency was the most important factor affecting the maximum size of the epifauna, resulting in a mean decrease of 17% (range 0–66%). Total biomass was predominantly affected by wave stress and tidal velocity whereas fishing caused a mean biomass decrease of 8% (range 0–34%), equivalent to 1.8 g m^{-2}. The results have implications for conservation because they allow assessment of fishing impacts by the fleet as well as supporting identification of areas where important seabed habitats are most vulnerable to fishing.

Keywords: fishing impact, Irish Sea, photographic survey, sessile benthos.

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ICES CM 2011/G:13

Modelling kelp species occurrence and biomass along temperate rocky coastlines

Daniel Gorman, Touria Bajjouk, Jacques Populus, and Axel Ehrhold

Understanding the dynamics of keystone species at spatially relevant scales is an essential requirement of coastal management and conservation. We seek to address this need by demonstrating the successful application of habitat models to predict the distribution, covers, and biomass of kelp forests at local and regional scales (i.e. tens to hundreds of kilometres). Forest attributes were modelled with field-collected and remotely sensed environmental data (known *a priori* to influence kelp species) using statistical modelling routines that were integrated within a geographic information system (GIS). We produced highly detailed maps (5-m horizontal resolution) that predict forest occurrence and structure at two locations where direct survey data are currently limited (total area >1000 km²). Forest occurrence and covers were modelled as the additive multiple regression of bathymetry, seabed topography, light, and wave exposure. Biomass predictions for individual species were improved by including local-scale phenomenon (e.g. hillshade and seabed deviation from mean swell direction), thus reminding modellers of the need to consider scale dependence when developing national mapping programmes. The precision and accuracy of our predictions were assessed through cross-validation and comparisons with independent survey data. The resolution of mapped outputs will not only facilitate local-scale management (e.g. marine parks and resource harvesting), but expand our understanding of factors that determine current and future species distributions within temperate marine ecosystems. Modelling approaches can greatly assist marine spatial planners to maintain ecosystem services and preserve biological diversity on a rapidly changing planet.

Keywords: Brittany, ecological distribution, generalized additive modelling, Laminariales.

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ICES CM 2011/G:14

Application of species distribution models in the marine environment

Henning Reiss, Sarah Cunze, Konstantin König, Hermann Neumann, and Ingrid Kröncke

Knowledge of the spatial distribution of benthic species and communities in marine ecosystems is an essential prerequisite for the understanding of ecosystem functioning and processes as well as for conservation and spatial planning issues. Especially in the marine environment, where the fauna are much more difficult to access and to monitor than in terrestrial systems, requirements for spatial planning and ecosystem management are often confronted with fragmentary information about species and habitats. Therefore, we have applied different species distribution models (SDMs) to predict the distribution of several benthos species in the North Sea, by using ten environmental variables as predictors. Most of the SDMs exhibited good or very good performance in terms of predictive power and accuracy, with the highest mean AUC values of 0.845 and 0.840 for the models MAXENT and GBM, respectively. The poorest performance was found for the BIOCLIM model with a mean AUC of 0.708. Nevertheless, the mapped distribution patterns varied remarkably depending on the model used. Furthermore, the distribution type (niche width) of the species seems to affect the model performance. For species with a narrow distribution range in the North Sea, the models exhibited a better performance than for species with a broad distribution range. Ecosystem management approaches depend on large-scale, full coverage estimation of species and community distribution and SDMs will be used to generate this information, including the distribution of invasive species or key species of marine ecosystems.

Keywords: benthic communities, habitat suitability modelling, macrofauna, marine ecosystems, niche modelling, North Sea.

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ICES CM 2011/G:15

Developing a habitat template for offshore benthic habitats of Rhode Island, USA

E. J. Shumchenia, J. W. King, and M. LaFrance

The Environmental Mapping Laboratory at the University of Rhode Island (northeastern USA) is currently conducting a baseline characterization of benthic habitats in offshore waters to support the Rhode Island Ocean Special Area Management Plan (OSAMP). The size of the OSAMP study area (3800 km^2) and the costs of high-resolution acoustic mapping and ground-truthing preclude the use of traditional benthic mapping tools and methods in creating a full-coverage OSAMP benthic habitat map. We have created high-resolution biotope maps for smaller areas (hundreds of square kilometres) that have been identified as priority sites for offshore renewable energy development by integrating interferometric sonar, underwater video tows, and grab samples in a top-down framework. Although we have established abiotic–biotic linkages in these relatively isolated areas, similar relationships have not yet been established over the entire OSAMP study area. We will use these data, along with physical, chemical, and geologic datasets that have been collected at broader scales, to model the distribution of benthic communities and biodiversity across the study area utilizing the Kostylev habitat template method. A validation of the habitat template with underwater video and grab samples will be discussed. The habitat template will provide ecologically relevant information for management plans such as the OSAMP, and in the case of Rhode Island, will also be used as a starting point for ecosystem valuation and monitoring.

Keywords: biotope, broad spatial scales, ecosystem valuation, top-down.

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ICES CM 2011/G:16

EUSeaMap: modelling a consistent map for Europe

Andy Cameron, Anita Carter, and the EUSeaMap consortium

Acquiring sufficient full coverage data and biological ground-truthing for widespread direct mapping of seabed habitats at a European scale would be prohibitively expensive and take many years. There is now an implicit requirement for continuous mapping that can be applied across European regions for the initial assessments under the Marine Strategy Framework Directive (MSFD). Transnational marine spatial planning and information-based management need to be informed by the best-available data if they are to achieve long-term sustainable use and management of the marine environment and its resources. There is therefore a clear need to create full coverage maps by predicting seabed habitats. The European Commission (EC)-funded project EUSeaMap (www.jncc.gov.uk/EUSeaMap) provides such maps. Under the initiative to build a European Marine Observation Data Network (EMODnet), EUSeaMap has produced broad-scale predictive habitat maps for over 2 million km^2 of seabed covering four geographic areas of European seas: Celtic, North, Baltic, and western Mediterranean. The project has built on similar methods applied in the Northwestern Atlantic through MESH, the Baltic through BALANCE, and the UK through UKSeaMap. A suite of environmental variables, which form the basis of the models, have been developed and improved, and made publicly available. Biological data have been incorporated into the modelling process, through the development of ecologically relevant thresholds. The models are structured to allow easy update of the maps, as new, higher quality data become available in future. Quantitative and qualitative methods were developed to assess and illustrate spatially the confidence associated with the maps.

Keywords: confidence, EUNIS, habitat mapping, MSFD.

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ICES CM 2011/G:17   Poster

The use of $\delta^{13}C$ and $\delta^{15}N$ stable isotope maps to trace site fidelity and the tropic base of fish populations in the eastern Gulf of Mexico

Kara R. Radabaugh, Sheri A. Huelster, David J. Hollander, and Ernst B. Peebles

Stable-isotope maps, or "isoscapes", created using the isotopic composition of marine organisms, provide new spatial and temporal perspectives on the site fidelities of motile marine species and the dominant primary production pathways that support their biomass. SEAMAP (Southeast Area Monitoring and Assessment Program) groundfish surveys at more than 130 locations on the West Florida Shelf (eastern Gulf of Mexico, USA) were used to acquire over 1600 fish and invertebrate specimens for analysis of bulk-tissue $\delta^{13}C$ and $\delta^{15}N$. The West Florida Shelf $\delta^{15}N$ isoscapes exhibited strong latitudinal and longitudinal isotopic gradients and high interannual stability. $\delta^{15}N$ composition revealed site fidelities were generally high for these trawl-caught fish. $\delta^{13}C$ isoscapes exhibited depth gradients with greater seasonal and interannual variability. Benthic algae from sea urchin stomachs were enriched in ^{13}C by an average of 4.2‰ relative to phytoplankton, providing a marker for trophic pathways that originate in benthic primary producers. Some fish species (e.g. littlehead porgy, *Calamus proridens*) appear to obtain nearly all of their biomass via benthic primary production through trophic intermediates, whereas others (inshore lizardfish, *Synodus foetens*, and dusky flounder, *Syacium papillosum*) ultimately derive their biomass from a combination of benthic and planktonic primary producers. These findings provide additional evidence that variation in the benthic light environment will have a selective effect on the production of fish biomass. Calculation of photosynthetically active radiation and light attenuation from satellite data will promote the understanding of controls on the $\delta^{13}C$ values of benthic algae and their dependents at higher trophic levels.

Keywords: fish site fidelity, foodwebs, Gulf of Mexico, stable isotopes.

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ICES CM 2011/G:18   Poster

Spatial distribution and structure of benthic communities in Herve and Cardozo Coves (Admiralty Bay, King George Island, South Shetlands, Antarctica)

Anna Kidawa and Tomasz Janecki

In the last 50 years a significant climatic shift has been observed along Antarctic Peninsula (e.g. glacial retreat, temperature rise). Such changes may have a significant impact on the structure and diversity of benthic communities. Underwater photographic documentation of macrobentos was carried out in Cardozo and Herve Coves (Admiralty Bay, King George Island, Antarctica) during austral summers 2007–2008 and 2009–2010. Observations of bottom morphology and sediment type were done by scuba divers. Both coves are formed by retreating glaciers, but they differ in area, depth, isolation from the main waters of Admiralty Bay, and glacial input. Analysis of data revealed significant changes in the density, diversity, and species composition of benthic communities in both coves. Large, open Cardozo Cove supported more diverse macrofauna (35 species compared with 16 in Herve Cove). Areas recently freed from ice were colonized mostly by bivalves such as *Laternula elliptica* and *Yoldia eightsi* (Herve Cove) or ascidians such as *Molgula pedunculata* and *Cnemidocarpa verrucosa* (Cardozo Cove). Areas adjacent to open waters of Admiralty Bay were dominated by sea anemones (*Edwardsia* sp.) and amphipods (*Cheirmedon femoratus*) (Herve Cove) or sea urchins (*Sterechinus neumayeri*) and diverse sea stars (Cardozo Cove). In the last 15 years the macrofauna of Herve Cove has been enriched by species previously unknown or incidental there, such as isopods (*Glyptonotus antarcticus*), sea urchins (*Sterechinus neumayeri*), sea stars (*Odontaster validus*) and limpets (*Nacella concinna*). Changes in areas covered by *Edwardsia* sp. were observed. Collected data will be used in long-term monitoring and mapping changes in benthic communities under environmental stress.

Kyewords: Antarctica, benthic communities, climate changes.

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ICES CM 2011/G:19   Withdrawn

ICES CM 2011/G:20   Poster

Sublittoral habitat mapping: remote sensing and modelling

Rosa Freitas, Victor Quintino, and Ana Maria Rodrigues

Studies conducted with a single-beam ground discrimination system (QTC VIEW, Series V), off the Portuguese coast, have revealed the ability of this system to identify and map distinct benthic habitats based on sediment and/or biological characteristics of the seabed. However, the single-beam design of this system means that in order to produce continuous coverage data layers of the survey area, it is necessary to interpolate the acoustic data between survey lines, even if survey lines are tightly spaced. The present study used statistical models to determine associations between *in situ* ground-truthing and remotely sensed acoustic datasets. These datasets were modelled for the main biological assemblages and sediment types using canonical analysis of principal coordinates (CAP), in order to verify how well the acoustic data discriminate the biological and the sedimentary affinity groups. The application of models contributes to a better understanding of the factors and processes which structure the distribution and composition of marine habitats and their associated biological communities at a coarser yet more integrated scale than that achieved using direct methods. The relationship between marine species and their habitats is a key component in the understanding of species distribution patterns. An improved understanding of the relationship between species and their habitat provides a sensible platform to model and predict their distribution and abundance in order to generate habitat maps. Thus, for a spatial assessment of seabed habitats, prediction using models is an advantageous approach.

Keywords: mapping benthic habitats, models, single-beam acoustic system (QTC VIEW, Series V).

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ICES CM 2011/G:21   Poster

Spatially explicit tools to support an ecosystem-based management: modelling of nursery grounds in the German EEZ

Antje Gimpel, Vanessa Stelzenmüller, Jens Floeter, and Axel Temming

Ecosystem-based marine spatial planning (MSP) as a process maintains ecosystem health and services by informing about the spatial distribution of activities and processes in the oceans. The protection of the marine environment and sustainable development are the most important objectives of the German MSP. Here we present spatially explicit tools to assess the consequences of spatial management scenarios for both activities and important ecosystem components such as the nursery grounds of *Pleuronectes platessa*, a fish species of high commercial importance. The first aim is to gain an overview about general conflicts between the objectives mentioned, a conflict analysis of human activities, and their ecological footprints. The scoring of activity combinations highlight potential conflicts based on a conflict matrix. Human activities, the calculation of their footprints and the resulting conflicts, were mapped using a geographic information system (GIS). Second aim was to investigate the impact of these activities, and make a risk analysis of human pressure on the nursery grounds of plaice. Nursery grounds were modelled using generalized additive models (GAM) and visualized taking advantage of the GIS. The individual human activities were allocated to generic pressure categories and their (combined) effect on the nursery grounds were evaluated by accounting for the spatial overlap and sensitivity to those pressures. In order to assess future conditions, a third aim was to study the risk of the implementation of new

activity in the German EEZ in a spatial management scenario. The spatial information was mapped using the GIS approach.

Keywords: generalized additive models (GAM), geographic information system (GIS), marine spatial planning (MSP), nursery grounds.

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ICES CM 2011/G:22   Poster

Changes in spatial distribution of North Sea herring (*Clupea harengus*) in relation to abiotic and biotic factors

Dominik Gloe, Saskia Otto, and Christian Möllmann

The distribution of marine fish species is controlled by several abiotic and biotic factors. In particular, climate-related changes as a response to elevated temperatures have been reported, although density-dependent behaviour may play a role. North Sea herring (*Clupea harengus*) is one of the commercially and ecologically most important pelagic fish species in the North Sea and historically has exhibited drastic changes in abundance and distribution. Here we study the distribution of autumn-spawning North Sea herring prior to spawning using annual abundance estimates derived between 2003 and 2009 during June/July. Age-specific abundance estimates were recorded for the entire North Sea during the International Herring Acoustic Survey (HERAS) with an ICES square-based horizontal distribution. After mapping, horizontal distributions were analysed applying habitat modelling using generalized linear and additive mixed modelling (GLMM and GAMM). Distribution changes were analysed in relation to hydrographic parameters such as salinity and temperature. Furthermore, the potential influence of tidal mixing fronts was tested using indices derived by satellite-based remote sensing data. Further abiotic predictors include sediment types and biotic predictors include horizontally resolved predator and prey fields.

Keywords: acoustic abundance estimates, biotic and abiotic factors, habitat modelling, International Herring Acoustic Survey, spatial distribution.

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ICES CM 2011/G:23   Poster

Marine landscapes mapping in the Russian part of the Gulf of Finland

D. Ryabchuk, M. Orlova, V. Zhamoida, and N. Kovalchuk

Mapping of marine landscapes plays an important role in the investigation and monitoring of ecological and geological environment as a basis for prognosis of its state and management. Collection and processing of detailed data on basic components of the marine landscapes, including bottom relief and surface sediments, are the foundation of mapping. In the eastern Gulf of Finland a first attempt at marine habitat mapping was done for two shallow water areas: part of the northern nearshore zone of Kurortny District and an area within Vyborg Bay. Both differ widely in terms of geological and sedimentological features and distribution of benthic organisms. The nearshore zone of Kurortny District is characterized by freshwater to oligohaline conditions with short-term salinity increases following upwellings and inflows; the depth at which wave action impacts the bottom sediments extends down to 4–5 m depth. Different marine habitat areas were found within very shallow nearshore areas with dense vegetation of green filamentous algae (*Cladophora glomerata*), the surface of the nearshore submarine terrace (zebra mussel and colonial hydroid polype *Cordylophora* and *Cladophora glomerata*), the terrace slope, and the submarine accumulation plain (where macrozoobenthos is represented by Chironomidae and Oligochaeta). The area of Vyborg Bay is characterized by variable and mosaic distribution of bottom relief forms and surface sediment types (e.g. shallow nearshore areas and glacial till ridges (banks) and their slopes), areas of low sedimentation rates with fields of spheroidal ferromanganese concretions, and

submarine bottom depressions with oxic, oxic/anoxic, and anoxic conditions. These factors together form patterns of living benthic assemblages.

Keywords: eastern Gulf of Finland, marine landscapes.

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ICES CM 2011/G:24   Poster

Mapping megabenthic diversity and AMBI index: the Portuguese platform between Aveiro and Porto

N. Silva, P. Santos, E. Soto, P. Moura, and M. Gaspar

This work provides new data on the diversity and habitat quality for the Portuguese platform, as few studies have been done in this area, the north coast. The results are important for the management of natural resources and habitat between Aveiro and Porto. Sampling was performed in May/June 2008 using two dredges simultaneously, between 5 and 50 m depth. In all, 180 hauls were performed, each one for 5 min. For all samples we computed diversity, biomass, and ecological quality, using the software PRIMER and AMBI. Maps for spatial distribution of diversity, biomass, and habitat ecological quality (AMBI index) were produced using ArcGIS.

Keywords: AMBI, benthos, diversity, ecological quality, Portuguese platform.

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ICES CM 2011/G:25   Poster

Habitats and associated benthic–demersal communities of mud volcanoes and adjacent zones in the Gulf of Cadiz (southern Iberian Peninsula)

Emilio González, Juan Gil, José Luis Rueda, Carlos Farias, Alejandra Fernández, Nieves López, Luis M. Fernández, Victor Díaz del Río, Candelaria Burgos, and the INDEMARES/CHICA 02/11 team

Habitats and benthic–demersal communities in mud volcanoes (MVs) within Spanish waters of the Gulf of Cadiz are being studied in the interdisciplinary LIFE+ project INDEMARES/CHICA to assess their importance for future conservation. Mud volcanoes display morphological and sedimentary complexities that allow different habitat types and communities and have been poorly studied. Sampling was carried out at the summit, on the slopes, depression, and adjacent bottoms of Albolote, Gazul, Tarsis, Pipoca, Anastasya, and Chica MVs (340–760 m depth). Otter trawls (12 samples), beam trawls (27), and boxcorers (30) were used to characterize the spatial distribution of habitats and communities. More than 500 species have been found to date, including new records for this area. In Gazul and Chica MVs, sponge aggregations (*Asconema setubalense*, *Petrosia* sp., *Phakellia* sp.) and coral gardens (*Acanthogorgia* spp., *Callogorgia verticillata*, *Madrepora oculata*) occur. Sea pen and burrowing megafauna communities (*Funiculina quadrangularis*, *Kophobelemnon stelliferum*, *Pennatula* cf *aculeata*) with bamboo corals (*Isidella elongata*) were found in Tarsis, Pipoca, and Anastasya MVs. Benthic communities associated with leaking gases (Habitat 1180 Natura 2000 network) were found on the summit of Anastasya, dominated by frenulate polychaetes (*Siboglinum* sp.) and the bivalves *Acharax* sp. and *Lucinoma* sp. This represents the first record for this type of habitat and community within Spanish waters. Differences between MVs and their associated habitats and communities may be linked to substrate types (mud breccia vs. hard bottoms with authigenic carbonates), seepage activity (active vs. latent conditions), and the MOW influence, increasing the biodiversity and spatial heteReogenety within the Gulf of Cadiz.

Keywords: Gulf of Cadiz, habitats, mud volcanoes, pennatulaceans.

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ICES CM 2011/G:26   Poster

The INDEMARES CHICA Project: a proposal to make a habitat mapping and biodiversity inventory in the Gulf of Cadiz

Juan Gil, José Luis Rueda, Marina Delgado, Candelaria Burgos, Carlos Farias, Emilio González, Víctor Díaz del Río, and the INDEMARES/CHICA team

The protection of the environment is a key element of the European Union's sustainable development, and therefore is a priority for community co-financing. LIFE is the European Commission's financial instrument exclusively dedicated to supporting environmental and nature conservation projects. Spain is one of the richest European countries in marine biodiversity. It has 8000 km of coastline with 23 million inhabitants, which is 58% of the Spanish population. Protection of our seas is mandatory. Almost a quarter of the Spanish territory is included in the Natura 2000 Network. However, in the marine environment, the Natura 2000 Network is at a very early stage because the offshore area is less than 0.5% of Spanish territorial waters. Within this frame the LIFE project: "Inventory and designation of marine Natura 2000 areas in the Spanish sea (INDEMARES)" was born, coordinated by the Biodiversity Foundation and including relevant institutions in research, management, and conservation of the marine environment. Its main objective is to contribute to the protection and sustainable use of biodiversity in the Spanish seas through the identification of ten valuable areas for the Natura 2000 Network. One of these areas is in the Gulf of Cadiz, based on the discovery of submarine chimneys and pavements related to leaking gases. The INDEMARES CHICA project discusses the role of these submarine structures in terms of habitats. The new ROV LIROPUS 2000 will play a fundamental role in obtaining the necessary information for completing the requirements from the OSPAR Commission directives and the European Council Habitats Directive.

Keywords: Gulf of Cádiz, INDEMARES CHICA project, Natura 2000 Network.

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ICES CM 2011/G:27   Poster

The use of ROV images from the gas pipelines inspection survey in the Strait of Gibraltar area to estimate habitats and its associated benthic–demersal communities

María Elena de la Calle, Juan Gil, Carlos Farias, Emilio González, José Luis Rueda, and Ignacio Sobrino

The systematic mapping of the marine benthic habitat and its biological communities requires very specialized oceanographic instrumentation. The use of remotely operated vehicle (ROV) video images should provided high-resolution megafaunal abundance and biodiversity information. In March 2011, two gas pipelines were inspected with ROVs in the Strait of Gibraltar area. We had the opportunity of participate in the survey as observers and the online video footage shows high coral colonization of the gas pipes. So we asked the gas company for the video files because we considered that it could give very useful information about the Strait of Gibraltar sea ground and some idea about its habitats. Although the main objective of the survey was inspection of the two gas pipelines that link the Spanish and Moroccan coasts, this study presents another approach for seabed habitat mapping based on an integrated analysis of the video recordings from three cameras on the ROV performed in the Strait of Gibraltar. These pipes should be considered as 45-km transects which should be analysed related to their environmental features. The habitats should be primarily distinguished on several bases such as biological associations, water depth, sediment type, current strength, and also north–south axis. Another approach that may be taken into account is local-scale anthropogenic disturbance such as lost fishing gear and garbage that appears all over the gas pipes, which act as a barrier on the marine bottom. This study demonstrates the possibilities of using high-quality civil engineering information for scientific purposes.

Keywords: habitats, ROV, Strait of Gibraltar.

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ICES CM 2011/G:28   Poster

Fishery and biology of *Cancer bellianus* off the Azores: considerations for management

M. Inácio, E. Isidro, J. Gonçalves, and M. R. Pinho

Crustaceans are an important resource in the Azores. The crab *Cancer bellianus* is almost considered a virgin stock, being punctually captured during spring and summer on two islands. However, effort has been made by fishers to develop a targeted commercial fishery. Information published up till now has been scarce and has been related to certain aspects of the biology and abundance of the species. This work aimed to characterize the actual fishery, summarize key biological information, assess the potential yield of the resource, and discuss management issues before the development of the fishery. The crabs were caught with traps at depths between 100 and 600 m. Traps were baited using various species, including sardine (*Sardina pilchardus*), congro (*Conger conger*), and dolphinfish (*Coryphaena hippurus*). In all, 5345 crabs (1423 males and 3737 females) were sampled. Sizes ranged from 7 to 290 mm carapace width (CW). The highest abundance occurred at depths from 300 to 500 m. Females were relatively more abundant at depths of 300–400 m and males relatively more abundant at depths of 500–600 m. Only two ovigerous females were caught during September and October. The distribution area of the resource includes coastal areas and seamounts around the Azores EEZ. The species habitat was mapped and potential fishing areas around the EEZ highlighted. The estimated potential yield of the resource suggests that it would not support an industrial fishery. Thus, artisanal fisheries on a community-based management system around the islands are suggested and discussed.

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Joint ICES/PICES Theme Session H

Recruitment processes: Early life-history dynamics—from eggs to juveniles

ICES CM 2011/H:01

A multispecies synthesis approach to understanding early life-history aspects of recruitment dynamics in relation to environmental change

Miriam J. Doyle and Kathryn L. Mier

Synthesis of a multi-decade time-series of ichthyoplankton and environmental data from the Gulf of Alaska (GOA) reveal synchronies and similarities in abundance trends and links to environmental variables that reflect life-history and ecological variation among species, particularly during early ontogeny. Similarities in response to environmental forcing are apparent when there are similarities in early life-history exposure to the environment. A pilot study on selected fish species in the GOA illustrates the utility of incorporating multiple early life-history characteristics into a comparative analysis of environmental exposure–response coupling among marine fish populations. Ordination by principal component analysis of a matrix of species by reproductive and early life-history attributes resulted in a wide distribution of species along three primary early life-history gradients. These gradients are synonymous with the quantity of egg and larval production, the phenology of egg and larval production, and the ubiquity of larvae, the latter representing the temporal and spatial "spread" of larvae. From this analysis, a conceptual model is proposed for GOA fish species early life-history representing trade-offs in adaptation to prevailing environmental conditions, and associated risk and resilience factors that set the initial recruitment response to environmental forcing. The working hypothesis for this ongoing research is that we can utilize similarities in reproductive and early life-history characteristics among species to identify: (i) ecologically determined species groups that are predisposed to respond to environmental forcing during early life in similar ways, and (ii) plausible environmental predictors of recruitment variation.

Keywords: early life history, exposure–response coupling, ichthyoplankton, recruitment.

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ICES CM 2011/H:02

Externally driven mortality of cod early life stages in the central Baltic: hydrography vs. predation

Viola Neumann, Fritz Koester, Matthias Schaber, Hans Harald Hinrichsen, Margit Eero, and Axel Temming

Cod (*Gadus morhua* L.) recruitment success in the central Baltic Sea is influenced by various abiotic and biotic factors, which include ambient salinity and oxygen conditions as well as predation pressure on early life stages by planktivore clupeids, such as sprat (*Sprattus sprattus*) and herring (*Clupea harengus*). After a period of very low recruitment and stock size during the 1990s–early 2000s, the eastern Baltic cod stock exhibits signs of recovery, at least partly owing to several stronger year classes formed in recent years. In this paper we investigate whether or not changes in predation pressure by clupeids on the early life stages of cod could have enhanced cod recruitment in recent years. The analyses are based on a large dataset of stomach content of clupeids, cod egg abundances from ichthyoplankton surveys, and hydrographic measurements. We investigate temporal and spatial variability in predation pressure on cod eggs, both within and between years, and relate this to variability in hydrographic conditions. Preliminary results indicate lower predation pressure on cod eggs in the recent period compared with some earlier years.

Keywords: Baltic Sea, cod egg, hydrography, mortality.

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ICES CM 2011/H:03 Withdrawn

ICES CM 2011/H:04

An integrative approach to model recruitment dynamics in barnacles

Luis Giménez and Stuart Jenkins

Recent work suggests that recruitment of larvae and juveniles is affected by traits of organisms such as body size. We propose an integrative framework to study recruitment that incorporates organism traits. The main argument is that mortality should be affected by the product of population density and body size, which defines the amount of resources consumed by recruits. This amount defines the level of mortality owing to resource limitation. We apply this model to the recruitment of the barnacle *Semibalanus balanoides* from two different shores. In both shores post-settlement survival is better explained by models based on density and operculum area as a trait than by models based on density alone. Operculum area, a trait that does not respond plastically to changes in barnacle density, is a better predictor than basal area that responds to density. Survival follows a sigmoid function with a threshold at 30–40% of percentage cover. In future these models may incorporate physiological processes and evaluate the role of metabolism on recruitment patterns, facilitating the study of recruitment from the perspective of oceanographic- and climate-related processes, such as match–mismatch and temperature increase. More generally, we emphasize the need to develop a theory of recruitment integrating individual variability to processes operating at the population level.

Keywords: competition, recruitment, trait-mediated effects.

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ICES CM 2011/H:05 Withdrawn

ICES CM 2011/H:06

Larval fish retention in the northwest African upwelling in spring

Marta Moyano, Jose María Rodríguez, and Santiago Hernández-León

Dispersal of fish larvae into unfavourable areas may be devastating for early life stage survival and recruitment. In highly dynamic upwelling environments, such as the northwest African region, it is critical to understand the magnitude of offshore larval transport. This upwelling system remains still largely unstudied in terms of early life-history stages of fish, even for the most commercial species (European sardine and anchovy). In this work, we describe for the first time the entire larval fish community present in the area in spring, identifying a coastal and an oceanic larval assemblage. Our spring sampling identified two filament–eddy complexes between Cape Juby and Cape Bojador. The interaction of these mesoscale structures not only influenced the distribution of neritic species, but also oceanic species. Neritic larvae (sardine, anchovy, mackerel) were retained by the upwelling front, located some 100 km offshore. The interaction between the anticyclonic and the cyclonic eddy may then work as a mechanism to return the larvae to the African coast. On the other hand, oceanic species were present at nearly all sampling stations, although there were accumulations observed in a northern area near the shelf break (enhanced by the cyclonic eddy) and southern area owing to the interaction of the southern filament–anticyclonic eddy complex.

Consequences of larval dispersal for survival and recruitment for the relevant species are discussed in the light of the results.

Keywords: Canary upwelling, larval fish assemblages, larval transport.

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ICES CM 2011/H:07

Temporal settlement patterns and size at transition of juvenile cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and whiting (*Merlangius merlangus*) in the northern North Sea

Dorota K. Demain, Alejandro Gallego, Colin Millar, Imants G. Priede, and Emma G. Jones

Cod, haddock, and whiting are among the most economically important species in the Scottish demersal fishery. Juvenile settlement, the transition from pelagic to demersal habitat, has been identified as an important milestone for these species, but there is insufficient knowledge and data on this life stage. It is believed that the period of settlement has an impact on recruitment success, as important density-dependent processes may take place, such as competition for suitable substrate, refuge or prey. Also, knowledge of settlement timing and duration is relevant to understanding population connectivity and thus to the development of successful conservation measures. Sampling was conducted between April and August 2004, June and September 2005, and June and July 2006 at an inshore site off the east coast of Scotland. Over 4000 0-group cod, haddock, and whiting were collected. The results demonstrated that the transition from the pelagic to the demersal habitat was associated with clear and progressive changes in the prey composition of the juvenile fish. The size of fish that could be considered settled was estimated for cod at 4.9 (±0.3) cm, haddock at 7.8 (±0.4) cm, and whiting at 8.5 (±0.6) cm. The results also suggested clear differences in the patterns of settlement between the different species. Initially juvenile haddock favoured deeper, further offshore locations, while cod occupied shallower, inshore waters. Whiting settled much later in the season and over a protracted period of time.

Keywords: 0-group gadoids, northern North Sea, settlement size.

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ICES CM 2011/H:08

The potential for larval fish data from continuous plankton recorder (CPR) surveys to inform survival and recruitment of sandeels in the North Sea

Christopher Lynam, Sophie Pitois, Cindy Van Damme, Nicholas Halliday, and Martin Edwards

The continuous plankton recorder (CPR) survey has been sampling fish larvae since 1950. However, because the CPR is primarily designed to catch copepods and phytoplankton, the fish larval data have not been subject to much analysis. The visual identification of separate families and, where possible, species in CPR larval samples in the period 1979–2005 was completed in 2010 and combined with historical paper records (1950–1978) to provide a complete dataset for 1950–2005. The two most abundant families are the Clupeidae (herring/sprats) and Ammodytidae (sandeels). Here we show that the spatial pattern in CPR data for North Sea sandeels agrees with catches by dedicated fish larval samplers (Gulf and Bongos) during ICES WGEGGS coordinated surveys in 2004 and 2009. We explore potential relationships between fish larvae in the North Sea to prey abundance (copepods), phytoplankton (diatoms and dinoflagellates) and climate indices (sea surface temperature and North Atlantic Oscillation, NAO). We examine the possible use of the larval data for stock assessment, in particular for the sandeel stock of *Ammodytes marinus* in the North Sea and conclude that the data are particularly useful in three of the sandeel assessment areas covering the Dogger Bank, Wee Bankie, and Shetland regions.

Keywords: recruitment, seasonality, spatial, temporal.

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ICES CM 2011/H:09

Environmental influences on reproductive traits of anchoveta, maternal effects, and the chances of egg and larval survival under contrasting spawning habitats

Leonardo Castro, Gabriel Claramunt, Humberto González, María C. Krautz, Alejandra Llanos-Rivera, Joyce Méndez, Wolfgang Schneider, and Samuel Soto

Fish species distributed over a wide latitudinal range or with protracted spawning seasons usually develop tactics to enhance their offspring chances of survival in different environments. Determining whether or not trait variations are adaptive, however, may be difficult because potential adaptations for one life stage may be the result of processes occurring in a different stage. We show results of studies on the early life stages and adult reproductive traits of anchoveta, *Engraulis ringens*, obtained from environmentally contrasting spawning habitats: from two locations 17° latitude apart, from different dates during a same spawning season, and in years of contrasting environmental characteristics during the peak spawning months. Our results reveal marked differences in egg quality between populations, and also from the beginning to the end of the spawning seasons, suggesting a connection between the quality of the offspring, the environment they are to face during their development, and their chances of survival at the larval stage. Variations in reproductive parameters also occurred between populations and dates indicating the differences in the quality of eggs were the result of processes occurring during oogenesis, Moreover, differences in fatty acids in the eggs during environmentally contrasting years revealed the relationship between the adult females' feeding environment before spawning and the quality of eggs spawned. Although the effects of the environment on the females seem to result in an adequate quality of the offspring under different first-feeding larval environments, the overall results on recruitment may not be so clear when other oceanographic aspects of the nursery habitat are taken into account.

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ICES CM 2011/H:10

Climate-driven changes in recruitment success of marine invertebrates: the role of food supply

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A potential consequence of climate change on species with pelagic larvae is that shifts in the timing of larval release or of food availability may cause variation in recruitment governed by match/mismatch mechanisms. Species may avoid mismatch by synchronizing larval release to pulses of food or may develop physiological adaptations to tolerate low food levels. In the UK, the barnacle *Semibalanus balanoides* releases larvae in response to the spring phytoplankton bloom, whereas *Elminius modestus* releases larvae over a longer summer period. We experimentally tested if the pattern of larval release of *S. balanoides* in response to food density was related to larval food limitation and whether or not larvae of *E. modestus* display higher tolerance of food limitation than *S. balanoides*. Larvae of both species were reared under three food levels of *Skeletonema costatum* (4×10^5; 2×10^5, and 0.4×10^5 cells ml^{-1}), reproducing those known to affect *S. balanoides* larval release. Larvae were obtained from eight adults to account for parental influences on larval tolerance. Experiments were run at 15°C, where larval survival of both species is reportedly high. Duration of development was shorter for both species under highest food density. No differences in survival and success of metamorphosis to juvenile were observed for *E. modestus*. In *S. balanoides* the lowest food density led to a significant reduction in survival and rates of metamorphosis to

juvenile. This pattern was consistent across larvae from different adults although there was a highly significant parental influence.

Keywords: barnacle larvae, food availability, recruitment success, UK.

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Identifying and monitoring limiting factors of recruitment: anchovy in the Bay of Biscay

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The controls of recruitment are conceptually multiple and potentially changeable over the years. In effect, recruitment results from many processes during spawning, larval drift, and the juvenile stage. Coupled physical biogeochemical models now provide realistic hindcasts that spatially resolve environmental conditions. Such information is useful to identify limiting conditions over the different habitats of the different life cycle stages. Environmental indices can be estimated and serve as indicators of processes favouring or limiting recruitment, allowing us to revisit conceptual understanding, such as the importance of retention or match–mismatch. This approach was applied to anchovy in the Bay of Biscay, for which a series of low recruitments occurred recently that previous understanding and regression models could not explain. Indices of physical features were estimated (river plumes, gyres, stratification, fronts) as well as indices of larval dispersal, primary production, and temperature. Also estimated were indices of spawning aggregations derived from fisheries survey data. The indices were estimated in different areas and seasons corresponding to the habitats of spawning adults, larvae, and juveniles. Limiting factors were searched for by evaluating the statistical significance of a quantile regression fit between the recruitment series and each index. Results demonstrated that the larval period was where many indices responded, confirming that it is a critical period. The limiting factors changed across the series, confirming the multiple nature of the determinism of recruitment. The danger of spurious correlation when searching many indicators is discussed. Rather than predict recruitment, monitoring a suite of indicators is advised.

Keywords: anchovy, hindcast, physical–biogeochemical models, quantile regression, recruitment.

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ICES CM 2011/H:12

Dynamics of larval and juvenile rockfish (*Sebastes* spp.) recruitment in coastal waters of the northern California Current

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Relatively little is known about recruitment dynamics of the many (> 80) rockfish (*Sebastes* spp.) species that occur in the northern California Current. To evaluate their relative recruitment success, we examined the occurrence of early life stages of rockfish caught in various plankton nets and trawls, and also their occurrence in the diets of piscivorous salmon, from 1998 to 2010. Larval rockfish were consistently among the dominant ichthyoplankton taxa collected in all years. Mean densities varied little from 1998 to 2003, were high in 2004–2005, decreased dramatically in 2006, and then steadily increased through the remainder of the decade to the highest levels recorded in 2010. Seasonal densities were consistently highest in June and July. Peak catches of juvenile age-0 rockfish during coastal surveys in June (1999–2010) were in 2004 and 2010. The juvenile rockfish caught in 2004 were also significantly larger than any other year. Age-0 rockfish (20–90 mm total length, TL) were caught during all 13 years of surface trawling off the Columbia River. However, 2004 marked the first large recruitment pulse of rockfish observed. Similar densities were observed in 2005 and 2006, with subsequent recruitment pulses observed during 2008 and 2010. Directed

surveys for juvenile rockfish begun in 2004 demonstrated that mean concentrations of age-0 rockfish increased until 2008 (highest density recorded), with a slight decrease in rockfish density for 2009 but a rebound in juvenile rockfish in 2010, which demonstrated the greatest mean size of the 7 survey years. Juvenile coho and Chinook salmon consistently ate age-0 rockfish, which contributed on average 29.0% and 22.4% of Chinook salmon diets by weight, respectively. Age-0 rockfish typically were eaten in May only during years of increased catches of juvenile rockfish in our sampling nets, with 2010 exhibiting the largest proportion of juvenile rockfish in Chinook salmon diets (40.8%). We used these multiple indicators to identify upcoming strong year classes in rockfish; they suggest that 2004 and 2010 were above average for rockfish recruitment.

Keywords: ichthyoplankton, juveniles, recruitment indicators, rockfish.

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ICES CM 2011/H:13

Changes in the reproductive success of the Gulf of Riga herring

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Gulf of Riga herring is a small stock of spring-spawning Baltic herring inhabiting the Gulf of Riga in the eastern Baltic. It differs substantially by size-at-age from the neighbouring herring stock in the Central Baltic, as well as in stock dynamics and year-class strength. Gulf of Riga herring spawns in March–May in the shallow coastal zone of the gulf. Since the 1950s, rich year classes of Gulf of Riga herring appeared after mild winters, whereas severe winters cause the formation of poor year classes. A series of mild winters starting in the 1980s contributed to the emergence of rich year classes and a fast increase in stock size. The successful reproduction conditions allowed intensive exploitation of the stock. Significant relationships were found between the year-class strength, water temperature, and zooplankton abundance in spring. Investigations on the spawning grounds revealed that spawning is longer, all spawning grounds are used, and the eggs are distributed more evenly when the water temperature is higher during spawning season. The zooplankton abundance evidently determines the feeding conditions and survival of larvae. In the 1990s, water temperature and zooplankton abundance were successfully used for the prediction of recruitment. However, after the emergence of several (2000, 2002, 2005) very rich year classes, this relationship has weakened. The paper analyses what other factors, in particular feeding conditions in summer, contribute to the reproduction success of the Gulf of Riga herring.

Keywords: Baltic Sea, Gulf of Riga herring, reproduction.

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ICES CM 2011/H:14

Recruitment of Pacific cod (*Gadus macrocephalus*) in southern Korean coastal waters

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Pacific cod have been traditionally important commercial fish species in Korea. Two distinct stocks were proposed: the Yellow Sea stock mature one year earlier than stocks in the Japan/East Sea and Korea Strait. Recruitment of cod in Korean waters seems to have been lower from the 1950s to the 1990s. Recently, however, the commercial cod catch has steadily increased from 0.5×10^3 t in 1998 to a record high at 7.2×10^3 t in 2007, which is in contrast to the recent declining trend since 1997 in the eastern North Pacific areas (Gulf of Alaska and Bering Sea). Coincidentally, the annual catch of Pacific herring (*Clupea pallasii*), a dietary component of cod, has also dramatically increased from 1.9×10^3 t in 2002 to a record high at 43.8×10^3 t in 2008, indicating a match–mismatch or a common prerequisite between herring and cod for successful recruitment. Since the late 1990s, bottom temperatures in the southern coastal waters during the winter spawning season have significantly decreased, probably related to strengthened mixed layers and increased frequency of cold-water

penetration from the Japan/East Sea. We speculate that these decreased bottom temperatures favour the survival of cod eggs, which are demersal and hatch at 5–12°C. In addition, annual catch of cod in southern coastal waters revealed a significant correlation with time-lags of 1–2 years with respect to the volume transport of the Tsushima warm current during March, when cod larvae leave the spawning grounds. We expect comparisons with the eastern North Pacific will give insights into the roles of hydrographical changes and bottom-up controls in recruitment processes of Pacific cod.

Keywords: climate change, Pacific cod, Pacific herring, recruitment, western North Pacific.

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ICES CM 2011/H:15

Spatial and temporal patterns in the dynamics of prerecruit rockfish on the US West Coast

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Since 1983 the US National Marine Fisheries Service has conducted an annual midwater trawl survey off the coast of central California. The survey is designed to generate indices of prerecruit abundance of pelagic juvenile rockfish (*Sebastes* spp.) for use in stock assessments. More recently the survey has expanded to cover the entire US west coast. This extensive 28-year time-series of data, in conjunction with recruitment estimates from stock assessments, affords the opportunity to address a variety of topics relating to the establishment of rockfish year-class strength. In summarizing these research results we describe a remarkable degree of annual synchrony in abundance among 10 winter-spawning species in the central California area. Standardized catch-per-unit-effort time-series reveal both high- and low-frequency cycles of abundance, with individual species demonstrating unique spatial and seasonal distributional patterns. Among- year variation indicates that year-class strength is established prior to the survey, which occurs in the late spring. Moreover, comparisons of the abundance of pre- and post-settlement juvenile young-of-the-year indicate that settlement has no major impact on year-class strength. Evidence also suggests that density-dependent compensatory mortality occurs post-settlement and prior to recruitment to the fishery. The most recent midwater trawl survey data, which is based on geographically extensive sampling, highlight the importance of broad spatial survey coverage to capture interannual variations in the distributions of pelagic juvenile rockfish, owing to highly anomalous results in 2005. Despite these findings, there is broad spatial cohesiveness in species-specific geographic patterns of recruitment to the fishery, which is consistent with inferences drawn from oceanographic dispersal modelling and genetic analyses. Despite two decades of work, however, the incorporation of survey indices into rockfish stock assessments has met with limited success.

Keywords: California, recruitment, rockfish, year-class strength.

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ICES CM 2011/H:16   Withdrawn

ICES CM 2011/H:17

Resolving the relative importance of fish nursery habitats using otolith elemental fingerprints

Holly J. Rolls, David L. Jones, Carole C. McIvor, Janet A. Ley, and Ernst B. Peebles

Quantification of the relative importance of fish nursery habitat areas is necessary in order for resource managers to effectively prioritize their conservation. Scientists are increasingly using elemental signatures contained within fish otoliths to identify nursery areas that contribute

disproportionately to adult fish stocks. The chemical composition of the otolith acts as a natural tag, reflecting the occupation of different water bodies, and can thus be used to distinguish fish from different geographic origins. With the purpose of understanding the relative importance of specific tidal tributaries as nursery habitat throughout Tampa Bay, Florida (USA), we are using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to analyse elemental fingerprints within the otoliths of two estuarine-dependent species of fish, common snook (*Centropomus undecimalis*) and red drum (*Sciaenops ocellatus*). Distance-based canonical discriminant analysis applied to otolith elemental fingerprints of young-of-the-year fish suggest that surficial geology of the sampled nurseries is a primary contributor to differences in otolith chemistry between nurseries, and has provided relatively high classification success (70–80%) of juveniles to their known nursery sites. Maximum likelihood estimation of the elemental signatures from the core portions of adult otoliths from the same cohort will permit us to identify their probable nursery areas, as defined by young-of-the-year otoliths. Overall, our geology-based classification framework has distinguished nursery regions on a geographical scale of resolution of approximately 20 km, providing an effective tool for fine-scale management of highly productive nursery grounds for two estuarine-dependent species in Tampa Bay, Florida.

Keywords: natural tags, nursery habitat, otolith elemental fingerprinting, west-central Florida (USA).

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ICES CM 2011/H:18

Effects of photoperiod and temperature on recent growth rates of sprat larvae in the Baltic Sea

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Growth rate has been shown to affect survival and recruitment of marine fish. How growth rates in the field are affected by larval development and environmental variability is poorly understood. Recent growth rates of sprat larvae, a key species in the Baltic marine ecosystem, were determined by converting RNA/DNA ratios from individual larvae into recent growth based on a laboratory-calibrated RNA/DNA temperature growth model. Several factors (larval size, temperature, and photoperiod) that may contribute to the observed variability in recent growth sampled in the spawning seasons 2002–2004 were analysed with a variety of models. Best fit was found for the generalized additive models (GAMs). Larval size (dry weight), photoperiod, and temperature terms explained 29% and 36% of the variability observed in recent growth of sprat larvae in the Baltic Sea, respectively.

Keywords: effect on recruitment, GAM model approach, growth rate, larval sprat, photoperiod, temperature.

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ICES CM 2011/H:19

Environmental and habitat effects on early life stages and subsequent recruitment variability of the common cuttlefish (*Sepia officinalis*) within the English Channel

Isobel Bloor, Emma Jackson, Jean-Paul Robin, and Martin Attrill

In short-living, fast-growing cephalopod species like *Sepia officinalis*, which consist of only one or two overlapping age classes, sustainable exploitation can depend heavily on successful annual recruitment. Recruitment strength of *S. officinalis* is known to fluctuate widely from year to year and this variation is commonly attributed to environmental conditions, which may vary both spatially and temporally throughout the spawning season. The sensitivity of cuttlefish to environmental variability during the early life history is thought to be high and the subsequent impact on recruitment to the fished stock is important in understanding population dynamics. In

this paper we present results from subtidal surveys looking at the different densities of eggs among habitats, locations, and months and use environmental and physical information collected during these surveys to investigate the effects of habitat choice and environmental conditions on the potential survival and recruitment of early life stage *S. officinalis* to the fished stock within the English Channel. We examine the behaviour of spawning adults within a spawning ground using acoustic tagging to monitor their movements with the aim of identifying specific behaviours that may indicate site choice in terms of the best habitat for early life stage survival and hence recruitment. Finally we look at the results of predictive habitat modelling of juvenile grounds and compare the environmental conditions highlighted in our models with those measured at actual sites studied during subtidal surveys and relate this back to recruitment success.

Keywords: cephalopod, English Channel, habitats, recruitment.

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ICES CM 2011/H:20

Examine and quantify connectivity between spawning areas and nursery habitats of two North Sea key species: brown shrimp and plaice

Marc Hufnagl, Adriaan Rijnsdorp, Richard Nash, Axel Temming, Thomas Pohlmann, Maarten Boersma, and Myron Peck

Connectivity between essential habitats can often be a critical bottleneck influencing the recruitment dynamics of marine organisms with pelagic early life stages. We examined connectivity issues in two North Sea key species, brown shrimp (*Crangon crangon*) and plaice (*Pleuronectes platessa*). The early life stages of both species have specific habitat requirements during settlement to shallow coastal waters and tidal flats. Spawning mainly occurs offshore during winter and nurseries have to be reached after a planktonic drift phase. For brown shrimp, timing of simulated recruitment agreed well with observations on larval and juvenile abundance. In general, winter recruitment is distributed over a larger area and juvenile shrimps observed at the German coast originate in Dutch and Belgium hatching areas. Summer recruitment, in contrast, mainly remains close to the hatching site. The impact of different hydrographic situations on recruitment and North Sea landings are discussed. Known plaice spawning locations that were successful over the simulated period were in broad agreement with main centres of egg production. The suitability of southeastern spawning grounds increased over the 30-year period. Reasons, such as changes in drift or development, are discussed.

Keywords: brown shrimp, connectivity, drift, nursery areas, plaice, recruitment, spawning grounds.

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ICES CM 2011/H:21

The different approaches to evaluations of eastern Baltic cod annual egg production on diverse spawning grounds and a possible role of skipped spawning in stock decline

E. M. Karasiova

The significant growth and subsequent decline of the eastern Baltic cod in the 1970s and 1980s attracted attention to both the reproductive biology and fishery-independent indicators of variability of that stock. Based on interannual ichthyoplankton surveys for 1957–1996 and literature sources, fluctuations in annual cod egg production were considered in connection with some traits of cod reproductive behaviour on most remote from the Danish Straits the Gotland spawning ground. A significant correlation between annual egg production assessment and trawl survey series could be found only for Bornholm Basin with environmental conditions for yearly cod reproduction. However the total annual egg production calculation including the Gdańsk Deep and the largest cod spawning ground in the past—the Gotland Basin—revealed a temporal

discrepancy between peak values of annual egg production and spawning–stock biomass in the late 1970s–early 1980s. It is supposed that an increase in the share of adult not-matured cod females during the spawning season in the Gotland Basin may be a reason for the discrepancy observed. It is hypothesized that skipped spawning in the Gotland Basin could be a result of deficiency of reproductive resources in the eastern Baltic Basins because of a prolonged absence of Kattegat water inflows and worsening environmental conditions for cod reproduction. It is demonstrated that a correlation between total annual egg production and spawning–stock biomass is increased by incorporating egg mortality and maturing cod female share into annual egg production. A possible role of skipped spawning for the eastern Baltic cod stock decline is discussed.

