

## Theme Session M

### How much habitat is enough? Evaluating habitats in terms of their ecosystem function, goods, and services

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#### ICES CM 2008/M:01

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##### **An economic evaluation of restoring fishery production through the creation of coastal saltmarshes**

T. J. Minello, L. P. Rozas, G. A. Matthews, and P. A. Caldwell

Penaeid shrimp support one of the most valuable fisheries in the northern Gulf of Mexico, and productivity of these species has been linked to coastal wetlands. Saltmarshes in this region are characterized by large populations of juvenile shrimp, and population size is related to the amount of marsh edge. In response to continuing wetland loss in the region, a variety of wetland restoration projects have been developed that attempt to mimic natural marsh landscape characteristics and maximize marsh edge. We estimated shrimp populations and production from five created wetlands in Galveston Bay, Texas (USA) and compared the value of this production with wetland construction costs. Production of shrimp attributable to the created wetlands ranged between 112 and 179 kg ha<sup>-1</sup> y<sup>-1</sup>. Based on an ex-vessel price of US\$4.17 per kg (\$2.14 per pound), the value of shrimp production per \$1 of construction cost ranged from \$0.02 to \$0.12. For marsh terracing projects, this analysis indicated that the cost of wetland construction could be recovered in as little as 8.1 years in shrimp production alone. If the market value of shrimp was used, this recovery cost would be 3.5 years.

Keywords: penaeid shrimp, salt marsh, fishery, habitat restoration.

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#### ICES CM 2008/M:02

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##### **Modelling fish community habitat in the eastern English Channel: tentative prediction of habitat distribution change under different climatic variation scenarios**

S. Vaz, A. Carpentier, and F. Coppin

Fish habitats correspond to geographic areas within which ranges of environmental factors define the presence of a particular species. Habitat modelling was used to relate the geographic distribution of fish to environmental factors and to delineate optimum habitats. This study was based on data obtained from Ifremer's Channel Ground Fish Surveys 1988–2007, which included fish, cephalopod, and macro-crustacean species abundance and environmental data. Redundancy analysis was used to relate depth, temperature, salinity, bedstress, and sediment to community structure. As a result, different assemblage affinities were related to the gradient of the environmental variables. The resulting redundancy analysis model was used to map, using GIS, the optimum habitats of these subcommunities. Two climatic scenarios simulating opposite directions of change in part of the modelled environment (salinity and temperature) were applied to the habitat model and the resulting changes in the spatial occupation of the subcommunities are presented. The information obtained is discussed in the context of the conservation and protection of natural habitats in the face of climate change and anthropogenic disturbances.

Keywords: eastern English Channel, fish communities, habitat, GIS.

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#### ICES CM 2008/M:03

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##### **Identification and characterization of winter spawning grounds in the eastern English Channel and southern North Sea**

S. Lelièvre, S. Vaz, C. Martin, and Y. Verin

The fragility of some exploited fish stock indicates that marine spawning grounds should be considered as “sensitive habitats” and their study has become essential. This study aims to locate the winter spawning grounds in the eastern English Channel and southern North Sea, to characterize their habitats, and to specify the importance of the environment on the use of these habitats. The study of spawning habitats requires rigorous techniques, including sampling protocols, precise species egg identification methods, spatial analyses, and habitat modelling statistics. Distribution mapping (using geostatistical analyses) and habitat modelling of various fish spawning areas was carried out using observed densities of stage 1 eggs and associated physical conditions such as temperature, salinity, seabed shear stress, chlorophyll *a* concentration,

and bottom sediment type. This enabled us to quantify the importance of the environment on the use of these habitats and led to a thorough knowledge of these winter spawning grounds based on rigorous scientific methods. The relative importance of these explanatory parameters was identified and used to predict the extent and location of spawning grounds. The results of this approach are discussed in the context of the protection and conservation of critical spawning grounds of each species.

Keywords: winter spawning grounds, CUFES, eastern English Channel and North Sea, geostatistical mapping, spawning habitat modelling.

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#### ICES CM 2008/M:04

### Modelling and mapping fish habitat suitability of European Plaice (*Pleuronectes platessa*) in the eastern English Channel

V. Lauria, S. Vaz, C. Warembourg, P. D. Eastwood, F. Coppin, and A. Carpentier

Conservation and fisheries management require that our knowledge of fish species distribution is continually improved using new tools. Habitat modelling and GIS mapping are very useful tools to predict species–environment relationships. The aim is to model species abundance as a function of environmental parameters in order to be able to predict species abundance in geographical locations where there is no information. Fish habitat refers to a geographic area within which ranges of environmental factors define the presence of a particular species, moreover fish habitat use can change seasonally and during different life stages. European plaice is a commercially important species in the English Channel. In this study, the distributions of adult (over one year old) and juvenile (group 0) plaice are modelled and mapped over two different seasons, in order to investigate the possible differences in life stages with the change of environmental conditions. Delta GLM and upper quantile regression modelling are used to relate the relative abundance of juveniles and adults to significant environmental factors in autumn and summer. The resulting regression parameters are used to map potential and preferential habitat distributions using GIS. Models are validated by comparing predicted against observed abundances. This study is supported by the Interreg IIIA CHARM project (<http://charm.canterbury.ac.uk>), and is based on data obtained from Ifremer’s Channel Ground Fish Survey 1988–2006 and CEFAS’s beam trawl survey 1989–2006. This work will be an important tool in improving our understanding of species distribution variation in the face of climate change and spatialized fishery management.

Keywords: fish habitat, distribution modelling, GIS, English Channel, CHARM.

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#### ICES CM 2008/M:05

### Will the North Sea still be a suitable habitat for herring in the years to come?

Christine Röckmann and Mark Dickey-Collas

Herring (*Clupea harengus*) have been an important source of food and economic wealth in Europe for hundreds of years. We describe the habitat of North Sea herring over the last 30 