Keywords: Baltic Sea, cod annual egg production, different environmental conditions, skipped spawning.

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ICES CM 2011/H:22   Withdrawn

ICES CM 2011/H:23

Recruitment of Atlantic menhaden to Chesapeake Bay: ecological processes during the larval–juvenile transition

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After two decades of high recruitments in the 1970s and 1980s, recruitment of Atlantic menhaden (*Brevoortia tyrannus*) declined to historically low levels in Chesapeake Bay and has remained there since the 1990s. Two underlying mechanisms were evaluated to explain recruitment variability: (i) variable larval-stage ingress from the coastal ocean and (ii) trophodynamic/energetics processes operating on juveniles within Chesapeake Bay. Surveys at the Bay mouth were conducted to estimate abundance of ingressing larvae, hatch dates and growth rates. Long-term data on recruitment levels of juveniles in the Bay were analysed with respect to environmental variables. Growth and bioenergetics models were developed for filter-feeding menhaden to determine interannual and regional variability. Annual abundance of larvae at ingress in 2006–2008 varied ninefold but levels were not concordant with recruited juvenile abundance 6 months later. Hatch dates of larvae were mostly in October to January, but surviving juveniles hatched mostly in January–February. Ingressing larvae grew fastest in 2007, the year of lowest abundance. Juvenile recruitments from 1989–2004 were strongly correlated with chlorophyll *a*. The bioenergetics model, parameterized for body size, temperature, and chlorophyll *a*, accurately portrayed observed growth and growth based on a temperature–degree day model. Regional climate variability acting on survival of eggs and larvae, combined with variable primary productivity and predation rates acting on juveniles, are believed to drive long-term recruitment levels of menhaden in Chesapeake Bay.

Keywords: Atlantic menhaden, Chesapeake Bay, recruitment variability.

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ICES CM 2011/H:24

Exploring larvae recruitment variability of Peruvian anchovy and sardine with modelling and data assimilation

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A Spatial Eulerian Ecosystem and Population Dynamic Model (SEAPODYM) is used in a data assimilation study aiming to estimate model parameters that describe spawning conditions and dynamics of anchoveta and sardine larvae in the Humboldt Current system (HCS) off Peru. Initially developed for large pelagic fish (e.g. tuna), SEAPODYM was adapted for this study to small pelagic species, and configured to a regional domain using the ROMS-PISCES coupled physical–biogeochemical model as an input. Environmental variables are used to define a spawning habitat. This habitat is critical because it controls the initial recruitment of larvae in the first cohort and subsequent spatio-temporal variability of natural mortality during their drift with currents described by a system of Eulerian equations. We conducted a series of optimization experiments using sampling data of anchovy and sardine larvae to estimate the parameters of the spawning habitat of both species. Different mechanisms proposed to control the fish larvae recruitment are explored: temperature, trade-off between presence/absence of prey and predators of larvae, retention or dispersion by currents. The large interannual to multidecadal fluctuations observed in the recruitment of both anchovy and sardine species is analysed and discussed with regard to the optimal parameterization achieved.

Keywords: anchoveta, end-to-end model, parameter optimization, population dynamics, sardine, SEAPODYM, spawning habitat, upwelling ecosystem.

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ICES CM 2011/H:25

The impact of climate change on Baltic sprat population dynamics—a matrix model approach

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Baltic sprat (*Sprattus sprattus balticus* S.) is a key species in the pelagic ecosystem of the Baltic Sea. Most small pelagic species are characterized by natural, fishery-independent fluctuations which make it difficult to predict stock development. Baltic sprat recruitment is highly variable, which can partly be related to climate-driven variability in hydrographic conditions. Results from experimental studies and field observations demonstrate that a number of important life-history traits of sprat are affected by temperature, especially the early life stages. The predicted climate change may affect important processes throughout the entire life cycle of sprat, survival and development during the egg and larval phase, as well as the reproductive output of the adult stock. This study presents a stage-based matrix model approach to simulate sprat population dynamics through time in relation to different climate change scenarios. Data obtained from experimental studies and field observations were utilized to incorporate stage-specific growth and survival rates into the model. This approach allows us to identify the most critical life stages of Baltic sprat in relation to a temperature change and its consequences for sprat population dynamics.

Keywords: Baltic Sea, life stage-based model, sprat.

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ICES CM 2011/H:26

Cuttlefish (*Sepia officinalis* L.) early life history from different coastal areas of the English Channel: comparison between experimental hatchlings and wild prerecruits physiological performances

G. Safi, I. Bloor, E. Jackson, M. Gras, J. P. Robin, and N. Koueta

The cuttlefish (*Sepia officinalis* L.) lays its eggs in coastal waters where the incubation conditions affect hatchling weight and length, influencing growth thereafter. The aim of this work was to study the impact of different spawning sites from English Channel coasts on egg incubation and on the physiological performance of prerecruits. Two approaches were used to characterize the site impact: an experimental approach on hatchling growth and study of the physiological performance

of wild prerecruits. In 2009 and 2010, eggs from two coastal French sites (West and East Cotentin) and two English coastal sites (Torbay and Selsey) were transported to the marine research station to be reared in similar conditions. Preliminary observations indicated differences in hatching and survival rate between Selsey and the three other sites. Hatchlings were also bigger and grew faster in specimens from Seine Bay (East Cotentin), Selsey, and Tor Bay than from the West Cotentin site. Similar differences were thereafter observed in digestive and immune enzymatic assays made on each batch. On the other hand, comparison of prerecruits collected from West and East Cotentin (the two French sites) suggested a reverse growth profile from that obtained in the experimental rearing. The experimental hatchling growth and the wild prerecruit physiological performances observed can, however, be explained by differences between sites in habitat characteristics that affect egg incubation and then early juveniles growth. This study revealed an impact of the different spawning sites on juvenile physiological performances and the observed differences are a result of the eggs' environmental incubation conditions in the various sites. Assessing early life performance is a step towards the analysis of the quality of eggs and juveniles coming from different spawning sites.

Keywords: cuttlefish, habitats, hatchlings, juveniles, physiological performance, prerecruits, *Sepia officinalis*, spawning sites.

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ICES CM 2011/H:27

Population dynamics of plankton in the Gulf of Maine

Brian J. Rothschild and Yue Jiao

Various surveys over the past 30 years have sampled zooplankton abundance in the Gulf of Maine. Examination of the intra-annual abundance of each of the 15 most abundant species generally reveals a peak in abundance during one of the spring or summer months. This peak can be thought of as "apparent recruitment". The subsequent intra-annual decline in abundance reflects "apparent mortality". The apparent recruitment and apparent mortality for each species is calculated. The recruitment and mortality rates for each year are compared and fit to a mixed regression model. Preliminary calculations using *Calanus finmarchicus* data reflect plausible recruitment and mortality rates. Considerable variability in recruitment masks any interannual differences in recruitment. There are, however, significant interannual changes in mortality rate. A doubling of mortality rates is coincidental with explosion of the herring population. Apparent recruitment and apparent mortality for each of the 15 species will be presented and subject to mixed-regression analysis. Information on correlations among recruitment and mortality for the 15 species are critical to an understanding of ecosystem functioning.

Keywords: Northwest Atlantic, plankton dynamics.

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ICES CM 2011/H:28

Trait-based modelling of marine fish early life stages

Klaus B. Huebert and Myron A Peck

Building mechanistic models of the growth and development of marine fish from eggs and yolk-sac larvae to feeding larvae and juveniles generally requires species-specific parameterization of physiological and behavioural processes. This approach has been successful for several well-studied fish stocks, but essential laboratory measurements for a much wider range of species are lacking. However, owing to the functional morphology of fish, it is possible to estimate missing parameters from readily available morphometric measurements and their robust, statistical relationships with physiological and behavioural traits. We are developing a generic individual-

based model that simulates early life stages of marine fish based on observed and theoretical combinations of morphological traits and morphometric measurements. The analysis is based upon a thorough review of larval fish growth physiology and foraging behaviour. Our goals are to explore trade-offs among different developmental strategies (e.g. are "theoretically ideal" combinations of morphometrics similar to those realized in nature?), examine past and present biogeographic ranges (how do different developmental strategies match specific environments?), and provide a relatively simple tool for estimating development and survival of fish early life stages that have not been studied sufficiently for precise species-specific parameterization.

Keywords: fish larvae, individual-based model, morphometrics.

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ICES CM 2011/H:29

Multiple indices shed light on transport-related condition of coral reef fish larvae

M. J. Hauff, S. Sponaugle, K. D. Walter, and R. K. Cowen

Despite the potential for long-distance dispersal of larval fish, recent research indicates that local retention of larvae may be more important in replenishing coral reef fish populations than influx from distant sources. Because of carryover effects between life stages, larvae that exhibit different levels of condition in the plankton may differ in their post-settlement mortality. Thus, in order to better understand the relative contributions of local retention and long-distance dispersal in maintaining reef fish populations, it is necessary to examine the relationship between larval condition and dispersal trajectory. To this end, we undertook three cruises in the summers of 2007 and 2008, collecting ichthyoplankton and environmental measurements (MOCNESS and CTD) at 90 stations on cross-shelf transects along the Florida Keys reef tract, and in the Loop Current upstream of the Florida Keys. MOCNESS tows at each station yielded larvae from a broad range of coral reef fish taxa and, for a subset of larvae identifiable to species, RNA/DNA ratios were obtained, allowing for evaluation of condition in individual larvae collected across distinct water masses. Although results varied among species, data indicated that, for some taxa (bluehead wrasse, pearly razorfish), larvae collected closer to shore exhibited significantly higher RNA/DNA ratios compared with larvae collected offshore, and this pattern became more pronounced with increasing larval size and age. Otolith-based indices of condition (growth rate, size-at-age) corroborated these findings, which provide support for the theory that locally-retained larvae benefit from enhanced condition and subsequent increased survivorship on the reef.

Keywords: early life history, Florida Keys, larval condition, RNA/DNA.

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ICES CM 2011/H:30

Predator-specific growth-selective predation and dynamics of the growth-based survival mechanisms in anchovy larvae

Akinori Takasuka, Ichiro Aoki, Ayumu Sakai, Yoshioki Oozeki, and Dominique Robert

Slower growing individuals are more vulnerable to predation mortality than faster growing conspecifics, even if they are the same size at a given moment. This "growth-selective predation" mechanism was proposed as one of three functional mechanisms of the general "growth–mortality" hypothesis in our previous study, which focused on the characteristics of the actually ingested larvae vs. the original populations. This talk summarizes our subsequent studies on predator-specific "growth-selective predation" and dynamics of the growth-based survival mechanisms in Japanese anchovy (*Engraulis japonicus*) larvae in Sagami Bay, Japan. The mechanism was tested based on comparisons of growth rates between the ingested larvae from the stomachs of predatory fish and the surviving larvae from the original populations. Through this approach,

predator-specific "growth-selective predation" was demonstrated by comparisons among different predatory species. Small pelagic fish were identified as growth-selective predators, whereas piscivorous fish were identified as non-growth-selective predators. On the other hand, the three growth-based survival mechanisms ("bigger is better", "stage duration", and "growth-selective predation") were tested for multiple cohorts of anchovy larvae based on the characteristics of the survivors vs. the original populations. As a result, each mechanism was detected to be effective at least in some cohorts, but none of the mechanisms was universally appropriate to all of the cohorts. The three different mechanisms actually regulated the short-term survival processes independently and synergistically. The relative contributions of the mechanisms were dynamic although the "growth-selective predation" was identified to be the major one regulating survival in anchovy larvae in the study site.

Keywords: anchovy larvae, bigger is better, growth-selective predation, stage duration.

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ICES CM 2011/H:31   Poster

Overwinter survival of larval herring *Clupea harengus* Björn Illing, Marta Moyano, and Myron A. Peck

It is important to gain a cause-and-effect understanding of how climate-driven changes may influence the survival and recruitment potential of marine fish stocks. Interannual differences in the overwinter survival of larvae may regulate year-class success of Atlantic herring in the Baltic and North Seas. We are exploring how larval size and condition, prey dynamics, and water temperature may interact to influence overwinter survival in herring larvae from the northeastern Baltic (Gulf of Riga, GOR) and southwest North Sea (Downs subcomponent, NSD). We have also included measurements on larvae of spring spawners from the southwest Baltic (Kiel Bight, SWB) so that population comparisons can be made across a broad range of habitat salinities (6–34 psu). Physiological measurements are made both on individuals (e.g. micro-respirometry, protein-specific growth rates, metabolic enzymes) and small groups (e.g. swimming activity, point-of-no-return feeding trials) which are augmented with direct quantification of ontogenetic changes in salinity and temperature tolerance. Initial results indicate that physiological tolerances markedly increase with body size: larger larvae better withstand very low salinity (0.5–5.0 psu). We compare and contrast environmental conditions experienced by GOR, NSD, and SWB larvae and discuss our approach to reveal physiological mechanisms regulating survival of early life stages of herring.

Keywords: Baltic and North Seas, ecophysiology, herring larvae, overwinter survival.

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ICES CM 2011/H:32   Poster

Maternal effects: from environment through molecular and individual levels, towards population ecology; the shore crab (*Carcinus maenas*) as model species

Gabriela Torres, David Wilcockson, David Thomas, Nia Whiteley, and Luis Giménez

We evaluated the effect of embryonic conditions and seasonal variability on traits and performance of early larval stages of the shore crab (*Carcinus maenas*). This is a predatory species native to the European coast, but a destructive invasive species elsewhere. We investigated the combined effects of temperature (15°C and 18°C) and salinity (25‰ and 35‰) experienced by embryos and larvae on biomass (elemental carbon and nitrogen), gene expression of Na^+-K^+-Cl^--cotransporter, developmental rates and survival of zoea I stage obtained from females collected at different times of the year. There was a significant effect of season on carbon and nitrogen content of freshly hatched zoea I; higher body mass was associated with faster development and higher survival. Larvae hatched from females exposed to 25‰ had higher survival rates, and demonstrated higher carbon content and higher expression levels of the Na^+-K^+-Cl^--cotransporter than those originating

in females kept at 35‰. There was no significant effect of thermal stress (15°C) on larval performance under optimal osmotic conditions, but the combined effect of osmotic and thermal stress increased mortality and developmental rates. These results suggest that larval survival in *C. maenas* is the consequence of a complex interplay between seasonal variations, embryonic experience and the larval thermal and osmotic environment. These effects should be mediated by variations in the allocation of biomass into eggs and by the contribution of ion exchangers such as the Na^+-K^+-Cl^--cotransporter to the embryonic osmotic environment.

Keywords: none.

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ICES CM 2011/H:33   Poster

Is recruitment of plaice in the Irish Sea constrained by predation of eggs by sprat?

Antonio Plirú, Jeroen van der Kooij, Georg H. Engelhard, Clive J. Fox, Stephen P. Milligan, and Ewan Hunter

Since the late 1990s, Irish Sea plaice (*Pleuronectes platessa*) has exhibited a steady increase in spawning–stock biomass, whereas recruitment has remained constant. Over the same period, evidence suggests an increased abundance of sprat (*Sprattus sprattus*). Here we present a field study suggesting that plaice recruitment may be at least partially constrained by high rates of predation on the eggs. In Liverpool Bay (southeastern Irish Sea), an important and well-described plaice spawning area, we estimate that sprat may consume between 20% and 76% of all spawned plaice eggs. These results are based on the analysis of more than 400 sprat stomachs combined with simultaneous observations of plaice egg density in the water column. The upper and lower estimates represent variability in assumed evacuation rates and egg production values. These data suggest a possible "top-down" effect on the population dynamics of the larger fish species based on predation on fish eggs by the smaller forage fish. Sprat also consume eggs of other fish species spawning in spring. Changes in sprat abundance, distribution, and feeding behaviour require further investigation in the Irish Sea and elsewhere, because sprat predation on the early life-history stages could increasingly impact on fish stocks.

Keywords: early life history, eggs, Irish Sea, predation.

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ICES CM 2011/H:34   Poster

Choice of age to assess year-class strength in small pelagic fish of the Canary upwelling region

N. Timoshenko and N. Barkova

Recruitment estimation is the weakest point in fish stock management at low latitudes. Regular winter and summer samplings of ichthyoplankton were carried out in the Canary upwelling region. One of the goals was to obtain a tool to assess the recruitment trend. However, the trawl recruitment surveys in 2003–2010 had reduced our hope of using the "snapshot" larval abundance as a recruitment strength indicator. Long and irregular spawning reduces the validity of these estimates for sardine, horse mackerel, and chub mackerel. Despite the absence of a fishery, and hence the lack of fishery mortality, the abundance of 0-group does not always correspond to the later obtained estimates for the same generations. This suggests that year-class strength is determined here at a relatively late ontogenetic stage. The abundance indices of 1-year-old fish were found with satisfactory statistical precision. These indices demonstrate a good link with independent abundance estimates and the same environmental characteristics. Diagrams of joint dynamics of abundance indices and environmental parameters are presented.

Keywords: Canary upwelling region, recruitment, small pelagic.

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ICES CM 2011/H:35   Poster

Environmental factors influencing abundance fluctuations and distribution of fish maturity early stages in the central-east Atlantic

A. Arkhipov

It is known that the main parameters of abundance for fish generations are formed during the early life stages—embryonic, larval and juvenile. The basis of this work is material collected by the author and his colleagues in the area of the central-east Atlantic and the seas of the Mediterranean basin area from 1981 to 2010 and also data from the literature. Selection of any one crucial factor that determines abundance fluctuations for fish larvae and juvenile cannot be acknowledged as valid. The influence on abundance of all environmental factors that are available for analysis must be considered. Fish survival in early ontogenesis is determined by a complicated complex of biotic and abiotic parameters. We presented a generalized scheme of dependence between abundance and the distribution of studied fish juveniles and different environmental factors. We suggest that the scheme is applicable for the majority of mass fish species in the central-east Atlantic. Some considered factors influence juvenile abundance negatively, others positively, and some of the environmental parameters affect certain fish species in early ontogenesis differently. For instance, salinity is a favourable factor for predatory fish, but unfavourable for plankton feeders; a high abundance of spawning stock is a negative factor for cannibal species, but for species that change their habitat area with age it is a positive one; surface water temperature for summer-spawning species is a positive factor, for winter-spawning species it is a negative one, etc.

Keywords: central-east Atlantic, environmental factors, fish maturity early stages.

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ICES CM 2011/H:36   Poster

Recruitment dynamics of Baltic sprat and yield prediction of generations in the medium term

Fausts Svecovs, Guntars Strods, Alla Vingovatova, and TatianaVasilieva

The main objective of our research is to evaluate the abundance and biomass of sprat in the Baltic Sea and possible catch in future based on the calculation of changes in the fish stock. One of the determining factors on which the value of the stock depends is the size (yield) of separate generations. It is extremely difficult to predict the yield of Baltic sprat generations and this issue still remains unsolved by scientists from all the Baltic countries. When large numbers of sprat juveniles in autumn have a small length and mass, high mortality of juveniles in a severe winter is expected, and the numbers of this generation in spring will be low. Since the mid-1980s data from various surveys have been used to assess the yield of sprat generations. However, such estimates of yields of sprat generations can forecast stock abundance and optimal catch for no more than two years. Therefore we tried to find a pattern for the population dynamics of sprat generations which will predict the stock and available catch over the longer term. At the beginning of the forecasting method we smoothed kinks in the empirical curves of yearling numbers for the period 1972–2008. In the next steps we tried to create the resulting equation to predict the yield of generations in the medium term.

Keywords: Baltic sea, Baltic sprat, sprat generations.

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ICES CM 2011/H:37   Poster

Internal brooding as a beneficial reproductive strategy for sea anemones in the intertidal zone

Anita Kaliszewicz, Ninel Panteleeva, Izabella Olejniczak, and Paweł Boniecki

Brooding is an interesting reproductive strategy of sea anemones inhabiting a wide variety of sub- and intertidal zones. We focused on the spatial structure of sea anemones forming aggregations in the intertidal zone of the Barents Sea. We found three dominant arctic–boreal species in the study area: *Urticina crassicornis*, *Cribrinopsis similis*, and *Aulactinia stella*. All of these species are internal brooders. The first two species release fully developed young through the mouth, the third one releases juveniles using the tentacles. Although brooding is a reproductive strategy that reduces dispersion, it leads to rapid colonization of the sites occupied by the parents. We found mixed aggregations of three or two studied anemone species. *A. stella* appeared to be widely distributed around the coast. Although *U. crassicornis* and *C. similis* were less widely distributed, when present they formed dense aggregations. They preferred the sites between rocks that are sheltered from waves. The analysis of the distance between juveniles and the reproducing anemones revealed that the smallest young anemones of *U. crassicornis* were less abundant and settled significantly closer to parents compared with juveniles of *A. stella*. The strategy of releasing juveniles through the tentacles allows the young *A. stella* to attach directly to the substratum. It seems to be more beneficial in the littoral zone disturbed by waves compared with the strategy of the *Urticina* and *Cribrinopsis* species that release juveniles through mouth.

Keywords: internal brooding, reproductive strategies, sea anemones, spatial structure.

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ICES CM 2011/H:38   Poster

"Puffing" under the water surface—hatching process in *Balanus improvisus*

Anna Dziubińska and Anna Szaniawska

Balanus improvisus is the main component of benthic fouling communities in the southern Baltic Sea. Acorn barnacles in the Baltic Sea produce two broods, in summer and early autumn. According to majority of observations, hatched nauplii leave the mantle cavity of parental organism, but it is known that some Cirripedia may also release eggs. This process is not well described in barnacles inhabiting the Baltic Sea. Several observations of live barnacles growing on hard substrata (hard PVC panels) have been made in the Gulf of Gdańsk. A large number of barnacle eggs, covering other benthic organisms, were found on the assemblages inhabiting panels. More exact observations have allowed us to catch the moment at which barnacles "puff" large numbers of nauplii and eggs. The eggs that are "puffed" from the mantle drop on the surrounding fouling organisms. The released nauplii drift in the water column and concentrate in light spots generated by an artificial light source. We also observed that nauplii hatched from the external eggs. Supplying barnacles with artificial substrata in natural conditions allowed us to obtain massive releases of barnacle nauplii in the laboratory, comparable with those that occur in nature. Panels with live organisms were transported from natural conditions to the laboratory, where we observed the process of nauplii and eggs release. The next planned step is to check the effect of various factors on the hatching process of *B. improvisus*.

Keywords: acorn barnacle, Gulf of Gdańsk, hatching.

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ICES CM 2011/H:39   Poster

Spatial variability in zooplankton and feeding of larval Atlantic mackerel (*Scomber scombrus*) in the southern Gulf of St. Lawrence

Vanessa Paradis, Pascal Sirois, Martin Castonguay, and Stéphane Plourde

Availability of adequate zooplankton prey during the larval stage is a key factor for the emergence of a strong year class. There are inconsistencies in the literature on the importance of various zooplankton prey taxa for determining Atlantic mackerel recruitment in the southern Gulf of St. Lawrence. Previous studies identified the copepod *Calanus finmarchicus* as the most important prey influencing recruitment of Atlantic mackerel, whereas a recent study pointed to the importance of the copepod *Pseudocalanus* spp. The aim of this research was to examine the influence of various assemblages of copepod preys on the feeding of larval Atlantic mackerel. Fish larvae and their zooplankton prey were sampled over a grid of 65 stations covering the entire southern Gulf of St. Lawrence in June 2008 and 2010. We pooled stations in four groups based on zooplankton species assemblages. One assemblage was dominated by the copepods *Oithona* spp. and *Temora longicornis* and the three others were dominated by different proportions of *Oithona* spp. and *Pseudocalanus* spp. Feeding selectivity of mackerel larvae was measured by comparing zooplankton prey in their gut content with zooplankton found in their environment. Surprisingly, the diet in the 3.5–5.4 mm and the >5.4 mm size class was dominated by *Oithona* spp. and *T. longicornis*. Preliminary results indicated a positive selection for *Oithona* spp. and *T. longicornis*. These results about the preferred prey of Atlantic mackerel larvae will be useful to adjust predictive models of recruitment based on copepod production for this commercial fish.

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ICES CM 2011/H:40   Poster

A north–south comparison of abundance, growth, and mortality of juvenile black rockfish (*Sebastes cheni*) in seagrass beds around Japan

Jun Shoji, Ken-ichiro Mizuno, Yasuhiro Kamimura, Atsushi Fukuta, Shun-ichi Toshito, and Hikari Kinoshita

Black rockfish (*Sebastes inermis*) is a dominant component of fish fauna in vegetated habitats in temperate waters of Japan. Juvenile rockfish are abundant from spring through summer in the seagrass beds. In order to examine spatial variability in abundance, growth, and mortality of juvenile rockfish, biological and physical surveys were conducted at 21 sites (from Okinawa, 25°N, to Hokkaido Island, 43°N) in Japan in 2009 and 2010. Fish were collected with a dragnet (4-mm mesh) in each seagrass bed. Rockfish were sorted and preserved in ethanol for otolith analysis. Rockfish abundance and biomass were expressed as number and biomass 100 m^{-2}, respectively. Growth trajectories of rockfish juveniles were individually back-calculated by the use of the biological intercept method. Sampling was repeated at a northern (Miyagi Prefecture) and a southern (Hiroshima Prefecture) site in order to determine growth-selective survival. The back-calculated growth rate of the same-hatch date cohorts was compared between the post-immigration period (original population, OP) and those at ca. 4 weeks days after the immigration period (survivors, SV). Rockfish juveniles were abundant in Seto Inland Sea (Hiroshima Prefecture) and Sendai Bay (Miyagi Prefecture). Back-calculated growth rate during the larval and juvenile periods was higher at lower latitudes (Kyushu Island and Kyoto). There was a significant positive correlation between the juvenile growth rate and ambient temperature. Selection for fast-growing individual was positive at the southern site.

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ICES CM 2011/H:41   Poster

Cohort-specific survival of larvae and juveniles of an estuarine-dependent fish, Japanese sea bass (*Lateolabrax japonicus*): comparison between artificial and natural habitats

Yuji Iwamoto and Jun Shoji

Japanese sea bass is widely distributed in coastal waters of western north Pacific. The larvae migrate from coastal waters to tidal zones of the Ohta River estuary at a body length of ca. 15 mm (60 days after hatch). Larval and juvenile sea bass were collected with a seine net from February to May 2008 in an artificial habitat (AR: Ohta Diversion Channel) and a natural habitat (NR: Tenma River). Larval and juvenile fish abundance was adjusted based on the size-dependent catch efficiency. Abundance, growth, and mortality coefficients of the sea bass larvae and juveniles were compared between AR and NR. The larvae and juveniles were abundant from March to April. Approximately 90% of larvae and juveniles were collected at stations with salinity <10. Larval growth rates and hatch dates were estimated using otolith microstructure. Growth rate ranged between 0.08 and 0.09 mm d^{-1}, without significant difference between AR and NR. Seventeen hatch date cohorts (hatching from October 2007 to February 2008; 5 days for each hatch date period) were identified. Mortality coefficients of the larvae and juveniles, which were estimated from the exponential decrease in abundance of each cohort, were significantly higher in AR than in NR. Seasonal fluctuations in abundance of major prey organisms (estuarine copepods and Cladocera) and predators were suggested as important determinants for survival of the sea bass larvae and juveniles in the Ohta River estuary.

Keywords: estuary, *Lateolabrax japonicus*, mortality, Ohta River in Japan.

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ICES CM 2011/H:42   Poster

Some factors influencing year-class strength of Baltic sprat (*Sprattus sprattus balticus*)

Andrei Makarchouk, Galina Grauman, and Viesturs Berzinsh

We analysed the ichthyoplankton database of the "BIOR" institute separately for the five regions of the Baltic Sea: Bornholm Basin, Gdańsk Deep and the southern, central, and northern parts of the Gotland Basin, starting from the year 1973. Abundances of the eggs and larvae of Baltic sprat (*Sprattus sprattus balticus* Schneider) at different periods of time, coefficients of variation, and the time of spawning in the regions over large depths were taken into account, as well as different hydrometeorological data and the abundance of the main mesozooplankton species. Our analyses led us to a conclusion that the strength of year class of Baltic sprat was determined mainly at the stages of larvae and juvenile, and was a result of several varying factors. Analyses of correlations revealed that most of the predictors could not be used alone for the prediction of year-class strength. Using them in a complex gave better results. Temperature and wind regime influenced the strength of year class strongly. Maternal effect and the time of spawning were not statistically significant for the success of year class.

Keywords: Baltic sprat, recruitment, temperature, wind.

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ICES CM 2011/H:43   Poster

Success of reproduction in the Baltic herring: connections between maternal properties, environmental conditions, and herring fishery

Päivi Laine, Jan Eklund, Eila Lahdes, Raimo Parmanne, and Marjut Rajasilta

We studied the ovarian fat content and ovarian lipid class composition of spawning Baltic herring in the Archipelago Sea, and correlated these properties with fish condition and reproductive success both individually and at the population level. Fat content varied among the years, among females, and also between spawning populations. Ovarian fat consisted mainly of polar lipids, but lipid class proportions differed between the two years analysed. Total ovary fat did not correlate with fish size but with a combination variable of the condition and reproductive investment of females: high condition factor, muscle fat content, and low gonad–somatic index (GSI) were connected with high fat content in ovaries. Water temperature preceding the spawning period did not have a significant effect on ovary fat, but a positive link was found between ovarian fat and ambient salinity. Herring catch (12-month cumulative catch before the onset of spawning season) was positively correlated with ovary fat when salinity was used as a partial variable. Ovary fat was directly correlated with herring catch in areas where fishery yield includes a large proportion of young age groups. The mortality of eggs on spawning beds appeared to be lower in those years when ovarian fat content was high. The density of yolk-sac larvae in early summer was also higher in those years. Our results suggest that maternal effects, such as investment in ovarian fat, may play an important role in the determination of herring year-class strength in the Baltic Sea, and that reproductive success is also linked with Baltic salinity and the herring fishery.

Keywords: Archipelago Sea, Baltic herring, maternal effects, reproductive success.

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ICES CM 2011/H:44   Poster

Growth-selective recruitment from pelagic to demersal habitats for juvenile jack mackerel (*Trachurus japonicus*) in the East China Sea

M. Takahashi, C. Sassa, and Y. Tsukamoto

Juvenile jack mackerel (*Trachurus japonicus*) change habitats from surface to bottom layers during the early juvenile stage; however the recruitment processes to the demersal layer remain unclear in the shelf break region of the East China Sea. We examined the growth patterns of prerecruits in surface layers in April and recruited juveniles in bottom layers in May–June using otolith microstructure in two year classes with contrasting abundances: low in 2005 and high in 2009 in the East China Sea. Prerecruits had a slower growth rate during the larval stage than did recruited juveniles in 2005, whereas prerecruits in 2009 had a comparable growth patterns during the larval stage with recruited juveniles. This indicates that selection depending on the larval growth rate acted more strongly in 2005 than in 2009. Growth rate during the transforming stage from larval to juvenile morphs for the prerecruits was significantly slower than that of the recruited juveniles in both survey years. Thus, *T. japonicus* with a faster growth rate throughout the larval and early juvenile stages had a higher probability of successful recruitment to the demersal habitat than did those with a slower growth rate. Higher food availability and wider favourable temperature area resulted in a faster growth rate in 2009 than in 2005. Hence, growth rate during the early life stages of *T. japonicus* might be a critical determinant of recruitment abundance to the demersal habitat in the East China Sea.

Keywords: East China Sea, growth rate, habitat change, selective recruitment.

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ICES CM 2011/H:45   Poster

Identification of recruitment bottlenecks in the early life history of western Baltic herring (*Clupea harengus* L.)

P. Polte, S. Beyer, P. Kotterba, C. Hammer, R. Oeberst, and C. Zimmermann

Western Baltic spring-spawning (WBSS) herring requires shallow coastal areas covered by submerged vegetation for spawning and egg deposition, in contrast to most North Atlantic populations. The estuarine inshore waters of Greifswald Bay in the vicinity of the Island of Ruegen, Germany are the major spawning ground of WBSS herring. Analysis of extensive time-series data from weekly monitoring of larval herring abundance during reproduction periods in the past two decades indicates the important functions of the semi-enclosed basin as a retention area for herring early life stages. The monitoring data reveal that ecological recruitment bottlenecks are linked to small-scale dynamics of the retention area where the majority of herring recruitment is determined. To understand the mechanisms involved in herring recruitment, it is important to locate key life-history stages such as egg survival/development and larval survival/growth, where most of the prerecruitment mortality takes place. Using time-series data of larval mortality per size class and abundance of yolk-sac stages as a baseline for hatchling densities, our results indicate that recruitment bottlenecks are located as early as on the egg/hatchling stage before potential additional bottlenecks associated with first feeding and prey availability take place.

Keywords: herring recruitment, inshore ecosystems, western Baltic Sea.

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ICES CM 2011/H:46

Effects of temperature and salinity on the abundance of larval herring in the Pomeranian Bay during 1992–1998 and 2007–2010

Agnieszka Pawełczyk, Dariusz Fey, and Adam Woźniczka

Previous research indicates that despite the high variability of the Pomeranian Bay basin, it is a convenient place for the reproduction of many fish species, including herring. The goal of this work was to evaluate the possible effect of hydrological conditions (temperature and salinity) on the abundance of herring larvae in the Pomeranian Bay. Two sets of data were analysed: recently obtained (2007–2010) and historical (1992–1998). In both periods the herring larvae samples were collected between April and July at about ten stations located in the same area. The mean density for different years varied from 18 to 557 individuals 100 m^{-3}, with the maximum numbers observed usually in the second half of May. High abundance years were positively correlated with low temperature and high salinity. In addition, salinity was correlated with the timing of peak hatch, higher salinity leading to earlier hatching. The mechanism of those relationships is probably a mixture of several factors related to development and survival of eggs and early stages of larvae, as well as to timing and intensity of herring reproduction. In addition, this work allowed us to verify where the spawning places in the Pomeranian Bay are distributed.

Keywords: Pomeranian Bay, herring larvae, density.

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ICES CM 2011/H:47   Poster

Cannibalism as a regulating mechanism in the recruitment of crustaceans over their distributional range in European waters — a theoretical approach

Joana Campos, Cláudia Moreira, Fabiana Freitas, and Henk W. van der Veer

Along Europe, the crustacean decapods brown shrimp (*Crangon crangon*) and shore crab (*Carcinus maenas*) coexist and consistently account for most of the estuarine epibenthic biomass. Both species

have a relevant ecological role as prey and predators and are highly cannibalistic, also preying heavily upon each other. Some information exists on factors determining recruitment in these species, particularly for brown shrimp which has commercial value within the North Sea fisheries. However, no study deals with the importance of cannibalism, which can be significant because conspecifics may represent up to 9–20% of the diet of crabs and shrimps, causing 22% mortality in juvenile crabs. Both predation and cannibalistic pressure will vary with size and density of both the predator and the prey and also with food availability. In this work, studies focusing on cannibalism are reviewed along with the ones on availability of alternative prey and the impact of cannibalism on recruitment is emphasized. The hypothesis is that in both species cannibalism via density-dependent mortality regulates recruitment and that cannibalism and hence regulation increases with increasing latitude because of a decreasing trend in the abundance of alternative prey. Finally, proposals for future studies to clarify this subject are made.

Keywords: cannibalism, *Carcinus maenas, Crangon crangon*, recruitment regulation.

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ICES CM 2011/H:48   Poster

Turbot sperm quality changes during the spawning season

E. Gosz, J. Horbowy, and Z. Mirny

Sexually reproducing females need viable spermatozoa to reproduce. Meanwhile, the sperm quality varies during the spawning period and some of these changes are related to the sperm ageing. It is well documented that fish sperm volume decreases as spawning progresses. Morphometric variations in spermatozoa related to the sampling day have also been noticed in several fish species. On the other hand, little is known about the morphometric changes and their relation to the enzymatic activity of sperm cells. In this study, we investigated the variation of morphometric parameters and enzymatic activity of spermatozoa in relation to spawning day. As a model fish, we used the Baltic turbot, *Psetta maxima*.

Keywords: day of spawning, morphometry, *Psetta maxima*, spermatozoa.

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ICES CM 2011/H:49   Poster

Herring recruitment ecology: looking at the youngest

S. Beyer, C. Hammer, C. Zimmermann, O. Goni, P. Polte, and P. Kotterba

Annual ichthyoplankton surveys are conducted in the spawning grounds of the Rügen herring in the western Baltic Sea, the Greifswalder Bodden, to evaluate recruitment year-class strength. In the context of identifying reasons for recruitment failures in the period between 2004 and 2008, data on yolk-sac larvae and larvae recently switching to active feeding were collected during the survey from 2003 to 2010. The aim was to detect spatial and temporal distribution patterns of larval stages before and after first feeding to test for potential recruitment bottlenecks that might exist before larvae are actively feeding, now relying on additional factors such as prey availability. Geographic information system (GIS) and an adapted Gini-index were used to describe the homogeneity of the spatial distribution of the different larval stages. On a temporal average, we found a pronounced trend for a differing spatial distribution of yolk-sac larvae and actively feeding larvae. The former revealed their highest densities near the main spawning grounds in the Greifswalder Bodden, which were identified by various studies over the last 30 years. Average abundance of the different larval stages along the time-series exhibited a clearly analogous trend, however larval densities were highly variable among individual calendar weeks. In the period 2003 to 2010, results indicate that recruitment bottlenecks exist in the pre-feeding stage of early herring larvae. To identify the driving mechanisms, further research is needed.

Keywords: yolk-sac larvae, actively feeding larvae, variability, recruitment.

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ICES CM 2011/H:50   Poster

The pattern of genetic structuring in the European hake is highly dependent on the Bayesian model enforced but insensitive to the differentiation parameter used

Pita, M. Pérez, F. Velasco, and P. Presa

One relevant issue to deal with when managing geographical fish stocks is the spatial distribution of their genetic diversity. Population genetic studies on the European hake have pointed to the existence of limited gene flow between some grounds (i.e. Cantabrian Sea vs. Atlantic Iberia). However, recent genetic data have revealed a wide connectivity of this species all along the European coast (from the North Sea to the Canarian Sea) and a quasi-null restriction to gene flow among grounds (fixation coefficient, $F_{CT} = 0.0092$). Such discrepancies between studies can be related to the genetic marker applied to a given geographical scale, to the interannual fluctuation in the broodstock biomass, and/or to the variety of sampling strategies employed across studies. Less explored sources of uncertainty regarding structuring include differentiation parameters and statistical algorithms used to measure population structure. Genetic structure in fish has been inferred from the fixation coefficient among subpopulations (F_{ST}) which measures gene flow. However, recent mathematical advances in population genetics has revealed that F_{ST} does not measure differentiation, a finding that could partly invalidate previous genetic scenarios inferred from this parameter. Using the molecular variation of microsatellite data from the whole range of the European hake, we demonstrate that the degree of structuring is highly dependent on the model enforced to calculate the number of gene pools using Bayesian inference (from $k = 1$ to $k = 8$ in the species range) but much less dependent of the differentiation parameter considered (gene flow vs. genic differentiation) to infer it.

Keywords: Bayesian inference, differentiation coefficients, European hake, genetic structure, *Merluccius merluccius*.

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ICES CM 2011/H:51   Poster

Development of invertebrate assemblages on hard substrate in the coastal region of the Gulf of Gdańsk

Marcelina Ziółkowska, Adam Sokołowski, Irmina Plichta, Piotr Kukliński, Piotr Bałazy, and Maciej Wołowicz

Development of invertebrate assemblages on hard substrate has been studied experimentally in two shallow-water regions of the Gulf of Gdańsk (southern Baltic Sea) between March 2008 and March 2010. Experimental panels of 15 cm × 15 cm each were deployed horizontally on the seabed at 3.5-m depth at two sites: Gdynia Redłowo and Mechelinki. The colonization process (i.e. settlement of sessile and associated fauna) was examined monthly whereas succession and growth of epibenthos was monitored after 3, 6, 9, and 12 months of exposition each year. Species richness, abundance, and biomass of epibenthic fauna were analysed separately on the top and bottom surfaces of each panel on every sampling occasion. With regard to sessile fauna (without bryozoans), colonization on both sides at the Gdynia Redłowo site was dominated by barnacles *Balanus improvisus* (up to 100% of the total abundance) whereas at the Mechelinki site it was dominated by mussels *Mytilus edulis trossulus* (up to 100%). This probably reflects the presence of these species on the seabed in the neighbouring areas. At both sites, the bryozoan *Electra crustulenta* colonized only the bottom surface of the panels, probably to avoid the effect of sedimentation. On the colonization panels, the appearance of sessile and associated fauna was highly seasonal, with the highest abundance in summer (706 individuals 100 cm^{-2}) and lowest in winter (0 individuals

100 cm^{-2}). A succession process was not observed for the first three months whereas later *Balanus improvisus* dominated numerically, which can be attributed to its fast growth and resilience to the ambient environmental conditions. The contribution of mussels to both total abundance and biomass was low; bivalves are presumably weaker competitors for space because of their small size.

Keywords: Baltic Sea, colonization, field experiment, Gulf of Gdańsk, hard substrate, succession.

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ICES CM 2011/H:52   Poster

Larval development of the prawn *Palaemon serratus* under limited access to prey

Enrique González-Ortegón and Luis Giménez

Decapod crustacean larvae may experience temporal variability in the availability of planktonic food as the combined effect of prey patchiness and vertical migrations in the water column. The aim of this study was to assess whether temporarily limited access to prey would affect larval growth and survival of the prawn *Palaemon serratus*, a marine species with a high commercial interest. Tests were done through laboratory experiments under controlled conditions of temperature (18°C), food (freshly hatched *Artemia nauplii*) and photoperiod (12 : 12), and three salinity treatments (15, 25, 34). Replicate groups of larvae were fed *ad libitum* for 4 h per day (limited access to prey) and compared with continuously fed control groups. In seawater (salinity = 34) and at salinity 25, larval development was successfully completed irrespective of whether access to prey was limited or continuous, but larvae grew at a lower rate under limited access to prey. At salinity 15, limited access to prey led to higher mortality as compared with larvae fed continuously. Our results suggest that *P. serratus* is well adapted to withstand transitory lack of food and may be able to successfully exploit plankton patches under natural conditions.

Keywords: none.

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ICES CM 2011/H:53   Poster

Prerecruit survival and immune system evolution of cuttlefish (*Sepia officinalis* L.) from different spawning sites of the English Channel

G. Safi, C. Le Pabic, J. P. Robin, and N. Koueta

Antimicrobial defence mechanisms have been demonstrated in a variety of invertebrates, including the European cuttlefish (*Sepia officinalis* L.). Three immune enzymes were investigated in this study—lysozyme, antiprotease, and phenoloxidase—which play an important role in the cellular and humoral defence of invertebrates. The aim of this work was to adapt the enzyme assays to juveniles and then study the impact of four different spawning sites from the English Channel coasts on the hatchling survival and their immune system development in the early life stages. In 2010, different adult cuttlefish organs were collected to localize the immune activities. In parallel, experiments with juveniles from Seine Bay (SB-FR), Agon Coutainville (AC-FR), Tor Bay (TB-UK), and Selsey (S-UK) were used to investigate the immune assays. Results demonstrated that lysozyme activity was localized in adult organs, playing an important role in immunity, such as the white body and blood circulation system, and so this enzyme could be adapted for juveniles. Phenoloxidase activities were found in all organs with a maximal activity in the immune organs. Antiprotease activities were mainly localized in the digestive system organs so this enzyme was then excluded from the immune system evolution assays on juveniles. Lysozyme was used to investigate the evolution of the juvenile immune system. Preliminary observations indicated that hatching and hatchling survival rates varied between the four studied sites. Hatching and survival rates were, respectively, 60.4% and 90.6% for SB, 68.2% and 92.6% for AC, 66.7% and 98% for TB,

and 94.4% and 86.6% for S. The lysozyme assays also revealed differences in eggs and juveniles revealing a site impact on egg incubation that affected thereafter juveniles in the first development stages.

Keywords: immune assays, English Channel, *Sepia officinalis*, juveniles.

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ICES CM 2011/H:54   Poster

Inbreeding among farmed Atlantic cod (*Gadus morhua*) and possible effects on offspring quality

Olivia A. Puckrin, Edward A. Trippel, Craig F. Purchase, and Ian A. Fleming

Farmed Atlantic cod (*Gadus morhua*) spawn in cages, releasing eggs into the environment. With potentially thousands of siblings in a cage, the likelihood of inbreeding during spawning is high. Inbreeding may produce poor-quality offspring which could mature and interbreed with wild cod, possibly reducing the fitness of farmed–wild cod offspring. The goal of this project was to determine if inbreeding occurs among farmed cod, and if inbred offspring have reduced survival or are of poorer quality. Embryos collected from spawning events in tanks of sister–brother– unrelated male trios were analysed using microsatellite DNA analysis to determine parentage. Single and multiple paternity was observed across batches. In two tanks, the brother had greater spawning success than the unrelated male, however, females generally favoured unrelated males as spawning partners ($p < 0.001$). Offspring mortality, deformities, size, and hatching success were monitored in artificially fertilized inbred and non-inbred crosses of cod embryos and larvae. Data were collected from 14 replicates. The presence of deformities, larval survival, and size were not significantly different, with the exception of body depth (offspring from unrelated crosses were slightly larger, $p = 0.01$). Per cent hatch was slightly higher in offspring of unrelated crosses. Although inbreeding was revealed to occur in farmed cod, we did not see much of an effect on offspring quality. However, sample size was relatively small, and effects may not be obvious after one generation of inbreeding. More interesting findings may come from examining the broodstock, where families of cod have been maintained for many years.

Keywords: aquaculture, inbreeding, mating competition, Northwest Atlantic cod (*Gadus morhua*).

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ICES CM 2011/H:55   Withdrawn

ICES CM 2011/H:56   Poster

Individual growth trajectories identify critical periods in finfish early life stages

Fabian J. Schäfer, Sebastian Flues, Stefan Meyer, David A. Bengtson, Myron A. Peck

Critical periods of growth and survival during early ontogeny in finfish cohorts have been previously inferred by indirect methods such as otolith-based back-calculated growth trajectories and changes in body size frequency distributions. These population-based estimates provide some insight into processes acting on field cohorts but reveal little information on physiological differences among individuals contributing to differences in growth and survival. For example, phenotype plasticity in growth, realized by each individual genotype–environment interaction, may increase differences in size-at-age among individuals and could be an important factor for a population's ability to maintain adequate survival and growth rates. In this study, changes in food consumption rate, growth rate, and growth efficiency of individual fish larvae were tracked under controlled laboratory conditions to detect critical milestones in early ontogeny. Experiments identified the magnitude and timing of inter-individual differences in growth physiology of

individuals as well as siblings reared in groups. Pike-perch (*Sander lucioperca*) was used as the model finfish species and two 4-week experiments were conducted using 3- to 10-week post-hatch individuals (~6 to ~15 mm initial length). These and similar data collected on three marine fish species (summer flounder, striped bass and Atlantic silversides) indicate that potential discrete phenotype traits can be identified at an early ontogenetic stage via changes in food consumption and growth and that critical periods are species-specific.

Keywords: critical period, gross growth efficiency, individuals, larval fish.

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ICES CM 2011/H:57   Poster

Changes in growth and condition of larval herring in the Greifswalder Bodden (southwest Baltic Sea) reveal match–mismatch dynamics

Lars Christiansen and Myron A. Peck

The recruitment strength of the western Baltic spring spawner (WBSS) herring (*Clupea harengus*) stock has declined since 2003. The vast majority of this stock spawns in the Greifswalder Bodden (GB), a shallow, coastal system. Larval GB herring were intensively studied throughout the 2009 spawning season in an attempt to reveal the factors controlling early larval growth and survival. Larvae were collected at six stations for 14 consecutive weeks and otolith microstructure and RNA/DNA analyses provided individual lifetime growth trajectories and recent biochemical condition, respectively. Two main cohorts were observed with hatch periods in mid-April (cohort 1) and mid-May (cohort 2). In these cohorts, changes in larval body size, growth, and condition were tracked for larvae at ages 5–22 and 6–26 days post hatch, respectively. Larval growth rate and biochemical condition differed significantly within (by week) and between (by larval age) these cohorts. Although mean back-calculated growth rates were similar for both cohorts (0.47 and 0.49 mm d^{-1}, respectively), selective survival for faster growers was observed within the first but not the second cohort. Biochemical measurements indicated that larvae in the second cohort benefited from increased water temperatures and suggested that larvae experienced *ad libitum* feeding conditions.

Keywords: biochemical condition, field survey, growth, larvae, match–mismatch, western Baltic spring spawner (WBSS).

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Theme Session I

Integrating top predators into ecosystem management

ICES CM 2011/I:01

Body condition of predatory fish linked to the availability of sandeels

Georg H. Engelhard, Julia L. Blanchard, John K. Pinnegar, Jeroen van der Kooij, Ewen D. Bell, Steven Mackinson, and David A. Righton

Sandeels are eaten by a range of predatory fish including commercially fished species—but they are also exploited at large scale by industrial fisheries. Could sandeel depletions deprive predatory fish of food, so affecting their condition? In the North Sea, sandeel fishing is largely concentrated in the Dogger Bank region. Here we studied predator–sandeel interactions at two sites differing widely in sandeel abundance as well as in local sandeel fishing effort. Surveys took place in 2004, 2005, and 2006, years of comparatively low, rather high, and high sandeel abundance, respectively. In the two sandeel-rich years, as well as in the sandeel-rich study area, a range of predatory fish species exhibited higher sandeel consumption than was the case under sandeel-poor conditions, and they also exhibited better body condition indices. As body condition relates to growth, reproduction, and survival chances, we infer that predators in sandeel-rich conditions had a higher fitness. These links between sandeels, sandeel consumption, and predator condition hint that, if large-scale localized depletions of sandeels were to occur, negative indirect effects on predatory fish species might become an issue, thus underlining the importance of considering the sandeel fishery in a wider ecosystem context.

Keywords: body condition, North Sea, predators, sandeel.

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ICES CM 2011/I:02

Spatial selection of sandeel (*Ammodytes marinus*) by grey seals (*Halichoerus grypus*)

Geert Aarts, Sophie Brasseur, Anna Rindorf, Sophie Smout, Mark Dickey-Collas, and Jason Matthiopoulos

Because of the difficulty of observing marine mammals directly, understanding and quantifying their foraging behaviour and prey selection can be extremely challenging. However, by relating their spatial distribution with the distribution of their potential prey, we may better understand how their movement decisions are governed by prey availability and accessibility. The objective of this study is to quantify how the distribution of grey seals (*Halichoerus grypus*) in the North Sea relates to the distribution of one of their major prey species, sandeel (*Ammodytes marinus*). To do this, we use data from satellite relay data loggers attached to grey seals foraging from Dutch and UK colonies, and relate these to covariates including depth, sediment type, proximity to sandeel banks, and commercial cpue data. The seal locations are assumed to stem from an inhomogeneous Poisson point process and are modelled as a function of the covariates using generalized additive mixed models, which can capture non-linear variation in preference between individuals. This study reveals that grey seals strongly prefer sandeel banks. Some individuals visit forage sites located more than 300 km from their haulout site and spend up to 26 consecutive days at some banks (e.g. the Dogger Bank), diving to the bottom, both day and night. These results suggest that the rewards resulting from high prey density and/or quality take precedence over the relative large travel cost associated with such trips. In addition, given the speed of digestion relative to travel duration, standard diet analysis based on scat analysis may underestimate the importance of these offshore feeding events.

Keywords: marine mammals, North Sea, predator–prey, spatial distribution.

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ICES CM 2011/I:03

Consistent differences in fish and marine mammal diets at closely located sites revealed through stable isotope analyses, despite seasonal migration and population mixing

John K. Pinnegar, Katherine Read, Georg H. Engelhard, and Julia L. Blanchard

Locally sandeels can be very important for marine predators and thus, by implication, large-scale industrial fisheries targeting sandeels in the North Sea might be expected to affect other commercial fish stocks and marine mammals. However, where sandeels are less available, it has been demonstrated that predators can adapt, and do manage to find alternative prey resources. In the present study we used stable isotope analyses to examine differences in feeding preferences of predatory fish at closely located sites on the Dogger Bank. Despite known large-scale movements of predatory fish in the North Sea, several fish species exhibited significant differences in the δ^{15}N and δ^{13}C composition of their body tissues at sampling grids separated by only 28 km, indicative of fundamentally different feeding patterns throughout the year and strong feeding site fidelity. Animals at sites where sandeels were more abundant tended to exhibit more depleted δ^{13}C values, whereas animals from sites where sandeels were less abundant tended to exhibit slightly enriched signatures. Seasonal differences in δ^{15}N and δ^{13}C were also observed for some fish species, and these corroborate observed seasonal differences in stomach content data. Isotope signatures suggest that common porpoise and harbour seals target fundamentally different prey resources in this region, and that porpoises may be much more reliant on sandeels than are common seals.

Keywords: Dogger Bank, porpoise, predation, sandeel, seal, seasonality.

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ICES CM 2011/I:04

Spatial and temporal variability of tuna predation upon juvenile anchovy in the Bay of Biscay

Nicolas Goñi, Valérie Peninon, Haritz Arrizabalaga, and Andrés Uriarte

The recent collapse and recovery of the anchovy population in the Bay of Biscay raised the need to assess environmental influences on the mortality of juvenile stages, in particular the impacts of predation by tunas. Stomachs of 1354 albacore and 579 bluefin tunas were collected in several zones of the Bay of Biscay and adjacent waters in the summers of 2004–2007 (period of depletion in anchovy population) and of 2009–2010 (period of recovery). Among different years, average daily consumption of anchovy (when present in diet) varied between 6.7 and 26.5 individuals (max. 118) per day and predator for bluefin tunas, and between 4.8 and 15.5 (max. 103) for albacore. Anchovy consumption by tunas appeared to have an important interannual, seasonal, and geographical variability. Juvenile anchovy were absent from both albacore and bluefin tuna diets until early August in all years. They were also absent from albacore diet outside the inner Bay of Biscay (core area of anchovy) in 2004–2007, whereas they were present up to the most northwestern part of the Bay in 2010, which supposes a higher exposure to predation in the period of recovery. On the other hand, the absence of albacore in the inner Bay of Biscay since 2008 tends to reduce predation impacts. Anchovy appears to be a significantly more important prey for bluefin tuna than for albacore, particularly in the case of age-1 bluefin tunas. No significant relationship was found between tuna size and anchovy consumption.

Keywords: albacore, anchovy, Bay of Biscay, bluefin tuna, predation.

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ICES CM 2011/I:05

Monitoring life-history parameters in harbour porpoises

Graham J. Pierce, Sinead Murphy, Jennifer A. Learmonth, Bob Reid, and M. Begoña Santos

Implementation of the Ecosystem Approach to Fisheries Management will require monitoring of the status and trends in populations of top predators such as dolphins and porpoises. Existing monitoring, as required under (for example) the Habitats Directive typically involves collection of information on distribution, abundance, health status, and specific threats such as fishery bycatch. Here, we examine the types of information on population status which can be derived from cetacean strandings monitoring schemes (e.g. health and life-history parameters), and some of the inherent problems and biases. We illustrate this discussion using data collected on harbour porpoises in Scotland during 1992–2005. Specific findings include geographical differences in age distribution related to particular causes of mortality (e.g. fatal interactions with bottlenose dolphins), a low (but probably biased) estimate of pregnancy rate (reflecting the small number of "healthy" adult females in the sample) and evidence of increasing mortality rate (e.g. fewer animals over 10 years old in later years).

Keywords: cetaceans, life history, monitoring, population status, top predators.

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ICES CM 2011/I:06

Indirect effects of a bottom-trawl fishery on the diet of demersal fish species

A. F. Johnson, G. Gorelli, J. Hiddink, S. Jenkins, and H. Hinz

Bottom trawling has widespread impacts on benthic ecosystems. Although many studies report the effects of reduced faunal biomass, abundance, species richness, and size structure, few go on to examine the ramifications for associated demersal fish. Here we investigated the indirect impact of chronic trawling on the diet of demersal fish through changes in the benthic community. The stomach contents of demersal fish species from 15 soft-sediment stations over a gradient of chronic bottom trawling in a *Nephorps norvegicus* fishing ground (northern Irish Sea) were analysed. Bottom trawling had a significant effect on the diet of the flat fish plaice (*Pleuronectes platessa*) and dab (*Limanda limanda*) by altering prey availability and diet composition. Intermediate levels of trawl disturbance (5–7 trawls year^{-1}) exhibited the highest stomach content biomasses for dab, suggesting increased feeding potentials. We hypothesize this is related to the removal of the brittlestar, *Amphiura filiformis,* and the subsequent increase in potential prey items of dab. With increased trawling plaice targeted species whose abundance was less affected by trawling (*Nephtys* sp., *Abra alba*) and compensated for decreased prey sizes by feeding on larger numbers of these prey items. Therefore stomach content weight of plaice exhibited no significant relationship with trawl intensity. Changes in diet composition and feeding strategies of demersal fish could have important overall consequences for bottom-trawl fisheries by reducing optimal prey abundances, sizes, and availabilities. This study highlights the importance of fully understanding the indirect impacts of bottom fisheries and is an important step towards examining them.

Keywords: demersal fish, Irish Sea, predator–prey interactions, trawl fishery.

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ICES CM 2011/I:07   Withdrawn

ICES CM 2011/I:08

How does prey availability affect the provisioning of chicks by parent birds? A functional response for guillemots in the North Sea

Sophie Smout, Francis Daunt, Sarah Wanless, Mike Harris, Jason Matthiopoulos, and Anna Rindorf

Management of fisheries must aim to sustain fish stocks and viable fisheries while allowing the conservation of dependent species and thereby ensuring the maintenance of good environmental status. To achieve this, it is necessary to understand the relationship between fish stocks, fishing, and the dependent species. An important aspect of this link is the relationship between prey availability, and consumption by "top" predators (their functional response). However, such relationships are notoriously difficult to determine because of the lack of estimates of the availability of prey at relevant scales in time and space. This problem is particularly acute for central place foragers with restricted foraging ranges such as the small to medium seabirds that dominate the avian predator community in the Atlantic shelf seas. For the most abundant seabird in the northwestern North Sea (the common guillemot, *Uria aalge*) we make use of time-series data from a long-term observational study including chick provisioning rates and diet, and feeding locations of adult birds based on telemetry. We combine these with survey and fishery-based estimates of prey abundance and distribution in order to investigate the relationship between provisioning and prey availability. We use Bayesian methods to fit functional responses for multiple datasets in which the availability of prey is measured at different spatial/time-scales, and compare the results. Recent changes in chick diets, which exhibit a shift in emphasis away from sandeels and towards small clupeids, are consistent with general observed declines in sandeel cpue in the area.

Keywords: functional response, GES, top predators, *Uria aalge*.

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ICES CM 2011/I:09

Do seals and man fish in the same spots? Evidence of low spatial overlap between a top predator and specific fisheries off Irelands' west coast

M. A. Cronin, H. D. Gerritsen, and D. G. Reid

Seals and humans are both top predators in many marine ecosystems, often targeting the same food resource, leading to possible competition. This long-standing contentious issue is of mounting concern with fish stocks in global decline. With advances in telemetry technologies it is possible to track top marine predators at sea for extended periods and relate their distribution to that of the resource. However, it is difficult to obtain spatially and temporally discrete resource distribution data. Spatially and temporally explicit data are, however, now available for fishing activity from vessel monitoring system (VMS). Using this we can study the overlap of foraging activity for both seals and fishing vessels, and to examine whether or not overlap in space and time can be interpreted in terms of resource exploitation overlap. We used VMS and fast acquisition GPS to compare the distribution of fisheries and seals in Irish waters on the same spatial and temporal scale to quantify overlap. Our findings suggest a significantly low rate of spatial overlap between all grey seals tagged and the offshore whitefish fishery on the Irish continental shelf. If the sample is representative of the population of grey seals using Irish waters, it suggests direct competition for the resource may be far less than expected. Seal–fishery interactions in Irish waters may therefore be more of an issue at the operational and individual level (damage to gear and catch), suggesting that seal population management measures will be ineffective and therefore unjustifiable.

Keywords: fishery interactions, grey seal, Irish continental shelf, resource overlap.

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ICES CM 2011/I:10

Stickleback predation on early life stages of herring (*Clupea harengus* L.) in a shallow western Baltic retention area

P. Kotterba, S. Beyer, C. Hammer, and P. Polte

From historical documentation it is known that the three-spined stickleback (*Gasterosteus aculeatus*) is a relevant herring spawn predator. The sheer abundance of *G. aculeatus* in the Greifswalder Bodden, Germany, one of the major spawning areas of western Baltic spring-spawning herring, implies that predation pressure by sticklebacks might significantly affect the mortality of early herring life stages, such as eggs and larvae. We investigated stickleback abundance first in the immediate proximity of spawning beds and second throughout the estuarine basin, together with simultaneous sampling of herring larvae to evaluate the degree of spatial predator/prey overlap. Results indicate a significant overlap in spatial distribution of both species within different habitats of the basin. A stomach content analysis including specific herring genome detection via molecular techniques such as PCR will provide evidence whether or not predation pressure by sticklebacks influences herring recruitment success significantly within the inshore retention area. In addition, these results improve our understanding of where predation pressure is most pronounced in the early ontogenetic development of herring.

Keywords: predation, herring recruitment, stickleback, western Baltic Sea.

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ICES CM 2011/I:11

Fish consumption by cetaceans in Scottish (UK) and Galician (Spain) waters

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Studies on cetacean diets since the early 1990s, based on samples derived from strandings monitoring, have allowed assembly of a substantial database of information on the diets of common dolphins and harbour porpoises, and to a lesser extent several other small cetacean species, in Scottish and Galician waters. The availability of recent cetacean abundance data from the SCANSII and CODA surveys provides a new opportunity to estimate consumption by cetacean populations of commercially exploited fish and cephalopods. Important prey of these cetacean species include whiting, blue whiting, hake, horse mackerel, and sandeels. Here we synthesize the available data, review uncertainties, present new estimates of quantities consumed, examine evidence of spatio-temporal trends in diet and prey consumption, and discuss interactions with fisheries.

Keywords: common dolphin, diet, food consumption, Galicia, harbour porpoise, Scotland.

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ICES CM 2011/I:12

Estimating fish predation by marine mammals on the northeast US continental shelf

Laurel Col, Jason link, Steve Cadrin, and Debra Palka

Recently there have been a number of questions raised regarding the economic and ecological impacts of marine mammals through their consumption of fish and interactions with commercial fish stocks. However, the consumption estimates that are needed to address these questions are

lacking for the northeast US large marine ecosystem. This study provides initial quantitative bounds on marine mammal consumption of six prey groups including clupeids, scombrids, sand lance, hakes, large gadids (cod, haddock, pollock), and flatfish. Species-specific consumption was estimated for humpback whales, fin whales, minke whales, pilot whales, bottlenose dolphin, Atlantic white-sided dolphin, common dolphin, harbour porpoise, grey seals, and harbour seals, using ranges of daily individual consumption and diet compositions compiled from literature values. Consumption was expanded to annual population levels based on abundance estimates and annual residence of each species in the area. Bounds on consumption estimates of each marine mammal species were determined using Monte-Carlo simulations, and total marine mammal consumption was then summed for each prey group. Results indicate that marine mammal consumption may be similar in magnitude to commercial fishery landings for small pelagic and groundfish prey groups, although previous studies have indicated that targeted sizes may differ. Marine mammals are potential top predators off the northeast US, and as we move toward ecosystem-based fishery management, consumption by marine mammals should be included as a natural removal from prey populations when assessing fish stocks and in whole-system ecosystem models.

Keywords: consumption estimates, diet compositions, marine mammals, northeast US continental shelf.

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ICES CM 2011/I:13

Consumption of prey by minke whales in Icelandic waters

Bjarki Þór Elvarsson and Gísli Víkingsson

In the last few years there has been a lively discussion between the industry and fishery scientists on the effects of minke whales on the abundance of cod, and other gadoids, in Icelandic waters. The discussion has even gone as far as pushing for the harvest of minke whales to increase the abundance of cod. Quantitative data on the consumption of minke whales has up till now been unavailable. Special-permit hunting of minke whales, which was conducted in the years between 2003 and 2007, gave valuable insight into their feeding behaviour. Here, preliminary results on prey selectivity from the special-permit catches of minke whales are presented. An overview of the prey found in minke whale stomachs is shown and contrasted with recent developments in minke whale abundance. The results indicate that sandeel is the most important prey species of minke whale in Icelandic waters. A recent drop in sandeel abundance has had catastrophic effects on the breeding success of the local puffin population. And areal surveys of the abundance of minke whale in 2009 suggested that large numbers of minke whales had migrated outside the survey area. The remaining minke whales appear to compensate for low sandeel abundance by focusing on larger benthic species such as cod and haddock.

Keywords: prey suitability, top predator.

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ICES CM 2011/I:14

Squid in the North Sea: a new effective top predator with potential impact on fish recruitment and ecosystem shift

Daniel Oesterwind and Uwe Piatkowski

Cephalopods were sampled from bycatches of recent ICES international bottom-trawl surveys performed in the North Sea. In terms of numbers and biomass, the long-fin squids *Alloteuthis subulata* and *Loligo forbesi* were by far the most dominant. Relative catch numbers of both species were calculated from all stations of the surveys, and spatial interpolations such as deterministic inverse distance weighting and geostatistic kriging were applied to estimate the squid stock size numbers for the entire central North Sea. We estimated that the stock size of *A. subulata* reaches

2500 million animals in winter and 360 million in summer, whereas the stock size of *L. forbesi* reaches 77 million in winter and ca. 80 million in summer. Stomach content analysis revealed positive correlation between squid and prey size, with small squid favouring crustaceans and larger squid also taking fish. *A. subulata* feeds mainly on fish in summer and on crustaceans in winter, with daily consumption rates of fish reaching 361 t in winter (106 t in summer). For *L. forbesi* the daily consumption rate of fish amounted to 133 t in summer (295 t in winter). We estimated the squids' impact on the recruitment of major North Sea fish species, with *L. forbesi* taking 0.6% recruits of cod, 0.3% recruits of haddock, and 2.3% recruits of whiting per year. The high abundance of squid and their effective predation on fish underpin their important role as top predators on the North Sea ecosystem with potential to greatly influence the recruitment of traditional fish stocks.

Keywords: ecosystem, North Sea, predation, squid.

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ICES CM 2011/I:15

From past to future: environmental variability impacts on the distribution of oceanic predators

Maite Louzao, Thorsten Wiegand, Clara Péron, Karine Delord, and Henri Weimerskirch

Pelagic ecosystems are changing significantly owing to multiple threats, and marine spatial plans are urgently needed for the conservation of pelagic biodiversity. Obtaining long-term distribution data on indicator species could overcome the current limited identification of pelagic protected areas. Long-term spatial modelling studies are essential elements for predicting future species distribution in changing environments, since establishing historical distribution ranges of species provides baseline conditions to understand distribution shifts. In the marine environment, decades of research on marine ecosystems has demonstrated that climatic variables are primary drivers of distributions and dynamics of pelagic organisms and marine top predators are highly sensitive components of the marine ecosystem because major system shifts will be reflected in their populations. Within this framework, we developed an integrative ecological study for an oceanic predator, the vulnerable wandering albatross *Diomedea exulans*, in the highly dynamic Southern Ocean. Based on a long-term tracking database (1998–2008), we identified the current and historical marine areas where the species searched for prey (i.e. the foraging habitat), which were extended beyond observations thanks to the development of predictive habitat models. Albatrosses foraged over topographic features (pelagic areas surrounding main breeding sites, seamounts, and submarine mountain ranges) conditioned by dynamic oceanographic variables such as sea surface temperature and sea surface height. Our study provides the first quantitative assessment of the spatial response of a marine top predator to changing pelagic habitats of the Southern Ocean, offering new insights into the future effects of climate change on the pelagic realm.

Keywords: oceanic predators, Southern Ocean, spatial modelling, wandering albatross.

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ICES CM 2011/I:16

On the use of stomach content data from top predators in statistical multispecies models of marine populations

Bjarki Þór Elvarsson and Gunnar Stefánsson

The importance of multispecies models of marine ecosystems has, in the recent years, increased. The models have played a greater role when giving management advice. Integrating top predator interactions to the species of interest can produce valuable information on the biomass available to the fishery. Data on top predator behaviour is, however, often hard to obtain. This is particularly the case for large marine mammals, such as minke whales, where a whaling moratorium has been

in place since 1986. In addition to the lack of data, the robustness of estimation methods of the model parameters needs to be ensured. In particular, prey suitability parameters that define the species interaction need to be tested. Here a simple predator–prey simulation, with dynamics similar to cod and minke whale, is defined. Its basic properties are described and used to produce stomach content data sampled from 200 predators. The robustness of a parameter fitting procedure is then tested under varying degrees of error in the suitability parameters.

Keywords: gadget, multispecies models, prey suitability, statistical stock assessment, top predator.

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ICES CM 2011/I:17

Consumption of fish by top predators in the North Sea

Sophie Smout, Anna Rindorf, Morten Vinther, Ayoe Hoff, Hans Frost, Simon Northridge, Stefan Garthe, and Phil Hammond

Maintenance of populations of top predators, such as marine mammals, birds, and large fish, is key to ensuring marine biodiversity, an important aspect of good environmental status and hence of successful ecosystem management. However, their maintenance may come with a cost if top predators affect commercial prey species, so that fisheries and predators compete for available resources. We expect that the strength of competition may have varied over time, as both fishing and the abundance of top predators has changed. As a first estimate of the effects and costs of interactions between top predators and the fishery, we present and compare estimates of consumption (measured both in weight and commercial value) by important species of marine mammals, birds, and fish predators with removals by the fishery, and relate removals from these different sources to the size of the prey stock. The sources of uncertainty in consumption estimates are reviewed, and we suggest priorities for data collection. We conclude by presenting some examples to illustrate that to assess the true costs of removals by top predators, predictive models are required for consumption and population dynamics.

Keywords: cost, consumption, diet, top predator.

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ICES CM 2011/I:18

Assessing the effects of small pelagics fisheries on marine top predators: the Bay of Biscay case study

Géraldine Lassalle, Jérôme Spitz, Vincent Ridoux, Hélène Peltier, and Nathalie Niquil

Forage fish species in the Bay of Biscay have exhibited substantial changes (in abundance and distribution), including the recent "collapse" of the European anchovy. Owing to the central position of small pelagics in marine ecosystems, stock-specific management measures are expected to have consequences on other ecosystem components and, more broadly, on the foodweb dynamics. Small cetaceans are present all year long, feeding and breeding in the area. The Bay of Biscay is also heavily used as a migration route and as a wintering area by an important community of marine birds. The objective of this work was to evaluate the degree to which interactions between fisheries and top predators may occur in this ecosystem and to what extent it could affect the conservation of upper consumers. As a first step, a mass-balanced model of the continental shelf of the Bay of Biscay was created, in which apex predators totalized seven compartments. Landing and discards were estimated for all of the commercially exploited benthic and pelagic groups. Incidental captures for porpoises, small dolphins, and long-finned pilot whales were assessed to take into account fishery impacts not only related to prey availability (competition) but also to bycatch (negative operational interaction). The ecosystem appeared strongly "bottom-up" controlled and high-trophic status species were not identified as keystone groups. Moreover, no substantial interaction between fisheries and top predators emerged from the MTI (mixed trophic impacts) analysis. Furthermore, in this way, time predictions using plausible

scenarios of fishing on sardine and anchovy are under progress and will provide significant new insights.

Keywords: Ecopath with Ecosim, ecosystem-based fishery management, foodweb modelling, Northeast Atlantic.

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ICES CM 2011/I:19

Effects of mammal predation on small pelagic fish

Anna Gårdmark, Örjan Östman, Karl Lundström, Olle Karlsson, Jukka Pönni, Martin Lindegren, Anders Nielsen, Olavi Kaljuste, and Teija Aho

Predation by marine mammals on small pelagic fish is generally considered low relative to other mortality factors. However, in the northern Baltic Sea, the grey seal (*Halichoerus grypus*) population has increased fivefold during the last 25 years, and its main food items are the commercially important small pelagics sprat (*Sprattus sprattus*) and herring (*Clupea harengus*). Here we analysed the effect of increased seal predation on the Bothnian Sea herring population dynamics and body size relative intra- and interspecific interactions, hydro-climatic drivers and fishing. We show that herring biomass is mainly driven by bottom-up forces and that grey seal predation has small effects on both the population dynamics of herring and herring stock estimates. In contrast, size-selective predation by grey seals, as assessed from length distributions in stomach contents, has reduced the mean weight-at-age in the stock. We conclude that the multiple forcing on herring dynamics and body size distributions calls for an ecosystem-based management of herring in the Bothnian Sea, and we discuss how to produce advice for such management.

Keywords: Bothnian Sea herring, ecosystem management, top predators, trophic interactions.

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ICES CM 2011/I:20

Defining management reference points for a rockfish stock with fluctuating rates of natural mortality arising from changes in predator abundance

Shannon G. Obradovich and Murdoch K. McAllister

Coincidental to the population decline of yelloweye rockfish (*Sebastes ruberrimus*) in British Columbia inside waters, pinniped populations (particularly harbour seals (*Phoca vitulina*), Stellar sea lions (*Eumetopias jubatus*), and California sea lions (*Zalophus californianus*)) in the area have increased dramatically since the 1970s. All three pinniped species are rockfish predators, though rockfish may only represent an incidental prey item in their diet. These changes in ecosystem composition create potentially significant changes in natural mortality for yelloweye rockfish. Ignoring fluctuating natural mortality rates in a stock assessment framework could lead scientists to incorrectly attribute substantially greater mortality to fisheries and unduly influence management advice. We explore the inclusion of pinniped–rockfish dynamics in a variety of Bayesian single-species stock assessment models that attempt to account for the various uncertainties in the predator–prey dynamics of the system and the resulting issue of how to define and interpret management reference points for the stock in the presence of a predator treated as an additional fishery.

Keywords: management reference points, pinnipeds, predator–prey, stock assessment.

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ICES CM 2011/I:21

Top predator–prey interactions in the Barents Sea and implications for ecosystem monitoring and management

Mette Skern-Mauritzen, Per Fauchald, Edda Johannesen, Ulf Lindstrøm, and Harald Gjøsæter

The Barents Sea capelin stock has collapsed three times since the 1980s. The first collapse was associated with detrimental effects on top predator growth, body condition, recruitment, and survival, and with significant shifts in the spatial distribution of top predators. In contrast, no strong top predator responses were reported after the capelin stock collapse in 2003. The Barents Sea ecosystem surveys, started in 2003, provide a synoptic spatial coverage of zooplankton, pelagic fish, cod (including diet), marine mammals, and seabirds across the ecosystem. The spatial organization of the pelagic community in the capelin-poor situation (2003–2007) indicated that the typical capelin predators—cod, baleen whales, and Brünnich's guillemots—foraged on a northern prey assembly with polar cod, krill, amphipods, and capelin. The top predators exhibited a diverse response to the recovery of capelin (2008–2010), ranging from negative (avoidance of capelin) to positive (aggregating on capelin, increasing capelin in diet). Our results demonstrate that the capelin predators are generalists, implying that effects of capelin collapses depend on the availability of alternative prey. In capelin management today, cod predation on capelin is taken into account. However, to improve monitoring and management of the pelagic community, we suggest (i) increased monitoring of species of trophic importance, independent of direct economic importance, (ii) focused process-oriented studies on predator–prey interactions, and (iii) that in management, top predator–prey interactions should be considered as conditional on the availability of alternative prey, possibly as interactions across functional groups.

Keywords: ecosystem management, pelagic community, top predators, trophic interactions.

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ICES CM 2011/I:22

Significance of seal feeding on cod west of Scotland—results from a state space stock assessment model and comparison with an ecosystem model

S. J. Holmes and G. Tyldesley

Studies of grey seal feeding west of Scotland (ICES Division VIa) based on scat sampling have indicated consumption of commercially exploited fish species is increasing and that, in the case of cod, estimated annual consumption by seals could be comparable with single-species estimates of the cod biomass. Seal feeding data are only available for two years (1985 and 2002) but population estimates exist for an extensive time-series. The significance of grey seal predation on cod has been considered in two ways. First, a state space stock assessment model was adapted to include seal predation on cod as if seals were a fishing fleet. Data for this seal fleet was obtained by interpolating the seal feeding data on cod. Second, the grey seal population estimates were included as a tuning series in an ecosystem model of the west of Scotland. Both approaches offer comparisons between trends in partial mortality from seals and fishing activities. The state space model also addresses the extent to which seal predation reconciles the difference between estimated removals and reported commercial catch seen in stock assessments for cod west of Scotland that are fitted exclusively to survey data in more recent years. As well as providing an independent estimate of seal consumption of cod, the ecosystem model was used to test scenarios of stock response for three gadoid species (cod, haddock, and whiting) to future grey seal population size.

Keywords: assessment, cod, ICES division VIa, seals.

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ICES CM 2011/I:23

Grey seal predation on forage fish in the Baltic Sea

Eero Aro, Stefan Neuenfeldt, Teija Aho, Pekka Jounela, Karl Lundström, and Fritz Köster

The mean annual growth rate of grey seal stock in the Baltic has been on average 7.5% annually during the last decade. In 2010, a total of approximately 23 100 grey seals were counted. The increase in stock size was highest in the northern areas and the predation pressure of grey seals on clupeoids has increased accordingly. The diet of grey seal in the Baltic consists of ca. 20 fish species. The most abundant prey items in the Baltic proper are Baltic herring, sprat, and cod, and in the Bothnian Sea and Bothnian Bay Baltic herring, *Coregonus* sp., Baltic salmon, and sea trout. An adult seal consumes on average round 4.5 kg fish per day, of which 55% are clupeoids in the Baltic Main basin and 70% in the Bothnian Sea and Bothnian Bay. According to acoustic estimates, predator–prey distribution patterns, migration patterns, and multispecies analysis (SMS), the predation effect of grey seals on Baltic herring and sprat stocks is still at a very low level. Hence, with present grey seal stock sizes, the impact of seal predation can be ignored in whole Baltic-scale herring and sprat stock management considerations. Locally, however, grey seal–fishery interactions play an important role and should be taken into account in future spatial planning and ecosystem management.

Keywords: Baltic herring, ecosystem management, Grey seal, multispecies interactions, sprat.

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ICES CM 2011/I:24

Could seals prevent cod recovery in the Baltic Sea?

Brian R. MacKenzie, Margit Eero, and Henn Ojaveer

Fish populations are increasingly affected by multiple human and natural impacts, including exploitation, eutrophication, habitat alteration, and climate change. As a result many collapsed populations may have to recover in ecosystems whose structure and functioning differ from those in which they were formerly productive and supported sustainable fisheries. Here we investigate how a cod (*Gadus morhua*) population in the Baltic Sea whose biomass was reduced as a result of a combination of high exploitation and deteriorating environmental conditions might recover and develop in the twenty-first century in an ecosystem that will probably change owing to both the already started recovery of a cod predator, the grey seal (*Halichoerus grypus*), and projected climate impacts. Simulation modelling, assuming increased seal predation, fishing levels consistent with management plan targets, and stable salinity, reveals that the cod population could reach high levels well above the long-term average. Scenarios with similar seal and fishing levels but with 15% lower salinity suggest that the Baltic will still be able to support a cod population which can sustain a fishery, but biomass and yields will be lower. At present knowledge of cod and seal interactions, seal predation was found to have much lower impact on cod recovery, compared with the effects of exploitation and salinity. These results suggest that dual management objectives (recovery of both seal and cod populations) are realistic but success in achieving these goals will also depend on how climate change affects cod recruitment.

Keywords: Baltic Sea, climate change, cod, ecosystem, fishery, management, seals, sustainability.

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ICES CM 2011/I:25   Withdrawn

ICES CM 2011/I:26   Poster

Feeding ecology of black scabbardfish (*Aphanopus carbo* Lowe 1839) in the deep water of the Northeast Atlantic

Ana Ribeiro Santos, Emer Rogan, and Paul Connolly

The black scabbardfish is a deep-water species of high commercial interest in the Northeast Atlantic. Despite the increasing commercial interest in this species, life history and feeding ecology are poorly understood. For this study, specimens were collected in commercial trawls off northwest Scotland and west Ireland, between September 2008 and May 2010. Of the 1995 specimens analysed, 137 had stomachs with prey remains. Thirty prey species were identified, comprising fish (68% *N*), cephalopods (15% *N*), and crustaceans (22% *N*), with blue whiting (*Micromesistius poutassou*) constituting 40% of the prey. Results demonstrate that smaller individuals had a diet dominated by blue whiting (41%), whereas larger individuals consumed more mesopelagic species. Seasonal shifts in diet were observed, with a predominance of blue whiting (70%) in the first quarter of the year, shifting to a more diverse diet throughout the year. These results may indicate that black scabbard carry out vertical and spatial migrations to feed mostly on blue whiting, but may also opportunistically forage on any food available in the restricted environment that characterizes the deep-water habitat. Trophic level was estimated at TL = 3.8, suggesting that black scabbardfish is a top predator in the deep-water environment. This is the first study to describe the diet of black scabbardfish in Northeast Atlantic, which contributes to a better understanding of trophic dynamics and foodwebs in the deep-water ecosystem, information which is fundamental for the ecosystem approach to fishery management.

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ICES CM 201.1/I:27   Poster

Harbour porpoise and bottlenose dolphin in Ireland: diet and interactions with fisheries

Gema Hernandez-Milian, M. Begoña Santos, and Emer Rogan

Harbour porpoise and bottlenose dolphin are the two main cetacean species inhabiting coastal waters and the continental shelf of Ireland, where commercial fishing activities also take place that are economically important for the country. In all, 58 non-empty stomachs of harbour porpoises and 8 non-empty stomachs of bottlenose dolphins were analysed between 1996 and 2008. We investigated differences in diet between areas, sex, seasons, and cause of death (strandings or bycatches), as well as interannual variability in harbour porpoise diet. The most important prey items in the diet of harbour porpoises were *Trisopterus* spp. (55.2% FO), clupeids (50.0% FO), and whiting (*Merlangius merlangus*, 36.2% FO). Bottlenose dolphin diet exhibited a wider range of prey with a preference for whiting or blue whiting (*Micromesistius poutassou*) and pelagic squid; however this species appeared to demonstrate some specialization in feeding. Whiting, blue whiting, and clupeids are species of high commercial importance in Ireland and therefore exploiting the same resources than the fishery puts dolphins at risk of dying as a result of entanglement in nets. The cause of death of 17 animals (28% of harbour porpoises and 13% of bottlenose dolphin) was identified as fishery bycatch.

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ICES CM 2011/I:28   Poster

Overlapping on diet of some demersal fish off Angola

K. Kilongo, V. Jonico, and F. Delicado

Demersal fish fishery represents the most valuable part of the Angolan fisheries. A large number of species are captured, both as targets and bycatch. The prey spectrum off Angola is described from the stomach contents of 3687 individuals, of which *Merluccius polli* (Benguela hake, 1040), *Dentex macrophthalmus* (large-eye dentex, 593), *Pomadasys jubelini* (spotted grunt, 786) and *Pomadasys incisus* (grunt, 1268) collected from the north (6°S) to the south (17°15′S) of the coast during the bottom-trawl surveys carried out in 1995, 1997, and 2010. All predators were found to be opportunist feeders, feeding mainly on fish (Myctophidae), crustaceans (the shrimps *Parapenaeus longirostris* and *Aristeus varidens*), euphausiids, and polychaetes. The variety of prey increases with fish size, with a systematic effect of depth on the diet. The dominant prey types varied as a function of fish size as well as spatially, demonstrating the different ecological niches provided by the Angola Current off northern Angola, the cold Benguela Current off southern Angola, and the Angola–Benguela Front off southern Angola.

Keywords: Angola, overlapping, predator, prey.

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ICES CM 2011/I:29   Poster

Shifts in seabird species habitats owing to the global climatic change

Oleg Krasnoborodko, Litvinov Feodor, and Remeslo Alexander

Shifts in the ranges of different marine species significantly influence ocean ecosystems, and therefore are considered in frameworks of complex ecosystem approaches. Monitoring the habitat ranges of widespread top predators such as seabirds provides an appropriate basis for such analysis. Seabirds are an abundant and clearly detected component of marine ecosystems which contact with various prey species, many of which are economically important. The trends in the upper ocean layers of temperature, circulation, primary production, and some commercial fish stock assessments were compared with seabird species habitat shifts, occurrences, and abundances, and the species compositions of seabird communities in the open waters of the central eastern Atlantic, southwest Atlantic and southeast Pacific Oceans. Data of seabird observations collected by AtlantNIRO in 1996–2010 were analysed against literature sources. The conclusion was that observed seabird distributions can shift through 7–15° of latitude and/or longitude for some species, such as *Oceanodroma melania, Oceanodroma leucorhoa, Procellaria aequinoctialis, Procellaria westlandica, Puffinus gravis, Pterodroma leucoptera*, etc. A pronounced correlation between seabird range shifts and changes in environmental parameters in recent decades was demonstrated. The maps of seabird distribution, surface temperature, circulation, and primary production along with time-series are presented.

Keywords: central eastern Atlantic, ecosystem shifts, global climatic changes, seabirds, southeast Pacific, southwest Atlantic.

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ICES CM 2011/I:30   Poster

Antarctic cranch squid (*Mesonychoteuthis hamiltoni*)—a top predator of the Antarctic waters—its distribution and relationship with Antarctic (*Dissosticus mawsoni*) and Patagonian (*Dissosticus eleginoides*) toothfish

Alexander Remeslo, Christine Hieber, and Oleg Krasnoborodko

Mesonychoteuthis is a very big species of squid (maximum recorded weight 498 kg), which hitherto has been caught only very rarely. Soviet and Russian biologists described the morphology of *Mesonychoteuthis*, calculated its biomass and also created a map defining its habitat on the basis of numerous finds in the stomachs of sperm whales. The material we collected during several assignments as CCALMR observers on longliners reveals a complex food and behavioural relationship between *Mesonychoteuthis* and Antarctic as well as Patagonian toothfish. When caught on longline hooks, toothfish are obviously exposed to attacks by squid. Our photographic material confirms that *Mesonychoteuthis* sometimes release their prey only when it is raised to the vessel's deck. On the bodies of numerous toothfish deep wounds and marks of large suckers were found. On the other hand, in the stomachs of big Antarctic toothfish pieces and beaks of *Mesonychoteuthis* were found, one beak having belonged to a squid with an estimated mantle length of not less than 180 cm. Possibly toothfish feed on dead or dying *Mesonychoteuthis*, but it also might be that the squid itself becomes the prey when attacking large toothfish. Patagonian toothfish with traces of an attack by squid were found not only in the waters around Antarctica to the south of the Antarctic convergence zone, but also to the north of the Antarctic convergence. Therefore we believe, that *Mesonychoteuthis* may penetrate the northern borders of its usual habitat with waters of Antarctic origin flowing north into the Subantarctic zone.

Keywords: Antarctic cranch squid, Antarctic toothfish, CCALMR, Patagonian toothfish.

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ICES CM 2011/I:31   Poster

Identifying ecologically important marine areas in the Northeast Atlantic: preliminary results for the conservation of marine top predators

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Few protected pelagic areas exist because many pelagic species are highly mobile (some species travel annually thousands of kilometres) and, in turn, it is not possible to integrate the whole distribution range of individual species within a unique Marine Protected Area (MPA). Alternatively, spatially explicit marine conservation initiatives can be implemented during critical periods (e.g. breeding season) or key marine areas (e.g. migration corridors, foraging grounds) during the annual cycle of single species, which often are used by many pelagic species. Moreover, these multispecies hot spots are regularly driven by mesoscale oceanographic features such as oceanographic fronts and are spatially and temporally predictable to a certain extent. Within this framework, we identified hot spots of marine predators in the southern Northeast Atlantic environment based on the PELACUS ecosystem-based monitoring programme. The PELACUS research survey series is an annual monitoring survey programme that studies the pelagic ecosystems on the southern Bay of Biscay (Spain). Based on the small-scale distribution patterns of seabirds, we present the first preliminary results of the identification of ecologically important marine areas for marine top predators in this biogeographic area. Understanding the features that determine the distribution of marine predators is a prerequisite for identifying key areas for their conservation, and hence guides the establishment of MPAs.

Keywords: ecologically meaningful marine areas, ecosystem-based monitoring programme, marine predators, Northeast Atlantic.

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ICES CM 2011/I:32   Poster

Cod as top predator in the southeastern Baltic: results of the winter observations in 1992–2010

F. A. Patokina, Ch. M. Nigmatullin, and S. M. Kasatkina

In the Baltic Sea, despite the presence the common top predators such as seabirds, mammals, and salmon, the mainstream top predator is the adult cod, owing to its large numbers and its quantitative role as consumer. It has achieved dominant top control of pelagic and near-bottom ecosystems, and is in first place in the stocks of most abundant pelagic fish sprat and herring. The stomach contents of 6730 adult cod that were obtained on trawl surveys in the Russian EEZ of ICES Subdivision 26 were studied in February–March 1992–2010. The main aim of this communication is to study the long-term variability of adult cod food consumption on sprat and herring in the late winter period. Two main periods were defined: (i) In 1992–1995 cod food was dominated by sprat (73–90% by weight, mean 85% in cod of length 30–60 cm and 56–98%, 76% in cod of length 61–100 cm) and secondary food was herring (3–27%, 12% and 3–21%, 10%, respectively). In 2010 the same situation prevailed with dominance of sprat (92.2 and 92.8%) and a minor role of herring (7.2 and 7.5%). (ii) During 1996–2009, cod consumption of sprat decreased (but it was still the main food: 30–60%, 50% and 9–53%, 24%) with parallel increases in the role of herring (5–54%, 25% and 4–55%, 24%) and isopods (*Saduria entomon*), fish (*Osmerus eperlanus, Pomatoschistus minutus*, and *Platichthys flesus*). Thus, in the studied period sprat and herring were stably the main and secondary food of adult cod, respectively, and the role of herring increased in a period when the share of sprat in cod food decreased.

Keywords: none.

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ICES CM 2011/I:33   Poster

A study to evaluate survival of adult spring/summer Chinook salmon migrating from the mouth of the Columbia River to Bonneville Dam (Rkm 234)

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In the Columbia River basin, upstream-migrating adult salmon may encounter several sources of mortality and delay. Some, such as harvest and dam passage, have been studied extensively, and the information gained has resulted in improved migration conditions and survival rates. Other potential sources of mortality, such as predation by marine mammals remain to be empirically quantified. Predation by pinnipeds, most notably California sea lions (*Zalophus californianus*), Steller sea lions (*Eumetopius jubatus*), and harbour seals (*Phoca vitulina*) is a potentially significant component of mortality in the estuary and lower river. Populations of these marine mammal predators have increased considerably along the north coast since passage of the Marine Mammal Protection Act in 1972. Today the total pinniped population in the lower river is estimated to be approximately 7000 animals. To begin gathering data on this critical portion of the salmon migration, in 2010 we implemented a two-tiered mark/recapture pilot study, wherein returning adult spring Chinook salmon (*Oncorhynchus tshawytscha*) were tagged with passive integrated transponder (PIT) tags or with both PIT tags and acoustic transmitters (AT). Study fish were captured, tagged, and released in the Columbia River estuary. Data from PIT tags provided an overall survival estimate from the estuary to Bonneville Dam (Rkm 234). Acoustic tracking provided information about fish movement/residence within five subdivisions of the lower river. Survival information gained from this study will be utilized to improve run forecasts and inform harvest allocation decisions that currently do not incorporate natural and variable losses of adult salmon through the estuary.

Keywords: pinniped, predation, salmon, survival.

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ICES CM 2011/I:34   Poster

A role of clupeid predation on fish eggs and larvae in the Gdańsk Deep of the Baltic Sea

E. M. Karasiova, F. A. Patokina, and N. A. Kalinina

Stomachs of herring and sprat were collected seasonally in the Gdańsk Deep of the Baltic Sea during trawl surveys in 1995–2008 to investigate the role of clupeid predation on fish eggs and larvae. The herring was a main predator consuming four species of fish eggs and nine species of fish larvae during the spawning season from early spring to autumn. The most species richness of eggs and larvae in herring stomach content was observed in May. Early ontogenetic stages of sprat were predominant preys in herring diet with prevalence of sprat eggs in May and of sprat larvae in August. The main role of herring as a predator on sprat early developmental stages was defined by a high degree of overlap between the vertical distribution of adult herring and sprat larvae and eggs. The daily consumption of large sprat larvae by herring in August exceeded fivefold the daily consumption of sprat eggs in May. The herring predation on cod eggs was observed only in years and areas with favourable salinity and oxygen regime and depended on cod eggs and larvae occurring in the ichthyoplankton. Low indices of cod egg consumption by herring were also related to relatively low degrees of vertical overlap in the Gdańsk Deep owing to peculiarities of the hydrographic regime. It is supposed that consumption of large sprat larvae by herring in late summer could have some significance for survival on that ontogenetic stage. This study was carried out in the framework of the AtlantNIRO participation in UNCOVER Project.

Keywords: Baltic Sea, clupeids, predation on fish and larvae, predominant prey.

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ICES CM 2011/I:35   Poster

The importance of prey quality and availability on plankton predation by keystone Arctic species, the little auk

K. Błachowiak-Samołyk, L. Stempniewicz, E. Trudnowska, J. M. Węsławski, R. Boehnke, and M. Wichorowski

Little auk is considered a keystone plankton predator in the Arctic ecosystems because of its huge numbers (c. 30 million pairs) and important role in transportation of large amounts of organic matter of marine origin to ornithogenic tundra. These bi-environmental birds inhabit the west coast of Spitsbergen, but their distribution differs. Little auks depend almost exclusively on zooplankton and prefer large energy-rich Arctic *Calanus glacialis* to Atlantic *C. finmarchicus*. To cover their high energetic demands they have to search for rich feeding grounds situated within cost-effective distance from their colonies. In consequence, little auks are expected to respond to changes in the distribution of Arctic and Atlantic waters on the Spitsbergen shelf and thus in the availability of preferred prey items. The present study is based on multidisciplinary observations of little auk prey carried out with zooplankton net sampling (WP2) and a laser optical plankton counter (LOPC) over two summer seasons (2009–2010) on the West Spitsbergen Shelf. Several net samples delivered a detailed zooplankton species composition, whereas modern LOPC techniques allowed continuous mapping of different zooplankton size classes with high spatial resolution. Concurrently to oceanographic observations the food delivered to little auk chicks were collected from two distinct colonies, Hornsund and Magdalenefjorden, located in different hydrological regimes. Despite the predominance of Atlantic species in zooplankton their share in the birds' diet was still significantly lower than Arctic components. Comprehensive knowledge of zooplankton

distribution in the sensitive Arctic region will allow us to predict better the possible consequences of climate change for their keystone consumers.

Keywords: bi-environmental seabirds, climate change, West Spitsbergen, zooplankton.

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ICES CM 2011/I:36   Poster

West African chondrichthyan species as top consumer and food competitor of economically important fish

Feodor Litvinov, Faina Patokina, and Nikolay Timoshenko

Chondrichthyan species are top predators consuming a wide variety of organisms and strongly influencing ecosystems. This paper summarizes data on feeding of 24 shark, 18 batoid, and 1 chimaera species. In total, 2188 stomachs were investigated and 150 different food components observed. Eighty taxa of fish prey were recorded, over 50 crustacean species, 10 cephalopod, and 20 benthic invertebrates. The most important resource for the West African fishery is small pelagics, which are significant food item for chondrichthyans. *Engraulis encrasicolus* occurred in 6 shark species, *Sardina pilchardus* in 6 species, *Sardinella* sp. in 2 species, *Scomber* spp. in 12 species, and *Trachurus* spp. in 7 species. Small pelagic species were important prey for batoids as well: *S. pilchardus* was recorded in 5 species, *Trachurus* spp. in 4 species, *Scomber* spp. and *D. punctatus* in one species. Chondrichthyans consume mainly adult fish, but members of the fish pelagic community feed upon smaller fish of 4–7 cm long. For example, 187 (51%) stomachs of *Caranx rhonchus* demonstrated the presence of significant predation within the pelagic community. It is not only able to compete with chondrichthyan species, but strongly influences survival of juvenile Clupeiformes. Feeding spectra of chondrichthyans overlap with several fish taxa, including economically important ones; crustacean species with Sparidae and Triglidae; fish species with Merlucidae and others. Seasonal, spatial, and interannual changes are discussed and feeding spectra are presented.

Keywords: feeding spectra overlap, sharks, skates, rays and chimaera diets, small pelagic fish consuming, Western African waters.

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ICES CM 2011/I:37   Poster

Comparative analysis of the impact of trawl and longline fishing on the Barents Sea ecosystem

Andrey A. Grekov and Konstantin V. Drevetnyak

In the Barents Sea, bottom fish species are harvested by both bottom trawls and longlines. Despite the similar main target fish species for these gears (cod, haddock, halibut) they differ in selectivity. The species and length composition of catches by trawls and longlines is dissimilar. Because of this, fisheries by bottom trawl and longline have a diverse impact on separate fish stocks and the whole Barents Sea fish fauna. Some fish stocks of the Barents Sea are difficult to access by longlining although they are successfully fished by trawling; in contrast, longlines can be used to target fish species that are present in trawls as a bycatch. In fishery both gears intensively affect the bottom biotope and the biocenoses having formed there. A trawl is an active gear towed at the bottom, whereas a longline lies passively on the ground; therefore a trawl undoubtedly has a greater negative impact on bottom biocenoses. However, unlike a longline, a trawl does not have the disadvantage of catching birds. The paper gives a comparative analysis of the impact of bottom trawling and longlining in the Barents Sea on separate elements of its ecosystem. The effect of those gears on bottom biocenoses, fish stocks, and bird communities was analysed.

Keywords: Barents Sea, bottom biocenosis, bottom trawl, longline, species and size selection.

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Theme Session J

Climate and fisheries-related influences on marine ecosystems at regional and basin scales

ICES CM 2011/J:01

Cyclic climate changes and major commercial stocks in the Arctic region

O. A. Bulatov, L. B. Klyashtorin, and V. M. Borisov

Long-term dynamics of spring-spawning herring and northeast Arctic cod recruitment is reported to be in line with the several main Arctic climatic indices, such as Arctic air surface temperature (Arctic dT) and mean temperature of 200-m water column along the "Kola Meridian" section (Kola meridian dT). Variation in the herring stock recruitment is shown to be correlate with the Arctic dT and Kola meridian dT dynamics, although the cod recruitment follows these indices with a 8- to 10-year lag. The Russian Arctic and Antarctic Research Institute (AARI) reports that for the last 100 years Arctic dT has displayed some 60-year regular fluctuations with maxima in the 1940s and 2000s, and suggests a descending trend in the Arctic dT in the most recent 10–20 years. Thus, in the next 10 years, commercial herring stocks are likely to decrease, whereas the cod commercial stocks are likely to increase. The walleye pollock fishable biomass in the Bering Sea for the past 35 years was shown to vary in line with the PDO (Pacific Decadal Oscillation), the main temperature index of the North Pacific. In particular, higher values of the walleye pollock fishable biomass were attributed to positive PDO anomalies, whereas the lower values of biomass were characteristic of negative PDO anomalies. Analysing both PDO and solar activity dynamics for the past 100 years, a negative PDO trend in the North Pacific may be forecast. Therefore, a gradual decrease in the fishable walleye pollock biomass is likely to take place in the next 10–20 years in the Bering Sea.

Keywords: Arctic climate impacts, cod, herring, walleye pollock fishable biomass.

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ICES CM 2011/J:02

Crustacean crossroads: active analysis of population connectivity of copepods and euphausiids in the North Atlantic Ocean

Ann Bucklin, Leocadio Blanco-Bercial, Nancy J. Copley, and Peter H. Wiebe

Population connectivity (i.e. exchange of individuals) is an essential characteristic of species, which affects their resilience to external pressures, including climate change and anthropogenic impacts. Spatial structuring and population differentiation of key species in the diverse continental shelf, slope, and open ocean environments across the North Atlantic are critical foundations for ecosystem approaches to fishery management. Use of a standard measure of connectivity, such as DNA sequence divergence of the mitochondrial cytochrome oxidase I (COI) barcode gene, allows comparisons of patterns of connectivity among species and over time. In this study, patterns and pathways of gene flow are characterized and compared for ecologically important North Atlantic species of copepods (e.g. *Calanus, Pseudocalanus, Clausocalanus*) and euphausiids (e.g. *Meganyctiphanes norvegica, Stylocheiron* spp.) based on COI sequence variation. Results are discussed for the effects of life history and behaviour, biogeographical distribution, impacts of past climate effects (e.g. bottlenecks with glaciation), and possible responses to recent environmental changes. Future research directions include exploring conceptual and statistical approaches to using population connectivity in the context of ecosystem approaches to fishery management.

Keywords: connectivity, gene flow, population genetics, zooplankton.

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ICES CM 2011/J:03

Long-term changes in zooplankton community in the southern part of the Baltic Sea—search for evidence of climate change and impact of fishery pressure

P. Margoński, B. Kaczmaruk, and W. Kraśniewski

Zooplankton is a key element in the food chain and in the specific Baltic Sea conditions it is extremely vulnerable to atmospheric forcing. Over the last 30 years changes in temperature and salinity have been significantly influencing the zooplankton community structure. At the same time, partly caused by the same climatic driving forces as well as by changes in fishery pressure, profound alterations in the central Baltic Sea fish community have been observed. As a consequence, the predatory pressure of fish on key copepod species have changed. Zooplankton samples for this work were collected by the Maritime Branch of the Institute of Meteorology and Water Management along the south coast of the Baltic Sea (Polish EEZ) within the HELCOM Combine Monitoring Programme. The dataset starts in 1979 with two stations located in the southern parts of the Bornholm and Gotland Basins. Since 1986 samples have been also taken at a station located in the Gdańsk Basin. Frequency of sampling varied in time but the spring and summer conditions can be described for each year. Considering the availability of long-term data, the analysis evaluating the impact of climatic forcing and fishery pressure on the mesozooplankton community structure should provide valuable information for our understanding of ecosystem functioning.

Keywords: climate change, fishery pressure, southern Baltic Sea, zooplankton.

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ICES CM 2011/J:04

Ecosystem responses in the North Atlantic to the cold period of the 1970s and 1980s

Ken Drinkwater and Trond Kristiansen

In the North Atlantic following the warm period in the middle part of the last century, temperatures generally declined, reaching a minimum in the 1970s or early 1980s, depending on location. This presentation provides a synthesis of the ecosystem responses to this widespread cooling phenomenon. Associated with the cooling there was a general increase in the sea ice distribution throughout the northern regions and a change in the circulation patterns with less transport of warm water into the Labrador, Nordic, Barents, and North Seas. In response to these changes, spring blooms were delayed as well as there being a general decline in phytoplankton production. Zooplankton biomass also declined. Fish populations generally moved southwards and there was a general reduction in the fish production in the northern regions. In contrast, in southern regions the cooling may have contributed to increased production (e.g. the "gadoid outburst" in the North Sea). Phenology also changed, with later migrations northward and earlier retreats southward, and delayed spawning. Contrasts are drawn between this cool period and the warm periods immediately preceding and following it. The cool period was also a time of increasing fishing intensity and we will address the issue of fishing vs. climate in accounting for the foodweb changes we observed. Finally, the lessons learned with regard to the effects of future climate change on North Atlantic ecosystems will be addressed.

Keywords: climate, cold period, ecosystem response, North Atlantic.

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ICES CM 2011/J:05   Withdrawn

ICES CM 2011/J:06

Baltic Sea ecosystem changes and thresholds

T. Blenckner, M. Llope, M. Casini, C. Möllmann, M. Rodriguez-Medina, C. Humborg, and N. C. Stenseth

Recent studies have demonstrated the existence of regime shifts in the temporal dynamics of ecosystems, which have been explained mainly to be a result of multiple causes (e.g. climatic forcing, overexploitation, or a combination of both). The Baltic Sea, the largest brackish water body in the world, and its spatially connected subsystems are strongly affected by climate-induced changes in temperature and salinity, eutrophication, and overfishing. The presence of distinct dynamic regimes in the Baltic have been put forward as a suitable conceptual framework to explain its different configurations observed over the last 30 years. To assess the existence of separated regimes (and hence regime shifts) in the Baltic Sea, we performed a state-of-the-art statistical analysis allowing the detection of non-linearities and thresholds in foodweb interactions and their relationship to drivers such as eutrophication, overfishing, and climate. The analysis was applied to the large dataset of hydroclimatic, nutrient, phyto- and zooplankton as well as fisheries variables collected in the central Baltic Sea during the period 1979–2006. This approach allowed us to study the importance of more global (i.e. climatic) forcings relative to basin-wide (e.g. fisheries and eutrophication) forcings. It further allowed us to investigate whether the foodweb response is non-linear with a special emphasis on thresholds. The importance of the results for ecosystem-based management across sectors will be discussed.

Keywords: climate, eutrophication, foodweb, regime shifts.

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ICES CM 2011/J:07   Poster

Oscillations in abundance of some economically important fish related to hydroclimate of the Northwest Atlantic

Igor K. Sigaev

Analysis of oscillations in meteorological and oceanographic parameters in the Northwest Atlantic (NWA) in the last 50 years revealed three periods in their development. The first one lasted from the end of the 1950s to the end of the 1970s–beginning of 1980s; the second one from beginning of the 1980s to the mid-1990s and the third one from the mid-1990s to today, which is to be completed soon. These periods and their sequence appear in the many-years trend of the North Atlantic Oscillation (NAO) index, in temperature variations at the surface and near bottom on the NWA shelf, in the volume of the cold intermediate layer, in the variability of ice-covered areas, and in shifts of hydrological fronts along the meridian. These variations in environmental conditions are well-coordinated with oscillations in the abundance and stocks of generations in some economically important fish of NWA (Greenland halibut, redfish, cod, thorny skate, Atlantic mackerel, herring). Here we present diagrams of water temperature changes, NAO indices, the dynamics of the localization of oceanic fronts, and oscillations in fish abundance.

Keywords: NAO index variability, Greenland halibut, redfish, cod and other economically important fish of the NWA, interannual variability.

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ICES CM 2011/J:08

Environmental regulation of capelin in the Northwest Atlantic

Alejandro D. Buren, Mariano Koen-Alonso, Fran Mowbray, Brian Nakashima, Garry Stenson, Pierre Pepin, and Neil Ollerhead

During the early 1990s the Northwest Atlantic underwent extensive ecosystem changes. For capelin, these changes included a major reduction in acoustic offshore abundance estimates, reduced size and age at maturity, reduced somatic condition, and delayed spawning. Invoking metabolic reasoning, the timing of spawning has been explained by a combination of fish length and temperature conditions during February to June, whereas the drivers modulating the biomass trajectory have remained elusive. The initiation of the spring bloom in the Newfoundland Shelf is determined by light availability and seasonal sea ice dynamics. Using data from 1980–2010, we study the relationship between sea ice, capelin biomass and timing of spawning to explore the hypothesis that capelin dynamics are environmentally regulated through food availability. We found that simple models with a break in 1991 and sea ice as modulator account for more than 80% of the variability in peak spawning date and more than 90% of the variability in capelin biomass. We predict biomass levels during the 1970s and found good agreement with estimates based on advisory models of sequential capelin abundance. Our results support the hypothesis that bottom-up control mechanisms may be at play. Given capelin's role as a key forage species in this ecosystem, these findings are particularly relevant as they provide an avenue to explore the potential impacts of climate change on ecosystem productivity.

Keywords: bottom-up, climate change, forage fish, sea ice.

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ICES CM 2011/J:09

Applying the shiftogram approach for identifying ecosystem changes—the Baltic Sea as a multivariate test case

Joachim Gröger, Christian Möllmann, Thorsten Blenckner, Anna Gårdmark, Martin Lindegren, Bärbel Müller-Karulis, Philip Axe, Maris Plikshs, and Georgs Kornilovs

Regime shifts in ecosystems whose patterns and properties may be very complex and thus manifold have profound implications for sustainability. Detecting structural breaks in natural processes, however, turns out to be an ambitious task because the lack of well-defined target values and reference periods renders application of standard statistical (process or quality) control methods all but impossible. Recently an iterative procedure has been developed combining econometric, time-series, and quantile methods that produce a graphic display referred to as a "shiftogram", which indicates potential shifts within univariate components of an ecosystem of interest by characterizing their specific and often fairly complex properties. The shiftogram approach has been originally developed for univariate time-series. Here we extend the shiftogram approach to (i) a multivariate case study using multi-trophic level data and (ii) further introduce a "concentrogram" summarizing the timing of structural breaks in multiple time-series in one graphic. We apply these techniques to the central Baltic Sea, an ecosystem where multi-trophic level data are available and an ecosystem regime shift has been recently demonstrated.

Keywords: none.

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ICES CM 2011/J:10

Improving the stock–recruitment relationship by including environmental data

Geir Ottersen and Esben Moland Olsen

Trying to understand what regulates recruitment variability in marine fish populations has been a central issue in fishery science since the early twentieth century. Intuitively, the size of the spawning stock should influence recruitment. In practice, however, the relationship is most often weak. It is to be expected that a Ricker-type stock–recruitment relationship (i.e. overcompensation) would occur at limited food levels, whereas as food availability improves the recruitment curve monotonically increases towards an upper limit (i.e. a Beverton–Holt-type stock–recruitment relationship). Lack of food will slow down the growth of the larvae and delay the time to metamorphosis. This may cause the larval cohort to experience density-dependent mortality to the extent that the recruitment curve becomes overcompensatory. Here, we demonstrate how the environmental conditions (temperature and the food availability for fish larvae) influence the stock–recruitment relationship and indeed determine the balance between a more Ricker or Beverton–Holt-type relationship. Using unique zooplankton data from the continuous plankton recorder, we find that food availability (i.e. zooplankton) in essence determines which model applies for the once large North Sea cod stock. Furthermore, we confirm that recruitment is strengthened during cold years and weakened during warm years. Our combined model explained 45% of the total variance in cod recruitment, whereas the traditional Ricker and Beverton–Holt models only explained ca. 10%. Furthermore, we will explore the general usability of this modelling approach by applying it to other important Northeast Atlantic stocks where suitable data are available.

Keywords: cod, model, North Sea, recruitment.

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ICES CM 2011/J:11

Fishery- and climate-induced changes in predator distribution trigger a spatial reallocation of its prey: the cod–sprat dynamics in the Baltic Sea

Michele Casini, Ulf Bergström, Valerio Bartolino, Eero Aro, Martin Lindegren, Philip Axe, and Markus Meier

Understanding the processes regulating population spatial distribution is crucial in ecology in general and management of exploited resources in particular. Previous studies have revealed that overall the sprat population drastically increased in the Baltic Sea from the early 1990s. This increase in sprat stock size occurred mainly in the northern areas of the Baltic Proper. Here we use spatially explicit fishery-independent (acoustic and bottom-trawl surveys) data and physical–biochemical modelling covering a 30-year period to explore the factors affecting Baltic sprat distribution. Generalized additive models identified a strong negative spatial correlation 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 also likely the result of hydroclimate changes (decrease in salinity and increase in anoxic sea bottoms). This suggests the appearance of a spatial pattern in the trophodynamic control of cod on sprat, which was unveiled by a fishery- and climate-induced spatial reallocation of the predator. The increase in temperature over the Baltic Sea could, however, have also contributed to the northward expansion of the thermophilic sprat. The strong increase of the sprat density in the northern Baltic was also accompanied by a severe drop in sprat body condition in this area, probably as a result of density-dependent effects. Overall, this study stresses the importance of including spatial aspects in management decisions for both species.

Keywords: Baltic Sea, geographical distribution, physical-biochemical modelling, spatial top-down control.

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ICES CM 2011/J:12

The influence of the North Atlantic Oscillation on the abundance of *Pagellus bogaraveo* of the Azores

M. R. Pinho, I. Bashmachnikov, and A. Martins

Recent studies suggest that climate variability may act in the marine environment from the bottom-up, via primary and secondary productivities or from the top-down through controls on key predator populations, potentially inducing substantial, wide-ranging, and complex responses both within and among communities. Given the potential profound and varied effects of climate variability on the biomass, age structure, and growth rates of fish in the Northeast Atlantic ecosystems (namely, within the Azores region, where commercial fisheries constitute a strong economic regional revenue), a detailed description and understanding of climate patterns, processes, and impacts became critical for developing better fish management strategies in the region. In this study we use 15 years of demersal fish cruise surveys and relate *Pagellus bogaraveo* (a commercial fish species of the Azores) abundance indices with North Atlantic Oscillation (NAO) seasonal indices for the same period of time. Preliminary results are encouraging and demonstrate positive and significant correlation between the fish abundance and the atmospheric indices. This work raised new scientific questions and challenges by integrating for the first time in the Azores, expertise from scientists from different fields (physical/biological oceanographers and fishery biologists), in an attempt to describe, explain, and establish climate–ecosystem relationships for the region.

Keywords: abundance, climate variability, deep water, management.

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ICES CM 2011/J:13   Poster

Rock cod (*Patagonotothen ramsayi*) as a key species in the Falkland Islands ecosystem

Vladimir Laptikhovsky, Alexander Arkhipkin, and Paul Brickle

Rock cod (*Patagonotothen ramsayi*) is a key species in the shelf waters of the Falkland Islands. It consumes a variety of planktonic and benthic organisms and together with the squid (*Loligo gahi*) is the most important prey for large predatory fish, representing 35–60% of the diet of rays (*Bathyraja brachiurops* and *B. scaphiops*), frogmouth (*Cottoperca gobio*), subadult toothfish (*Dissostichus eleginoides*), kingclip (*Genypterus blacodes*) and hakes (*Merluccius hubbsi* and *M. australis*). Recently, the species became the most abundant fish on the Falkland shelf, its annual catches increased from 1500–5000 t before 2005 to 60 000–70 000 t in 2008–2010. This increase followed a strong decrease in abundance of the most important planktivore fish such as blue whiting (*Micromesistius australis*) and squid (*Illex argentinus*). It also coincided with increasing catches of hakes and kingclip as well as with increase in abundance in the subadult toothfish. We suggest that possible changes in plankton diversity and abundance caused by decrease in predatory pressure in pelagic layers resulted in more food available to the near-bottom rock cod. This could lead to an explosion in its abundance, that in consequence began to attract more predatory fish to the area leading to an important ecosystem restructuring.

Keywords: ecosystem, Falkland Islands, *Patagonotothen ramsayi*, rock cod.

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ICES CM 2011/J:16   Poster

The response of the Baltic Sea to climate variability

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During the recent 40-year period from 1970 to 2009, changes in atmospheric conditions have been observed in the Baltic Sea area. These modifications in the regional atmospheric conditions are the consequence of changes detected in large-scale atmospheric patterns. For the Baltic Sea area, especially during winter, there have been changes in the prevailing wind direction, surface temperatures, as well as in the tracks and number of deep cyclones. Here we focus on the response of the Baltic Sea to the observed changes in atmospheric conditions for the period 1970–2009. If mean temperature and salinity profiles of the two 20-year periods (1970–1989 and 1990–2009) taken from the ICES subdivisions dataset for the Baltic Sea are compared, unidirectional spatial changes in the water mass properties with a warming of the upper to halocline waters together with a freshening of waters within this depth range can be observed. To investigate changes in the general circulation patterns of the Baltic Sea we use a high-resolution coupled sea ice–ocean model of the Baltic Sea, with realistic atmospheric forcing, applied for the same period 1970 to 2009. We find similar changes in magnitude and direction in the mean temperature and salinity profiles as in the observational dataset. In addition, we observe an intensification of the circulation patterns accompanied by changes in the salinity distribution, especially during winter. Because such changes could severely affect the spatial distribution, habitat utilization, and recruitment processes of Baltic fish and zooplankton populations, it is crucial to investigate and understand the connection between possible future changes in the atmospheric conditions and the response of the Baltic Sea.

Keywords: Baltic Sea, climate variability, modelling.

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ICES CM 2011/J:17   Poster

Effects of future climate on physiology and egg production in Baltic Sea sprat

Christina Frisk, Axel Temming, Jens-Peter Herrmann, Kristine Skovgaard Madsen, and Ken Haste Andersen

Recruitment in Baltic Sea sprat stocks has strong and seemingly unpredictable year-to-year variations owing to fluctuations in the physical environment as a response to atmospheric forcing and longer term climate trends. Because sprat is short-lived, the fluctuations in year-class strength generate large alterations in stock abundance, thereby reinforcing the unpredictability of the forthcoming recruitment. The variations in recruitment can be partly explained by whether or not the eggs and larvae are transported to favourable habitats in a given year. However, there may be an additional source of variation in how the egg production of the adults depends on the climate. To investigate the effect of temperature on growth and reproduction we develop a bioenergetic model which resolves the effect of temperature on physiological processes. Special focus is on the dynamics of the reserve pool and the allocation to reproduction during the season. We demonstrate that the model is able to reproduce the general pattern of growth and reserve dynamics of sprat. We then simulate the metabolic processes and egg production under two climate scenarios: 1960–1990 and 2070–2100. Hereby we find that the increased temperature in the 2070–2100 scenario predicts reduced individual sizes and annual egg production.

Keywords: Baltic Sea, bioenergetic model, climate scenarios, *Sprattus sprattus*.

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ICES CM 2011/J:18   Poster

Possible impact of temporal changes of sea temperature on *Aurelia aurita* L. quantity in the Baltic Sea

Krzysztof Pawlikowski

The impact of temperature changes on marine zooplankton is a growing concern these days. High variability in the numbers of jellyfish (*Aurelia aurita* L.) has been observed since 1983. This work aims to explain that variability on the basis of both data recently collected by the author (2008–2010) and historical data (1983, 1986–1991). The historical data come from the ICES database (water temperatures for central Bornholm Basin) and from previously published studies (*A. aurita* biovolumes). All of the biovolume data were collected in third quarter of each year and represent areas of the southern Baltic Sea in the Polish EEZ. Mean biovolumes calculated for each year for an entire EEZ ranged from 240 $cm^3 \times 1000$ m^{-3} in 1986 to 8178 $cm^3 \times 1000$ m^{-3} in 2008. It should be emphasized that maximum quantities in 2008 were over five times greater than maximum quantities measured two decades ago. Mean biovolumes were divided into two ranks: low quantities (from 100 to 1000 $cm^3 \times 1000$ m^{-3}) and high quantities (from 1000 to 10 000 $cm^3 \times 1000$ m^{-3}). Spearman rank correlation coefficents were then calculated for the ranked biovolume data and for lowest temperatures in the winter period, as well as highest temperatures in the summer of each year. High correlation has been obtained for winter lowest temperatures ($r_s = 0.853$; $p < 0.05$) and much lower correlation for summer highest temperatures ($r_s = 0.497$; $p < 0.05$). Moreover, it was noted that high quantities of medusae occur when minimal winter temperatures are above +2.91°C. It can be concluded, therefore, that minimal winter temperature should be considered a significant factor controlling *Aurelia aurita* abundance.

Keywords: abundance, *Aurelia aurita*, Baltic Sea, temperature.

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ICES CM 2011/J:19   Poster

Interannual dynamics of zoobenthos in the Vistula Lagoon, Baltic Sea in 1997–2010

Elena Ezhova

The Vistula Lagoon is one of the biggest and the most highly productive coastal shallow basins of the Baltic, characterized by quite high values of quantitative parameters of zoobenthos. In the 1950s–1980s average annual biomass in the Russian part of the lagoon was ca. 20 g m^{-2}, but it has increased to 60–90 g m^{-2} on average in the 1990s, since the North American polychaete *Marenzelleria neglecta* invaded lagoon bottom communities in 1988. In the 1990s this species amounted to 90% of the total biomass. During the 2000s, at first gradual, then a sharp drop in total benthic biomass has happened, mainly as a result of a permanent decrease in *M. neglecta*. A clear opposite trend has been recorded for the Oligochaeta group, whose share in the total benthos biomass was increasing during the 2000s. Analysis of the interannual dynamics of mass benthos species production (*Hediste diversicolor*, *M. neglecta*, *Chironomus balatonicus*, *Potamopyrgus antipodarum*, and Oligochaeta group), estimated on the basis of energy metabolism, has revealed a tendency for considerable decrease in two polychaete species production and increase in Oligochaeta production. Interannual dynamics of total benthos biomass, abundance, and production and those of various groups of benthos are mainly defined by the reduced contribution of Boreal and Subarctic–Boreal species as well as by the increase in the contribution of Ponto–Caspian and Mediterranean–Boreal ones. The registered changes in the productivity of zoobenthos and separate groups of invertebrate correlate with a positive trend in water temperature (+2°C) for the Vistula Lagoon in 1997–2007.

Keywords: biomass, production, Vistula Lagoon, zoobenthos.

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ICES CM 2011/J:20   Poster

Shifts in the genetic structure of the European hake metapopulation as fingerprints of migration between fishery grounds

A. Pita, A. Leal, C. Piñeiro, and P. Presa

Recent population genetics studies have demonstrated the lack of a stable spatio-temporal genetic structuring in the European hake from the North Atlantic. More specifically, the existence of a large history of connectivity between central grounds (Porcupine–Great Sole) and southern grounds (south Biscay Bay) of this fishery was inferred from genetic data collected from microsatellite markers. Such a pattern of connectivity was characterized by fixed migration geometry (from central grounds to southern grounds), but appeared to fluctuate consistently between years. Using genetic markers, in this study we aimed to quantify the migration intensity between those two major fishery grounds on the temporal framework of the last decade. Global molecular variance was nearly zero among year samples within fishery grounds because of their known broad inner connectivity. However, the genetic variance in the years 2004 and 2007 was highly significant in the southern Biscay Bay population. In addition, in those years, a reduction of the genetic differentiation between fishery grounds and an upwards shift in the number of subpopulation units ($k > 1$) was observed in the southern population, which typically has had an across-years monotonic subpopulation value ($k = 1$). Present results are in agreement with a southerly directional migration of fixed geometry and variable intensity between fishery grounds from the North Atlantic. Because genetic data are proving to be practical at detecting and quantifying the migration that takes place between fishery grounds, they are useful in the assessment of this important fishery.

Keywords: connectivity pattern, European hake, genetic markers, *Merluccius merluccius*.

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Theme Session K

Integrating micro- and meso-zooplankton in marine foodweb research

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ICES CM 2011/K:01

Impact of the alien predatory cladoceran *Cercopagis pengoi* on zooplankton: evidence from laboratory experiments

Henn Ojaveer, Mart Simm, and Maria Põllupüü

The predatory cladoceran *Cercopagis pengoi* invaded the Baltic Sea in the early 1990s. Since then, several changes observed in the local zooplankton have been attributed to this alien species, as a result of direct predator–prey interactions. We have studied feeding of *C. pengoi* in laboratory conditions by using both newborn first instar individuals as well as older parthenogenetic females as predators. Various single and mixed prey with different size and escape reactions (copepods, copepodites, nauplii of *Eurytemora affinis*, *Bosmina* spp., and larvae of *Balanus improvisus*) were offered in densities that correspond to field conditions when *C. pengoi* is present in the water column. Our results confirm earlier findings that *C. pengoi* is a very aggressive predator with the ability to consume virtually any prey available. Probably because of size limits, only the newborn young ones were unable to eat adult copepods. Copepod nauplii and the native small-sized cladoceran *Bosmina* spp. were, when available, the major and preferred diet for this alien species. In general, higher prey density resulted in elevated consumption rates of *C. pengoi.* The outcomes of the current study widen our knowledge base to interpret results obtained from the field observations and assist in quantifying ecosystem impacts of this invasion.

Keywords: alien species, Baltic Sea, predator–prey interactions, zooplankton.

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ICES CM 2011/K:02   Poster

Production of planktonic crustaceans in the southeastern part of the Baltic Sea (in 1995–2010)

Anna Semenova and Natalia Zhigalova

Planktonic crustaceans form the main part of the zooplankton abundance and biomass in the Baltic Sea and play an important role in energy and material transfer and cycling through marine foodwebs there. Zooplankton samples were taken in the southeastern Baltic Sea in 1995–2010 at 30–35 stations. Altogether more than 900 zooplankton samples were collected. The production was calculated using a balance ratio between ration, production, expenditure on metabolism, and undigested food. The main production (90%) was produced by dominant zooplankton species: *Pseudocalanus elongatus*, *Temora longicornis*, *Acartia* spp., *Centropages hamatus*, *Bosmina maritima*, and *Evadne nordmanni. Pseudocalanus elongatus* contributed most production in winter and one-third in spring. Cladocera contributed more than one-half of production in spring and summer. The lowest production was observed in winter (1% of annual production), in spring the production increased (up to 16%), it was maximum in summer (72%), and decreased in autumn (up to 11%). Maximum production was observed in years with high water temperature due to mass development of Cladocera in spring and summer of these years. Thus, the composition of the dominant complex of species, the proportion of Cladocera and Copepoda, temperature, and salinity of water influence production of crustaceans in the southeastern area of the Baltic Sea. In recent years there has been a clear trend towards an increase in average annual temperature, which leads to massive development of Cladocera, and an increased production in spring and summer.

Keywords: planktonic crustaceans, production, south Baltic Sea, zooplankton.

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ICES CM 2011/K:03

From zooplankton to large pelagic fish: production and biomagnification in a tropical coastal pelagic foodweb adjacent to Lihir gold mine (Papua New Guinea)

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Deposition of mine tailings into the sea (deep-sea tailings placement) has generated widespread criticism, despite little knowledge of its effects on marine communities. Here we investigate the effect of the disposal of tailings from a gold mine into the sea off Niolam Island (Lihir group), Papua New Guinea, and subsequent potential biomagnification in the local foodweb. We use a comparative approach contrasting the effects of the mine with a control site on the other side of the island away from the influence of the mine. We found abundance and diversity of zooplankton, micronekton and pelagic fish to be similar or higher at the mine site compared to the control. However, we also found relatively high trace metal concentrations in lower trophic level groups, especially zooplankton, but no differences in tissues concentrations between mine and control regions for micronekton and pelagic fish. Biomagnification of some trace metals was evident within lower trophic groups in the control region, but, with the exception of Hg, it does not persist into the more mobile and widely ranging higher trophic level species. We conclude that deep-sea tailings placement at Niolam Island has a local effect on the smaller and less mobile pelagic communities with heavy metal concentrations, but has little effect on the abundance and biodiversity of the local foodweb, and is unlikely to affect the local people that consume the coastal pelagic fish. This is one of the first studies of biomagnification in pelagic foodwebs from tropical regions.

Keywords: deep-sea tailings placement, Papua New Guinea, pelagic foodweb, trace metals.

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ICES CM 2011/K:04   Withdrawn

ICES CM 2011/K:05

Trophic interactions among zooplankton and fish species within the pelagic ecosystem of the Iceland Sea

Hildur Petursdottir

Trophic relationships of important pelagic zooplankton and fish species were investigated in August 2007 and 2008 in the Iceland Sea, north of Iceland. Carbon and nitrogen stable isotopes and fatty acid biomarkers were used to study trophic linkages and trophic ecology of the most important pelagic species in this ecosystem. It is concluded that there are 3–4 trophic levels in this pelagic ecosystem, excluding birds and mammals. The primarily herbivorous copepod *Calanus hyperboreus* occupies the lowest trophic level of the animal species studied but adults of capelin (*Mallotus villosus*) and blue whiting (*Micromesistius poutassou*) the highest. *Calanus* spp. proved to be an important diet component of most of the studied species. The euphausiid species *Thysanoessa inermis* and *T. longicaudata*, however, are exceptions as *Calanus* spp. are of minor importance in their diet. The chaetognath *Eukrohnia hamata* is a pure carnivore, feeding heavily on *Calanus* spp., while most of the other zooplankton species studied practise omnivorous–carnivorous feeding mode. Young euphausiids are an important food component for capelin larvae, and the amphipod species *Themisto libellula* is important in the diet of adult capelin. The importance of *Calanus* spp. or a *Calanus*-derived diet increases with the size of capelin. Adults of capelin and blue whiting share the same feeding habits and could therefore be competing for food.

Keywords: capelin, fatty acids, Iceland Sea, stable isotopes, trophic ecology, zooplankton.

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ICES CM 2011/K:06   Withdrawn

ICES CM 2011/K:07

Essential fatty acid (docosahexaeonic acid, DHA) affects RNA:DNA ratio of larval herring in the field

Matthias Paulsen, Catriona Clemmesen, and Arne M. Malzahn

Larval fish growth and survival depends not only on prey quantity, but also on prey quality. To investigate the effects of fatty acids on larval herring growth we collected seston, potential prey, and larval herring at two contrasting environmental situations in the Kiel Canal in spring 2009. Along with biotic and abiotic background data we analysed fatty acids in seston, potential prey organisms, and in the larvae as well as the RNA:DNA ratio of the larvae as the response variable. Although DHA-poor Chlorophyceae dominated the phytoplankton community, high concentrations of DHA were found in the seston samples, indicating trophic upgrading by protists. Seston DHA was tightly coupled to DHA of early larval herring stages, and this relationship ceased with herring size. Larger larvae always had higher DHA concentrations, and DHA concentrations in the larvae were positively related to the nutritional condition of the larvae. This finding indicates the increasing importance of DHA in larval fish development.

Keywords: essential fatty acids, herring larvae, mesozooplankton, nutritional condition, protists.

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ICES CM 2011/K:08   Withdrawn

ICES CM 2011/K:09   Poster

Specific long-term variability of Baltic Sea zooplankton stocks due to environmental and anthropogenic influences—and potential consequences

Lutz Postel and Carola Wagner

Zooplankton variability in the Baltic Sea is influenced by climate-induced temperature and salinity changes as well as by anthropogenic effects, such as eutrophication, introduction of alien species, and fishery-related aspects. Different zooplankton components react differently. While *Pseudocalanus acuspes* stock is mainly correlated to precipitation and saltwater inflows, the microphagous *Acartia* species, rotifers, and larvaceans mainly react to changes in eutrophication. Small pelagic fish must be affected by foodweb relationships as well. *Temora longicornis* and *Bosmina* spp. are more tightly coupled to interannual variations of summer temperature than others. *Oithona similis* stock in the central Baltic Sea deep water is an indicator for the origin and strength of deep-water renewals below the permanent halocline. Conversely, few specimens of *Limnocalanus macrurus* (an indicator for low salinity in the northern Baltic Sea) in the same depth levels of the southern Gotland Sea indicate a thermohaline water exchange. Furthermore, there is evidence of a certain carrying capacity for adult calanoid copepods. The contribution is a result of long-term monitoring studies, based on interdisciplinary data compilation, and statistical analysis.

Keywords: Baltic Sea, copepods.

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ICES CM 2011/K:10

Carbon dioxide affects copepod production by reducing the nutritional quality of their algal diet

Jorge Rafael Bermúdez, Dennis Rossoll, Monika Winder, Helena Hauss, Kai Schulz, Ulrich Sommer, and Ulf Riebesell

The reaction of carbon dioxide (CO_2) with water generates one proton (H^+) for each bicarbonate ion (HCO_3^-) and two protons for each carbonate ion (CO_3^{2-}) formed, decreasing the water pH. It is known that this reaction affects several primary producers, such as coccolithophores, whereas diatoms show a change in their total lipid content when cultured under high-CO_2 conditions. Fatty acid (FA) composition is a critical factor that regulates energy transfer efficiency between primary producers and consumers since essential FAs cannot be synthesized *de novo* by heterotrophic organisms and have to be acquired through their diet. Polyunsaturated fatty acids, in particular, play an important role in the growth, development, and reproductive processes of heterotrophs. A CO_2-related pH decrease seems to be a significant factor, causing shifts in the FA composition of several phytoplankton species, which may have important consequences for primary consumers and higher trophic levels. In a full factorial laboratory experiment, the copepod *Acartia tonsa* was grown at ambient (380 ppm) and increased (740 ppm) CO_2 and fed with *Thalassiosira pseudonana* cultured under the same conditions. Development, egg production rate, and FA content per female were measured. The results show that these three parameters are all reduced when fed with *T. pseudonana* cultured at high CO_2 conditions. We therefore conclude that CO_2 concentration affects the fatty acid composition of *T. pseudonana* and that this alteration has a significant influence on the life cycle of *A. tonsa*. Further research is required to determine if the observed effects also occur in the natural environment.

Keywords: carbon dioxide, copepods, diatoms, fatty acids.

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ICES CM 2011/K:11

Egg or female—who decides the fate of an egg type? A laboratory study on Baltic *Acartia tonsa*

L. Holste, N. Schulz, B. Diekmann, J. Peters, J. Renz, and M. A. Peck

Diapause egg production has been known to be one of the overwintering strategies for various copepod species for more than three decades. Because of uncertainties regarding the quantity of overwintering eggs within sediments and environmental trigger(s) for their production and hatching, realistic predictions of the seasonal population dynamics of many copepod species remains problematic. Investigations have considered temperature and photoperiod to be the main abiotic factors controlling diapause egg production and hatching in *Acartia* congeners. It still remains unclear whether eggs are affected directly by environmental conditions or whether the female induces an arrested development in the eggs. We incubated single *Acartia tonsa* females and their eggs over two generations in a variety of different environmental conditions manipulating temperature (6 and 20°C), photoperiod (12 : 12 and 6 : 18 L : D), salinity (high and low) and food quantity (low feeding level and *ad libitum*) in a crossover experiment to look at egg morphology, hatching success, and respiration rates of single eggs. Morphologically different egg types were identified, partly confirming findings from other authors: spiny eggs, small spined eggs, rough and smooth eggs. Hatching success was the same in all morphological types >80%. Furthermore, marked variability of egg morphology was observed among individual females and days of production; a clutch produced by one female within 24 h consisted of >90% eggs of the same morphological type. Our first results give evidence that (i) females induce the type of egg independently of environmental condition and (ii) *A. tonsa* produces only quiescent and no true diapause eggs within the Baltic Sea.

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ICES CM 2011/K:12

Results from zooplankton size structure surveys in the Bay of Biscay during the last decade

Pieter Vandromme, Enrique Nogueira, Martin Huret, Ángel López-Urrutia, Gonzalo González-Nuevo, Pierre Petitgas, and Marc Sourisseau

Linking lower to higher trophic levels can only be achieved through a deep understanding of the mid-trophic levels (i.e. zooplankton). One of the most important areas of information on zooplankton for fluxes of mass lies in its size structure. We present here an extensive dataset of zooplankton size spectra covering the entire Bay of Biscay in spring and autumn, from 2002 to 2010. Data were acquired during coordinated Spanish and French small pelagic fisheries surveys. Zooplankton size spectra were characterized using two complementary methods: (i) *in situ* measurements of the size distribution by the laser optical plankton counter (LOPC), a particle counter recording individuals from 100 to 2000 μm ESD with a vertical resolution of about 50 cm, and (ii) in lab imaging of net samples (WP2 and Multinet, 200 μm mesh size) using the ZooScan methodology. ZooScan data were compared with LOPC data since the latter do not provide information on the state of recorded objects (e.g. living zooplankton or detritus). The main patterns of spatial, vertical, seasonal, and interannual dynamics of zooplankton size spectra and their relationships to anchovy and sardine at different developmental stages, feeding on distinct size range, are presented.

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ICES CM 2011/K:13

Modelling the global-scale transfer of energy between primary producers and mesozooplankton

Charles A. Stock and John P. Dunne

The flow of energy from phytoplankton to fish in aquatic ecosystems is modulated by potentially complex planktonic foodweb dynamics. Ecosystem models resolving these processes on global scales are essential to making improved, quantitative projections of the affects of climate variability and change on future global fisheries production. Most climate projections archived in the CMIP3/IPCC-AR4 multi-model database, however, resolve only the physical climate system (sea ice, atmosphere, ocean, and land surface). Where ecosystem models are included, they are formulated primarily to resolve global-scale carbon and nutrient cycling rather than planktonic foodweb dynamics. This often forces fisheries projections to rely on highly empirical relationships with physical variables or, at best, primary production. The dynamics of the ecosystem model within the Geophysical Fluid Dynamics Laboratory's Earth System Model were augmented to address this limitation. Additions included three zooplankton groups with flexible feeding formulations, explicit bacteria and microbial loop processes, and improved bioenergetic formulations. Global-scale ocean-ice simulations forced with historical atmospheric forcing from the past 60 years were conducted with this model and used to explore (i) mean global-scale patterns in the transfer of energy between primary producers and mesozooplankton, and (ii) the affect of climate variability on the transfer of energy between primary producers and mesozooplankton.

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ICES CM 2011/K:14

Plankton trophic dynamics in hypoxic waters: seasonal effects and foodweb implications

James J. Pierson, Diane K. Stoecker, Michael Roman, David Elliott, Ed Houde, Mary Beth Decker, Katherine Liu, and Ali Barba

The prevalence of hypoxia in coastal regions and estuaries, and concern over its effects on aquatic ecosystems, is increasing worldwide, including within the ICES region. A substantial body of research has addressed causes and controls of hypoxia, as well as effects on benthic and demersal organisms. Far less attention has been directed at effects on pelagic and planktonic organisms, and especially on the sublethal effects of hypoxia on foodwebs. We are investigating trophic interactions in planktonic foodwebs that experience seasonal hypoxia through a concerted process-oriented field programme in Chesapeake Bay. To discern the effects attributable to hypoxia, we compared aspects of plankton ecology from two sites with similar temperature and salinity regimes but with different bottom-layer oxygen concentrations. Specifically, we documented vertical distributions of phyto-, microzoo-, mesozoo-, and ichthyoplankton, as well as gelatinous and juvenile fish predators. Grazing, reproductive, mortality, and migration rates of the copepods were also measured in both hypoxic and normoxic water columns. Results indicate that impacts of hypoxia vary seasonally, and the contribution of microzooplankton to trophic transfer between primary producers and mesozooplankton was enhanced with increasing hypoxia in summer. Mesozooplankton dependence on microzooplankton remained high through autumn with the retreat of hypoxia. The implications of these findings are examined in light of the current trends of hypoxia worldwide and in conjunction with warming coastal seas and estuaries.

Keywords: copepods, Chesapeake Bay, hypoxia, trophic interactions.

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ICES CM 2011/K:16   Poster

State of the Canary upwelling zooplankton in winter

O. G. Glushko

This work was performed on materials collected in winter 2007/08 and 2009/10 in the southern part of the Canary upwelling area (16–21°N). Zooplankton abundance was 11 377 individuals m^{-3} in 2007/08 and 8360 individuals m^{-3} in 2009/10. High abundance is stipulated by a growth of mass species: *Paracalanus indicus, Oncaea* spp., *Temora turbinata, Centropages chierchiae.* Fish larvae and eggs, Chaetognatha, and Siphonophorae formed the source of biomass. During these two years the biomass did not change (740 mg m^{-3}). In 2007/08 and 2009/10 there three sustained zooplankton communities were distinguished. The community of the cape Cap Blanc was located in the north of the area (20–21°N in 2007/08 and 19°30′–21°00′N in 2009/10) and was formed with *Paracalanus parvus*, *Oncaea media*, and *Temora turbinata*. The abundance and biomass of the community was higher than in 2009/10, and Shannon's index had reduced from 4.0 (2007/08) to 3.6 bits individual^{-1} (2009/10). The neritic community occupied the shelf area (16°00′-20°10′N—in 2007/08; 16°00′–19°30′N in 2009/10) and was characterized by a predominance of *Paracalanus indicus*, *Calanoides carinatus*, and relatively high Shannon's index (4.4 bits individual^{-1} in 2007/08; 3.9 bits individual^{-1} in 2009/10). In 2009/10 the abundance of the community had twice reduced, and biomass had hardly changed. *Paracalanus indicus, Oncaea conifera*, and *Calanoides carinatus* prevailed in the oceanic community in 2007/08. In 2009/10 the composition of predominant species had changed, being formed of *Oncaea conifera, Clausocalanus jobei, Oithona plumifera*, and *Paracalanus indicus*. In

2007/08 the community was located from 16 to 21°N, in 2009/10 between 17°80' and 19°00'N, excluding the shelf area. In 2009/10 abundance, biomass, Shannon's index reduced.

Keywords: none

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ICES CM 2011/K:17   Poster

Spatio-temporal and interannual variability of mesozooplankton (holoplankton) in the eastern part of the Gulf of Gdańsk (Baltic Sea)

Luiza Bielecka, Paweł Maruszak, and Beata Sobczak

The studies were based on material collected in the eastern part of the Gulf of Gdańsk. The hydrological regime of this region is under significant influence of river inputs (Vistula), which strongly contrasts with the hydrological conditions present in the western part of the gulf. The zooplankton community of the eastern part of the gulf is not well documented—the last papers on this topic go back to the mid-1980s. The plankton material was collected at seven stations located in two profiles (Świbno and Krynica). Samples were taken between January 2006 and November 2007 at monthly intervals to a maximum depth of 30 m using a Copenhagen vertical haul plankton net with a 100-µm mesh size. The diversity of mesozooplankton in the eastern part of the Gulf of Gdańsk was represented mainly by typically brackish forms with variable/irregular contribution from freshwater and marine species. Both the taxonomic and numerical structure of holoplankton depended on hydrological conditions, inputs from the Vistula River, and temperature fluctuations. The basic mesozooplankton components observed in 2006 and 2007 were animals belonging to the Copepoda, Rotatoria, and Cladocera. Among Cladocera two non-indigenous species, *Cercopagis pengoi* and *Evadne anonyx*, were found.

Keywords: Baltic Sea, estuarine waters, variability, zooplankton.

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ICES CM 2011/K:18   Poster

Interannual changes of holozooplankton in the southern Baltic (Gulf of Gdańsk, 2006–2007)

S. Mudrak-Cegiołka, M. Kalarus, and A. Renusz

The coastal zone is exposed to many changes in natural and anthropogenic factors. Our investigation focused on the holozooplankton, which is an important part of the local pelagic community, especially as a food item for higher trophic levels. Biological materials were collected from six stations in the western part of the Gulf of Gdańsk (the southern Baltic) in 2006 and 2007. Samples were taken by vertical hauls each month, using a Copenhagen net with 100-µm mesh size, and analysed according to HELCOM standards. The spatio-temporal variability of holozooplankton showed a typical composition for this region. Copepoda (above all *Acartia* spp. and *Temora longicornis*) were always present, whereas Rotifera and Cladocera were encountered mostly during the warmer months. *Pseudocalanus minutus elongatus* (Copepoda) and Appendicularia preferred the winter. Compared with previous studies, a decreasing role of Cladocera was observed and increasing significance of *Acartia longiremis* (Copepoda) throughout the whole period of studies (species considered so far as typical for the cold season). We observed interannual differences in abundance and biodiversity of particular taxa. Average concentrations of crustaceans (Copepoda, Cladocera) were clearly higher in 2007 than in 2006, but reverse situation was seen in relation to Rotifera. The species composition of Rotifera was more diverse in 2006—10 species compared to only 4 in 2007. Moreover, only in 2006 two invasive species of Cladocera were also noticed: *Cercopagis pengoi* and *Evadne anonyx*. To sum up, regular observations of zooplankton are necessary to show the variability of this pelagic component over short- and long-term periods, which can influence other elements of the marine ecosystem.

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ICES CM 2011/K:19   Poster

Hydrographic patterns conditioning variable trophic pathways and early life dynamics of bullet tuna larvae (*Auxis rochei*) in the Balearic Sea

R. Laiz-Carrión, J. M. Quintanilla, A. Pérez-Torres, P. Reglero, A. García, and F. Alemany

Zooplankton was collected by means of oblique tows above the thermocline, simultaneously with larvae sampling, in the Balearic Sea (northwest Mediterranean) during August 2008. A total of 40 stations were grouped in two classes by principal component analysis of the hydrographic conditions (temperature, salinity, and mesozooplancton biomass; 86.6% representation) distinguishing Mediterranean (MW) and Atlantic (AW) water masses. Size-fractioned zooplankton analysis revealed greater biomass ($p < 0.001$) in the fraction >250 μm in the AW stations, while the nitrogen and carbon composition of this fraction was higher in the MW stations ($p < 0.005$). *A. rochei* larval abundance was positively correlated ($r = 0.36$; $p < 0.05$) with this mesozooplancton biomass fraction. Larger ($p < 0.001$) and heavier ($p < 0.005$) bullet larvae with a higher Fulton's condition factor ($p < 0.05$) together with higher daily growth ($p < 0.01$) were found in MW. The nitrogen and carbon isotopic signature (δ^{15}N and δ^{13}C) did not show significant differences for the zooplankton fractions from either the MW and AW, but higher δ^{13}C ($p < 0.0001$) found in MW larvae, suggesting different food supplies with more oceanic energy sources in AW. The higher δ^{15}N ($p < 0.05$) content in bullet larvae collected in MW suggest a greater trophic specialization, probably consequent with differentiation of the zooplankton community of the water masses (lower zooplanktonic biomass with higher energetic content). A significant ^{15}N isotopic enrichment between the *A. rochei* larvae and the zooplankton fractions was observed, positioning the larvae at a higher trophic level. The stable isotope studies have proven to be a useful tool for distinguishing variable trophic pathways during early life stages of fish inhabiting open sea marine ecosystems.

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ICES CM 2011/K:20   Poster

Trophic interaction between zooplankton and anchovy larvae (*Engraulis encrasicolus*) with daily growth variability implications

J. M. Quintanilla, R. Laiz-Carrión, A. Uriarte, M. Iglesias, F. Alemany, and A. García

Zooplankton samples were collected at night time by means of vertical tows simultaneously with oblique tows for icthyoplanktonic sampling during July 2009. *Engraulis encrasicolus* larvae were sorted onboard for a combined study of daily growth and isotopic signature. Anchovy larvae were collected from two contrasting environmental scenarios, particularly larvae originating in the Ebro River spawning area on the Catalonian coast and larvae retained in the Almeria Bay (Alborán Sea). A greater microzooplankton biomass ($p < 0.0001$; 55–200 μm) fraction was observed in Alborán waters, together with higher carbon (C, $p < 0.0001$) and nitrogen (N, $p < 0.003$) content. Different daily growth patterns for anchovy larvae were observed according to their size–weight relationship, within the same standard length (SL) range. Better somatic growth covariated by age was observed ($p < 0.005$) in Alborán larvae, whereas heavier ($p < 0.0001$) and older ($p < 0.008$) larvae were found in Ebro-spawned larvae. The C/N analysis revealed a linear decrease with age in both larval groups, with higher ratios ($p < 0.005$) in the Ebro-spawned larvae. Although δ^{15}N did not show significant differences for microzooplankton, it was higher ($p < 0.0001$) in Ebro-spawned larvae, in line with its higher nitrogen isotopic enrichment ($p < 0.0001$), which indicates a greater trophic specialization. Higher δ^{13}C found in Alborán Sea microzooplankton and larvae could indicate its pelagic energy origin in contrast to the Ebro River ecosystem. The positive correlation

($r = 0.4$; $p < 0.0001$) observed between microzooplankton and larval $\delta^{15}N$ indicate its foraging preference. This study shows trophic pathways variations in relation to larval growth differences from combining otolith microstructure analysis and early life foodweb dynamics.

Keywords: anchovy larvae, growth, Mediterranean Sea, stable isotope, trophic interactions, zooplankton.

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ICES CM 2011/K:21   Poster

Feeding and fecundity of *Calanus finmarchicus* and *Temora longicornis* in Breiðafjörður, West Iceland

Vigdís Sigurðardóttir, Erla Björk Örnólfsdóttir, and Ástþór Gíslason

Insights into the life cycles of zooplankton, their fecundity and energy requirements, provide essential information for better understanding of energy transfer through trophic levels in marine ecosystems. Zooplankton abundance, community composition, and developmental stages of individual species of zooplankton were monitored at two locations in Breiðafjörður, West Iceland, every 10 days in the summers of 2008–2009. In addition, egg production and gut content were measured for the two most abundant species of copepods, *Temora longicornis* and *Calanus finmarchicus*. The abundance of females of *T. longicornis* varied between years with annual mean abundance of 31 000 females m^{-2} in 2008 and 300 females m^{-2} in 2009. Annual mean abundance of *C. finmarchicus* was 6000 females m^{-2} and 3000 females m^{-2} in 2008 and 2009, respectively. Feeding of copepods was estimated based on gut content, quantified as chlorophyll *a*. The gut content of *T. longicornis* was similar throughout summer in both years, while for *C. finmarchicus* the gut content was fairly consistent through both summers, with occasional higher values during the second summer. The egg production of *T. longicornis* was on average higher in 2008 (2–14 eggs female^{-1} d^{-1}) than in 2009 (42–62 eggs female^{-1} d^{-1}) whereas *C. finmarchicus* egg production was on average similar in both years (4–60 eggs female^{-1} d^{-1} in 2008 and 14–70 eggs female^{-1} d^{-1} in 2009). This study revealed that species abundance, feeding, and fecundity of *T. longicornis* and *C. finmarchicus* were characterized by annual rather than spatial variability in Breiðafjörður.

Keywords: copepods, egg production, gut fluorescence, Iceland.

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Theme Session L

Biophysical modelling tools and their potential use in marine spatial management: a strategic dialogue

ICES CM 2011/L:01

Biophysical assessments and adaptive spatial management for tropical trawling

Rodrigo H. Bustamante, Cathy M. Dichmont, Nick Ellis, Shane P. Griffiths, Wayne A. Rochester, Aijun R. Deng, and Elisabetta Morello

We present an operational spatial management simulation framework that addresses quantitatively multiple conservation, economics, and fisheries management objectives. We integrate bioeconomic stock and ecological risk assessment models with the affected foodweb, together with the simulated effects of trawling and biophysical distribution models, all interacting in a double-adaptive cycle form of a spatial management strategy evaluation framework (sMSE). The sMSE evaluates scenarios of static and dynamic closures and Marine Protected Areas (MPAs). These closures did not affect fisheries management targets and at current fishing effort levels, the trawling-induced changes are small, with little variation across a range of performance metrics. These changes increase as fishing effort increases. All scenarios exhibited high spatial variability, with most effects on fishing-affected habitats. These effects varied regionally and the affected biota showed positive and negative changes. Depending on the management objectives, the scenarios can act as best, nil, and worst-case scenarios for biotic group performance. For threatened and endangered species, closures could increase and decrease the biomass of such taxa, largely due to movements and trophic interactions. Comparing across simulated scenarios, the greater the fishing closures, the more responses as whole and the coarser the spatial scales, the less changes detected. These results confirm the need for spatial information at the same spatial scale as the impacts. No single scenario satisfied all or most management objectives. This work provide a front-end example of the use of biophysical modelling tools for the implementation of an ecosystem-based approach for the conservation management of Australia's marine ecosystems.

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ICES CM 2011/L:02

The impact of hydrodynamics and hydrography on western Baltic cod early life stage survival

H.-H. Hinrichsen, K. Hüssy, and B. Huwer

Fish recruitment is influenced by the size and structure of the spawning stock and by variable survival of early life stages, which in turn is influenced by environmental conditions such as water temperature, salinity, and oxygen conditions as well as ocean currents. The objective of this study was to assess (i) the importance of different western Baltic cod spawning grounds on the early life stage survival success in relation to variability of their occurrence, (ii) the affect of the timing of western Baltic cod spawning on early life stage survival, and (iii) the transport of western Baltic cod early life stages from spawning grounds to hatching areas. We used a spatially and temporally resolved biophysical model of the Baltic Sea in order to describe the long-term evolution of the occurrence of suitable habitats for western Baltic cod spawning. Habitat identification was based on environmental threshold levels for stage-specific survival of early life stages derived from ambient hydrography. The survival success of stage-specific early life stages is described along their transport patterns obtained from biophysical modelling approaches. In general, the long-term

resolution of environmental conditions allowing western Baltic egg and yolk-sac larvae survival indicates that favourable conditions mainly occurred only in western Baltic habitats during the late spawning season in April/May, while minimum survival rates could be expected from January to March. Relative survival probability of cod eggs and yolk-sac larvae is highest at the end of the spawning period. Unsuitable habitats exhibiting the highest mortality rates are mainly characterized by large proportions of eggs and yolk-sac larvae being lost due to the bottom contact or due to ambient water temperatures below the critical survival threshold.

Keywords: egg and larval development, environment-related western Baltic cod stage-specific survival, spawning habitat, transport processes.

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ICES CM 2011/L:03

The response of a Gulf estuary plume and hypoxia to windforcing

Meng Xia

The plume structure of the Perdido Bay Estuary (PBE), a typical bay on the Florida/Alabama coast along the Gulf, was simulated using an existing calibrated model. To better understand plume dynamics in the PBE and similar bay systems, idealized sensitivity experiments were conducted to examine the influence of windstress on the three-dimensional plume signature. Results indicate that wind direction dominates plume orientation, while wind magnitude significantly influences plume size, width, length, and depth. The plume size was reduced under the effect of wind and increased windforcing. A northerly wind could extend the plume length and duration at a lower windspeed (e.g $3 \, \text{m s}^{-1}$), but its surface size will be smaller than with no windforcing, and plume length and width will usually be decreased with the wind effect compared to no windforcing. Bay–shelf salt flux and water flux were also investigated since they are important for the formation of a three-dimensional plume structure. Model simulation shows that water flux to the coastal ocean is stronger under a northerly wind, westerly wind, or easterly wind compared to under a southerly wind at a given speed, and it could explain why the plume signature varies under a changing wind direction. In strong winds, the water flux typically increased compared to light or no wind scenarios, but salt flux to the coastal ocean results in a relatively high salt outflow so that the surface plume size is reduced. Thus, the surface plume appears to be significantly correlated with the combination of bay–shelf water and salt flux. A detailed understanding of this water and salt flux is essential to the study of plume dynamics. Additional particle transport analysis using variable windforcing was conducted to validate the existence of the transport mode, which also determined the influence of the plume on particle movement. The results showed a consistency between surface plume, salt flux, and particle transport. In addition, hindcasts of Perdido Bay bottom hypoxia in response to local windforcing are provided. Observed average windspeeds of $3 \, \text{m s}^{-1}$ in July were capable of redistributing hypoxia, stressing the entire estuarine ecosystem. Easterly and westerly winds caused greater hypoxia near the shore, which put stress on nearshore habitats, including oyster beds, and resulted in phenomena such as jubilees. Westerly and southerly winds resulted in significantly larger areas of anoxic conditions due to longer water-residence times that allowed continued surface primary production and subsurface microbial decomposition. Northerly and easterly winds, in contrast, promoted water transport toward the Gulf of Mexico, enhancing freshwater discharge from the Perdido River. Windspeeds over $3 \, \text{m s}^{-1}$ were sufficient to enhance the advection of dissolved oxygen into bottom waters through vertical mixing and resulted in significant reductions in the area of hypoxia. Therefore, periodic summer storms may alleviate hypoxic conditions within the estuary.

Keywords: EFDC, hypoxia, plume.

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ICES CM 2011/L:04

Evaluating management scenarios using predictive habitat modelling—effects of eutrophication mitigation in the Baltic Sea

Ulf Bergström, Göran Sundblad, Anna-Leena Downie, Martin Snickars, and Mats Lindegarth

Eutrophication in the coastal zone reduces water clarity, which has important effects on the distribution of both macrophytes and fish. The Baltic Sea Action Plan (BSAP) sets out targets for combating eutrophication, using Secchi depth as the main status indicator. However, the potential effects of these targets on the distribution of ecologically important species and habitats have not been assessed. We show how predictive habitat modelling in combination with scenario analysis can be used to assess the effects of changing eutrophication on the distribution of habitats in the Baltic Sea. As case studies we selected the recruitment habitats of two coastal fish species, perch and pikeperch, and stands of bladderwrack and eelgrass in the vast archipelago of the northern Baltic Proper. Species distributions were statistically related to water depth, wave exposure, and Secchi depth using maximum entropy modelling. By changing the Secchi depth according to a set of scenarios corresponding to the BSAP, the effects on the spatial distribution of these habitats were explored. Increased Secchi depth (i.e. reduced eutrophication) led to increases in perch recruitment areas, while reducing the recruitment areas of the commercially important pikeperch. For vegetation, increasing Secchi depth led to different levels of increase in the areas suitable for eelgrass and bladderwrack. Our study demonstrates how management scenarios can be evaluated using predictive habitat modelling. The highly species-specific responses to a change in Secchi depth illustrates the importance of detailed studies for understanding how marine ecosystems may respond to management actions.

Keywords: eutrophication, habitat modelling, MaxEnt, scenario analysis.

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ICES CM 2011/L:05

The application of a biophysical model to the north Aegean anchovy fishery: its implication for spatial management

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Achieving benefits from spatial management policies requires spatial information on habitat, species distribution, and larval, juvenile, and adult transports. A coupled biophysical model of the anchovy full life cycle has been applied in the northern Aegean Sea, simulating the spatial and temporal variability of the anchovy growth, abundance, movement, and catches. Current fishing information (age-dependent fishing mortality, observed fishing grounds) and regulation measures (spatio-temporal closures, minimum legal landing size) have been parameterized in the model. In this study, we discuss the use of the model in the context of evaluating the likely affect of alternative spatial management measures on anchovy abundance. The potential of the present modelling tool to consolidate the sporadic habitat, biological, and fisheries information under a unique management framework towards the sustainability of the anchovy resources was explored. Alternative scenarios of imposing a network of protected areas were examined through sensitivity analysis experiments. Model results are presented and discussed. The model has been developed in the framework of SESAME, MEECE, and REPRODUCE EU projects.

Keywords: IBM anchovy model, north Aegean Sea, spatial management.

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ICES CM 2011/L:06

Modelling nutrient to fish model — an Eulerian approach

Wolfgang Fennel and Hagen Radtke

A new generation of a model that integrates lower and upper parts of the marine foodweb in a three-dimensional circulation model is presented for the example system of the Baltic Sea. The Baltic is an excellent test bed because the fish stocks are dominated by two prey species (sprat and herring) and one predator (cod). The NPZDF model has an explicit two-way interaction between a biogeochemical model and size-dependent Eulerian fish model. The dynamics of the fish model is driven by size (mass class)-dependent predator–prey interactions while the interaction between the NPZD and fish models is established through feeding of prey fish on zooplankton and recycling of fish biomass to nutrients and detritus. The fish model component is embedded in the advanced three-dimensional biogeochemical model ERGOM of the IOW. In order to grasp fish behaviour, such as migration, we let the fish swim to follow the food and to go to their respective spawning areas during the reproductive season. This approach can also be transferred to other systems. Among the various aspects that can be studied with this model system, we look at the role of fish regarding transport of matter. In particular, in the spawning areas of cod and sprat, it seems that fish contribute significantly the deposition of matter to these areas.

Keywords: 3d-modelling, cod, fish migration, herring, predator–prey interaction, sprat.

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ICES CM 2011/L:07

Sepia officinalis: spawning habitat modelling in the English Channel and its potential for fisheries management

Isobel Bloor, Charlotte Marshall, Emma Jackson, Jean-Paul Robin, and Martin Attrill

Information on the spatial and temporal distribution of spawning grounds is essential to both stock inference and good fisheries management. The common cuttlefish (*Sepia officinalis*) is an important commercial species in the English Channel and in spring, sexually mature adult cuttlefish concentrate in shallow coastal areas on both sides of the Channel to reproduce and spawn. These temporal aggregations are targeted by coastal métiers (e.g. pots), but one issue encountered with coastal métiers such as potting is the tendency for females to lay their eggs on the traps themselves rather than on natural substrata. The eggs laid on traps are often lost from the system, thereby potentially reducing the reproductive capacity of the spawning stock. In order to mitigate against such negative impacts to the population, various fisheries management techniques need to be investigated and proposed as appropriate. Such strategies could include the closure of key spawning grounds during peak spawning months. Although it has been possible to identify spawning grounds and locations on a broad scale, from the presence of fisheries, predictive habitat modelling has the potential to allow the location and scale of these grounds to be identified or predicted independently and at a much finer resolution. The aim of this study was to develop a species-distribution model for *S. officinalis* allowing the predictive mapping of areas of suitable or potential habitats for egg deposition along the UK coastline of the English Channel. Maximum entropy (Maxent) modelling and regression techniques were used to develop models relating key environmental variables, such as bathymetry, time (e.g. month, day), water temperature, salinity, chlorophyll, wave exposure, and sediment type, to data of spawning adults and eggs, that can be used to investigate the applicability of various fisheries management techniques to this stock.

Keywords: cephalopod, English Channel, fisheries management, spawning habitats.

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ICES CM 2011/L:08

Spatial management scenarios for the brown shrimp fisheries in the German Bight: Possible influences of product prices, TAC for plaice and sole, and Natura 2000 management plans

T. Schulze, V. Stelzenmüller, A. Sell, J. Berkenhagen, and K. Schulte

Brown shrimp (*Crangon crangon*) is a commercially important target species in Germany, the Netherlands, and Denmark. In recent years, decreasing market prices and rising fuel costs have tightened the economic situation for fishers. Furthermore, fishers are constrained by total allowable catch (TAC) quota for alternative target species (plaice and sole) and in future potentially by the loss of fishing grounds due to the implementation of Natura 2000 sites in the EEZs of EU member states. VMS, logbook and business (e.g. investments, capital consumptions) data, market prices, and the fuel index are used to investigate past fishing patterns where fisheries were not constrained by Marine Protection Areas in the EEZs. The distribution hot spots of brown shrimp and their spatial variance will be assessed with regard to environmental conditions such as temperature, salinity, and nutrient inputs. A modelling approach evaluates the influence of effort displacement, changes in market prices, and the use of alternative target species on the revenues of the German shrimp fisheries. With this study we provide an assessment framework which allows for integration of environmental and economic components in order to support an ecosystem approach to fishery and marine spatial management. This study is part of the COEXIST project, a multidisciplinary EU FP7 project, with 13 partners from 11 countries, evaluating competing activities and interactions in European coastal areas (www.coexistproject.eu).

Keywords: brown shrimp, economics, Marine Protection Areas, marine spatial planning.

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ICES CM 2011/L:09

Near real-time prediction and spatial management of Pacific skipjack tuna

Patrick Lehodey and Inna Senina

The Spatial Ecosystem and Population Dynamics Model (SEAPODYM) is a tool for investigating the spatial population dynamics of fish under the influence of both fishing and environmental effects. Driven by environmental variables (temperature, currents, primary production, and oxygen), the model predicts the temporal and spatial distributions of functional groups of prey, and age-structured predator populations from larvae to adults. It also describes fishing activity and predicts catch and the size frequency of catch that are used for parameter optimization based on fishing data assimilation techniques. The model has been applied to the Pacific skipjack tuna population and its fisheries. Skipjack catch in the western and central Pacific represents almost 50% of the world tuna catch. The 2009 catch (>1.7 million t) was the highest ever recorded. Until recently, the simulations used coarse resolution (typically 1° or 2° × month) with environmental forcing from coupled physical–biogeochemical models, the objective being to assess long-term trends in the population and to characterize climate and fishing signals. The effects of ENSO variability in particular have been well documented, with *El Niño* events tending to result in eastwards displacement of tuna resources and fishing activity, higher catchability by purse-seine fisheries through shoaling of the thermocline, and positive effects on recruitment. Recently, we tested the model at a much higher resolution (1/4° × week) with a realistic environmental forcing from the MERCATOR-OCEAN operational model and with satellite-derived primary production. The model predicted the catch and catch rates of the various fisheries very well, as well as the size distribution of catch of these fisheries. The simulation is updated in near real time every two months and can be used to test or monitor various spatial (and temporal) management measures, such as changing the fishing effort of a given fishery or implementing a fishing closure area. Examples are presented to illustrate how this model can help in assessing the impact of spatial management measures at the level of the population.

Keywords: ecosystem modelling, Pacific skipjack tuna, population dynamics, spatial management.

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ICES CM 2011/L:10

The potential use of operational biochemical models in marine spatial management

Frank Janssen, Tian Tian, Zhenwen Wan, and Karen Edwards

Numerical ocean modelling systems have been developed and applied to the physical environment for many years now. Several operational systems are in place in the North Sea/Baltic Sea region and provide thousands of customers with fore- and hindcasts of sea level, currents, or temperature every day. This model-based information has become a cornerstone in planning, management, and decision-making in many coastal and offshore applications. In recent years more and more of the once only physical model systems have been extended by biochemical components, providing information on nutrient, oxygen, and phytoplankton concentrations, sometimes even with stage-resolving zooplankton modules. These biochemical model systems can now provide information not only on the physical, but also on the environmental status at sea. We will present results from two of these coupled physical–biochemical model systems which are now applied in operational mode and provide data on a daily basis. The data provided by, for example, the MyOcean project (http://www.myocean.eu) are available on the global and the regional scale in a common format free of charge. It is foreseeable that environmental model-based data will gain the same importance within the next few years in environmental management that the physical model data have already today.

Keywords: Baltic Sea, biochemical model, ecosystem model, North Sea.

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ICES CM 2011/L:11

Retention of western Baltic herring larvae within the main spawning area

Robert Bauer, Daniel Stepputtis, and Ulf Gräwe

During 2004–2008, the western Baltic spring-spawning herring (WBSS) recruitment has shown a rapid decline. This requires an in-depth investigation of the causes. The recruitment of WBSS has been the subject of continuous scientific investigations since the early 1970s with special focus on the Greifswalder Bodden (GB), the main spawning ground of WBSS. Among others, larval drift is one crucial factor that is known to affect larval survival and therefore could influence recruitment success. This might be of particular importance for herring which spawn within distinct retention areas that are assumed to provide more suitable conditions for larval survival. Within this study, simulated depth-integrated two-dimensional flowfields of a hydrodynamic model (GETM) were coupled to a particle-tracking model to analyse herring larval drift within the GB and the adjacent open Baltic Sea. The wind dependence of drift patterns, their intra- and interannual variability during the spawning season of WBSS and their potential effects on recruitment success were investigated. Based on model runs under constant atmospheric wind conditions the GB was clearly characterized as a retention area. Even after one month of constant windspeeds of 9 m s^{-1} more than 20% of larvae remained within the bay, regardless of the wind direction. A retention index was developed that recognizes wind-dependent drift, using weekly releases of virtual cohorts.

Keywords: Baltic Sea, biophysical modelling, Greifswalder Bodden, herring, larval drift, recruitment, retention.

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ICES CM 2011/L:12

Can biophysical individual-based models reliably tell us why most larvae die in the sea?

Myron A. Peck and Marc Hufnagl

Biophysical individual-based models (IBMs) might be the only tool that can provide both spatial and temporal estimates of changes in mortality rates of early life stages of marine organisms and how various processes contribute to observed changes in mortality in the wild. For IBMs to become useful tools for managers, it is essential to communicate the sources and levels of uncertainty of projections. After briefly reviewing mortality processes acting during early life and how IBMs have attempted to estimate those processes, we summarize sensitivity analyses and scenario results from 40 IBM studies. Studies estimated mortality due to advection into unfavourable habitats, starvation mortality due to unfavourable prey fields, and/or mortality from predators. We also present the results of new simulations revealing the sensitivity of spatio-temporal estimates of the abundance and distribution of larval North Sea herring (*Clupea harengus*) to assumptions regarding mortality rates experienced during early life. Despite the growing number of studies applying IBMs, only 20% of articles reviewed here included parameter sensitivity analyses. Studies examined (i) ontogenetic changes in larval swimming behaviours, (ii) larval foraging parameters such as visual field estimates, and (iii) parameters associated with growth physiology (e.g. assimilation efficiency, active metabolism). Advancements in modelled physics have greatly outpaced those in physiology. Research programmes are needed that not only construct and apply larval fish IBMs but also conduct the ecophysiological experiments required to advance model parameterization.

Keywords: advection, IBMs, larval fish, mortality, scenarios, sensitivity, starvation.

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ICES CM 2011/L:13   Withdrawn

Theme Session M

Assessment and management of large marine ecosystems

ICES CM 2011/M:01

Changing states and adaptive management actions of the Yellow Sea large marine ecosystem

Qisheng Tang

The Yellow Sea is a semi-enclosed shelf sea with the distinct characteristics of a large marine ecosystem, which has distinct bathymetry, hydrography, productivity, and trophically dependent populations. The sea is favourable for coastal and offshore fisheries, and it has well-developed multispecies and multinational fisheries. However, over recent decades, the resource populations and fisheries structure in the sea have changed greatly. The purpose of this paper is to describe the Yellow Sea as a large marine ecosystem, emphasizing the changing states of productivity and biomass yields in the ecosystem and the effects of overexploitation, eutrophication, and climate change. Generally speaking, changes in the quantity and quality of biomass yields in the Yellow Sea as a typical coastal ocean ecosystem are attributed principally to human activities. Recent studies show that climate change has important effects on the shift in species composition of resource populations. A new study has indicated that ecosystem regime shifts occurred in the years around 1900, 1938, 1970, and 2006. In the long term, perturbations from both man-made and climate effects on the ecosystem resources may be mingled. Adaptive management actions in this large marine ecosystem could include developing carbon sink fisheries and integrated multitrophic mariculture.

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ICES CM 2011/M:02

Environmental genotoxicity levels in the "Baltic Sea–North Sea–Atlantic" marine system

Janina Baršienė, Aleksandras Rybakovas, Thomas Lang, Laura Andreikėnaitė, Wlodzimierz Grygiel, and Arvo Tuvikene

The study reflects the first attempt to describe the environmental genotoxicity level changes in different fish species from over 160 selected sites in the Baltic Sea, the North Sea, and the northern Atlantic in the period 2001–2010. Three genotoxicity biomarkers were analysed in fish: (i) formation of micronuclei reflecting action of aneugenic and clastogenic compounds; (ii) induction of nuclear buds indicating an unequal capacity of organisms to expel damaged, amplified, failed replication, or improperly condensed DNA chromosome fragments without telomeres and centromeres from the nucleus; and (iii) formation of binucleated cells with nucleoplasmic bridges, a specific marker of dicentrics indicating radionuclide action. Elaborated criteria and a scale for the assessment of environmental genotoxicity levels revealed highest responses in fish from areas influenced by contamination from the largest rivers, extensive shipping routes, oil and gas platforms, as well as from areas of dumped chemical munitions, construction of gas pipelines, nuclear power plants, and discharge of industrial and municipal effluents. GIS mapping indicated the highest genetic risk in fish populations from the Gulfs of Bothnia, Finland, and Riga (the Baltic), the southern Baltic Sea, the German Bight, Ekofisk oil field (the North Sea), and areas close to the Seine estuary (the Atlantic). The reference sites were located in Icelandic waters. The increase of cytogenetic damage and genetic risk prediction in fish populations from zones affected by dumped chemical munitions and by large underwater gas pipeline construction is discussed. The relevance of genotoxicity markers for future integrated assessments of marine ecosystem health will be outlined.

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ICES CM 2011/M:03

On the way towards the MSFD: sensitivity analysis of size-based fish metrics for the use as indicators in an ecosystem-based assessment framework

Wolfgang Nikolaus Probst, Heino Fock, Vanessa Stelzenmüller, and Matthias Kloppmann

Size-based metrics of the North Sea fish community were related to fishing mortality to test their viability as indicators within the German Marine Strategy. Because a viable indicator must respond to its pressure in a sensible time, we analysed the cross-correlations between the large fish indicators and the 95-percentile size class of the length–frequency distribution vs. the fishing mortalities from ICES assessments of seven North Sea stocks. We propose an interpretation framework of cross-correlation function plots, where positive cross-correlations with negative time-lags between state and pressure indicators represent response of the pressure to a favourable state and negative cross-correlations with positive time-lags indicate an adverse effect of the pressure on the state. We performed the analysis on scales of the entire North Sea and the German EEZ to compare the operationalizability on a regional and national scale. The OSPAR LFI had a negative cross-correlation with positive time-lag to the community fishing mortality (F_{com}). A similar pressure-state response was found between F and the 95-percentile length class time-series of plaice and whiting. The comparison of sensitivity on North Sea and national scale yielded similar but less significant results for the German EEZ. State indicators need to be selected carefully within existing viability frameworks and evaluated with respect to scale to obtain meaningful national assessments within the Marine Strategy Framework Directive.

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ICES CM 2011/M:04

Main bioproductivity features of the western Arctic LMEs

G. G. Matishov, P. R. Makarevich, E. I. Druzhkova, O. V. Karamushko, and O. S. Lyubina

In five large marine ecosystem (LME) modules, one of the keys is bioproductivity. The Norwegian Sea and Iceland Shelf LMEs are referred to as highly productive Arctic shelf areas; the Chukchi Sea, Bering Sea, Faroe Plateau, and southwestern Barents Sea are classed as areas with moderately high productivity. The rest of the Arctic water areas are considered as having low productivity. Based on the results of MMBI cruises on board the nuclear icebreakers, the functioning of the detritus trophic chain in the Barents and Kara Seas coastal zones during the polar night has been determined. Bacterioplankton in the season is the only food substrate for zooplankton organisms before the development of cryoflora vegetation. The productivity of key links in the plankton trophic chain for the Barents, White, Kara, and Laptev Seas weakens towards the eastern Siberian Sea. According to our data, zoobenthos productivity depends on inner secular climate fluctuations and the succession stages of bottom communities. Somatic production in coastal areas is approximately 2–3 times higher than in the open Barents Sea. The Barents Sea coastal bottom biocenoses production rates yield to the Sea of Okhotsk and North Sea, but are close to the Bering Sea indices. Until recently, only tentative production values (production to biomass (P/B) coefficient) of 0.125–0.170 were applied to the Barents Sea fish. Our research indicates they are significantly higher and are from 0.3 to 1.0 for the Barents and White Seas cod, deep-water redfish (perch), and Arctic cod. Determined values and regularities are of theoretic and practical importance and may improve methods of forecasting ecosystems and the selection of optimal ways in which to exploit marine bioresources.

Keywords: Arctic, bioproductivity, LME, P/B coefficient.

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ICES CM 2011/M:05

Assessing pelagic fish stocks from acoustic and trawl survey data in the Baltic Sea

Jarno Vanhatalo, Teppo Juntunen, Heikki Peltonen, and Samu Mäntyniemi

We constructed a Bayesian spatial model to estimate fish abundances in a pelagial multispecies environment. Concurrent acoustic and trawl survey data attached to environmental variables are used to predict acoustic signal strengths, relative abundance of different species, and their mean length for the whole area of interest. Combining these three predictions, we can estimate the total biomass for each species. The model comprises a linear predictor on environmental variables and spatial random effect given by a Gaussian process. The Bayesian approach is optimal in problems like this where a model is multilayered and uncertainty accumulates in the final biomass estimate. We apply the model to a case study in the Gulf of Finland (GoF) located in the eastern Baltic Sea. Three species dominate the pelagic waters: sprat (*Sprattus sprattus*), herring (*Clupea harengus*), and three-spined stickleback (*Gasterosteus aculeatus*). We present the results of each model layer, the resulting biomass distribution in a 2 km × 2 km lattice, and the total biomass in the GoF for each species in June 2004. The posterior mean of the total biomass of sprat was ca. 45 000 t, of herring ca. 25 000 t, and of three-spined stickleback ca. 2000 t. Total biomass of all species with 95% probability was between 50 000 and 90 000 t.

Keywords: acoustic survey, Bayesian spatial modelling, Gaussian process, multispecies.

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ICES CM 2011/M:06

Chloropigments *a* in sediments in coastal zone as markers of eutrophication and environmental conditions

Małgorzata Szymczak-Żyła, Grażyna Kowalewska, and J. William Louda

Eutrophication is a big problem not only for the Baltic, which is a semi-enclosed sea, but also for many other coastal and shelf sites in the world. There are a variety of methods for estimating the extent of eutrophication. One of the most popular is the determination of chlorophyll *a* in seawater as a biomass marker. However, this parameter changes significantly in time and space. Determination of chlorophyll *a* and its derivatives in sediments gives results averaged in time for an area. Multi-annual chloropigment data for recent and old sediment samples collected from different sites in the southern Baltic related to environmental conditions indicate that the contents and proportion of individual chloropigments *a* in sediments depend on primary production, sedimentation rate, grazing, oxygen content, and post-depositional and hydrodynamic conditions, resulting from, among other factors, climate change. These results were verified on sediments from different coastal sites, including the Mediterranean (Venice Lagoon) and Atlantic Ocean (Scotland coast and Florida coast). It can be concluded that the sum of chloropigments *a* in bottom sediments, collected from a properly selected site, is a good and quantitative marker of eutrophication for an area. The percentage of particular chlorophyll derivatives in the sum depend on different abiotic and biotic factors, which are characteristic for a given location.

Keywords: chloropigments *a*, depositional conditions, eutrophication, sediments.

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ICES CM 2011/M:07

Towards holistic ecosystem assessments—achievements of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB)

Christian Möllmann, Lena Bergström, Thorsten Blenckner, Juha Flinkman, Anna Gårdmark, Martin Lindegren, and Bärbel Müller-Karulis

Holistic ecosystem assessments are a crucial prerequisite for the implementation of the ecosystem approach to management of the marine environment and their resources. As a response to this, ICES together with HELCOM in 2006 initiated a process towards holistic ecosystem assessments which resulted in the foundation of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB). Since 2007, the group has worked on three major tasks: (i) conducting trend and status assessments of different subsystems of the Baltic Sea integrating overall trophic levels and evaluating the importance of various anthropogenic drivers on the ecosystems; (ii) conducting ecosystem modelling to anticipate future ecosystem developments under different scenarios of natural and human-induced change; and (iii) contributing to and developing ecosystem-based management strategies for the Baltic Sea. The latter includes integrating environmental information into traditional fish stock assessments, as well as contributing to HELCOM assessment activities and indicator development, for example, the EU Marine Strategy Framework Directive and the HELCOM Baltic Sea Action Plan. This paper reviews the achievements of the WGIAB, especially its work in detecting and explaining "ecosystem regime shifts" in various Baltic Sea subsystems, the development of "biological ensemble modelling" of the potential future of eastern Baltic cod, and links between the WGIAB and the ICES Baltic Fisheries Assessment Working Group. Eventually, future necessary steps towards a fully integrated ecosystem assessment management cycle will be elaborated.

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ICES CM 2011/M:08

The Celtic Sea Biscay Shelf and Western Iberian LMEs: how they differ from most other LMEs and why that difference should be valued

Dave Reid, Maria Fatima Borges, Pascal Laffargue, and Enrique Nogueira

The Celtic Sea and Bay of Biscay and Western Iberian areas are two candidate large marine ecosystems (LMEs), but are considered as one ICES ecoregion. This is geographically and politically relatively easy to define but possibly unique among LMEs in its heterogeneity. Physically, it is characterized by wide shelf areas in the north and much narrower shelf areas in the south. There are strong poleward currents during some parts of the year, and some parts of the area are subject to upwelling events at the shelf edge or substantial river run-off near the coast, which are believed to impact fish recruitment. Many commercial and vulnerable species reach their southern or northern limits within the region, and marine community patterns show a high latitudinal gradient. There are many important fisheries across the area, many of which are under considerable fishing pressure, with consequences for both exploited and bycatch species as well as habitats. This region also represents both an interface and a pathway between the open ocean (the Atlantic) and important regional seas (the North and Irish Seas). Together these characteristics make the area a natural laboratory for examining the effects of large-scale effects such as climate change. We will present a summary of the physical, hydrographic, biological, anthropogenic forcing, and ecosystem characteristics of the area, with an emphasis on those components representing the heterogeneity of the area. This paper will be based on the work of ICES WGEAWESS, which is working towards the application of an integrated ecosystem assessment for the area.

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ICES CM 2011/M:09

Implementation of the science plan in the Benguela Current large marine ecosystem

Moses Maurihungirire

The Benguela Current Commission (BCC) Science Programme, which commenced at the end of 2008, has an overall goal of ensuring optimal and sustainable utilization of the resources of the Benguela Current large marine ecosystem (BCLME) while restoring, maintaining, and conserving the ecological integrity of the system. The specific purpose of the Programme is to provide BCC Member States with the best available scientific advice for the management of the BCLME. The Programme is outcome oriented and will result in (i) an implemented programme of transboundary scientific activities; (ii) establishment of formal structures of the operation of the Ecosystem Advisory Committee (EAC) and for cooperation among the regional scientific and technical staff; and (iii) improvement and strengthening of human scientific and technical capacity in the region. Implementation of the science programme has resulted in some important outcomes which define the scientific activities inherent to the Programme. By the end of 2009, 14 projects had been contracted out with implementation commencing at the beginning of 2010. Activities range from transboundary fish stock and environmental parameter surveys to species-specific and EAF research. Result from these will form the backbone of the advice to be made available to managers in the region for the sustainable management of natural resources in the BCLME.

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ICES CM 2011/M:10

The Gulf of Mexico Large Marine Ecosystem Project: the way ahead

Porfirio Alvarez-Torres, Antonio Díaz de Leon-Corral, Jose Ignacio Fernandez- Mendez, Ramon Chavez-Amparan, Carolina Quiroz, Orlando Iglesias, Javier Acevedo, Ivonne Cruz, Susana Hernandez, Leoncio Frias, and Rafael Arreola

The Gulf of Mexico Large Marine Ecosystem (GoM-LME) Project started in mid-2009, with the participation of Mexico and the United States (for the first in an LME project as a partner). It aims to establish a regional ecosystem-based management framework to address the major environmental causes of eutrophication, habitat modification, and overfishing in the LME. Education and outreach have been added to the Project activities. The two countries differ in political organization and governance system: Mexico concentrates most of its marine management in federal institutions, whereas State governments have an active role in marine management in the US. Differences in research/monitoring ability and stakeholder integration are noticeable. The US has several regional marine observation systems (including the Gulf of Mexico Coastal Ocean Observing System, GCOOS) and Mexico is just developing its first marine observatory. The Gulf of Mexico Alliance (GOMA) in the US includes governmental and non-governmental actors. Planning schemes that include marine areas are still in development, such as marine spatial planning in the US and land use planning of marine space in Mexico. The "Deepwater Horizon" oil spill resulted in testing transboundary assessment and cooperation schemes, showing a pathway for coordinated actions that began to be followed by the two nations. A transboundary diagnostic analysis (TDA) is about to be finished. The Strategic Action Programme (SAP) that will define policy/legal/institutional reforms needed for regional collaboration on priority transboundary concerns is to be developed this year. This work deals with "the way ahead" for these reforms.

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ICES CM 2011/M:11

Organic contaminants in sediments as indicators of pollution—a case study of the Gulf of Gdańsk

Grażyna Kowalewska, Anna Filipkowska, Ludwik Lubecki, and Małgorzata Szymczak-Żyła

The majority of harmful compounds are hydrophobic and concentrate in the finest fraction of sediments. On the basis of seawater analysis, it can be stated that pollution levels in the environment are negligible, but results of sediment analysis may indicate a real threat to biota. Monitoring of sediments collected at carefully selected sites and times gives information on average contamination of the whole basin. This may be a cheaper, quicker and more representative method for characterizing an area than water monitoring. From an analysis of the sediment depth profiles of contaminants, one can get information about trends in the past. Correlation with different environmental parameters can give a large amount of information on processes going on in the environment. All these can be illustrated by examples of contaminant results for the Gulf of Gdańsk sediments (PCBs, PAHs, OTs) related to environmental conditions. The Gulf of Gdańsk, a part of the southern Baltic Sea, is a basin under strong anthropopression (emissions from the Tricity agglomeration, inflow of the Wisła River, collecting water from over half of Poland). High freshwater input decreases salinity in the Gulf and causes seawater stratification. Because of limited vertical mixing and saline water exchange only through the Danish Straits, the Deep of Gdańsk suffers from hypoxia/anoxia. All these and negligible tides make the area an exceptional model basin for studies of contaminant biogeochemistry in the sea. On that basis conclusions were drawn concerning the sources and fates of the main organic compounds in the Gulf and their indicators for this environment are proposed.

Keywords: Baltic Sea, indicators, organic pollutants, sediments.

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ICES CM 2011/M:12

Reversing the degradation of the Canary Current Large Marine Ecosystem

Birane Sambe, Birgitta Liss Lymer, Ana Maria Caramelo, and Merete Tandstad

The Canary Current Large Marine Ecosystem (CCLME) region includes important upwelling areas and is characterized by the presence of significant fish resources. Many of these resources undertake transboundary migrations. The coastal and estuarine areas provide vital goods and services, such as critical fish habitats, wood from mangroves, and tourism locations. The CCLME is an important food and economic resource for much of western Africa. However, fish resources in the Canary Current are on the decline. Factors contributing to this include the over-capacity of the fishing fleets and weak management. The region is also experiencing degradation of several important habitats including estuaries, wetlands, mangroves, and benthic habitats, much of it caused by the overharvesting of wood, salinity changes, sedimentation, and trawling. These issues are also aggravated by the effects of climate change. The CCLME Project is unique in its strategic combination of fisheries and ecosystem governance frameworks. Strong collaboration between fisheries and environment sectors will lead to improved management. The Project links several important initiatives in the region that are all contributing to CCLME objectives. The partner mechanism provided by the CCLME Project is crucial in order to achieve joint and concerted efforts to reverse the degradation of the CCLME.

Keywords: Canary Current, ecosystem, fisheries, transboundary.

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ICES CM 2011/M:13

The application of MSFD indicators in the Baltic Sea: How good are they?

Daniel Oesterwind and Christian von Dorrien

The EU's Marine Strategy Framework Directive (MSFD) requests Member States to develop strategies for the marine areas under their responsibility. The strategies should contain a detailed assessment of the state of the environment, a definition of "good environmental status" (GES), and the establishment of clear environmental targets and monitoring programmes. In a guidance document, the European Commission published a number of criteria and methodological standards outlining how to define GES in marine waters, including a hierarchical system in which the MSFD's 11 descriptors are grouped into criteria and indicators. Here we present the first results of the application of various indicators for the Baltic Sea. As one example, we investigated how useful one indicator, the "large fish indicator" (LFI) is to assess Descriptor 4 (Foodweb) in the Baltic Sea. Other examples and comparisons with other regions are used to present some open questions regarding the implementation of some of the MSFD indicators.

Keywords: Baltic Sea, descriptor, indicator, large fish indicator, Marine Strategy Framework Directive.

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ICES CM 2011/M:14

Decision support for the economic analysis of trade-offs in coastal and marine spatial planning (CMSP) for the US Northeast Shelf LME

Porter Hoagland and Di Jin

Coastal and marine spatial planning (CMSP) is a process for improving the management of coastal and marine resources in order to promote their sustainable development. Sustainability necessitates that decisions be made about existing and future spatial and temporal distributions of human uses (and non-uses) of the coastal and marine environment. Such decisions require methods for making trade-offs. Extant US State-level planning efforts, particularly in Rhode Island and Massachusetts, have begun developing approaches for making CMSP trade-offs, but these methods are still emergent. We present the outlines of an economic methodology based upon models of spatially distributed regional economic impacts to characterize the social welfare effects of trade-offs among alternative CMSP policies. We show how a regional computable general equilibrium (CGE) model of the US Northeast coastal economy could be used to assess changes in the spatial and temporal distribution of human uses and activities in the US Northeast region. This work extends earlier efforts to develop a regional input–output (IO) model of the Northeast Large Marine Ecosystem and to link a regional IO model to linear models of a marine foodweb. The resulting CGE model could be used to analyse marginal changes in social welfare with respect to policy changes and to evaluate trade-offs by estimating the socio-economic net benefits of alternative scenarios. We present some examples of how the model could be used to simulate trade-offs such as those involving the siting of ocean wind farms, deep-water ports, or open ocean aquaculture facilities.

Keywords: coastal and marine spatial planning, Northeast Large Marine Ecosystem, regional economic models, trade-offs.

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ICES CM 2011/M:15

Best practices for assessments of LMEs (and larger)

Jake Rice

In response to calls from the UN General Assembly (UNGA) and the World Summit on Sustainable Development (WSSD), an international group of experts was formed to review global experience in assessment of marine ecosystems and their human uses. Between 2007 and 2009 the 18 experts, augmented by a Steering Committee and liaison officers from several intergovernmental organizations, reviewed thousands of assessments (including the large marine ecosystem (LME) assessments) on scales from regional to global, and thematically from individual ecosystem properties, pressures, and uses (such as fish stocks, levels of specific contaminants, or ecotourism) to integrated assessments across many ecosystem components, multiple sectors, and social, economic, and ecological dimensions of sustainability. This work culminated in the Assessment of Assessments report (AofA), which has a chapter summarizing best practices for assessments— viewing "assessment" as both a process and a product. Based on the conclusions and options in the AofA, the UNGA has commenced the first cycle of the Regular Process for Global Marine Assessments, including social and economic factors. This global assessment, due in 2014, will fully integrate existing assessments (with the LME assessments being important inputs) into a holistic view of the world's oceans and the sustainability of their uses. The approach to be taken has been refined by a new group of experts working from the AofA options, and with extensive negotiation among States regarding both the products and processes of the regular process. This talk will summarize the conclusions in the AofA regarding best practices for marine assessments. It will also highlight the issues that turned out to be crucial in gaining agreement from States and agencies to support the regular process. These experiences revealed a number of important lessons not just about how to do assessments but also about how to get them taken seriously by States.

Keywords: none.

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ICES CM 2011/M:16 Withdrawn

ICES CM 2011/M:17

MESMA: Methodology for assessing the management of marine areas

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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 currently developing innovative methods and integrated strategies for governments, local authorities, and other managerial bodies for planning and decision-making at different local, national, and European scales, for sustainable development of European seas. A generic framework to evaluate marine management strategies and to support the dialogue between politicians, stakeholders, and the public in general has been produced, and its application will be the tested within five European encompassing regions (i.e. the North Sea, the Baltic Sea, the Atlantic region, the Mediterranean region, and the Black Sea). This approach makes it possible to compare pressures and perspectives 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, governance, marine spatial management, MSFD, MSP, SMA, sustainable development.

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ICES CM 2011/M:18   Poster

Interannual dynamics of zooplankton in the Canary Current Ecosystem

V. V. Lidvanov

Monitoring of the Canary Current Ecosystem in the water area near the Atlantic coast of Morocco has been carried out systematically since 1994. It allows the interannual variability of mesozooplankton to be assessed, including changes in its species, biotopic, and spatial structure. Two types of zooplankton communities have been distinguished during the research period: oceanic and neritic. The neritic community biotopically belongs to the shelf water. To the south of Cape Bohador it is transferred outside the shelf. Fluctuations of about 6000 individuals m^{-3} are observed in the community abundance dynamics up to 1999. Afterwards there was a sharp skip and a transition of interannual fluctuations of abundance to a new level. In the species structure of the community a predominance of neritic species and a relatively low Shannon's index and evenness were recorded. The oceanic community is biotopically associated with the Canary current waters. The community abundance dynamics has a positive trend and also a fluctuating range expansion. The community differs in the prevalence of oceanic and oceanic–neritic taxons, high indices of species diversity and evenness. After 1999, structural changes were revealed as a replacement of subdominants were found in the interannual dynamics. These changes and also a feature of abundance and biomass dynamics were caused by climatic shifts after 1999, reflected in an intensification of upwelling and a corresponding cooling of the Canary current waters. The aforesaid scheme is not suitable for the zooplankton state in the summer of 1998. That anomaly was determined by specific oceanological conditions in the *El Niño* year.

Keywords: none.

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ICES CM 2011/M:19   Poster

Primary productivity and eutrophication in two different types of large marine ecosystem— the Baltic Sea and the Canary Current

Sergey Aleksandrov

The Canary Current and the Baltic Sea are two different types of large marine ecosystem (LME) in which primary productivity and eutrophication are determined by specific driving forces. The primary productivity of the Canary Current (16–36°N 6–18°W) has been assessed using data from 13 studies at 40–157 stations during 1994–2004. The primary productivity of the Baltic Sea has been assessed using data from three seasonal studies at 47–89 stations from the Gulf of Finland to the German coast (54–60°N 14–27°E) during 2005–2006 and 22 seasonal studies at 18–22 stations in the Gdańsk Basin (54.5–56°N 19–21°E) during 2003–2010. Primary production was measured by the radiocarbon method and spectrophotometric determination of chlorophyll. In the Canary Current the highest primary productivity was observed in areas of all-the-year-round upwelling (21–24°N) and the Senegalese–Mauritanian front (19–21°N in summer) where waters of eutrophic and hypertrophic status predominate. Southward of the Senegalese–Mauritanian front upwelling is almost absent, and waters of oligotrophic and mesotrophic status predominate. Northward of 24°N, highly productive areas have local character and the regularity of transition from eutrophic and hypertrophic waters in coastal zone to mesotrophic and oligotrophic waters, in places of

penetration on the shelf of oceanic waters, was observed. The Baltic Sea belongs to the temperate zone and primary productivity was characterized by considerable seasonal variability and spatial heterogeneity. The waters of the Baltic Proper can be characterized as mesotrophic. The increase of primary production to eutrophic level were observed in the gulfs and bays and in coastal zones. The highest hypertrophic level is characteristic of lagoons.

Keywords: Baltic Sea, Canary Current, eutrophication, primary productivity.

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ICES CM 2011/M:20   Poster

Flying fish, marine birds, and elasmobranchs as integrated biological indicators of LME boundaries and their spatial and temporal changes

Litvinov Feodor and Oleg Krasnoborodko

Assessment of large marine ecosystems (LMEs) and integrated ocean management require the determination of boundary positions and their seasonal, interannual, and long-period changes. The data on significant shifts in position of sea fronts, water masses, currents, etc. serve as important signals of possible changes in the states of LMEs. A first step in revealing such shifts may be observations of integrated indicators or living organisms. The most pronounced shifts in LMEs boundaries are observed at the extreme ranges of species/communities, positions of highest abundance and gaps inside species and higher taxa ranges. For example, trans-equatorial transects north–south and south–north in December 1999—March 2000 revealed seasonal shifts of extreme fish range boundaries to the south by more than 3° of latitude. In September 2010, the northernmost boundary was observed at 38°N (against 22°N in 1999 December and 19°N in 2000 March). Despite their highly developed ability to move, seabirds strictly observe certain boundaries in the ocean, determined by oceanographic features. Thus, the highest density of seabirds in the southeastern Pacific Ocean in spring 2009 corresponded to the seasonal position of the Subtropical Southeastern Pacific Frontal zone between 33 and 37°S. The gaps inside species ranges were observed in a number of West African elasmobranchs species at 34°N, 24–28°N, 19–20°N, and 8°N. If such gaps exist for a long time they may cause the emergence of isolated fish stock units, and, in extreme cases, twin species. The coincidence of such gaps in several species of different ecology suggests the existence of boundaries between communities and ecosystems that are not yet recognized.

Keywords: biological indicators of LMEs boundaries, eastern Pacific and Atlantic, flying fish, seabirds and elasmobranchs.

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ICES CM 2011/M:21   Poster

Who eats whom? Insights into the complex foodweb of Chesapeake Bay

Maja Walter, Muriel-Marie Kroll, and Ute Jacob

Disentangling predator–prey interactions in foodwebs provides important knowledge to understand the unique and complex structure of an ecosystem (i.e. identifying key species, energy fluxes through the trophic levels, shifts in species composition, changes in species interactions). Here we present to our knowledge the most extensive foodweb study that has been conducted for a large estuary. Located in the mid-Atlantic coastal region, Chesapeake Bay is the largest estuary in the United States. It provides a rich habitat for over 700 species and comprises an important commercial and recreational system. A literature review was conducted to gain information on descriptive parameters (diet, body weight, body length, distribution area) for each species. Literature sources were preferably scientific journals. In some cases, scientific and educational

websites and field guides were also used. Eventually, over 700 interactions of species were analysed with regard to diet, size, weight, trophic level, and origin of links. Furthermore, a cross-system comparison was conducted with other published foodwebs with regard to connectance, resolution, trophic links, and species composition. Our study presents an extensive insight of the Chesapeake Bay and its inhabitants and displays the complexity of a large and unrivaled system.

Keywords: Chesapeake Bay, connectance, cross-system comparison, foodweb, trophic interactions.

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ICES CM 2011/M:22   Poster

A two-stage biomass model to assess the English Channel cuttlefish stock

Michael Gras, Beatriz Roel, Franck Coppin, Eric Foucher, and Jean-Paul Robin

The English Channel cuttlefish (*Sepia officinalis*) is one of the most important cephalopod stocks exploited in the northeastern Atlantic Ocean in the Celtic Biscay Shelf Large Marine Ecosystem. It is a shared resource fished mostly by French and UK fishers. Previous stock assessment exercises were carried out using depletion methods or virtual population analysis (VPA) adapted on a monthly scale. Unfortunately, depletion methods are not easy to fit in a migratory species that shows variable catchability. Monthly cohort analysis is highly data-demanding and difficult to apply to cuttlefish, which has a very variable inter-individual growth rate. The two-stage biomass model, which has already been successfully used to assess short lifespan species such as the Irish Sea Herring or the Bay of Biscay anchovy, seems to be suitable for species with a two-year lifespan in which a more detailed age structure is difficult to obtain. Abundance indices were calculated using two bottom-trawl surveys of the eastern part of the English Channel: a July cruise by Cefas and an October cruise by Ifremer. Abundance in other months is derived from commercial bottom trawlers' catch per unit of effort (cpue) corrected with a GLM method. Results reveal how cuttlefish production trends can be influenced by fishing pressure and cohort strength. This tool is useful to analyse the relationship between coastal abundance during the reproductive period and offshore abundance in wintering grounds (where the bulk of the catch is made). The final objective of this work is to develop a biomass model which is able to predict the abundance of cuttlefish in winter, knowing the abundance in summer.

Keywords: abundance index, Celtic Biscay shelf, cpue, cuttlefish, English Channel, *Sepia officinalis*, stock assessment.

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ICES CM 2011/M:24

Assessing changing states of large marine ecosystems

Kenneth Sherman

The National Oceanic and Atmospheric Administration (NOAA)'s Large Marine Ecosystems Program is engaged in the application of an ecosystem-based approach to support the assessment and management of the changing states of marine goods and services. The approach is based on the results of systematically monitored spatial and temporal suites of indicators of LME, including: (i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socio-economics, and (v) governance. The multisectoral suites of indicators provide the scientific and economic data for development and application of ecosystem-based models, assessments, and evaluations in

support of adaptive management actions leading to the recovery and sustainability of stressed LMEs.

Keywords: none.

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Theme Session N

The future of marine fish stocks and foodwebs—advancing methods for projections in the face of uncertainty

ICES CM 2011/N:01

Predicting recovery trajectories for the large species and large fish indicators

Tak Fung, Keith D. Farnsworth, Samuel Shephard, David G. Reid, and Axel G. Rossberg

How quickly and to what level do commercial fish stocks recover following release from fishing? Addressing these questions is imperative for long-term management of overexploited stocks. We use an innovative multi-trophic model to predict how fish community structures recover from different fishing scenarios when fishing is reduced. This model realistically captures many properties of Northeast Atlantic shelf communities. In particular, it has a unique stochastic algorithm allowing up to thousands of model species to stably coexist, thus allowing realistic species richness to be modelled. Fish community structure is quantified using the large species indicator (LSI) and large fish indicator (LFI), two complementary size-based indicators. We discovered that targeting large fish species or non-selective fishing of all fish species always decreased the LSI and LFI. In addition, equilibrium recovery levels decreased with increasing fishing mortality rate F and duration of fishing, reflecting local population extinctions of large fish species. Importantly, recovery times were typically decadal but can be longer than a century, supporting management on at least decadal time-scales. Furthermore, model communities with realistic richness had recovery trajectories that followed exponential functions, providing a potential gateway for estimating future states. However, those with unrealistic richness had trajectories that fluctuated more and did not follow exponentials—methodologically, this cautions against using models with unrealistic richness to predict recovery. Lastly, simulations for the North Sea, with LFI dynamics following empirical data from 1920 to 2001, suggest that an average F across species <0.2 year^{-1} is required for LFI recovery to the reference point.

Keywords: community structure, large fish indicator, Northeast Atlantic, recovery.

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ICES CM 2011/N:02

A size-based modelling approach for the evaluation of ecological indicator performance under changing fishing pressure

Jennifer E. Houle, Keith D. Farnsworth, Axel G. Rossberg, and David G. Reid

Many indicators have been proposed as being suitable to measure marine ecosystem health in response to fishing pressure, and it is often difficult to tell from empirical data how well these indicators will perform. This work uses a size-based modelling approach to assess the suitability of a range of size-based fish community indicators for an ecosystems approach to fisheries management. In particular, the sensitivity of indicator values to changing fishing effort and the specificity of indicator responses to fishing vs stochastic change of model parameters, representing environmental variability, is examined. Trawl and gillnet fishing scenarios with a range of fishing effort levels and mesh sizes are considered. The model used is dynamic, resolved into abstract species defined by their maturation size, and based on the size spectrum theory of Andersen and Beyer. The modelling results suggest that there is no one perfect indicator, as indicators respond differently to gill and trawlnet scenarios, but using a number of indicators would help quantify the effects of fishing on the wider fish community. Importantly, the model provides a tool to evaluate the performance of a wide range of size-based indicators that would not be possible with empirical data, and allows us to explore a range of feasible scenarios in fisheries management that would deliver both demonstrable improvements in the health of the fish community and, critically, appropriate metrics with which to monitor this.

Keywords: ecological indicators, ecosystem approach to fisheries management, marine community model, size spectrum.

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ICES CM 2011/N:03

Scenarios of ecological and economic consequences of rebuilding paths of depleted populations

Núria Calduch-Verdiell, Ken H. Andersen, Brian R. MacKenzie, Lars Ravn-Jonse, and James W. Vaupel

There is an increasing trend in the number of fish stocks throughout the world that are overexploited, depleted, or rebuilding and for which effective rebuilding plans are required. It has recently been suggested that the largest and oldest females of a stock (the "big–old" fish) produce more eggs than smaller, younger females, and therefore a rebuilding plan may have to pay particular attention to these big–old individuals. This paper develops an ecological–economic evaluation tool to explore the effect of choosing a rebuilding scenario based on the time needed to rebuild the stock and on the net benefit generated by the fishery during the rebuilding period and beyond. This is done by merging a classical age-structured model for a single-species population and an economic cost–evaluation framework to describe the consequences for the fish populations and for the fishery. Different rebuilding scenarios for two theoretical stocks with life history traits typical of a large and long-lived species and of a small and short-lived species are evaluated and compared. The results show that time to rebuild a depleted population increases as a function of asymptotic size. Removing fishing mortality on big–old fish during the rebuilding period allow the stock to rebuild at a faster rate than fishing all age groups. However, the analysis shows that a shorter rebuilding period does not contribute to increase the net benefit of the fishery during the rebuilding period and beyond. From an economical perspective, the choice of the rebuilding scenario is irrelevant.

Keywords: age–stock structure, big–old fecund female (BOFF), cost–benefit analysis, maximum sustainable yield, overfishing, rebuilding plan.

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ICES CM 2011/N:04

Estimating the minimum commercially viable population size and the maximum viable body size of harvested species

Matthew G. Burgess

One of the central goals of fisheries management is to ensure that populations of harvested species do not fall below their minimum viable population sizes (MVP), the thresholds below which extinction risk from stochastic forces becomes very high. This task will be most challenging for stocks whose minimum commercially viable population size (MCVP), which I define as the population below which fishing operations fail to catch enough to recover their basic operating costs, is smaller than their MVP. While estimates of MVP exist for a wide variety of stocks, no attempt has been made to widely measure their MCVP. I present a novel approach to estimating the MCVP of harvested stocks, and apply this method to a variety of well-studied marine fish, mammal, and invertebrate stocks using publicly available government and scientific data. I then compare these estimates to published estimates of MVP. While recent meta-analyses have suggested that MVP is negligibly correlated with body size, I find a strong negative relationship between MCVP and body size. This finding has two key implications. First, extinction risk measures based on rates of population decline may underestimate extinction risk to large-bodied harvested species and may overestimate extinction risk to small-bodied harvested species. Second, there is an approximate maximum body size beyond which extinction of harvested species is very

likely without regulation. These results provide important insights for understanding present extinction risks from overharvesting, and highlight the need for more mechanistic extinction risk measures for harvested species.

Keywords: extinction risk, global, maximum viable body size, minimum commercially viable population size.

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ICES CM 2011/N:05

An end-to-end model of a coastal upwelling system: propagation of lower trophic level variability to upper trophic levels in the Northern California Current

James J. Ruzicka, John H. Steele, Marisa N. C. Litz, William T Peterson, Richard D. Brodeur, and Thomas C. Wainwright

Predicting ecosystem response to future climate variability requires a mechanistic understanding of ecosystem dynamics. Foodweb models are useful platforms for estimating functional group response to structural changes among energy flow pathways. However, they do not themselves incorporate the physical processes that drive variability among bottom-up energy supply processes. The Northern California Current (NCC) ecosystem is a seasonally productive upwelling system. Plankton productivity and community composition vary on interannual and decadal time-scales due to variable nutrient input via coastal upwelling and due to climate-scale processes that force changes of the local meso-zooplankton grazer community via large-scale water-mass transport. To study propagation of lower trophic level variability across all trophic levels, an NPZD (nutrient–phytoplankton–zooplankton–detritus) model was used to drive an end-to-end foodweb model of the NCC ecosystem. The plankton model was coupled to a one-dimensional, cross-shelf Ekman transport and upwelling model. System production was balanced between new production supported by input of upwelled nutrients and loss of plankton from the shelf domain via Ekman transport. The functional response parameters of the meso-zooplankton were varied seasonally appropriate to time-series observations of the copepod community size composition. Propagation of model error during alternate scenario runs was analysed via Monte-Carlo sampling of potential foodwebs drawn from observed (or assumed) biomass, physiological parameter, and diet distributions. Qualitative validation of modelled energy flow pathways was possible by comparison of diatom and dinoflagellate-derived fatty acid tracers in forage fish tissues to the modelled/predicted composition during years of differing phytoplankton community composition.

Keywords: foodweb model, Northeast Pacific, NPZD model, propagation of uncertainty.

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ICES CM 2011/N:06

Biological ensemble modelling to improve marine science and ecosystem-based management advice

Anna Gårdmark, Martin Lindegren, Stefan Neuenfeldt, Thorsten Blenckner, Eero Aro, Outi Heikinheimo, Bärbel Müller-Karulis, Susa Niiranen, Maciej Tomczak, Anders Wikström, and Christian Möllmann

Projecting future development of fish populations fundamentally relies on mathematical models of population dynamics. The ecosystem-based approach to fisheries management further requires that management accounts for interactions among species and other ecosystem processes. Thus, diversity and complexity of models used for projecting fish population responses to management have increased. Yet, the structural uncertainty associated with alternative models is rarely accounted for. Here we present the biological ensemble modelling approach (BEMA) to investigate

and communicate such model uncertainty. We further illustrate how the technique can be used to disentangle model uncertainty from statistical uncertainty of climate projections. Three single-species models, four multispecies models, and one foodweb model were used to investigate the response of eastern Baltic cod (*Gadus morhua callarias*) to three alternative fisheries management scenarios and two climate change scenarios, assuming no further climate change or a warmer and less saline future Baltic Sea. Although the responses differed quantitatively as well as qualitatively between the models, the BEMA provided a means to (i) present the full range of projected stock responses, (ii) assess whether these imply different advice on management, and (iii) draw general conclusions valid across all models used. Thus, ensemble modelling approaches should .be used to further both marine science and ecosystem-based management advice.

Keywords: Baltic cod, climate change, ecosystem-based management, ensemble modelling.

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ICES CM 2011/N:07

Ecological–economic multispecies management of the Baltic Sea fisheries: trade-offs between objectives in an ecosystem context

Rudi Voss, Jörn O. Schmidt, Maciej T. Tomczak, Martin F. Quaas, and Thorsten Blenckner

The central Baltic Sea fish community is dominated by just three species—cod, herring, and sprat. The fishery mainly consists of single-species fisheries. However, fisheries are closely connected as there are strong ecological interconnections between the species (i.e. predation by cod and competition between clupeids). Therefore, management measures taken for one species will inevitably affect the other species and its related fisheries. We developed and applied an age-structured ecological–economic multispecies optimization model. This model offers the possibility to calculate optimal multispecies *F*-vectors for different management objectives. As a reference case, the maximum net present value of the combined fisheries is calculated. A weighting scheme in the objective function offers the possibility to calculate the actual costs of side conditions (as deviation from optimum), such as maintaining clupeid stocks above a limit biomass or maintaining a certain amount of profit in the single fisheries. This model, however, does not include an ecosystem perspective. Therefore, we combine the Eco² model with the central Baltic Sea foodweb NEST model. The ecological–economic model calculates multispecies fishing mortality vectors to achieve management goals (or trade-offs between different goals). The *F*-vectors are used to drive the NEST foodweb model, which will predict the future development of the Baltic Sea ecosystem. This exemplary application and combination of models of different complexity allows a comparison and quantification of the risks that key indicators are negatively affected by management measures. This approach also allows taking future climatic variation into account.

Keywords: Baltic Sea, ecological–economic model, multispecies.

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ICES CM 2011/N:08

What is the dominating contribution to the density-dependence of fish population growth?

Axel G. Rossberg, Tak Fung, David Reid, and Keith D. Farnsworth

The question of how density-dependence arises in the population dynamics of fish stocks and, hence, what determines their carrying capacity, is paramount for many issues of modern fisheries management. The identification of maximum sustainable yield in a multispecies context, for example, depends on it, and so do the time-scales for population dynamics in complex assemblages of stocks. Yet, despite decades of research, the question has remained enigmatic. Three lines of reasoning are explored in approaching this question. The first highlights the observation that, in marine community size spectra, the density of biomass along the logarithmic body-mass axis is

approximately constant over many orders of magnitude in body mass. Most theories explaining this phenomenon invoke carrying capacities entirely determined by trophic interactions. The second line of reasoning highlights the high prevalence of non-trophic density-dependences in foodweb models. It is documented that these non-trophic effects are often motivated by their stabilizing effects on population dynamics, rather than biologically. It is pointed out that alternative modelling strategies can lead to complex, stable communities regulated by feeding interactions alone. The third line of reasoning discusses empirical evidence supporting alternative mechanisms for density-dependence.

Keywords: carrying capacity, density-dependence, stock–recruitment relations.

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ICES CM 2011/N:09

Bayesian learning and updating in selecting catch-at-age stock-assessment models and its implications for population projections in the face of uncertainty

Yan Jiao, Donald J. Orth, Eric P. Smith, and Robert L. O'Reilly

Model selection uncertainty exists when one specific model is selected without comparison to other hypothesized models. The characteristics of population dynamics can vary over time. In this study, using the Atlantic weakfish (*Cynoscion regalis*) fishery as an example, four statistical catch-at-age models to assess the population dynamics were developed. Models used included a statistical catch-at-age model (SCA, M1) with constant natural mortality, an SCA with time-varying natural mortality (M2), an SCA with varying population spatial heterogeneity over time (M3), and an SCA that was a hybrid of models 2 and 3 (M4). These four models incorporated alternative hypotheses about variations of natural mortality and the population's spatial distribution. A Bayesian approach was used to estimate parameters and the performance of the models was compared by goodness-of-fit and the retrospective patterns of the models. M4 was found to have the best goodness-of-fit in most of the years, but M2 and M3 were comparable with M4 in some years when retrospective error and the predictive p-value were considered. Bayesian model averaging (BMA) was used to make inferences about the parameters and population/fishery status based on model goodness-of-fit, retrospective error and model predictive p-values. The BMA approach not only avoided model selection uncertainty but also provided an urgently needed framework for determining suitable models for updating stock assessments. Our results suggest that model selection and BMA results should be considered in the population projection stages. We illustrated the possible approaches for short-term and long-term population projection in the face of model selection uncertainty and non-stationary population dynamics.

Keywords: Bayesian learning, Bayesian model averaging, population projection, statistical catch-at-age.

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ICES CM 2011/N:10

Influence of possible long-term environmental condition development scenarios on Baltic cod stock and recruitment dynamics

Maris Plikshs and Bärbel Müller-Karulis

Cod (*Gadus morhua*) is a temperate marine fish that spawns in bottom-water layers of the continental shelf and produces pelagic eggs. In contrast to other gadidae, cod is able to penetrate into the brackish waters of the semi-enclosed Baltic Sea. However, conditions in the Baltic Sea are marginal for this marine species because of the low salinity. In the central Baltic Sea, salinity ranges from 10–23 PSU in the bottom water to 7–8 PSU at the surface. In the past, the Baltic cod stock has shown great variations in abundance and recruitment. In recent times, an increase in recruitment has been observed after major inflows of saline water into the Baltic that provide water volumes

suitable for successful cod reproduction, the so-called "reproduction volume", with salinity higher than 11 PSU and oxygen content above 2 ml l^{-1} in the Baltic central basins. In the present work we perform long-term predictions of cod spawning-stock biomass and recruitment dynamics under different environment regimes and fisheries scenarios. Stock development predictions are based on a Ricker stock–recruitment relationship modified to include environmental variables as the magnitude of cod "reproduction volume" and salinity in the spawning depth layer in the eastern Gotland Basin.

Keywords: Baltic Sea, cod, long-term predictions, reproductive volume.

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ICES CM 2011/N:11   Poster

Signatures of fishing on marine foodweb structure

Tak Fung, Keith D. Farnsworth, David G. Reid, and Axel G. Rossberg

The Marine Strategy Framework Directive requires EU states to develop indicators characterizing marine environmental status. As acknowledged by the EU Commission in 2010, there is a need to develop indicators that capture the structure of foodwebs. To allow informed management, it is essential that chosen indicators are sensitive to anthropogenic pressures. We consider three species-resolved foodweb indicators and assess their sensitivity to an increasing fishing mortality rate F, using a multi-trophic species-resolved model parameterized for the Northeast Atlantic. This model uses a special algorithm mimicking community assembly, which generates communities with hundreds to thousands of dynamically coexisting model species, reflecting the species richness of real marine foodwebs. Thus, this modelling approach is a highly appropriate method for projecting future states of fished foodwebs to assess the sensitivity of species-resolved foodweb indicators. The three indicators we consider are the Shannon–Wiener Index (SWI), average degree of satiation (related to average productivity) and average number of prey species, as computed using all fish species. We found that with increasing F, the SWI and average prey diversity decreased whereas the average degree of satiation increased. However, for all three indicators, the percentage change was < 25% for $F \leq 0.5$ year^{-1}. Thus, these indicators are not particularly sensitive to fishing. We show that sensitivity can be substantially improved when computing these indicators using a subset of fish species in a specified range of trophic levels or species size classes.

Keywords: biodiversity, foodweb, Northeast Atlantic, productivity.

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ICES CM 2011/N:12   Poster

State of fish food supply in the eastern part of the Gulf of Finland in 2010

Olga N. Susloparova, Yuri A. Zuyev, and Vera A. Ogorodnikova

Studies were performed in August 2010 in the eastern part of the Gulf of Finland. This region includes shallow-water and deep areas in the Luga, Koporskaya, and Vyborg Bays. The objects of study were zooplankton and zoobenthos, which constitute a food source for planktophagous and benthophagous fish and juveniles of all fish species. With regard to zooplankton, crustaceans dominated everywhere, mostly copepods, including *Eurytemora hirundoides*, *E. affinis*, *Thermocyclops oithonoides*, and *Mesocyclops leuckarti*. At selected sites in shallow-water areas and bays, *Daphnia cristata* and *Limnosida frontosa* also dominated; in the deep area, *Limnocalanus grimaldii* dominated. Average abundances and biomasses in these areas were 20 720–57 660 individuals m^{-3} and 0.813–1.106 g m^{-3}, respectively. Maximum abundance was observed in the shallow-water area, Luga and Koporskaya Bays. With regard to zoobenthos, oligochaetes (*Limnodrilus hoffmeisteri*) dominated in terms of numbers in the eastern part of the shallow-water area; introduced species of polychaetes (*Marenzelleria* sp.) dominated in terms of numbers in all other areas and everywhere in terms of

biomass. The average abundances and biomasses in these areas were 3 756 000–7 203 000 individuals m^{-2} and 10.76–28.03 g m^{-2}, respectively. The maximum levels of benthophagous fish food supply were recorded in the deep-water area (Moshchnyi and Seskar islands areas) and stations in the open parts of Luga and Koporskaya Bays. In 2010 the indicator levels of food supply abundance were significantly higher than in recent years. One of the main reasons for this increase was the high summer temperature.

Keywords: food supply, Gulf of Finland, zooplankton, zoobenthos.

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ICES CM 2011/N:13   Poster

Diet of the Cunene horse mackerel (*Trachurus trecae*) off Angola

Henriette Lutuba Nsilulu, Filomena Vaz-Velho, and Carl Van Der Lingen

The diet of Cunene horse mackerel (*Trachurus trecae*) was investigated on the basis of pelagic and bottom-trawl collections taken from 2000 to 2003 during routine acoustic surveys off Angola. Fish size influences the diet of composition of Cunene horse mackerel. Gut contents of small fish (<21 cm length, range 12–20 cm) comprise approximately 96% fish larvae, while larger fish (>21 cm, range 21–48 cm) feed mainly on euphausiids (85%), with copepods and crustaceans making up 7% and 6% of the diet, respectively. In the northern region Cunene horse mackerel feed largely on euphausiids, in the central region they feed on approximately equal proportions of euphausiids (33%) and copepods (30%), and in the southern region the diet composition is dominated by euphausiids (46%), with copepods and crustaceans representing 35% and 15%, respectively. Feeding periodicity is size-dependent, with smaller fish showing an increase in mean stomach content during the period 12:00–14:00 hours and 18:00–20:00 hours. For the larger fish maximum feeding occurs in the period 12:00–16:00 hours. The rate of gut evacuation of small fish was estimated to be 0. 0.3596 h^{-1} and in the large fish is 0.332 816 h^{-1}. Using the Elliot and Persson methods, the daily ration was estimated as 3.35% d^{-1} for small fish and 2.39% d^{-1} for large fish. The daily ration decreases from north to south.

Keywords: Angola, Cunene horse mackerel, feeding periodicity, rate of gut evacuation.

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ICES CM 2011/N:14   Poster

Predicting ecosystem response to decadal-scale climate variability using an end-to-end ecosystem model

Kelly A. Kearney, Charles Stock, and Jorge L. Sarmiento

The Eastern Subarctic Pacific has shown decadal variations in ecosystem state, sometimes characterized as regime shifts, that are correlated to the Pacific Decadal Oscillation and have been documented at all trophic levels, from primary producers to top predators. While correlative links between changes in physical properties and population changes at various levels of the food chain have been demonstrated, the underlying mechanisms of these population shifts remain unclear. Here, we use an end-to-end ecosystem model to investigate the response of an oceanic foodweb to changes in the physical environment. The end-to-end model couples a one-dimensional physical model, a biogeochemical model, and a predator–prey foodweb model, allowing two-way feedback between all trophic levels. An ensemble approach that accounts for uncertainty in fishery foodweb interactions is used to assess the range of potential responses of the ecosystem to climate variability. While this study is focused on the pelagic Subarctic Pacific ecosystem, the modelling methodology is designed to be generic to any ecosystem, and provides one potential framework for investigating ecosystem response to climate variation.

Keywords: climate variability, end-to-end model, Subarctic Pacific.

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Theme Session O

Surplus production models: quantitative tools to manage exploited fisheries and compare the productivity of marine ecosystems

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ICES CM 2011/O:01   Withdrawn

ICES CM 2011/O:02

A new quantitative tool for stock assessment of the yellowtail flounder in the Northwest Atlantic Ocean

Saang-Yoon Hyun

One of the critical problems in stock assessment models (e.g. VPA, SCAA) lies in over-parameterization. To get around the problem, almost all models require some parameters (e.g. natural mortality) to be fixed at plausible values to calculate the other parameters. Obviously a parameter such as natural mortality changes over years and ages, and the manipulation results in a considerable uncertainty in stock assessment. Here, the number of parameters was reduced to avoid the above manipulation and to stably estimate all parameters by focusing on exploitable abundance instead of raw abundance. The exploitable abundance is defined in years as the sum of age-specific products of "raw abundance and fishery selectivity in the year". In practice, the sum of raw abundances over ages is larger than that of exploitable abundances because the selectivity <1 at ages before fish are fully recruited to a fishery. In addition, a more accurate pdf of catch data than the common treatment of the logarithm of the catch as a lognormal pdf was sought. Furthermore, variances in the respective objective functions in the new model were treated as derived parameters rather than as free, to save degrees of freedom. Outputs of the new model include maximum sustainable yield. The new model is applied to three yellowtail flounder stocks in the Northwest Atlantic Ocean: the Southern New England–Mid Atlantic, Georges Bank, and Cape Cod–Gulf of Maine. Outputs from the model provide a comparative measure among those three ecosystems.

Keywords: exploitable abundance, maximum sustainable yield, over-parameterization problem.

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ICES CM 2011/O:03

Contrasts across levels of aggregation, ecosystems, and drivers: lessons learned from fisheries production estimates in 11 northern hemisphere ecosystems

Jason S. Link, Sarah Gaichas, Thomas J. Miller, Tim Essington, Alida Bundy, Jennifer Boldt, Ken F. Drinkwater, and Erlend Moksness

Here we report on multilateral international workshops that focused on the application of various surplus production model configurations as a tool for ecosystem comparison. These efforts were conducted to answer the following questions: (i) how does ecosystem structure and function interact to support fisheries production, and (ii) what processes amplify, dampen, or obstruct the production that ecosystems provide? The surplus production modelling was applied to 11 northern hemisphere ecosystems and results compared across systems, levels of species aggregation, and drivers (including several covariates). We also estimated and compared management-relevant metrics and ecosystem attributes. There are varying degrees of utility in applying surplus production models at single-species, multispecies, aggregated species, and full-system levels; doing so demonstrated categorically across ecosystems that the different levels of aggregation provide distinct, but complementary information. Preliminary results confirm that systemic yield is less

than the sum of SS yields, which has important ramifications. Furthermore, some MS and aggregate yields may, in fact, lead to excessive harvesting of some component stocks as compared to such estimates from SS yield methods, depending upon the amalgamated properties of those grouped yields. Further implications of our results for future work relevant to operational oceanography, population and community modelling, and ecosystem-based fisheries management are discussed in the context of relative prominence among the "triad of drivers" that can differentially influence the dynamics in these ecosystems. We conclude by elucidating and reiterating the challenges and opportunities of fitting such modelling approaches in anticipation of their further use in living marine resource management.

Keywords: aggregate biomass estimates, ecosystem comparison, environmental covariates, fisheries management, multispecies models, surplus production.

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ICES CM 2011/O:04

The effects and relative importance of fishing, trophodynamic and environmental drivers on ecosystems

Caihong Fu, Jennifer Boldt, Jason Link, Alida Bundy, Sarah Gaichas, Robert Gamble, Adam Cook, Kjell Rong Utne, Hui Liu, and Kevin Friedland

Marine ecosystems are influenced by a triad of drivers (fishing, trophodynamic, and environmental) that operate and interact over multiple scales, resulting in non-linear or abrupt responses to perturbation. The inherent complexity of marine ecosystems suggests that progress towards an understanding of factors that affect fisheries production will be most efficient if researchers adopt a comparative approach across ecosystems using a suite of indicators. The goal of this study was to explore the effects of common drivers at the basin scale, and compare the relative influence of the triad of drivers among ecosystems. We examined a suite of biological response indicators (e.g. annual surplus production) for ten northern hemisphere ecosystems relative to indices that capture important fisheries drivers, environmental drivers, and trophodynamic drivers. Multivariate (MV) statistical methods were used to explore relationships among the biotic response indicators and to estimate the relative importance of each of the triad of drivers. Results indicate that fishing pressure is typically a prominent driver and that in some ecosystems environmental perturbations can also be quite important, dependent upon local oceanographic conditions. The relative importance of drivers is affected by the choice of fisheries-centric biological response indicators examined, and additional biological indices are suggested for future analyses. Implications for use in ecosystem-based fisheries management are discussed.

Keywords: ecosystem comparison, fisheries management, indicators, multivariate statistical methods, surplus production.

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ICES CM 2011/O:05

Modelling long-term population productivity variation using non-stationary surplus production models

Yan Jiao and Rob O'Reilly

Stationary surplus production models and catch-at-age models have been widely used in fisheries stock assessment. However, most fish populations have been found to be very dynamic and influenced by many factors, such as climate changes and species interaction. A stationary, density-dependent population growth model often fails to capture the dynamics of a fish population. In this study, using the Atlantic weakfish (*Cynoscion regalis*) fishery as an example, we developed a non-stationary state–space population dynamics model and then compared it with the commonly

used stationary surplus production model to assess the population dynamics. The available information on weakfish and these used in this study include catch data from the 1920s till now, and survey relative abundance indices from the 1970s and 1980s till now. The long time-series of the weakfish catch and surveys provided a great example to study its long-term non-stationarity and the possible driving factors on its population dynamics. The parameters and population abundance were estimated using a MCMC algorithm of Metropolis–Hasting within Gibbs, and performance of the models was compared by goodness-of-fit of models. Our study found that weakfish population growth rate varies over time and the trend of the population growth rate strongly correlated with the Atlantic Multi-decadal Oscillation (AMO) rather than the North Atlantic Oscillation, which implies that the AMO is probably the major drive factor that causes weakfish population to vary. We recommend the approach to be used for many other species that show non-stationary dynamics patterns.

Keywords: Atlantic weakfish, Bayesian, long-term population dynamics, non-stationary surplus production model.

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ICES CM 2011/O:06

MSY oriented management of the Baltic Sea herring under regime shifts

Noel M. A. Holmgren, Niclas Norrström, Robert Aps, and Sakari Kuikka

The ecosystem of the Baltic Sea has undergone dramatic changes, perhaps a regime shift, during the last four decades. The Baltic Sea herring spawning–stock biomass (SSB) has declined to a third and weight-at-age has halved due to plankton prey deficits. The management objective of the herring is currently in transition to a cautionary maximum sustainable yield (MSY). We modelled the main basin Baltic Sea herring under the current regime, and analysed the effect of a recovery of the cod stock and the food availability as they were in the early 1980s. We recommend a target F_{MSY} of 0.16, but with a recovery of the cod, recommended target F_{MSY} is 0.10. A simultaneous increase in both cod and food availability is estimated to increase the yield to 40% at the target F_{MSY} of 0.20. We present functions to calculate F_{MSY} and estimate the expected yield depending on the abundance of cod and food availability. A retrospective application of our functions indicates overfishing in the 1990s and early 2000s, and a net loss in yields with a landing value of about €440 million.

Keywords: density-dependence, fishing mortality, productivity, sustainability, weight-at-age, yield.

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ICES CM 2011/O:07

Can a full multispecies production model tell us anything single-species models with covariates can't?

William T. Stockhausen, Thomas J. Miller, Mariano Koen-Alonso, Timothy E. Essington, Sean M. Lucey, Robert J. Gamble, Jason S. Link, and Sarah K. Gaichas

We define extended single-species production models (ESSPMs) as those production models that incorporate time-series of principal prey and/or predator species as biological covariates. One advantage to ESSPMs over single-species production models without biological covariates is that these models can be used to test the existence and direction of (one-way) species interactions. However, estimates of actual interaction strengths are confounded with scaling of the covariates (i.e. catchability). In addition, biological reference points (BRPs; e.g. maximum sustainable yield, MSY) that can be calculated in ESSPMs may be of limited value compared to those estimates that more directly incorporate species interactions, because of a lack of feedback between prey and predator species in ESSPMs. We thus developed a full multispecies production model (MSPM) to

estimate biological interaction strengths and examine trade-offs in multispecies MSY. As a preliminary demonstration, we fit this model to functionally analogous cod and herring species across multiple northern hemisphere large ecosystems. We compared results from the MSPM with those from ESSPMs that examined the same species groupings. In most cases, estimated species interactions from the two approaches were consistent regarding significance and direction, although not in all. In contrast, the two approaches produced different MSY estimates in most of the ecosystems. At this point, the answer to the question posed in the title is a qualified "yes", but the trade-offs between modelling approaches to estimating BRPs for cases where biological interactions are important, merit further examination before use in a fisheries management context.

Keywords: none.

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ICES CM 2011/O:08

Assembly rules for aggregate species production models: simulations in support of management strategy evaluation

Michael Fogarty, Sarah Gaichas, Hugues Benoit, Tim Essington, Caihong Fu, Robert Gamble, Mariano Koen-Alonso, and Jason Link

A key aspect of ecosystem-based fisheries management is assessing sustainability at multiple levels of organization beyond single target species. For this, appropriate biological reference points (BRPs) for aggregated groups of species need to be developed. But what are the potential risks and benefits of applying aggregate management measures to the individual species in the ecosystem? We used multispecies surplus production models to determine the potential consequences of applying alternative aggregate BRPs to a simulated fish community (based on Georges Bank). Population trajectories of individual interacting species in the community were simulated in a manner that included predation and competitive interactions among species. Species trajectories were then binned into aggregates by functional feeding guild, taxonomy, habitat association, and at the entire community level. We derived BRPs (e.g. maximum sustainable yield; MSY) by estimating production model parameters based on each type of aggregated time-series. We then applied the MSY fishing rates associated with these aggregations as alternative fishing strategies to the simulated community and compared equilibrium biomass and yield under each strategy. In general, species aggregated with similarly productive species fared well under an aggregate fishing strategy, with little loss in yield and with similar equilibrium biomass compared to a single-species strategy. However, less productive species were at risk of extinction when grouped with highly productive species. We propose a set of guidelines as operational advice for developing aggregate reference points based upon these results.

Keywords: none.

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ICES CM 2011/O:09

Simulating the triad of drivers with MS-PROD, a multispecies production model

Robert Gamble, Jason Link, Michael Fogarty, Sarah Gaichas, Janet Nye, Hugues Benoit, and Tim Essington

Complex large marine ecosystems contain ecological components that are highly connected both to each other (via ecological interactions) and their environment, as well as being affected by human exploitation. These three drivers—trophodynamic, biophysical, and exploitation—are therefore all important when considering ecosystem-based fishery management. Many simpler models focus on one or two of these drivers, but there is a need for minimally realistic models that allow the exploration of all three of these drivers to compare the relative importance of each within an

ecosystem. We propose that a multispecies production model with ecological interactions, and simple parameter adjustments to simulate effects of climate, can be used to explore the combined effects of the triad of drivers mentioned above. Doing such *in silico* experiments allows fishery managers to explore potential harvest levels under different climate scenarios, helping them to determine possible risks to both targeted and non-targeted species in an ecosystem. We present results exploring such scenarios in models parameterized for northern hemisphere large marine ecosystems. Our results indicate that harvest and/or climate changes are unlikely to have simple effects due to the complexity of the trophodynamic interactions between species. The likelihood of indirect effects and unanticipated consequences is high in these scenarios: as such we recommend the use of operating models such as MS-PROD as part of a toolbox to be utilized in ecosystem-based fishery management.

Keywords: none.

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ICES CM 2011/O:10

Comparison of surplus production estimates with and without environmental covariates: patterns for functionally aggregated groups across ten large marine ecosystems in the northern hemisphere.

Sean M. Lucey, Robert J. Gamble, Thomas J. Miller, William T. Stockhausen, Jennifer L. Boldt, Dag O. Hjermann, Kevin Friedland, and Jason S. Link.

We fit simple production models with and without covariates for several functionally aggregated groups using data for ten large marine ecosystems. Species were aggregated based on habitat (demersal/pelagic), size (small/medium/large using standard length to maximum body size ratios) and trophic guild (benthivore/planktivore/zooplanktivore/piscivore). Covariates included common, broad-scale physical forcing functions such as the Atlantic Multi-decadal Oscillation (AMO) and Pacific Decadal Oscillation (PDO) (depending upon ocean basin), as well as sea surface temperature. For all aggregated groups, we fit models with and without covariates. Models were compared using typical maximum sustainable yield (MSY)-based outputs. The specific affects of aggregation and covariates differed among systems, but major patterns among the different ecosystems were similar. The evaluation of species groupings showed that various levels: (i) were notably conditioned by environmental conditions, (ii) varied with ecological considerations, and (iii) although variable in output due to level of aggregation, were all more robust and conservative when compared to the sums of the component single species estimates. We note how these aggregate groupings could be used in future fisheries management contexts.

Keywords: none.

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Theme Session P

The interface between management and science—
moving forward

ICES CM 2011/P:01

Development of a revised approach to providing fish stock assessment advice in the northeast region of the United States

James R. Weinberg, Richard Merrick, Fredric Serchuk, Paul Rago, and George Darcy

The waters of the northeast region of the United States include over 40 federally managed fish and invertebrate stocks. In 2008, the US Congress passed legislation requiring that all US stocks be managed using annual catch limits (ACLs), as opposed to input controls such as limiting the number of fishing vessel days-at-sea. This change in the law has increased the demand for stock assessments and resulted in additional work for Fisheries Science Centers. Each stock assessment is now expected to (i) include more complete quantitative descriptions of assessment uncertainty, and (ii) indicate how this uncertainty affects estimates of stock status and fishing intensity. Fishery managers and the public are aware that this scientific uncertainty influences the size of the buffer between the overfishing fishing limit (OFL) and the annual acceptable biological catch (ABC) for each stock. As a result, demands have increased on assessment scientists to develop more sophisticated stock assessments having less uncertainty. In the northeast region, a diverse working group of fishery scientists, regulators, and managers are revising the process for providing assessment advice to address these challenges in a synoptic manner.

Keywords: fishery management, fishery science, stock assessment, US northeast region.

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ICES CM 2011/P:02   Withdrawn

ICES CM 2011/P:03

Co-production of science and policy—how does it work?

R. Aps, M. Fetissov, and Ü. Suursaar

Activities at the interface of environmental science, policy, and society demonstrate that the nominally scientific assessments of environmental risks underpin the legitimacy of claims about the need for new political cooperation and institutional change. At the same time, political cooperation has proved necessary to support the legitimacy and credibility of scientific assessments of the environmental risks concerned. The term "co-production" is used to refer to processes that connect the production of knowledge with the organization of policy-making, where science and policy together define problems and create knowledge. Hybrid management, boundary organizations, boundary objects, and boundary work are increasingly common phonemes. Building on a boundary object framework, this paper discusses the active involvement of policy and society in a process of development and implementation of ICES science advice. Using the boundary object characterization model the ICES science advice as a boundary object is characterized by attributes: type, functionality, utility, information, granularity, context, and familiarity. The role of ICES as the system integrator in communication, coordination, and collaboration between different organizations is addressed. The issue is exemplified by the case of the ICES science advice for the central Baltic Sea herring.

Keywords: boundary object framework, co-production of science and policy, hybrid management.

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ICES CM 2011/P:04

The added value of participatory modelling in fisheries management. What have we learned?

Christine Röckmann, Clara Ulrich, Marion Dreyer, Kjellrun Hiis Hauge, Edward Borodzicz, Daniel Howell, Ewen Bell, Päivi Haapasaari, Samu Mäntyniemi, George Tserpes, and Martin Pastoors

How can uncertain fisheries science be linked with good governance processes, thereby increasing fisheries management legitimacy and effectiveness? Reducing the uncertainties around scientific models has long been perceived as a cure for the problems around fisheries management. Increasingly, there is realization that uncertainty in numbers will remain. A lack of transparency with respect to these uncertainties can damage the credibility of science. The EU Commission's Green Paper on the Reform of the Common Fisheries Policy promotes increased stakeholder involvement in research projects and research-based advice. One way of encouraging higher transparency and improved participation is to include stakeholders in the modelling process itself. The JAKFISH project (Judgment and Knowledge in Fisheries Involving Stakeholders) invited fisheries stakeholders to participate in the process of framing the management problem, and to give input and evaluate the scientific models that are used to provide fisheries management advice. JAKFISH developed questionnaires and other tools to assess and communicate about uncertainty around fish stock assessments and fisheries management questions. Here, a synthesis is presented of the participatory work carried out in four European fishery case studies (western Baltic herring, North Sea nephrops, central Baltic herring, and Mediterranean swordfish), focusing on the uncertainty tools used, the stakeholders' responses to these, and the lessons learned. Furthermore, we reflect on whether the tools developed deserve a future in fisheries management.

Keywords: EU waters, JAKFISH, participatory modelling, uncertainty.

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ICES CM 2011/P:05

The TAC fallacy

Kjartan Hoydal

ICES has been the provider of scientific advice for decades on how to control fishing mortality to national management authorities and regional management organizations in the Northeast Atlantic. Overwhelmingly, management authorities have requested annual advice on catch levels—total allowable catches (TACs)—that will keep fishing mortality at sustainable levels. Single-stock TACs have been used for all fisheries, from clean, single-species fisheries for pelagic, schooling species to mixed multispecies multifleet bottom fisheries. Experience shows that it is a very difficult job to estimate the TAC corresponding to an agreed level of fishing mortality with any accuracy. The advice has been delivered in a set-piece, where the advice is given "ex-cathedra" without the possibility for dialogue between the ICES advisory bodies and managers on the factual advice for a given year. Problems in implementation and control and enforcement have been common and social and economic consequences have not been taken into account in the advisory process. The focus on TACs has led to a lack of research in other ways to regulate the level of exploitation and patterns, for example with control of effort (TAEs), area closures, and changes in gear technology. This paper discusses the inherent problem in controlling fishing mortality with annual TACs, possible new ways for delivery of advice, a more flexible use of various management tools, and how to make sure that the ecological advice is accompanied by information on social and economic consequences in the short and medium term.

Keywords: fishing mortality, fisheries management, management tools, scientific management advice, social and economic consequences of management measures.

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ICES CM 2011/P:06

Arms length science: a communicative action approach to understanding the organizational challenges

Douglas C. K. Wilson

The effectiveness of science for policy advice depends on three factors: scientific credibility, public legitimacy, and saliency to the needs of policy-makers and other users. Many analyses of science policy processes have shown that different ways of organizing the development and delivery of advice often involve trade-offs where improvements on one factor make meeting others more difficult. Some attempts to develop more "arms length" science, for example, increase the legitimacy of the advice but make saliency more difficult. This presentation, based on sociological research into ICES advisory work, uses the theory of communicative action to develop an abstract model of the kinds of discussions that take place at different stages of the advisory process. Rational communications in the development of advice require that science, advice, and policy be dealt with through step-by-step processes in which different kinds of validity claims are kept clearly separate. In day-to-day science and advice generation this can be a difficult challenge. This research identified six sets of quality standards which ICES scientists draw upon in their daily advisory work. These range from standards ensuring purely scientific credibility to those ensuring purely social questions of ICES organizational legitimacy. An analysis of how different kinds of quality standards map on to different steps in the science to advice system can provide expert group chairs and other with a tool to help ensure a rational progression that maximizes the credibility, legitimacy and saliency of advice.

Keywords: boundary objects, Europe, science–policy interface, theory of communicative action.

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ICES CM 2011/P:07   Withdrawn

ICES CM 2011/P:08

A product of procedure? The apparent disconnect between science and management in New England

Emily F. Keiley and Brian J. Rothschild

Concern about overfishing has resulted in progressively more restrictive and complex management measures in the United States. Despite significant efforts, more than 30 years after the enactment of the Magnuson Stevens Act, many species in the northeast region remain overfished, and the associated fishing communities continue to deteriorate. Is this perceived failure a breakdown of science or a problem inherent in the management system? The effect of institutional arrangements on the efficacy of fisheries management is often overlooked; however, the processes and people that contribute to management decisions are arguably as important, with respect to the outcome, as the scientific input. We describe the fishery science and management system in the northeast region and identify the significant constraints and objectives. Specifically institutional arrangements and the management model will be described, and the role of each player (scientists, managers, stakeholders, government) is examined. To demonstrate the utility of this type of analysis several case studies from the region are discussed; specifically the management of the data-poor skate complex, and the implementation of annual catch limits in the multispecies fishery.

Keywords: constraints, institutional arrangements, management system, objectives.

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ICES CM 2011/P:09

A risk-based interface between science and management in the US fisheries system

Steven X. Cadrin and Daniel L. Georgianna

The strategy for managing US marine fisheries was recently revised to require annual catch limits that avoid overfishing and allow overfished stocks to rebuild. Catch recommendations are derived from an overfishing limit, scientific uncertainty in estimating the overfishing limit, and stakeholders' desired risk tolerance, where stakeholders are represented by regional Fishery Management Councils. Catch recommendations are derived by regional scientific and statistical committees made up of academic and agency scientists as well as private consultants who have expertise in stock assessment, marine ecosystems, social systems, and economics. The first iteration of the system was implemented in 2010 and 2011, and catch limits have been largely driven by scientist's estimates of limits and recommended probability of overfishing, or expert judgement for the many stocks that have data-poor or problematic assessments. Initial risk tolerance decisions range from 10% to near-50% probability of overfishing, but most catch limits are not based on explicit risk decisions. More extensive risk management would include cost–benefit analyses, in which multiple utilities (revenue, profit, employment, etc.) and consequences of events (e.g. cost of overfishing, cost of triggering a rebuilding plan, cost of foregone yield) would be considered in the evaluation of risk tolerance. As overfishing is limited to the desired low frequency of occurrence and stocks are rebuilt, the roles of social and economic analyses for defining and achieving optimal yield are expected to expand.

Keywords: fishery management, overfishing, risk.

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ICES CM 2011/P:10

The advantages of proactive management over reactive regulations for implementing accountability in the US sea scallop fishery

Catherine E. O'Keefe

Management of US marine fisheries is based on annual catch limits (ACLs) as output controls for all fish stocks, and accountability measures (AMs) to ensure ACLs are not exceeded. The Atlantic sea scallop fishery, valued at US$350 million, has an ACL for the target species determined by an examination of foregone yield from the fishery in contrast to the probability of exceeding the overfishing limit. In addition, there is a sub-ACL of yellowtail flounder, a rebuilding stock of lower monetary value, which is encountered as non-targeted bycatch in the scallop fishery. When the yellowtail flounder sub-ACL is exceeded, AMs force in-season closure of prime scallop grounds and subsequent year closures of large areas. These reactive AMs were designed using scientific advice about bycatch rates and regulatory mandates for the rebuilding flounder stock. The AMs ignore socio-economic incentives to reduce bycatch through altered fishing behaviour. The narrow focus on punitive AMs, rather than proactive and preventive measures increases the likelihood that ACLs will be exceeded regularly, with no conservation benefit to yellowtail flounder and large economic costs to the scallop fishery. Innovative measures for voluntary bycatch avoidance, such as real-time communications and gear modifications could be expanded to achieve both the conservation and socio-economic goals of the fishery. This case study examines the roles of science, management, and industry stakeholders in determining AMs for the yellowtail flounder sub-ACL to the scallop fishery, focusing on successful strategies and persistent problems.

Keywords: accountability measures, fisheries management, sea scallops.

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ICES CM 2011/P:11

Twenty-first century fisheries management: a spatio-temporally explicit tariff-based approach combining multiple drivers and incentivizing responsible fishing

Sarah Kraak, Dave Reid, and Mike Fitzpatrick

Traditionally, fisheries management has focused on biomass and mortality, expressed across relatively large management units. The ecosystem approach to fisheries management (EAFM) (and Marine Strategy Framework Directoive, MSFD) require many more indicators, and at finer scales. Quotas and effort/capacity control are largely inappropriate for ecosystem drivers, but remain our principal tools. Incorporating ecosystem targets (e.g. habitat damage, mammal bycatch, biodiversity impacts) would need additional and potentially conflicting management tools. This would further complicate an already confusing micromanagement approach which benefits neither industry, science, nor policy-makers. We suggest an approach that is simple, relevant to the ecosystem approach, and provides incentives for "good behaviour". It is adapted from the idea of fishing credits articulated by Rijnsdorp. Essentially, fishers would be given a number of credits to spend according to spatio-temporally varying tariffs per fishing hour or day. Tariffs could be based on ecosystem and fish stock targets. The fisher could choose how to spend his or her credits (e.g. limited fishing in sensitive areas, or much longer in less sensitive areas). The data used to set the tariff would be transparent to assist in that choice. The approach could facilitate further devolution of responsibility to industry and matches well with industry-developed sustainable fishing plans proposed in the Common Fisheries Policy (CFP) reform process. The development of these fishing plans and the enhanced focus on spatial issues would provide greater opportunities for incorporation of fishers' local knowledge and an associated more adaptive and robust management regime.

Keywords: EAFM, fisheries management, incentives, tariffs.

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ICES CM 2011/P:12

Developing science for result-based management in fisheries—a digression?

Mogens Schou

Biological and economic fisheries science and advice are serving public management rather than private exploitation of fisheries resources. Management regulates the fisher's choice of methods, technology, area, and level of activity with increasing detail, thus fuelling the demand for such science. Basically, present management is aimed at reducing the gap between registered catches (landings) and total catches and at targeting larger fish. Management needs time to prepare and legislate and it regulates with rigid and uniform rules. This leaves little room for the industry to adapt to the dynamics of resource utilization opportunities. In contrast, results-based management sets the targets (catch quotas, where all fish count on the fishers quota), and leaves the choice of method in harvesting to the exploiter, together with the obligation to document (by e-log and CCTV) that targets are observed. As the EU considers results-based management in the form of full catch accountability, science might look at the opportunities of such management. It is concerned with comparing the ability of results-based management vis-à-vis regulatory management to optimize food output in an environment where the ideal harvesting pattern is highly complex and variable. It is also concerned with developing approaches and tools for the industry to continuously improve the results of the output. This paper points to possible science topics and areas that could contribute to the development and optimization of results-based management, such as biological/hydrographic, economics/market, optimal management models, and technology/methods.

Keywords: catch-quota management (CQM), EU fisheries policy, full documentation, North Atlantic, results-based management.

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ICES CM 2011/P:13

New demands for science and other stakeholders in fisheries governance: implications of a "reversed burden of proof" under a revised CFP

Sebastian Linke

Current changes in European fisheries governance suggest speaking not only of a "communicative turn" but a complete turnaround in the communication approaches various actors will face. Recent reform attempts for stakeholder participation in the Common Fisheries Policy (CFP) with Regional Advisory Councils and the idea to replace the burden of proof on the resource users (fishing industry) in the context of the next CFP reform imply completely new demands for the interaction between fishers and other stakeholders (e.g. NGOs), policy-makers, and scientists. This paper addresses this shift from a traditional linear science–policy interface (ICES–EU Commission) towards a more interactive governance system with regard to the communication and negotiation strategies of different stakeholder groups. For example, fisheries and NGOs would need the help of scientists to prove a particular management strategy workable, while policy-makers and management agencies need science to prove that this proposal does or does not work. Furthermore, the paper will also discuss novelties, demands, and challenges arising from the "communicative turnaround" for a transdisciplinary science (advice) system.

Keywords: CFP reform, fisheries governance, reversing the burden of proof, stakeholder involvement.

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ICES CM 2011/P:14

On the same team: a focus group for improving the management of blue whiting

David C. M. Miller and Aukje Coers

The late 1990s and early 2000s saw a period of high productivity for the ICES blue whiting stock (subareas I, IX, XII, and XIV). This was accompanied by large total allowable catches (TACs) and substantial fishing effort. Following 2005 a succession of poor year classes and continued high fishing mortality (F) led to a dramatic decline in stock size and very large reductions in TAC. In addition to this, the ICES assessment of this stock showed large annual revisions in the estimated stock size, both upwards and downwards. In response the Pelagic Regional Advisory Council (PRAC) initiated a blue whiting focus group to identify and address the many assessment and management challenges associated with this stock. This group includes both stakeholders and scientists from within the EU and Norway and has as its goal the creation of a common understanding between stakeholders and scientists on the current state of the blue whiting stock and on potential ways forward for the future management of the stock. This group has provided a useful platform for scientists to communicate scientific uncertainties (and their causes) with stakeholders. Likewise stakeholders have been able to communicate their perceptions of the stock, highlight their management priorities and suggest potential contributions of data to the management process. Although still in its infancy, there are clear signs of progress towards a common vision on improving management of blue whiting. The group aims to implement its findings through participating in the ICES benchmark assessment system and by potentially proposing a revised management plan for the stock.

Keywords: assessment, blue whiting, management, Pelagic Regional Advisory Council.

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ICES CM 2011/P:15

Fisheries ecosystem plans: how will they work and what data do we need?

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The Green Paper on the Reform of the Common Fisheries Policy identified the need for an ecosystem approach to fisheries management (EAFM), stated an intention to move towards a longer term approach to fisheries management, and made commitments to greater stakeholder involvement and management to support the three pillars of sustainability: ecological, social, and economic. The proposed transition would have considerable implications for the knowledge base required to underpin management and the need for approaches to integrate data from the three pillars. Through structured interaction with stakeholders (interviews and workshops) the Making European Fisheries Ecosystem Plans Operational (MEFEPO) project has developed operational fisheries ecosystem plans (FEPs) for three regional seas (North Sea, Northwest Waters, and Southwest Waters) to support this transition. Central to the FEPs is an objectives-by-management scenario planning matrix that can be used to explore the potential impacts of different combinations of management measures on ecological, social, and economic descriptors. This management support tool is demonstrated using case study fisheries within each regional sea and gaps in knowledge (ecological, social, and economic), which may limit our ability to successfully implement EBFM, were identified. The increase in data requirements for EBFM has consequences for those providing the data, in the skill base and resources required to identify, collect, and analyse appropriate data and provide advice.

Keywords: ecosystem, fisheries, knowledge base, management, sustainability, stakeholder.

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ICES CM 2011/P:16

"Pretty good governance": combining analytic hierarchy process, cognitive mapping, and participatory modelling to assist in choosing and applying fisheries management solutions

M. Fitzpatrick and D. G. Reid

Increasingly, fisheries and wider natural resource management research has demonstrated the need for mixed strategies as opposed to panacea-type approaches to solving "wicked" or complex and persistent problems. However, due to the complexity of social–ecological systems, detailed knowledge of each fishery is required in order to guide choices of combinations of management measures and how they should be applied. We report on a governance benchmarking exercise in relation to three Irish fisheries of varying complexity which highlights both shortcomings and opportunities. These issues must be regarded in light of the institutional and cultural setting in which the fisheries are embedded but they are useful in pointing towards solutions. We present an approach which combines the use of analytic hierarchy process and participatory modelling to address how the range of actors involved perceive the social and ecological drivers in these fisheries. The approach also allows a detailed analysis of how positive and negative issues arising from the benchmarking process can be addressed (e.g. broadening and clarifying management objectives, the application of property rights, and the scope for adaptive management capacity building in long-term management plans). We discuss the role of science in feeding this process with objective information in the first place and then participating in evaluation of management options. "Pretty good governance" relates to how solutions to complex and dynamic fisheries governance problems arrived at in this way may not be perfect but by collectively focusing on what is achievable, can move fisheries towards sustainability.

Keywords: fisheries governance, participatory modelling.

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ICES CM 2011/P:17

The COEXIST Project—governance of fisheries and aquaculture for integrating management and science.

Anne Marie O'Hagan and Vicki O'Donnell

COEXIST is a broad, multidisciplinary EU FP7 project, with 13 partners from 11 countries, tasked with evaluating competing activities and interactions in European coastal areas. The goal of COEXIST is to provide a roadmap to better integration, sustainability, and synergies across the diverse activities taking place in the European coastal zone. Currently, however, the desired balance between sectors which is required to meet environmental, social, and economic targets is hampered by various conflicts. This paper presents the results of a stakeholder survey which assessed issues around interactions between sectors in six case study areas adjoining European waters. In all study areas awareness and prevalence of conflict was higher than it was for synergies. Stakeholder attitudes towards marine policy instruments such as the Common Fisheries Policy, Marine Strategy Framework Directive, and Habitats Directive were also assessed. Certain stakeholders viewed their influence on decision-making as relatively weak while others felt considerably influential. This is of significance when formulating more integrated marine management and conflict mitigation strategies. The stakeholder survey was complemented by an analysis of the governance structure, management regime, and policy frameworks in each case study area. Findings from that work illustrate the diversity of arrangements and issues that exist in marine resource management. Ultimately, this work permits barriers to, and opportunities for, more efficient spatial management to be identified. This information will be synthesized and taken forward in future COEXIST work, culminating in best practice guidelines for spatial planning of fisheries and aquaculture with respect to other coastal interests.

Keywords: aquaculture, Europe, governance, management.

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ICES CM 2011/P:18

Bringing multiple stakeholders together in the management of marine fisheries: the role of Plan Development Teams in New England sector management

Anne E. Hawkins

United States law mandated the implementation of annual catch levels (ACLs) in all fisheries beginning in 2010. In the same year, a catch share management system replaced the previous days-at-sea (DAS) framework for the New England groundfish resource. These new management tools could have broad economic and social impacts in the region, and their development and review have occurred through a complex iterative public process that emphasizes extensive interaction among all stakeholders. A key feature of groundfish management is the Plan Development Team (PDT), a group of policy and science experts along with interest groups (e.g. fishers and conservationists) from diverse disciplines. PDTs provide reports to the Council's committees that develop and evaluate management alternatives, which are presented to the New England Fisheries Management Council for final consideration. The PDT not only incorporates biological advice from stock assessments and the Council's Scientific and Statistical Committee, but also performs socio-economic analyses of measures that are included in the Council's decision-making process. This paper analyses the role of various interest groups in the New England management process and whether this method has been successful in incorporating a broad range of analysis into final regulatory measures with a focus on its role in the transition to catch shares and ACLs. The PDT

process provides a unique example of how multiple interest groups can work together to develop and submit scientific advice to a management body, thereby providing an avenue for all stakeholders to take a direct role in the management process.

Keywords: fisheries management, New England, policy, science/management interface.

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ICES CM 2011/P:19

Public opinion and a new vision for Europe's seas

Laurence Mee, Tavis Potts, Cristina Pita, Olivia Langmead, and Tim O'Higgins

The European Marine Strategy Framework Directive follows an ecosystem approach and seeks to create a new shared vision for Europe's seas. But will this vision extend to the general public? The difficult and potentially costly choices to be made will need the backing of voters but how much do they know and value about the sea, the problems affecting its conservation and resources, the causes of these problems and the institutions competent and empowered to manage it? We conducted a public opinion survey in France, Germany, Italy, Poland, Portugal, Spain, and the UK. Opinions of over 1000 people in each country, stratified by age, gender, education, and distance from the sea, were commissioned to ICM as part of the 33-institute, 16 country, FP7 Project Knowledge-based Management of Europe's Seas (KnowSeas). We compared public perceptions of the problems, causes and state of Europe's seas with scientific understanding (using the results of our earlier FP6 project European Lifestyles and Marine Ecosystems). The public values the sea for a range of ecosystem services but is poorly informed about the nature of human pressures and very sceptical about public institutions (more confident about scientists and NGOs). Changing this situation will require a huge effort.

Keywords: ecosystem approach to management, ecosystem services, European Seas, public opinion.

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ICES CM 2011/P:20

National standards effective in US fisheries management

Sharon Lumsden

The Magnuson–Stevens Fishery Conservation and Management Act (MSA) had its 35th anniversary this year. The steps taken as a result of this landmark legislation have transformed fisheries management in the United States. In 2006 the US Congress reauthorized the Act and included several key provisions important both domestically and in the international arena. The most important change was the inclusion of the ten national standards (NS). Pre-eminent among those is NS1 "Optimum Yield" or "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the US fishing industry", requiring the United States to end overfishing in US waters by 2010. MSA national standards also require that the US government use the best available scientific information (NS2) in support of conservation and management while at the same time considering the socio-economics and communities (NS8) in decisions. The US fishing industry must minimize bycatch and bycatch mortality to foster sustainable fisheries. This paper discusses the successes and challenges encompassed in the MSA national standards, providing examples and opportunities for discussion.

Keywords: fisheries management, United States laws.

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ICES CM 2011/P:21

The science–management interaction on the Faroe Islands: a case study and proposal for changes

Asmundur Gudjonsson and Hans Lassen

The paper discusses elements in effective fisheries management with focus on information about decision structures and processes. The themes of the document include: (i) information and advisory functions; (ii) roles of the involved parties; (iii) management plans, and (iv) roles of the legislature and executive structures. An earlier version of the paper was used for discussion with the Faroese authorities and stakeholders and the paper is updated with developments that followed this discussion.

Keywords: none.

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ICES CM 2011/P:22

The role of science as fisheries and biodiversity policies and programmes converge

Jake Rice

For decades, policies and programmes for management of fisheries became more complete with regard to sustainable use and precautionary management of harvests. However, it was developed and implemented by fisheries management authorities, supported by fisheries science advisors. Policies and programmes for conservation of biological diversity evolved and expanded over the same period, with a strongly terrestrial focus. Again, policies and programmes were developed and implemented by environmental conservation agencies, supported by a community of experts in conservation biology. In the 2000s, fisheries communities were challenged by a large number of new policy requirements to achieve sustainability in much larger ecosystem contexts, while the biodiversity communities took to conservation of marine biodiversity with a passion. The developments in the 2000s have created a number of difficulties in achieving coherence and cooperation between these two communities of policy-makers and managers. Many of these difficulties will not be addressed effectively without governance changes that are proving hard to negotiate. Such difficulties are not surprising, as policy and management agencies take their mandates and jurisdictions seriously. However, the science experts supporting the fisheries and biodiversity policy and management authorities are also encountering challenges in adjusting to this new reality. However, the science advisory community has the opportunity to play an essential and unique role in fostering coherence in the policies and programmes in both fisheries management and biodiversity conservation. This paper provides specifics about changes in the policy and management environment over the past decade, and what new opportunities and responsibilities these present to the science research and advisory communities.

Keywords: none.

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ICES CM 2011/P:23

The ICES precautionary approach: failed attempts to neatly arrange the boundary between science and policy

Martin Pastoors

In this paper, the focus is on the process of boundary construction between science and policy in the domain of fisheries management. The implemention of the precautionary approach within the ICES advisory framework was initiated in the mid-1990s and resulted in a system of biological reference points that were intended to guide biological advice and fisheries management. This meant that the precautionary approach came to be a boundary-ordering device between science and policy. The ICES interpretation of the precautionary approach meant the pre-existing advisory

framework could be slightly amended to include the new "requirements". The discussion about the so-called "limit reference points" and "precautionary reference points" clearly illustrates how these concepts where intended to divide responsibilities between science and policy. Nevertheless, the introduction of the precautionary approach resulted in a shift of policy responsibility into the scientific realm. The interests and positions of management authorities and stakeholders were often pre-judged in the process of defining precautionary reference points. The lack of transparency about the the scientific basis of precautionary reference points has contributed to a detoriation of credibility of scientific advice on fisheries management.

Keywords: none.

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ICES CM 2011/P:24   Poster

Adaptative management in Polish inner marine waters

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Szczecin (Odra) Lagoon and Vistula Lagoon are transboundary coastal areas used by small-scale fisheries. Management for over 60 years has been based on adaptive management procedures elaborated between stakeholders and administration, limited by changes in the ecosystem, as well as in the political and economic systems. Here, we discuss the causes and methods of several changes of fishery rules, gear constructions, and area restrictions. On the basis of scientific knowledge and fishers' opinions, we place the effectiveness of each management method on a ladder of priority. Ultimately, technical methods such as gear modification and closed areas and seasons—especially if they have a strong basis in the fishers' experience—are found to be more effective than total allowable catch (TAC) or net number limitations.

Keywords: lagoon, MPAs, selectivity, small-scale fishery, TAC.

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ICES CM 2011/P:25   Poster

Knowledge engineering to improve the interface between stakeholders and management in the ecosystem approach to fisheries management

Deirdre E. Duggan, Keith D. Farnsworth, and David G. Reid

The aim of this study is to help stakeholders develop a greater understanding of the effects of their activities and of ecological communities. Community-level models need to become more accessible and credible to stakeholders, addressing questions directly relevant to them. The objective is to provide a user-friendly interface between stakeholders and the ecological models in the form of decision-support tools. To achieve this, a knowledge base of stakeholder preferences and objectives for the ecosystem and resource will be constructed about what aspects are valued and how important each aspect is. This will be accomplished through analysis of stakeholder opinions and values gained from collaboration with scientists within the research team and gaps between scientific and stakeholder objectives will be identified. Information on how stakeholders interpret ecosystem issues and scientific results, and methods of helping the interpretation will be addressed. This knowledge base will be used to create a suite of "common language" indicators, designed to be easily understood by audiences with little ecological expertise, allowing them to associate the relevancy of the indicators with valued environmental aspects but at the same time be scientifically robust. Collaboration with ecological modellers will ensure the technical accuracy of the indicators. The development of a web-based dashboard interface with user-manual pages, data source information, and various adjustable fishing scenarios using common language indicators to describe the status of an ecosystem will convey the effects of fishing and fisheries policies to the stakeholders.

Keywords: "common language" indicators, ecosystem approach, management interface, stakeholders.

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ICES CM 2011/P:26   Poster

The role of science in improving bycatch management in a high-volume fishery

Jamie M. Cournane and Jake P. Kritzer

Recent declines in river herring (alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*) runs along the North American Atlantic coast signal the possible collapse of the coast-wide stock. Currently, the US New England Fishery Management Council (the Council) is developing strategies to address ocean bycatch of river herring through Amendment 5 to the Atlantic herring fishery management plan. The relationship between management and science will be discussed using the development of river herring bycatch management as a case study. This work was conducted by the Atlantic Herring Plan Development Team to inform Council members during the development of the amendment. In particular, it examined recent (2005–2009) spatial and temporal patterns in distribution of fishing effort for the directed Atlantic herring (*Clupea harengus*) fishery and associated patterns of river herring bycatch. At-sea fisheries observer data showed that river herring bycatch occurred mostly during January–April and September–December when the fishery was primarily prosecuted in southern New England and the northern Mid-Atlantic Bight. River herring distributions from 1948 to 2008 detected using data from the seasonal National Marine Fisheries Service bottom-trawl surveys confirmed these patterns. Moreover, this provided information on the relative likelihood of encountering river herring for areas that have little to no fishing effort or observer coverage at present. What remains unknown is the linkage between where river herring run and where they go at sea. Thus, the next generation of research should address finer scale patterns to better understand the ecology of river herring and improve management at multiple scales.

Keywords: anadromous fish, bycatch mitigation, herring, New England.

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Theme Session Q

Atmospheric forcing of the northern hemisphere ocean gyres, and the subsequent impact on the adjacent marine climate and ecosystems (Joint ICES/PICES theme session)

ICES CM 2011/Q:01   Withdrawn

ICES CM 2011/Q:02

Oceanic and atmospheric forcing for the recruitment of Japanese sardine (*Sardinops melanstictus*)

Ichiro Yasuda, Haruka Nishikawa, Sachihiko Itoh, and Kosei Komatsu

Japanese sardine is known to undergo drastic inter-decadal catch variability. By using a high-resolution ocean circulation model hindcast output driven by observed atmospheric forcings, we found that the survival of the sardine is related to the oceanic environment around the Kuroshio jet during the transport of larvae and juveniles; deep winter mixed layer depth (MLD) and cold winter–spring cold temperatures are favourable to survival, whereas shallow winter MLD and warm winter–spring temperatures are unfavourable to survival. Large MLDs could lead to abundant plankton and food availability in spring and low sea surface temperature (SST) was reported to enhance larval growth. The shallow MLD and warm SST during 1988–1994 led to the collapse of the Japanese sardine. This unfavourable oceanic condition occurred because of the stronger Kuroshio current south of Japan and weaker winter atmospheric cooling, with weak East Asian winter monsoon winds. The stronger Kuroshio could be related to a westward propagated sea surface height anomaly forced by the central–eastern mid-latitude Pacific windstress curl.

Keywords: Japanese sardine, Kuroshio, Northwest Pacific.

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ICES CM 2011/Q:03

Climate-driven shifts in fish communities in Korean waters detected by application of multivariate analyses and Bayesian Markov switching models

Sukgeun Jung, Il Su Choi, and Suam Kim

To evaluate and project the influence of climate-driven oceanographic changes on Korean fisheries, we applied canonical correspondence analysis to summarize changes in oceanographic conditions (1968–2010), volume transports of the Tsushima warm current (TWC) and cold waters, taxonomic changes in fishery catches (1968–2010) and zooplankton biomass and taxonomic compositions in Korean coastal waters (1978–2006) related to the regime-shift hypothesis. Water temperatures and zooplankton biomass density, averaged for all Korean seawaters, have significantly increased. Although the combined annual fishery catch has been relatively stable since the 1980s, the annual catch of individual fish species has fluctuated more greatly. By applying Bayesian Markov switching models, we could define four regimes and their characteristic fish species: (i) saury (1968–1976), (ii) pollock (1977–1982), (iii) sardine (1983–1990), and common squid (1991–2010). Because these four species have been major fisheries species in the Korea Strait and Japan/East Sea, which are under the influence of the TWC, we analysed seasonal and annual variations in volume transports of the TWC and bottom cold waters through the Korea Strait, but could not detect significant shifts in monthly volume transports. We will apply multivariate geostatistical methods and regime-switching models to time-series data of depth-specific water temperature and salinity

at 175 fixed stations along 22 oceanographic lines in Korean waters to summarize and detect shifts in oceanographic conditions since 1968.

Keywords: climate change, fish, regime shift, Tsushima warm current, western North Pacific.

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ICES CM 2011/Q:04

Climatically induced impact of gyre dynamics on coastal ecosystems: a comparison of different oceans

Jürgen Alheit

Dynamics of basin-wide oceanic gyres are driven by climate variability. There are various examples demonstrating that the strength and extent of gyres in the Atlantic and Pacific cause changes in offshore, shelf, and coastal ecosystems. Changes in the dynamics of the Atlantic Subpolar Gyre, related to the North Atlantic Oscillation (NAO) and Atlantic Multi-decadal Oscillation (AMO), cause reactions in the fauna of a large number of North Atlantic ecosystems affecting plankton, fish, and whales. Changes in ocean circulation associated with the Pacific Decadal Oscillation (PDO) affect zooplankton in the California Current. Dynamics of the Kuroshio and Oyashio Currents affect population size of Japanese sardine. Alternations of anchovies and sardines in the Humboldt Current seem to be driven by the approach and retreat of oceanic offshore waters, probably associated with gyre dynamics. These basin-wide events in different oceans will be compared.

Keywords: climate variability, fish, North Atlantic and Pacific, oceanic gyres, zooplankton.

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ICES CM 2011/Q:05

Atmospheric forcing of the North Atlantic Subpolar gyre

Hjálmar Hátún

Previous studies have shown that the North Atlantic subpolar gyre regulates both the marine climate and the spawning distribution and post-spawning migration of blue whiting in the Northeast Atlantic. A so-called gyre index has been used to represent the gyre dynamics, but uncertainty remains about which aspects of the gyre this index represents—the size/shape of the gyre, the circulation strength or perhaps both. Meridional fluctuation of the zero windstress curl line is here identified as the most important driver of the characteristic sub-decadal variability, evident in the gyre index. A closer description of this dynamics might facilitate realistic forecasting of the recruitment to the blue whiting stock.

Keywords: atmospheric forcing, blue whiting, forecasting, subpolar gyre.

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ICES CM 2011/Q:06

Regime shift effects on fish and fisheries in the Northeast Pacific

Anne Hollowed, Megan Stachura, Nate Mantua, and Ray Hilborn

In the North Pacific, retrospective studies show strong linkages between time trends in northern hemisphere ocean gyre circulation and time trends in groundfish, salmon, and pelagic fish production. Statistical models suggest that the region has experienced at least three potential change points in environmental forcing (1976/77, 1988/89, 1997/98). Recent data suggest that another regime may have occurred in the late 2000s. This paper updates and reviews the evidence

of these linkages and develops conceptual models linking fish responses to shifts in ocean conditions. We begin with a review of the exposure of fish to different sources of stress by life stage. Key processes such as prey availability, metabolic requirements, predation, and competition are considered. Key environmental indicators linked to vital rate processes are identified. The statistical relationship between environmental forcing and fish production (growth and recruitment) are evaluated using the indicators selected for this process and the conceptual mechanisms identified by reviewing life-history processes. Of particular interest for this session is a review of the performance of the statistical models in explaining shifts in fish production over previously observed shifts in environmental forcing. The potential impact of regime shifts on commercial fisheries is examined by incorporating environmental thresholds in a stock projection model.

Keywords: gyre circulation, recruitment variability, regime shifts.

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ICES CM 2011/Q:07

The Pacific Decadal Oscillation and gyre–ecosystem linkages in the northern California Current (NCC): source waters which feed the NCC determine foodweb structure

William T. Peterson, Hongsheng Bi, Cheryl A. Morgan, Jennifer Fisher, Jay Peterson, and Ryan Rykaczewski

Analysis of hydrographic and zooplankton data collected every two weeks in the coastal upwelling zone off Oregon for the past 15 years has shown that variations in sea surface temperature, salinity, copepod biodiversity, species richness, and community structure are correlated with the Pacific Decadal Oscillation (PDO). When the PDO is in negative phase (as in 1999–2002 and 2008), cold Subarctic waters from the Gulf of Alaska feed the northern California Current (NCC), transporting large, lipid-rich copepods to the shelf waters of the NCC; when the PDO is positive (as in 1996–1998, 2003–2007, and 2009), warm subtropical waters from offshore and south of Oregon feed the NCC, transporting small, oceanic lipid-poor copepods to the coastal upwelling zone. Thus the basin-scale variations in winds that drive the PDO result in changes in transport that in turn controls food chain structure in the upwelling zone off Oregon. These changes in food chain structure correlate with (and predict) salmon returns to the Columbia River. Here we use hydrographic, sea level, and altimeter data to show that changes in phase of the PDO are accompanied by changes in source waters which feed the NCC and changes in copepod community structure. To determine how the coastal upwelling ecosystem of the NCC might react to a climate change, we will need improved understanding of how basin-scale winds and variations in gyre circulation patterns affect source waters which feed the NCC and gyre–ecosystem linkages. Use of ROMS and GCMs should prove useful for this endeavour.

Keywords: copepod community structure, gyre–ecosystem linkages, Pacific Decadal Oscillation, transport.

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ICES CM 2011/Q:08

Exploring mechanisms for coherent variations between ocean gyres of the northern hemisphere

Emanuele Di Lorenzo and Niklas Schneider

In the North Pacific the strength of the boundary current systems and of the subtropical gyre circulation is characterized by strong, low-frequency variations evident in observed sea surface height, temperature, salinity, and nutrients. These fluctuations are coherent on decadal time-scales and emerge statistically as the second dominant mode of oceanic variability in the North Pacific, also referred to as the North Pacific Gyre Oscillation (NPGO). By exploring the coupled ocean–

atmosphere dynamics of the NPGO we find that the fraction of windstress curl variability that explains the dominant gyre-scale fluctuations originates from the central tropical Pacific and is driven by changes in sea surface temperatures typical of the non-canonical expression of *El Niño*, referred to also as the *Modoki El Niño* or central tropical Pacific warming pattern (CPW). Given that the changes in the extra-tropical atmospheric circulation forced by the CPW have significant impacts over the North Atlantic we explore the CPW teleconnection dynamics as a way to explain coherent variations between the ocean gyres of the northern hemisphere. In this new framework, suggestions for more frequent CPW events under greenhouse forcing scenarios may lead to more energetic fluctuations of the northern hemisphere gyre-scale circulations and play an increasingly important role in shaping the ocean and ecosystem climate of the twenty-first century.

Keywords: none.

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ICES CM 2011/Q:09   Poster

Influence of circulation variability on Scotian Shelf (Northwest Atlantic) zooplankton communities

Catherine L. Johnson

Zooplankton communities of the Scotian Shelf (Northwest Atlantic) are influenced both by local conditions on the shelf and by inflow of water from the Gulf of St. Lawrence and Scotian Slope. Relationships between the abundance of immigrant communities on the shelf and environmental variability were examined using time-series data collected by the Atlantic Zone Monitoring Program (AZMP) from 1999 to 2010. On the central Scotian Shelf, the abundance of Arctic *Calanus* species, considered to be immigrants from the Gulf of St. Lawrence, was negatively correlated with the abundance of warm-water offshore zooplankton species, which are immigrants from Scotian Slope water. Arctic *Calanus* species had negative relationships to both surface and deep-water annual average temperature anomalies, while warm-water offshore species had positive relationships to both. Arctic *Calanus* abundance was negatively correlated with the North Atlantic Oscillation (NAO) Index with a two-year lag, while the abundance of warm-water offshore species had no relationship with the NAO. The Scotian Shelf is a transition region with respect to environmental response to the NAO. Periods of low NAO are associated with anomalously warm conditions on the eastern Scotian Shelf and regions to the east, while the central and western Scotian Shelf and Gulf of Maine are anomalously cool during low NAO periods. Thus, while the observed negative relationship between Arctic *Calanus* species and temperature is consistent with the environmental preferences of these species, it does not appear consistent with increased advection from the Gulf of St. Lawrence.

Keywords: advection, biogeography, North Atlantic Oscillation, zooplankton.

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ICES CM 2011/Q:10

A PICES–ICES climate mode

Skip McKinnell

This talk will explore observations of pan-hemispheric ocean/atmosphere variation with a view to understanding the nature of their variations and their interconnections. It is focused on the mid-1990s because little of what was normal before then appears to have persisted to the present in at least some parts of the northern hemisphere. The talk will explore the spatial scale of change by building outward from local to regional to global scales of variation, in the hope that getting the spatial scale right might provide insight into the nature of the forces at play. The ocean/climate

system of the North Pacific Ocean is known, for example, for low-frequency temporal discontinuity but the Atlantic and Pacific appear to share some of these characteristics.

Keywords: none.

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Theme Session R

Integration of multidiscplinary knowledge in the Baltic Sea to support science-based management

ICES CM 2011/R:01

Investigation of spatial–temporal patterns of the eastern cod stock in the Baltic Sea for management applications

S. Kasatkina and P. Gasyukov

Data from the Baltic international trawl surveys (BITS) from 1991 to 2009 were used in this study. The authors used the non-stationary random field model to characterize the density field structure of the eastern cod stock for 2–7 age groups by depth strata in ICES Subdivisions 25, 26, and 28. The patterns of temporal and spatial distributions of cod are described by the components of the fields in the Karhunen–Loève expansion (which is similar to principal component analysis used for density field discretization). Spatial distribution structure is represented by the eigenvectors, while the temporal dynamics are represented by the expansion coefficients. It was revealed that the mean field value and two components of the extension are sufficient to describe 90% of the field variance for age 2 (recruitment) distributions. The same procedure for age groups 3–4 and 5–7 requires three components. This study revealed that it is possible to improve estimates of cod recruitment abundance indices by filtering with subsequent application of expansion coefficients in the short-term prediction of recruitment, to rebuild the missed abundance indices by years and depth strata when observations were not made, and to improve the BITS design with regard to cod field structure. In addition, evidence with regard to the underestimate of cod recruitment abundance indices in BIAS 1991–2009 has been obtained. This may be explained by the existence of the pelagic components of fish stock that is supported by acoustic observations during BITS and acoustic surveys.

Keywords: Baltic cod, recruitment, spatio-temporal distribution, trawl and acoustic surveys.

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ICES CM 2011/R:02

Assessment of genetic risk in fish inhabiting zones of dumped chemical munitions in the Baltic Sea

Janina Baršienė, Aleksandras Rybakovas, Thomas Lang, Laura Andreikėnaitė, and Wlodzimierz Grygiel

In the Baltic Sea, there are exclusive zones—the Bornholm zone, the Gotland Deep and the Little Belt Sea—where many thousand tonnes of chemical munitions (CM) were dumped after the Second World War. The goal of the study is to assess environmental genotoxicity levels in different fish species inhabiting dumped CM sites with the aim of outlining genetic risk levels, integrating stress and fish population health. Genotoxicity biomarker responses, such as the formation of micronuclei (cytogenetic and DNA damage), nuclear buds (DNA damage), binucleated cells with nucleoplasmic bridges (radionuclide effects), binucleated, 8-shaped cells (alterations in chromosome segregation and cytokinesis), or fragmented apoptotic cells (elimination of cytogenetic damage), were analysed in blood erythrocytes of flounder, dab, plaice, turbot, herring, and Atlantic cod. Multifactorial analysis of genotoxicity biomarker responses was applied in relation to fish condition and other bioparameters, such as fish age, length, sex, body and liver weight, stomach fullness, and population origin. The main findings of the work were a significant increase of genotoxicity in 2009–2010, compared to 2001–2004, in fish from the Bornholm Basin (up to 57-times) and the Little Belt (up to 17-times) CM dumping sites. GIS mapping of 2009–2010 data showed the highest level of genetic risk (responses over threshold level in 80–100% of specimens) in herring and flounder from 14 sampling stations in the Bornholm Basin and at station B01, located closely to the CM dumping site in the Little Belt. The ecological significance of genetic

damage, characterized as a long-term irreversible process, is discussed in relation to the genetic risk for wildlife populations.

Keywords: Baltic Sea, dumped chemical munitions, fish, genotoxicity.

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ICES CM 2011/R:03

First attempt to use trends assessment in the Gulf of Gdańsk: an ecosystem-integrated approach

M. T. Tomczak, L. Szymanek, P. Margoński, A. Ameryk, S. Gromisz, W. Grygiel, R. Grzebielec, J. Kownacka, E. Kuzebski, M. Pastuszak, I. Psuty, J. Warzocha, and M. Zalewski

The outcome of long-term studies carried out in the Gulf of Gdańsk (southern Baltic Sea) points to changes in primary production, phyto- and zooplankton biomass, and fish species assemblages, which may suggest substantial shifts in the ecosystem functioning. Knowing that the Integrated Trend Assessment (ITA) has been successfully used by the ICES/HELCOM Working Group of Integrated Assessment of the Baltic Sea in defining the abrupt changes in the ecosystem of the large subregions of the Baltic Sea, we have decided to apply this approach to statistically test temporal changes in the ecosystem of the Gulf of Gdańsk. We used the following statistical analyses: STARS (sequential *t*-test), principal component analysis (PCA), chronological clustering (CC), as well as traffic light plots allowing visualization of the statistical analyses. The numerous environmental (e.g. temperature, oxygen, salinity, nutrients), biological (phytoplankton, zooplankton), and fisheries (landings and cpue) variables constituted the input data for the statistical analyses performed for over one decade. The obtained ITA results point to significant changes in the Gulf of Gdańsk ecosystem on the decadal scale. The outcome of our calculations is presented in the larger, Baltic Sea context.

Keywords: ecosystem change, Gulf of Gdańsk, Integrated Trend Assessment.

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ICES CM 2001/R:04

Science–policy interfaces and the governance of environmental risks in the Baltic Sea

Michael Gilek, Sebastian Linke, Oksana Udovyk, and Mikael Karlsson

The governance of a marine ecosystem such as the Baltic Sea can be regarded as a relationship between two systems: a "governing system" and a "system-to-be-governed". Both are diverse, complex, dynamic, and vulnerable. We argue that science–policy interfaces constitute a key sphere of interaction between the two systems through, for example, scientific advice and politically negotiated management decisions. However, it is not fully clear if and how science–policy interfaces have evolved differently in response to various environmental risks in the Baltic Sea. Nor is it clear how emerging management objectives linked to ecosystem-based, precautionary and participatory approaches influence these science–policy interfaces. Our paper investigates different science–policy relationships with regard to the risks of overfishing, eutrophication, hazardous chemicals, oil discharges, and invasive species in the Baltic Sea. Three major aspects of science–policy interactions are analysed: (i) organizational structures of risk assessment activities, (ii) coping with scientific uncertainties and disagreements, and (iii) adaptations to emerging management objectives such as those linked to the concept of "good governance" and the ecosystem approach to management. Our results expose problems and conceptual inconsistencies of science–policy interfaces in all of the studied risk cases. We show that the commonly expressed division between assessments and management cannot be maintained and that close interactions between the scientific advisory systems and policy-making agendas result in unforeseen problems

for adhering to the modes of "good governance", such as stakeholder participation and inclusion of non-scientific knowledge into policy.

Keywords: Baltic Sea, risk assessment, risk management, scientific advice.

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ICES CM 2011/R:05

Baltic herring and *Anisakis simplex* larvae: acetylcholinesterase biomarker response and host–parasite interactions in a polluted environment

M. Podolska, K. Nadolna, B. Szostakowska, A. Was, and E. Gosz

Acetylcholinesterase (AChE) is widely used as a biomarker of exposure to neurotoxic compounds in aquatic environments. The best known function of AChE is to terminate the transmission of neural impulses by the rapid hydrolysis of acetylcholine into the inactive products of choline and acetic acid. The role of AChE in many parasite species differs from that in free-living organisms and may be important in host–parasite interactions. The activity of this enzyme in parasites (*Anisakis simplex* larvae) and their hosts (herring, *Clupea harengus*) was inversely related. The most divergence was observed between the AChE activity in parasites (highest level) and male hosts (lowest level) from the Gulf of Gdańsk, a polluted area of the Baltic. The results of experimental exposure of *A. simplex* to carbofuran indicate that larvae have a high threshold of sensitivity to this carbamate pesticide. Moreover, AChE activity was significantly higher in larvae exposed to carbofuran concentration of 500 μg l^{-1}, when compared with control samples. This may suggest the phenomenon of AChE overproduction, a protective mechanism against enzyme inhibitors previously described in insects. Many parasitic nematodes synthesize AChE in secretory glands and release enzyme into their external environment. The presence of AChE was detected using a native polyacrylamide gel electrophoresis not only in somatic extracts, but also in excretory-secretory products of *A. simplex* larvae. A secreted form of AChE obtained from larvae was characterized by a high level of activity, especially in nematodes from male hosts.

Keywords: acetylcholinesterase, *Anisakis simplex*, herring.

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ICES CM 2011/R:06   Withdrawn

ICES CM 2011/R:07

The usefulness of information on infection of herring with *A. simplex* larvae in management of Baltic herring stock

J. Horbowy and M. Podolska

Samples of herring from Polish waters (western, middle, and eastern coast) and German waters (Rügen and Mecklenburg area) were collected during the spawning seasons in 2004–2005. Classical and landmark-based geometric morphometrics were performed to quantify the body shape of herring. Discriminant analysis was applied to assign individuals to a particular stock of western or central Baltic herring. The presence of *A. simplex* larvae was used as a marker for herring feeding migration outside the Baltic. Infected herring represented both western and central Baltic stocks. The share of both stocks in western and central Baltic was determined, giving the approximate migration rate of herring. Next, the age-structured model including migration was developed to test for the effects of ignoring migration in the present assessment and management of both herring stocks. The model was fitted for a range of assumed migration rates (0.1–0.4 for western and 0–0.1 for central stock). In the model, part of the western stock migrates to central waters in the first half

of the year while a part of the central stock migrates to the western area in the second half of the year. Surviving immigrants return back to both stocks at the end of the half-year periods. Assuming migration results in estimates of spawning-stock biomass for the western stock higher and for the central stock lower than in the model ignoring migrations. The effect of migration on catches and biomasses ranged from low (<5% change) to moderate (20% change) compared with projections neglecting migrations.

Keywords: Baltic, herring, migration, stock assessment.

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ICES CM 2011/R:08

PBDE levels, profiles, inter-tissue distribution, and BSAFs in female flounder from the southern Baltic Sea

Ilona Waszak, Henryka Dąbrowska, and Agnieszka Antoniak

Polybrominated diphenyl ethers (PBDEs) have been included on the list of hazardous substances by the Helsinki Commission. It is a group of contaminants that raise concerns about their effect on the health of humans and ecosystems due to their physico-chemical and toxicological characteristics. The study examined PBDE levels, profiles, and inter-tissue distribution in flounder (*Platichthys flesusus*) collected from three locations along the Polish coastal zone of the Baltic Sea. In addition, sediment samples were taken from the same locations as the fish in order to evaluate biota-sediment accumulation factors (BSAFs). The chemometrical analysis was performed using an Agilent gas chromatograph equipped with an electron capture detector (GC-μECD). Mean PBDE concentrations in muscles were in the range 0.12–0.48 ng g^{-1} wet weight (11–23 ng g^{-1} lipid weight). The concentrations in gonads were not different from those in muscles while in livers they were more than three times greater. BDE 47 was the dominant congener in all three tissue types, however its contribution to the total PBDEs ranged from 37 to 45% depending on the tissue. In sediments, the levels were in the range 0.20–0.75 ng g^{-1} organic matter. PBDE profiles, inter-tissue distribution, and transfer from sediment (BSAFs) will be presented and discussed.

Keywords: Baltic Sea, flounder, BSAFs, PBDEs.

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ICES CM 2011/R:09

Challenges for stakeholder participation and communication within regional environmental governance. Comparing five environmental risks in the Baltic Sea

Magnus Boström, Marion Dreyer, and Anna Maria Jönsson

This paper focuses on challenges for stakeholder participation and communication within regional environmental risk governance (international in a regional context). We focus on environmental risks in the Baltic Sea. Our point of departure is the theoretical and normative assumption that the inclusion of a broad range of actors has the potential to facilitate environmental risk governance in both substantive (inclusion of more knowledge and viewpoints) and democratic (inclusion of different values and improved accountability) dimensions. Yet, research so far has done little to investigate the actual potential and challenges for such broad stakeholder participation and communication in a regional context. Such challenges are substantial, because the countries among the Baltic Sea differ considerably in power relations, cultures, and political histories. The paper focuses on how organizers of stakeholder participation and communication can deal with such and other challenges by comparing such processes (e.g. public hearings, scenario workshops) in five key risk issues concerning the Baltic Sea: marine oil transportations, chemicals, overfishing, eutrophication, and alien species. The analysis is based on case studies undertaken within each issue-area in the international research project RISKGOV—Risk Governance of the Baltic Sea. To

investigate the content (what is defined as relevant to communicate about) and form (who can take part, when and in what ways) of stakeholder participation and communication processes, we make use of framing theory and theories of risk communication.

Keywords: Baltic Sea, communication, governance, participation.

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ICES CM 2011/R:10

Changes in the annual life cycle of eastern Baltic cod during 1950–2010

T. Baranova, B. Müller-Karulis, I. Šics, and M. Plikhs

The annual life cycle of cod consists of the following phases: gonad ripening, spawning, feeding and growth, and recovery for spawning in the following year. In the present paper we analyse survey and commercial catch data from 1950 to 2010 to identify long-term changes in maturation, spawning time, weight dynamics, and formation of annual growth zones on otoliths in the eastern Baltic cod population. We related changes in the annual life cycle to environmental conditions and density-dependent effects. In 1960–1980, eastern Baltic cod spawned in March—May. Strongly irregular and prolonged maturation has been observed since the mid-1990s during the long deep-water stagnation period. In 1995–2003, summer spawning dominated. The recovery period lasted until late autumn and feeding and growth started in autumn and extended to spring of the following year. After 2004, part of the population returned to spring spawning. Consequently, towards the end of each year it was possible to clearly distinguish two groups of fish: spent and recovering after late spawning vs. fish already ripening for spawning in the following spring. In the late spawning group current year growth had not started yet, whereas ripening fish had completely ended their growth period. Both groups had a hyaline zone on the edge of the otoliths, but the opaque zone formed during current year growth was only present in the ripening group. Therefore, without knowing the maturity stage of the fish it is almost impossible to define their age correctly.

Keywords: eastern Baltic cod, maturation, otolith growth zones, spawning.

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ICES CM 2011/R:11

A stochastic model to evaluate the impacts of nutrient abatement measures in the Baltic Sea

Lassi Ahlvik, Kari Hyytiäinen, Petri Ekholm, and Heikki Pitkänen

The Baltic Sea is threatened by numerous environmental problems, with eutrophication being one of the most severe issues. Mitigation of eutrophication requires policies and abatement measures which aim to reduce nutrient load to the sea. Without proper economic and ecological research, resources could easily be wasted on inefficient measures that do not lead to the desired goals. In this study, we present an integrated economic–ecological model to estimate effects of abatement measures in the Baltic Sea. The model takes into account interdependencies between abatement measures, the accumulation of phosphorus in soil, and the dynamics of nutrients in the sea as well as uncertainties in biological processes. The model is demonstrated by estimating the costs and effects of separate and joint reduction of the use of inorganic fertilizers in all the littoral countries. Reduction of phosphorus fertilization is a cheap abatement measure, especially in countries with high initial soil phosphorus levels. It was shown to be the cost-effective way to reduce the average levels of cyanobacteria in the Baltic Sea. Nitrogen fertilizer reduction was the most efficient way to reduce the amount of algae in the short term, but it increases the risk of cyanobacterial blooms. Joint reduction decreases both algae and cyanobacteria, but it is not the most cost-efficient way to reduce either individually. Furthermore, the ecological consequences of load reduction were

shown to vary significantly between different sub-basins. This result suggests that there is no single water management policy that would be optimal in all parts of the Baltic Sea.

Keywords: Baltic Sea, eutrophication, nutrient pollution, stochastic modelling.

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ICES CM 2011/R:12

Reference organisms for assessing the impact of ionizing radiation on the southern Baltic environment

Tamara Zalewska and Maria Suplińska

Assessment of the impact of ionizing radiation on the marine environment requires well-defined methodology including the analysis of exposure and effects. The exposure assessment is based on measurements of the intensity, frequency, and duration of exposure of organisms to radionuclides currently present in the environment or on estimation of hypothetical exposure related to possible accidental releases. One of the most important components of the assessment system is to identify reference organisms specific to the assessed area and fulfilling special assigned requirements with regard to radio-ecological sensitivity, widespread distribution, and amenability to research and monitoring. The following species specific to the southern Baltic Sea environment and representing diversified ecological niches were proposed as reference organisms: *Polysiphonia fucoides* as a representative of the macroalgae, benthic fauna represented by *Gammarus zaddachi* (crustacean), *Saduria entomon* (crustacean), *Hediste diversicolor* (polychaete), *Mytilus trossulus* (mollusc), and fish represented by *Clupea harengus* (pelagic planctotrophic fish), *Gadus morhua* (pelagic carnivorous fish), and *Platichthys flesus* (benthic fish). Activity concentrations of caesium-137 were determined in reference biota as well as in seawater and sediments as required for the total dose–rate evaluation and relevant concentration factors were calculated.

Keywords: Baltic Sea, ionizing radiation impact assessment, marine organisms.

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ICES CM 2011/R:13

Converging biology, economics, and social science in fisheries research—lessons learned

Päivi Haapasaari, Soile Kulmala, and Sakari Kuikka

It has been acknowledged that natural sciences cannot provide an adequate basis for the management of complex environmental problems. The scientific knowledge base has to be expanded towards a more holistic direction by incorporating social and economic issues. Besides this, multifaceted knowledge has to be summarized in a form that can support science-based decision-making. Interdisciplinary skills and methodologies are required that permit the integration of knowledge from conceptually different disciplines. We built an integrated decision support tool for the long-term management of the Baltic salmon stocks, using the Bayesian networks. It allowed the analysis of the outcomes of different management measures from biological, social, and economic perspectives. The synthesis was the final output of a learning process over eight years. We reflect how and what kind of interdisciplinarity between natural scientists, economists and social scientists grew from the need to better understand complexity related to the salmon fisheries in the Baltic Sea, what we learned about the fishery, and what we learned about interdisciplinary collaboration.

Keywords: Bayesian networks, interdisciplinarity, learning, multidisciplinarity.

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ICES CM 2011/R:14

Dynamics of the key foodweb flows in the central Baltic Sea

M. T. Tomczak, S. Niiranen, T. Blenckner, and O. Hjerne

The central Baltic Sea is a semi-enclosed, highly productive area with a low biodiversity, where only a few key species drive the system's dynamics. Recently, an ecosystem regime shift was described, with pronounced changes at all trophic levels driven by changes in fishery and climate and leading to foodweb reorganization and changes in the trophic flows. An Ecopath with Ecosim Baltic Sea foodweb model was developed to simulate and better understand the changes in trophic interactions. The model contains 22 functional groups that represent the main foodweb components, was calibrated to long-term monitoring data (1974–2006) covering multiple trophic levels, and is forced by fisheries and environmental time-series. Our results show a dynamic quantification of flows through the foodweb with an average transfer efficiency of 12% between the trophic levels II–IV. The model is able to explain 54% of the variation and to simulate the regime shift from a cod-dominated system to a sprat-dominated one. The results further show an increase in *Acartia* sp. biomass and the cascading effect from cod as well as sprat to *Pseudocalanus* sp. Macrozoobenthos was identified as an important element transferring energy directly from the trophic level I to top predators. Fisheries effects on the foodweb were detected as equally important to environmental change and a "fishing down the foodweb" was detected. Overall, this new Central Baltic Sea foodweb model is able to describe the past dynamics of multiple trophic levels. Uncertainties and limitations of the model approach and results in particular in relation to management options will be discussed.

Keywords: central Baltic Sea, foodweb, model, trophic flows.

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ICES CM 2011/R:15

Target strength relationship for herring and sprat in the southern Baltic Sea

Beata Schmidt, Natalia Gorska, and Joanna Szczucka

Acoustic surveys are systematically conducted to estimate the abundance of herring and sprat in the Baltic Sea. For the proper transformation of hydroacoustic estimates to fish biomass, the relationship between the size of fish and its acoustic target strength (TS) is critical. Currently, the target strength of Baltic clupeids, both sprat and herring, is estimated using regression: $TS = 20 \log L - 72.1$, where L is fish length obtained in the 1980s. However, *in situ* TS measurements of Baltic clupeids obtained in different parts of the Baltic Sea during last 10 years produced up to 8 dB difference. Additionally, it has been suggested that two TS–fish length relationship should be used—one for sprat and young herring and the other for adult herring. The acoustic target strength of herring and sprat was determined by an EK60 split-beam echosounder working at 38 kHz. It was accompanied by pelagic trawls giving the catch composition. These data were collected on board the RV "Baltica" during the Baltic International Acoustic Survey in 2009 and 2010 in the Polish part of the ICES Subdivisions 24, 25 and 26. The relationship between TS and L was determined using the equation $TS = 20 \log 10 \, L + b_0$. The results of the analysis are presented and discussed.

Keywords: acoustic survey, Baltic Sea, herring, sprat, target strength.

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ICES CM 2011/R:16

The possible sources of conflicts between nature protection and Polish coastal fishery. The Pucka Bay case

I. Psuty, B. Draganik, L. Szymanek, I. Wójcik, and R. Zaporowski

Pucka Bay is a relatively small site in the Polish Maritime Area, but many interests are represented here. It is a traditional fishery ground for coastal small boats, and a very attractive tourist area for summer holidays. There are big cities nearby with well-travelled water routes and developing underwater infrastructure. Pucka Bay has suffered from rapid urbanization processes, eutrophication, habitat destruction, and species alterations. There is also the NATURA 2000 site within the area. In recent years, a conflict has developed between the local community and proposed rules for nature protection directed toward certain fish and sea mammal species. We analyse the possible sources of conflicts together with socio-economic models of drivers, impacts, and responses. We specify the challenges for the scientific forum, including knowledge quality, uncertainty, and communication. The current situation in Pucka Bay is very complicated and has no simple solution. Effective and integrative operations are needed. Nature protection should be based on scientific knowledge, such as where and how to protect the most sensitive habitats and species. Concerning the gaps in knowledge, the expert's opinion is often the main factor determining law enforcement. The expert has the responsibility of summarizing findings and opinions, verifying them if possible, and giving advice based on risk assessment procedures. Real problems arise if there is no effective, three-way communication between community, scientists, and administration. The solutions can be found only upon recognition and resolution of the sources of difficulties.

Keywords: gillnet, grey seal, NATURA 2000, porpoise, small-scale fishery.

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ICES CM 2011/R:17

An integrated assessment of pollution and biological effects of the southern Baltic Sea coastal waters

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Within the framework of an EU-funded project "BEAST (Biological Effects of Anthropogenic Chemical Stress: Tools for the assessment of Ecosystem Health), effort was undertaken to assess pollution and biological effects in the southern Baltic Sea coastal waters. Parallel measurements of chemical contaminants and biological effects in a variety of matrices were conducted in order to establish integrated measures that can form a basis for the assessment. The contaminants measured included several groups of organic compounds and heavy metals. Measurements of biological effects included a set of techniques that targeted various biological processes in fish and invertebrates. In fish these were: ethoxyresorufin-*O*-deethylase (EROD) activity, DNA damage, histopathological alterations in livers and spleens, and gonado-somatic index (GSI). In invertebrates the endpoints were: acetylcholinesterase (AChE) activity, embryo malformation rate, lysosomal membrane stability (LMS), oxidative stress, cardiac activity, and hydrocarbon-degrading bacteria. The assessment also included sediment quality which was derived upon standard toxicity tests with marine invertebrates. The methodological approach and the assessment results will be presented and discussed.

Keywords: anthropogenic stress, Baltic Sea, biomarkers, ecosystem assessment.

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ICES CM 2011/R:18

Projected Baltic Sea ecosystem changes in future climates

H. E. M. Meier, H. Andersson, C. Dieterich, K. Eilola, B. Gustafsson, A. Höglund, R. Hordoir, I. Kuznetsov, T. Neumann, O. Savchuk, and S. Schimanke

Within the BONUS project ECOSUPPORT, the combined future impacts of climate change and industrial and agricultural practices in the Baltic Sea catchment on the Baltic Sea ecosystem have been assessed. An ensemble of model simulations for the period 1961–2099 has been performed to calculate the impact of nutrient load reductions in future climate and to quantify uncertainties. Four climate change scenarios using regionalized data from two general circulation models (GCMs) and two greenhouse gas emission scenarios (A2, A1B) have been used to force three state-of-the-art coupled physical–biogeochemical models. Four nutrient load scenarios ranging from a pessimistic business-as-usual to the more optimistic case following the Baltic Sea Action Plan have been investigated with the models. In this study we have focused on annual and seasonal mean changes of ecological quality indicators describing the environmental status of the Baltic Sea. Agreement and disagreement of the simulated changes have been assessed from the statistics of the ensemble. The model simulations suggest that projected changing climate is an important driver in relation to eutrophication and it will reduce the water quality of the Baltic Sea. Reduced salt water inflow of oxygen-rich water will increase hypoxic bottom areas and reduce Secchi depth in some regions. According to our results the efficiency of nutrient load reductions will be smaller in future climates compared to the present climate. Thus, measures included under current legislation might not be sufficient to improve water quality at the end of the century.

Keywords: Baltic Sea, climate change, eutrophication, modelling.

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ICES CM 2011/R:19

Herring as a link among pressures in multidimensional ecosystem management

M. Rahikainen, S. Mäntyniemi, I. Helle, and S. Kuikka

Eutrophication and global climate change are typical drivers of marine environmental change. Additional pressures may operate in some particular regions. In the Gulf of Finland, rapid and dramatic growth of tanker traffic has increased oil spill probability and related ecosystem risks. These risks are linked to recreational and commercial utilization of aquatic resources, maintenance of ecosystem services, and conservation of species richness. The drivers and pressures are managed by policy instruments related to agriculture, maritime traffic, and climate change. The decisions made in those domains affect the herring stock which supplies one of the most valuable fisheries in the area by size and value of landings. The implementation of fishery management affects the status of the herring stock and the wealth gained from the resource, but environmental pressures also play a role in shaping the future of herring and our anticipation of it. Eutrophication affects stock–recruitment relationships, possible oil spills pose a threat to the survival rate, and climate-induced fluctuations in salinity affect growth rate and production by altering prey composition. The uncertainty and risks to fisheries caused by contemporary drivers affecting various parts of the life cycle of herring were analysed using a Bayesian fish stock model, merging the available knowledge of the environment, human actions, and herring stock dynamics.

Keywords: Baltic Sea, Bayesian assessment, herring, risk.

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ICES CM 2011/R:20

Experiences on ecological status assessment of the Gulf of Bothnia different sites based on cardiac activity biomarkers of caged mussels (*Mytilus edulis*)

S. V. Kholodkevich, T. V. Kuznetsova, K. K. Lehtonen, and A. S. Kurakin

Physiological biomarkers are widely used for quality assessment of surface waters. To assess the ecological status of different aquatic environments an approach based on transplantation of mussels from a reference site and their exposure in cages in areas affected by anthropogenic impact over a selected period has been applied. The procedure of heart rate (HR) measurements is well developed and described previously. In the present study by means of standardized test stimuli, used as functional loading, the cardiac responses of *M. edulis* were recorded after ca. three weeks of caging exposure at four sites in the Gulf of Bothnia. The experimental work was carried out on board the Finnish research vessel "ARANDA" in September 2010. A tendency for a rapid recovery (after salinity stimuli) of individual HRs to return to their "background" values can characterize good physiological status of test organisms as having better adaptive capacities to restore their normal physiological status. The latter can give the opportunity to extrapolate data for assessment of ecosystem health status for various sites. The following cardiac activity biomarkers were used for evaluation of the physiological status of *M. edulis*: (i) time of organism recovery, calculated as time needed for HRs to recover to individual background-specific patterns (min) after salinity test (restoration of natural salinity); (ii) standard deviations (SD) of HRs over a group of test animals calculated 1 h after test stimulus removed. Based on the obtained data, the authors suggest the establishment of ranges for ecosystem state assessment for different sites in the Gulf of Bothnia.

Keywords: none.

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ICES CM 2011/R:21

Cross-scale linkages and trade-offs in multilevel water governance—a case study from the northern Baltic Sea river basin district

Monica Hammer, Mona Petersson, Ulla Mörtberg, and Jerker Jarsjö

In this paper, we apply an ecosystem approach to governance of water resources in the Baltic Sea drainage basin. In the Baltic Sea region, the EU Water Framework Directive (WFD) and the Marine Strategy Framework Directive are two of the most important pieces of legislation in recent years for developing the governance of joint water resources. The WFD provides a new regional administrative framework based on river basin districts along the lines of an ecosystem approach. However, the water authorities imply larger areas than would always be relevant from a local management perspective. Water-related ecosystem services, though often meeting needs expressed over large spatial scales such as the Baltic Sea, are actually generally delivered at the local scale, such as the Stockholm archipelago. There are still many uncertainties regarding appropriate forms and roles for participation, as well as use and transfer of knowledge from the local level. Hence, cross-scale interactions and trade-offs are critical for developing sustainable water governance in the Baltic Sea region. Focusing on the northern Baltic Sea river basin district discharging into the Baltic Proper, we analyse challenges and trade-offs regarding data and information management from the local landowner to the regional basin, applying hydrological mapping and GIS-based tools. Problems in ecosystem management as indicated in our case study include lack of and quality of data and information. The importance of institutional arrangements that can handle the variability of local situations and trade-offs between different solutions and priorities on different hierarchical levels are discussed.

Keywords: Water Framework Directive, ecosystem approach, data and information management.

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ICES CM 2011/R:22

Cadastre of the coastal zone of the Russian sector of the Baltic Sea—integrated information system

V. Zhamoida, D. Ryabchuk, B. Arseniev, G. Gogoberidze, and V. Sivkov

The coastal zone cadastre represents an integrated information system developed by the Russian Research Geological Institute (VSEGEI) in 2008. The principles of the cadastre were developed together with specialists of the ICZM Department of Russian State Hydrometeorological University. The cadastre is built according to regional principles, combining offshore and onland parts of the coastal zone in continuous interaction. The separate "cadastre objects" are distinguished according to complex indications, mainly based on superficial geological environments which are important for spatial planning and integrated coastal zone management. The cadastre consists of special information blocks covering: administrative structure, economics, and population; geology; geomorphology; landscape; and ecology. Information for each block is represented as layers of GIS maps, "passports"—short, formalized descriptions of the cadastre object, and "files"—comprehensive descriptions of cadastre objects. The set of GIS maps includes a map of bottom sediment distribution, a geomorphologic map, a facial map, a map of anthropogenic load, environmental geological maps, etc., which can be used as a basis for different purposes, including habitat mapping. The project was developed on the basis of software designed by VSEGEI using modern program–technological solutions. An integrated data medium for operation with GIS maps, MS Office documents, raster graphics, photos, etc., was designed. The software application in a local version is simply copied to the user PC. The installation of special GIS or database management systems is not required. The software application is easily transformed for network operation. This means users can work with the cadastre by means of a standard Internet browser. This software technology project can be easily integrated with different GIS technologies.

Keywords: cadastre, coastal zone, information system, Baltic Sea.

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ICES CM 2011/R:23

Stakeholders' participation and communication in invasive alien species risk governance in the Baltic Sea region

Zgrundo, P. Lemke, K. Smolarz, D. Pyć, Ch. Halling, and M. Wołowicz

Invasive alien species (IAS) are one of the most severe threats for the Baltic Sea. However, they are still not regarded as such an important and urgent problem as in other marine and freshwater basins, and only during the last couple of years have they received significant attention within EU structures. In general, it is not the introduction itself but the potential negative consequences associated with IAS establishment in the ecosystem that are regarded as the most important issue, as they are likely to cause changes in the structure and functioning of the ecosystems, and consequently affect goods and services of interest to humans. Based on our findings, we argue that currently effective preventive action and IAS management through dialogue and cooperation at regional, national, and local level is very difficult if not impossible because of the number of disagreements and the scope of misunderstanding on the issues as fundamental as the interpretation of alien species. Identified obstacles also include stakeholders' disagreement on framing, precautionary measures and communication of the risk, which is even strengthened by scientific uncertainty. Consequently, the development of a unified legislative framework and governance system allowing proper IAS risk assessment and management is significantly hampered. In the presentation we show the most important results of our studies on stakeholder participation and communication in IAS risk governance in different Baltic countries, and propose a normative framework for effective communication together with the development of public awareness.

Keywords: alien species, Baltic Sea, risk communication, risk governance.

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ICES CM 2011/R:24   Withdrawn

ICES CM 2011/R:25

Policy-driven non-compliance in the Baltic Sea pelagic fishery

J. Hentati-Sundberg, J. Hjelm, and H. Österblom

The limited capacity of the Common Fisheries Policy (CFP) of the European Union to deliver on social, economic, and ecological goals is broadly acknowledged. There is an ongoing discussion on options to transform the CFP in a sustainable direction in the current reform process. Negative feedback loops between scientific recommendations for quotas and corresponding political decisions may contribute to a failure to reach agreed goals. The subsequent poor economic prospects in the fishing sector may be contributing to non-compliance, thereby reducing the capacity of science to perform adequate stock assessment and recommendations. This study uses observed patterns of fishing and reporting, taken from fishers' logbooks. The study shows how 15 years of policy has created economic incentives for non-compliance in the Swedish Baltic Sea pelagic fishery. The response of fishers corresponds well to the incentive structure identified: incentives have driven non-compliance in reporting of fish quantities and species composition in landings. Data indicate that non-compliance is the rule rather than the exception in this fishery. The design of the TAC (total allowable catches) fisheries management system appears to be a fundamental reason for this pattern. The TAC system has not been successful in limiting fisheries mortality but has instead boosted non-compliance. The implications of the findings are discussed in the light of the ongoing reform of the Common Fisheries Policy.

Keywords: Baltic Sea, incentives, non-compliance, pelagic fishery, policy.

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ICES CM 2011/R:26   Poster

Selected highlights from the ECOSUPPORT project

The ECOSUPPORT consortium

The response of the marine ecosystem during the twenty-first century depends on several, partly competing drivers, such as expected reduced phosphorus and nitrogen loads, increased water temperatures, and reduced salinities. Thus, presently discussed targets for nutrient load reductions to improve the ecological status in the present climate might have a different outcome in future climate conditions. The main aim of ECOSUPPORT is to provide a multimodel system tool to support decision-makers to assess the anthropogenic impact on the state of the Baltic Sea environment. The tool is based upon scenarios from an existing state-of-the-art coupled atmosphere–ice–ocean–land surface model for the Baltic Sea catchment area, physical– biogeochemical models of differing complexity, a foodweb model, statistical fish population models, economic calculations, and new data detailing climate effects on marine biota. The expected outcome is an advanced modelling tool for scenario simulations of the whole marine ecosystem that can underpin and inform design strategies to ensure water quality standards, biodiversity, and fish stocks. For the aims of ECOSUPPORT, 14 research groups from 11 institutes and from seven Baltic Sea countries formed a consortium consisting of university institutes, national governmental agencies, and research institutes (including EU-recognized centres of excellence) with a wide range of expertise. The poster will summarize selected results from the work performed during the project.

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ICES CM 2011/R:27   Poster

Long-term changes of macrozoobenthos in the deep part of the Gdańsk Basin (Baltic Sea)

A. Gusev and L. V. Rudinskaya

In the last decade changes in the hydrological regime have been seen in the Gdańsk Basin (Baltic Sea). The qualitative and quantitative characteristics of the bathymetric distribution of macrozoobenthos have been analysed at depths more than 61 m. The material was collected at 10 stations during 2001–2007 and treated by standard methods. In 2001–2007, 14 macrozoobenthic species (8–10 in each year) were found at depths of 61–70 m. Abundance and biomass were 668–1691 individuals m^{-2} and 66–210 g m^{-2}. Five species (4 in 2001–2003, 2–3 in 2004–2007) at depths of 71–80 m were observed. In 2001–2003, abundance was 230–498 individuals m^{-2} and in 2004–2007 it was 25–92 individuals m^{-2}. Biomass also decreased from 29–82 g m^{-2} in 2001–2003, 29 g m^{-2} in 2004 to 1–2 g m^{-2} in 2005–2007. Macrozoobenthos was found at depths of 81–90 m only in 2002–2005. These were single specimens of *Bylgides sarsi* and juvenile *Macoma balthica*. In 2004, the polychaete *Scoloplos armiger* was found after a strong inflow in winter 2002–2003. Abundance and biomass were 2.5 individuals m^{-2} and <1 g m^{-2}. *Bylgides sarsi* was detected at depths more than 91 m in some years (2003 and 2006). Our results agree with earlier data. Previously, at depths of 71–80 m there had been low species diversity of macrofauna, but with high abundance and biomass. It is shown that in 2003–2007 conditions for the existence and quantitative development of macrozoobenthos in the depth range 71–80 m worsened and on the other bathymetric ranges remained the same.

Keywords: none.

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ICES CM 2011/R:28   Poster

On the acoustic estimation of Baltic herring biomass

Natalia Gorska and Jakub Idczak

Reliable assessment of commercially and ecologically important Baltic clupeids is a basic prerequisite to management of a sustainable fishery. Acoustic surveys efficiently quantify the abundance of fish stocks. The accuracy of the estimates are exceedingly dependent on the accuracy of the relationship between fish individual target strength *TS* and length *L*. The *TS–L* relationship developed for North Sea herring is used in acoustic stock assessment for Baltic clupeids. Previous studies demonstrated that the relationship is not accurate in the Baltic Sea. However, *in situ* measurements demonstrated strong variability of *TS* for Baltic clupeids in different regions and seasons, with up to 8 dB difference. Understanding variability is important in selecting a *TS–L* relationship that is reasonable for biomass assessment. This paper addresses the numerical analysis of the difference in the backscattering properties of two herring groups. The first group included herring individuals from the Swedish coastal zone (ICES Subdivisions 25, 27, and 29) and the second was from the Polish coastal zone (ICES Subdivision 26). The material was collected in October 2002 and 2010, respectively. An X-ray study was conducted for the second herring collection. Based on the X-ray images, the swimbladder and fish body dimensions were measured for each herring individual. The results were compared with the swimbladder morphometry parameters of herring from the first group. The effect of the observed swimbladder morphometry difference on the *TS–L* relationship was demonstrated. The analysis improved our understanding of the strong variability of Baltic clupeids *TS* in different regions and seasons.

Keywords: Baltic Sea, herring, numerical modelling, target strength, X-ray images.

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ICES CM 2011/R:29   Poster

Management strategy evaluation of MSY fisheries with combined catch-and-effort quotas

Noel M. A. Holmgren, Niclas Norrström, Robert Aps, and Sakari Kuikka

ICES is currently in the transition to establish maximum sustainable yield (MSY)-based advice, which includes the recovery of stocks that are out of bounds from MSY management. The harvest control rule (HCR) is based on a target fishing mortality (F) with a spawning stock biomass (SSB) reference point for reducing mortality. A stock harvested at F_{MSY} still exhibits considerable variation in yield due to interannual stochastic biophysical processes. The variation *per se* is economically problematic for the fisheries, and deviations from the most productive state of the stock results in yield losses. Here we present the results of a management strategy evaluation in which TAC quotas are compared with combined catch-and-effort quotas: Bayesian quotas. Bayesian quotas can be calculated with Bayesian statistics and used to define when the combined catch and effort indicates that the stock is at SSB_{MSY}. We have used an operational model of the Baltic Sea herring, applied virtual fishing, and made stock assessments with a statistical catch-at-age without modelling artificial surveys. We compare the total yields, variation in yields, SSB, and variation in SSB. These first-stage data are the basis for developing MSY-based HCRs. The second stage runs have implemented HCRs at which we again look at total yield, variation in yield, but also show how the stock behaves in relation to reference points such as $B_{trigger}$.

Keywords: harvest control rule, MSY, productivity, SCAA, sustainability, TAC, yield.

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Theme Session S

Extracting energy from waves and tides—what are the consequences for ecosystems, physical processes, and other sea users

ICES CM 2011/S:01

Accommodating wave and tidal energy—knowledge transfer and the role of marine spatial planning

Kate Johnson and Sandy Kerr

Harvesting the energy of waves and tides is still the subject of research and development as an increasing number of ingenious devices are invented and subjected to test. It is unclear which, if any, of these will ultimately be chosen for commercial deployment but the capacity for research and testing has expanded rapidly into an active multi-million pound sector. Preparations for a commercial phase are underway in Scotland with the allocation of seabed leases to developers in the seas around Orkney; just in advance of Scotland's first statutory marine spatial plan (MSP) which is under preparation in the area. Anxiety to build confidence in a new and nationally important industrial sector conflicts with a plethora of uncertainties about technology and impacts on the natural environment and existing uses. MSPs will help to build a new governance structure for marine space but in the Pentland Firth and Orkney (PFOW) waters area it is struggling to catch up with events. The EU FP7-funded MESMA programme is designed to create a generic framework and tools for MSPs tested through nine case studies across Europe, including one in the PFOW which is led by ICIT/Heriot-Watt University. This paper examines the PFOW case study and the gaps in knowledge which must be filled to build MSPs and the development of a balanced and sustainable marine energy industry.

Keywords: knowledge transfer, marine spatial planning, wave and tidal energy.

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ICES CM 2011/S:02

Marine Scotland Science: contribution of bathymetric surveys to marine planning for renewable energy developments off the west coast of Lewis

P. J. Hayes, M. Harrald, and I. M. Davies

Marine Scotland Science (MSS) has been tasked with contributing to planning for the emerging wave and tidal energy industries by providing regional datasets from selected areas around Scotland. One aspect of the work was to survey the bathymetry of the west of Lewis, which represents one of the best wave resource areas in the UK. Bathymetric data were collected using the FRV "Scotia" with a Reson Seabat 7125-B multibeam echosounder system. Transect lines were spaced so as to ensure greater than 50% overlap of adjacent swathes for the majority of the survey area. In total, 260 km^2 of predominantly hard ground were surveyed to the west of Lewis from 21 July to 6 August 2010. The data were post-processed using industry-standard software. A quantitative approach was applied to make the best use of the bathymetric dataset. Within Arc GIS, the bathymetric data were used to create shape files with 5-m depth intervals and 3° gradient intervals. A separate shapefile was created with buffer zones running parallel with 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 of wave power converters 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 2011/S:03

Marine Scotland Science: regional seabed habitat mapping contributing to planning for marine renewable energy development

M. Harrald, M. Robertson, P. J. Hayes, and I. M. Davies

Marine Scotland Science (MSS) has been tasked with contributing to planning for the emerging wave and tidal energy industries by providing regional datasets from selected potential development areas around Scotland. Sustainable development must take into account seabed conservation interests. Inshore waters to the west of the Isle of Lewis contain one of the best wave resource areas in the UK and have not previously been surveyed using multibeam systems. Bathymetric data were collected using the FRV "Scotia" with a Reson Seabat 7125-B multibeam echosounder system together with ground-truthing data collected using a drop-frame TV. In total, 260 km^2 of predominantly hard ground were surveyed, 36 seabed TV tows were completed and over 600 digital stills were collected to the west of Lewis from 21 July to 6 August 2010. The bathymetry and backscatter data were post-processed using industry-standard software. An integrated approach was applied in which bathymetric, backscatter, and derived datasets were used to identify changes in the seabed facies. Subsequent ground-truthing of the seabed facies using the footage from a drop-frame TV allowed the compilation of a regional seabed habitat map leading to an assessment of the conservation interests in the area.

Keywords: backscatter, bathymetry, habitat map, Lewis.

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ICES CM 2011/S:04

Disturbances of natural physical fields by technical activities and their implications for marine life: the case of the Baltic Sea

Eugeniusz Andrulewicz and Zbigniew Otremba

This paper deals with increasing marine environmental concerns stemming from existing and planned technical activities in the Baltic Sea. Some of these activities interfere with natural physical fields (such as acoustic, magnetic, salinity, temperature, etc.) as well as disturb different natural processes (such as natural coastal dynamics, sedimentation, migration patterns of mobile species, etc.). In order to illustrate this problem, the most recent large-scale constructions in the Baltic Sea (Oeresund Bridge, SwePol Link power cable, Nord-Sream pipeline, offshore wind farms, and coastal defence structures) were selected. Disturbances of natural physical fields and possible ecological consequences of such disturbances are analysed. Proposals related to necessary monitoring and research activities, as well as the mitigation measures, are presented.

Keywords: Baltic Sea, environmental disturbances, physical fields, technical constructions.

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ICES CM 2011/S:05

Seabird surveys at the wave energy test site, County Mayo, Ireland

Jackie Hunt, Jessica Beaubier, and Derek McLoughlin

A wave energy test site is proposed for inshore waters off the west coast of County Mayo, Ireland. The test site has been selected for its high wave energy levels, due to full Atlantic exposure conditions. Some seabird data for the test site is available from past surveys of Irish waters.

Detailed data are not available and baseline bird surveys as part of the environmental impact assessment began in 2009. Surveys at sea followed standard European Seabird at Sea survey methods. Eight surveys were completed between October 2009 and October 2010, excluding winter. A total of 8092 birds of 33 species were recorded. In March 2011 monitoring surveys began at the wave energy test site. The monitoring survey design has been adapted to detect the effects of wave energy-related activities on bird densities within the immediate area surrounding each test berth. It is an experimental approach that uses test (berth) and control sites with pre- and post-activity monitoring. Because there are only two test berths, the "treatment" sample size of any sampling design is limited to 2 in order to avoid pseudoreplication. This, coupled with natural variance in seabird numbers, means that the power to detect *small* differences in seabird densities will be rather limited. Large-scale differences should, however, be detectable. The key challenge has been how to develop an effective sampling strategy within practical and budgetary limitations and for a novel development. Baseline survey work was financed by Tonne Energy Ltd.

Keywords: none

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ICES CM 2011/S:06

Benthic monitoring at Strangford Lough Narrows in relation to the installation of the SeaGen current turbine

Robert Kennedy and Graham Savidge

A SeaGen current turbine was installed in Strangford Narrows, Northern Ireland in 2008. As part of the associated ecological assessment, epifaunal communities present on tide-swept reefs in the Narrows were surveyed. Four stations were sampled by video quadrat: a reference station and three impact stations along the axis of the Narrows. One pre-installation and five post-installation surveys have been carried out as of April 2011. The epifaunal communities of Strangford Narrows conform to EUNIS biotopes encompassed by CR.HCR.FaT very tide-swept faunal communities. The stations sampled in the baseline survey were strongly differentiated and only overlapped occasionally by community composition with their nearest neighbours. This pattern was maintained throughout the sampling programme, though there was a seasonal shift in the communities in summer. In this very high-energy area, there appears to be no significant deleterious effect of the turbine installation. The three-year period of monitoring up to this point while the current turbine is operating at a very low level of activity will provide a good baseline against which to assess future changes when the turbine becomes fully operational. Another project to determine the successional change in communities in relation to distance from the most high-energy areas of the Narrows commenced in 2011 using multibeam acoustic survey, current modelling, and drop-down video assessment of community structure. The outputs of this project may inform managers on the likely effects of the harvesting of kinetic energy from tidal flows in other, less optimal locations.

Keywords: benthic community, ecological impact, Ireland, tidal energy.

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ICES CM 2011/S:07

Ornithological interactions with wave and tidal energy developments in Scotland—filling the knowledge gaps

Ross McGregor, Andy Douse, George Lees, and Ian Davies

Climate change is an important threat to marine ecosystems, but its mitigation will include the generation of wave and tidal energy. It is important that mitigation does not come at a greater cost to marine ecosystems than climate change itself. To assist appropriate development, knowledge gaps relating to marine birds have been identified and addressed. Work has focused on

understanding bird collision risk from tidal turbines, by developing a method that uses exposure time population modelling. In tandem with this, trialling the application of sonar for tracking marine birds underwater has been undertaken and this will now be applied in a new research project. Work has also focused on developing suitable methods for bird surveys to provide an evidence base for future developments in Scotland using new survey techniques (including digital aerial imaging). Furthermore, we need a better understanding of connectivity between breeding locations (protected areas) and foraging areas so approaches using new, cheaper devices for tracking seabirds from suitable colonies have been developed. We are developing standardized guidance on survey methods and, because multiple developments have been proposed over small spatial scales, guidance on assessing cumulative impacts is being produced. The world's first demonstration array was recently given consent in Scotland, providing an opportunity to test the methods above and to identify new knowledge gaps. The production of suitable environmental assessment methods will aid the development of the marine renewables industry, ensuring that it can help mitigate the impacts of climate change while reducing the impacts of the developments themselves.

Keywords: birds, impacts, renewable energy.

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Coastal process impact assessment in relation to offshore wave energy development

Jimmy Murphy

At present there is no commercial operational wave energy site worldwide but a number of countries with high resource levels have set up test sites with the view to deploying pre-commercial prototype devices. The creation of these sites has led to the examination of potential impacts on the coastal physical environment, particularly since wave energy convertors (WECs) can have a direct effect on the local and far-field hydrodynamics. Potential changes to the wave and current regime could affect human activities (boating, surfing, etc.) as well as sedimentary processes, possibly leading to areas of erosion and accretion along the affected coastline. The magnitude of any impact depends on a number of factors, which include: size and type of WEC, array layout, location relative to shoreline, wave climate, seabed conditions, and coastline type. As it is likely that no two sites would be the same, it makes the development of a standard assessment methodology very difficult. Much of the work carried out thus far on offshore renewable impact assessments relate to wind turbine developments and while these provide useful information, the methodologies developed cannot be directly applied to WEC sites. Generally, for offshore wind developments apart from local effects around the foundation structure (primarily scour), the overall impact is negligible. Therefore in the current study existing site assessment methodologies are examined and a revised methodology is developed for wave energy sites, which is then applied to the Belmullet wave energy test site in County Mayo in Ireland.

Keywords: Ireland, physical processes, wave energy.

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Sources of underwater noise and disturbance arising from marine renewable developments

J. Side and R. Beharie

Anthropogenic underwater noise has received increasing attention in recent years and is one of the Marine Strategy Framework Directive's descriptors of good environmental status. Wave and tidal energy projects pose new challenges, not simply during their operational phase, but requiring a variety of installation methods for each device design where the disturbance arising from sources

of underwater noise are only now being considered. The paper reviews the sources of underwater noise associated with the development of this new sector using hydrophone data from a variety of sources and the methods and studies conducted to date to determine noise levels. Sources of underwater noise arising from the deployment of marine renewable devices are compared with background and other sources of anthropogenic noise in the location of marine renewable energy developments. We examine the models used for transmission loss and the present thresholds that are applied to the disturbance of marine mammals in the vicinity, highlighting those sources of most concern and suggesting methods of mitigation based upon the behavioural tendencies of particular protected species.

Keywords: marine mammals, tidal energy, underwater noise, wave energy.

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ICES CM 2011/S:10

Facilitation of wave and tidal power developments through the application of a spatial planning approach

Ian M. Davies, Marion Harrald, Mike Robertson, and Robert Watret

The development of wave and tidal energy extraction projects is an important developmental goal for Scottish coastal waters. Technologies are developing quickly, and are being shown to be able to generate power reliably in the hostile environments of strong tidal streams and exposed coasts. The translation of technical capability to socio-economic benefit requires appropriate levels of encouragement, facilitation, and management. The Scottish Government has expressed strong policy-level support for the wave and tidal power industries, and has encouraged their development through a range of actions, including the establishment of the Saltire Prize competition for a purse of £10 million for the most successful commercial project. Particular attention has been given to management of the siting of these new industries, and a multifactorial spatial modelling approach has been used to identify areas with high development potential but which avoid sensitive areas and minimize interactions with other users. This national-scale exercise has been followed by more detailed assessments of each area in the form of a Regional Locational Guidance publication. The success of the approach may be assessed through the interest shown by developers in new projects in these areas, and the granting of several agreements for lease of the seabed for marine renewables projects.

Keywords: marine spatial planning, renewable energy, Saltire Prize, Scotland, wave and tidal.

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ICES CM 2011/S:11

Assessment of collision risk for seals and tidal stream turbines

Ian M. Davies and Fiona Thompson

The development of marine renewable energy, including wave and tidal stream power, is a high priority for the Scottish Government. The environmental aspects of the licensing process have been brought together under a single Government body, Marine Scotland. Licensing requires that consideration is given to the requirements of the EU Habitats Directive, and this commonly leads to the need for an appropriate assessment of the potential risk to populations of protected species (notably grey and common seals) from collision with rotating turbines. An approach is described which combines a model of the foraging behaviour of seals with the probability of seals being damaged by passing through the volume of water swept by a turbine. The acceptability of the estimated potential mortality is assessed against an estimated potential biological removal (PBR) for the relevant populations. The scope for improvements in all aspects of the models is discussed as a guide to research and developmental needs.

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ICES CM 2011/S:12

Test centre to commercial arrays: progress towards wave and tidal energy in Scotland

Ian M. Davies, Mike Robertson, Gareth Jones, Robert Watret, and Jim McKie

There is considerable potential for the development of commercial wave and tidal energy projects in Scottish coastal waters. This was confirmed through a strategic environmental assessment, which noted in particular that these were new industries and that there was inevitably uncertainty regarding the performance of the technologies concerned, their environmental interactions (i.e. the overall contribution sustainability of wet renewables in the context of the need to reduce reliance on fossil fuels). Scotland has taken various actions to encourage the wet renewables industries to become established. Development is proceeding in a staged manner, to allow adequate field testing and assessment of generating equipment and associated infrastructure and working methods, and their environmental interactions. The initial stage was to establish a test centre for wave and tidal devices at EMEC in Orkney. Building on this, leases and, in some cases, full development consents have been granted for demonstration projects, including the world's first array of tidal stream devices in the Sound of Islay, with 10 MW generating capacity. Work is in progress to move from demonstration scale to full commercial scale projects. Agreements for lease are in place for 1300 MW generating capacity of a range of wave and tidal devices in the Pentland Firth and Orkney waters, to the north of mainland Scotland.

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ICES CM 2011/S:13

Fish distributions around structures in fast currents: natural and man-made proxies for tidal stream energy devices

I. M. Horsfall, J. Loman, and T. D. Pritchard

Little is known about fish distributions around structures in fast flows, with moving structures, such as tidal stream turbines, adding greater uncertainty. The behaviour of fish around moving structures in fast currents will likely play a significant role in the effect of the structure on fish communities. Aggregations of fish are also likely to attract piscivorous predators such as marine mammals. Therefore, understanding fish distributions around structures may also help in gauging potential impacts on seals, dolphins, and porpoises. In order to estimate potential impacts before device installation, fish distributions around surrogate structures such as natural reefs and offshore wind turbine pilings can be investigated. For this study fish distributions around the Scarweather monopile (Bristol Channel, South Wales) and natural rock pinnacles in Ramsey Sound (southwest Wales) were investigated. Fish positions were measured using dual-frequency echosounder at all states of the tide. Surveys were carried out on a number of occasions throughout the year. Species compositions were verified using otter and pelagic trawls and current speeds were measured at various locations around the structures throughout the tidal cycle. There was a greater abundance of fish around the structures when compared to the areas with no structure. Many fish around the structures were also close to the seabed and potentially below spinning blades of tidal stream turbines. Fish distributions around the structures changed with the tidal cycle. Investigating proxy structures close to deployment sites may be useful in estimating the potential impact of future tidal stream turbine installations.

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ICES CM 2011/S:14

Hydrokinetic energy as an ecological factor—how might wave and tidal energy extraction affect the distribution of marine organisms?

M. C. Bell, E. P. M. Grist, S. Baston, S. Rouse, M. Spencer Jones, J. S. Porter, A. Want, R. Harris, and J. C. Side

Water movements define some of the most important ecological factors determining the distribution of organisms in marine environments. This is true both at large spatial scales, where ecological connectivity and trophic coupling are defined by circulation patterns and vertical mixing structure, and at the much smaller scales at which individual organisms experience flow, turbulence, and shear forces. Moving water possesses energy, and this is increasingly regarded as a resource for power generation, potentially meeting 15% of energy demands at a European level by the middle of this century. Conversion of hydrokinetic energy into other forms of energy that are useful for human purposes inevitably involves diversion of physical processes from their "natural" pathways, with possible consequences also for ecological processes. In simple terms, extraction of energy from water flow involves reducing the average velocity of flow and hence changing the conditions experienced by an organism living in the flowing water. In reality, the hydrodynamic consequences of extracting energy are likely to be complex and site-specific, with changes in turbulence as well as both increases and decreases in local flow velocities. We use statistical models applied to survey data for a selection of marine species to examine the extent to which incidence and abundance may be governed by the same wave and tidal energy variables that influence the location of marine renewable energy developments, and address the question of whether it is possible to predict what might be the consequences of energy extraction for species distribution and population viability.

Keywords: ecological impacts, marine biogeography, tidal energy, wave energy.

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ICES CM 2011/S:15

Bryozoans as an indicator for ecosystem change in relation to renewable energy devices and climate change: a case example from Scottish coastal waters

S. Rouse, M. Spencer Jones, J. S. Porter, J. C. Side, and M. C. Bell

Spatial and temporal patterns in the distribution and biodiversity of Scottish bryozoans were determined using records from the eighteenth century to the present day. Bryozoans were found to predominantly occur on the west coast, Orkney and Shetland archipelagos, in high-energy, rocky environments within the infralittoral zone. This pattern is primarily explained by a sampling bias towards these areas. Community analysis revealed that, at the regional scale, bryozoans do not form distinct assemblages, however there is a gradation in community composition according to depth. Within the Orkney subregion, discrete communities were defined by depth and sampling methodology. The relationship between depth and community structure suggests that factors such as primary productivity or substrata availability/heterogeneity may be responsible for determining bryozoan assemblages. Biodiversity was assessed using the average taxonomic distinctness of species. Biodiversity varied across the region, with high values concentrated in Orkney. In contrast to community structure, biodiversity was found to be independent of depth. The highest values were associated with low-energy, coarse sediments in the deep circalittoral zone. The results of this study are mapped with planned licensed renewable energy development sites and with climate change parameters such as temperature change. For the first time this provides baseline spatial and temporal distribution data for Bryozoa and we discuss the relevance of this for environmental monitoring and spatial planning.

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ICES CM 2011/S:16

Monitoring marine habitats of West Mainland Orkney: will wave energy extraction contribute to long-term change?

Andrew Want, Michael C. Bell, and Jonathan C. Side

Wave energy exposure is an important factor in determining community structure on rocky shorelines. Energy extraction by wave energy-converting devices (WECs) might be expected to modify exposure characteristics shoreward of their location. In addition, it is assumed that increased sea temperature, as one component of observed global climatic change will also alter the composition of species on the rocky shore. Determining the relative roles played by concurrent environmental variables (i.e. energy exposure and sea temperature), as well as seasonal and other variables, will be challenging. Littoral and sublittoral monitoring of sentinel species can be used to detect wider ecological trends. Candidate species should be adapted to specific exposure levels, be potentially located at or near their geographical distribution limits, and be sufficiently accessible and prevalent to allow reliable sample collection. Monitoring protocols have been developed for several species on the wave-exposed west mainland of Orkney, an area at the forefront of the developing marine energy sector. Identifying similar species which respond differentially to changes in energy exposure and sea temperature, and monitoring changes in the relationship between these and our sentinel species (such as littoral zone width and height, and abundance), could help discriminate the precise part played by these two important environmental variables. Monitoring procedures include measuring distribution, abundance, density, and growth determination using biometric measurements, quadrat photography, and other sampling techniques on intact and cleared sites. Along with novel image analysis developments, these will provide baseline/control data for this important area.

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ICES CM 2011/S:17

Wave energy converters, sediment transport, and coastal erosion

Arne Vögler, David Christie, Malcolm Lidster, and James Morrison

As a simplified assumption the northwestern coastline of the Isle of Lewis in Scotland can be taken as a system in a state of equilibrium. The seasonal removal of sediment from the beaches during winter storm events is counterbalanced by a natural recovery period during summer. The area has one of the highest wave energy resources in Europe, and it is anticipated that large-scale deployments of wave energy converters will occur within the next decade. With a location at the edge of the Atlantic the area is also affected by the consequences of global warming, namely the forecasted increase of severe weather events and rising sea levels. Changes to one parameter in a system in equilibrium will force changes to the wider environment and this paper investigates if and how the smart siting of wave energy converters can be used to offset potentially destructive impacts caused by global warming. For example, the devices will absorb and dissipate wave energy: this could promote landside littoral deposit, augmenting coastal defences. Effects of large-scale installations of nearshore wave energy converters on the coastline are modelled numerically with experimental validation on micro-scale models. The importance of access to baseline data are described and the continuous research activity monitors seasonal changes to the sediment patterns of selected locations on the Isle of Lewis with the aim of supporting theoretical forecasted and modelled impacts on the system with hard data over the years.

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SOWFIA: learning from impact assessments of European wave energy developments

Ruth H. Leeney, Daniel Conley, Anne Marie O'Hagan, Brian Holmes, Cristina Huertas Olivares, Victoria Osta, and Deborah Greaves

The lack of a coordinated approach to conducting environmental impact assessments (EIA) at wave energy sites across Europe has been identified as a barrier to expansion of the wave energy industry. This is contributing to already inconsistent approaches to EIAs, resulting in a lack of effective and cohesive environmental monitoring. The SOWFIA Project aims to address this by bringing together ten European partners engaged in monitoring at a number of established wave energy test centres. Key objectives of the project are: (i) to identify barriers and accelerators in existing EIA processes in EU Member States; (ii) to assess EIA topics and methodologies utilized at test centres, and (iii) to make recommendations on how planning approval processes could be streamlined. To achieve these objectives, the project encourages active sharing and consolidation of information garnered from wave energy development consenting processes to date, with specific reference to best practices in implementing EIA for wave energy. The project has produced a catalogue of wave energy test centres across Europe, set in the context of EU targets for renewable energy, Member States' development aspirations, and spatial area requirements. This is complemented by an inventory of EIA datasets being collected at European wave energy test centres which will be incorporated into a data-management platform that will facilitate analysis of current impact detection capabilities. These initiatives should prove invaluable in suggesting how the EIA process can be streamlined to ensure environmental protection and more efficient, and economically effective, project development in future.

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ICES CM 2011/S:19

A modelling study of the effect of tide energy extraction on estuarine circulation and implications of changes in the marine ecosystem

Zhaoqing Yang, Taiping Wang, and Andrea Copping

Recent growing interest in developing in-stream tidal energy generation has raised concerns about the effects of tidal energy extraction on estuarine and coastal physical processes and the marine ecosystems dependent on those processes. There are few direct observations of the effect of energy extraction on living systems, but our understanding of the magnitude and importance of these effects can be enhanced through analytical, experimental, and numerical analyses at the appropriate temporal and spatial scales This paper presents a numerical modelling study to simulate in-stream tidal energy extraction and assess its effect on the circulation and mixing in a tidal-dominated estuary using a three-dimensional (3D) unstructured grid finite volume coastal ocean model. A tidal turbine module is incorporated into the hydrodynamic model using a momentum source/sink approach. The tidal turbine module is applied to simulate the tidal energy extraction in an idealized tidal bay and estuarine system. A series of numerical experiments are carried out to assess the effects of tidal energy extraction on the total volume flux, velocity distribution, salinity stratification, and mixing within the bay. The implications of changes in physical processes due to tidal energy extraction on water quality, the marine foodweb, and the ecosystem are also discussed.

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ICES CM 2011/S:20

Incorporating easily disposable components into the design of small-scale marine hydrokinetic energy converters

A. Johnson and B. Silvera

It is necessary to validate performance during the process of developing new marine hydrokinetic (MHK) energy converters. Devices which produce over 250 kW require rigorous testing, calibration and assessment of environmental impacts. The cost of the long-term testing and implementation during the design refinement phase requires significant investment over several years. Assessing the potential environmental impact necessitates routine inspection and analysis of site-specific data in coordination with comparative analysis of often numerous environmental influences that affect the local marine population. The difficulty of this process often leads to slowed development of new devices. Specific aims and an implementation strategy were outlined to improve and accelerate the design refinement process. The MHK converter concept designed to power an LED array was split into two main subsections: the core, comprising commercially available electrical components, and the shell, composed of replaceable hydrodynamic sections. This reinforced the specified aim of integrating key components that can be manufactured and replaced with low environmental impact. Components fabricated using processed wooden composites were designed to encapsulate electrical components and generate targeted hydrodynamic performance. The devices were submerged for a week to assess performance. The data gathered were utilized to refine the design of the hydrodynamic components and provided data on mitigating some negative environmental impacts. Future research will target further design refinements, evaluating the feasibility of scaling the design, and determining the feasibility of manufacturing kits with selected disposable components that have a minimum lifetime of two years.

Keywords: design strategy, disposable components, environmental impact, marine hydrokinetic energy, small-scale.

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ICES CM 2011/S:21   Poster

A simulation modelling approach to predicting the impact on seabirds of generating power from waves and tides

R. Langton, I. M. Davies, and B. E. Scott

During the next decade there is likely to be an increase in tidal stream and wave power generation activity in Scottish waters. Concurrently, there will be the designation of additional offshore areas for seabird conservation. Experience from other marine industries suggests that these devices have the potential to affect seabird behaviour and habitat, leading to changes in rates of energy acquisition (e.g. through altering prey abundance) or expenditure (e.g. shifting the commuting distances by modifying spatial arrangement of prey patches). These changes to seabird energy budgets could affect rates of reproduction or survival, resulting in conflict between the renewable energy and conservation policies. Simulation modelling is one possible tool which could be used to predict how the alterations to bird behaviour and prey availability might affect seabird energy budgets and hence adult condition and chick growth rates. A behaviour-based model is being constructed to estimate how a range of development scenarios could affect parent birds and their offspring. Individual units within the model include two interrelated adult birds and a chick. The behavioural state of each of the parents is based on the environment and their physiological condition. Preliminary results of the model will be presented, including important parameter estimates and sensitivity analyses.

Keywords: modelling, renewable energy, Scotland, seabirds.

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ICES CM 2011/S:22   Poster

A comparative study of three methods for the derivation of seabed habitat information from multibeam acoustic backscatter data

M. R. Robertson, M. Harrald, T. LeBas, P. J. Hayes, and I. M. Davies

Planning and development of marine renewable energy in coastal waters requires reliable information on seabed habitats. Acoustic backscatter data are increasingly being used to prepare habitat maps, but the underlying data handling and processing differ between interpretational software packages. Opportunity was taken during a research cruise on board FRV "Scotia" in 2010 to collect backscatter data from an area adjacent to Fair Isle, Scotland, which has recently been designated as an extension to the Special Protection Area (SPA) for breeding seabirds on sea cliffs round Fair Isle.. The data, consisting of bathymetric and snippets of backscatter information, were acquired using a Reson Seabat 7125-B multibeam swathe system. On completion of the survey and after initial processing and cleaning using the CARIS and Fledermaus software packages, bathymetric maps of the seabed around Fair Isle were created. Backscatter data were then processed using three different software packages: QTC Swathview 10, PRISM, and the Mosaic Editor module in CARIS. The sediment distribution maps created from these analyses were compared with ground-truthing from video and digital still underwater photographs.

Keywords: backscatter, bathymetric maps, facies maps, Fair Isle, multibeam acoustic survey, Special Protection Area.

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ICES CM 2011/S:23   Poster

Quantification of littoral wave action to establish the influence from wave energy converters

Robert A. Beharie and Jon Side

Wave energy converters have the potential to cause ecological change due to the attenuation of shoreline wave action. The widely accepted methods of estimating the amount of wave action or "exposure" in the rocky shore littoral zone include establishing the locally most abundant biotopes, the use of nearshore wave models and cartographic fetch methods. Difficulties occur when subtle differences in the environmental variables have a significant influence on species, altering the community structure such that no single biotope is indicative of a given level of exposure to wave action at all geographical locations. The fractal nature of shoreline precludes the use of offshore measurements for determining energy levels at the scale of individual species. Fetch estimates do not account for oceanic swell, the main prerequisite for where a wave energy device will be installed. A new device is presented that is able to measure a quantitative level of wave action and its directional components. Measurements are determined by the mass loss of a polymer block, made from an inert material, and subject to an abrading mechanism which is directly related to the level of wave action experienced by the device. Long-term monitoring data from Orkney are presented, showing good correlations of significant wave height and direction from concurrent wave buoy data. This new device will not only allow specific biotopes to be studied in relation to an objective measure of wave action over biologically meaningful time-scales but could also be used for economical evaluations of nearshore wave energy resources.

Keywords: classification systems, exposure, hydrodynamics, littoral ecology, rocky shore, wave action.

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ICES CM 2011/S:24   Poster

An inventory of future combinations of aquaculture, fisheries, and other activities

Marnix Poelman and Bas Bolman

Management of coastal zones is currently in a new state of development. Until recently the planning of coastal activities was primarily based on single sectors. Now, multifunctional use of coastal space might be one of the strategies needed to overcome competing claims in coastal areas. For fisheries and aquaculture this means that combinations with other activities need to be developed. Currently the main focus is still on unrealized combinations of aquaculture and windmills. Now several combinations of fisheries, aquaculture, and other activities have been identified and the application possibilities have been described. The use of (ex) oil and gas rigs and other ocean energy infrastructures, along with existing aquaculture infrastructures, may lead to new approaches for multilevel coastal zone management.

Keywords: aquaculture, coastal zone management, future combinations, multifunctional use.

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ICES CM 2011/S:25   Poster

Visual and acoustic monitoring of cetaceans at the wave energy test site, County Mayo, Ireland

Simon Berrow and Joanne O'Brien

The west coast of Ireland has some of the greatest potential for wave energy generation in Europe. It also has abundant and diverse populations of marine mammals. As part of an environmental impact assessment of the proposed wave energy test site in north Mayo, we carried out a visual and acoustic survey of marine mammals. Land-based and dedicated boat-based visual surveys were complemented by passive (towed hydrophone) and static (CPOD) acoustic monitoring. Twelve species of marine mammal, including two seal species, were recorded at the site. Harbour porpoise were mainly recorded visually inshore, while dolphins, mainly common dolphins, mid- and offshore. CPODs were deployed at the sites of the proposed berths: one each at berth A (on the 100-m contour), berth B (50-m contour), and berth C (inshore) and at four control sites. Control sites were situated 10 km either side of the proposed berths and along the same contour line. The results from static acoustic monitoring showed both dolphin and porpoise acoustic detection rates (expressed as DPM, detection positive minutes per day) increased offshore, with dolphins detected 2–3 times more frequently (1.7–25.6 DPM) compared to harbour porpoise (4.2–12.1 DPM). Surprisingly, DPMs were an order of magnitude greater along the proposed cable route connecting the berths for both harbour porpoise (mean: 7.5 DPM compared with 1.0 DPM) and dolphins (mean: 14 DPM compared with 3.6 DPM). We suggest that the features selected as suitable for developing a wave energy test site were also selected as favourable habitat for harbour porpoise and dolphins.

Keywords: acoustic monitoring, Ireland, marine mammals, wave energy.

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ICES CM 2011/S:26   Poster

Mapping fisheries for marine resource management using gear-specific vessel monitoring system data

Kilian M. Stehfest, Maria S. Campbell, Stephen C. Votier, and Jason M. Hall-Spencer

In order to reduce adverse effects of human activities on marine ecosystems, marine management is shifting towards an integrated multisector spatial planning approach. This requires large-scale, high-resolution data on fishing effort. We used vessel monitoring system (VMS) data from 2005–

2006 to map gear-specific fishing effort in and around the western English Channel (ICES areas VIIe–h), one of the most highly impacted marine ecosystems on the planet. Our maps highlight (i) the potential effects of fisheries closures around a proposed wave testing array station, Wave Hub, on the distribution of an international fishing fleet of large (>15 m length) vessels and (ii) spatial differences in the intensity of fishing by different gear types. Our VMS analyses show different gear types consistently have both spatially and temporally distinct effort patterns. In our case study, if proposed closures prevent use of all fishing gear then static gear users are likely to be the most affected due to the lower availability of their preferred fishing grounds and the high degree of patchiness of their effort. Active mobile gears show the highest effort intensity and widest distribution in the study area, hence impacts on benthic habitats and discarding are likely to have the most significant ecosystem effects in this area. We argue that the successful integration of fisheries management into marine spatial planning and ecosystem conservation requires high-resolution gear-specific effort data and show that the VMS is a valuable source of these data, if gear information is made available to fisheries managers and scientists.

Keywords: fisheries, marine renewable energy, marine spatial planning.

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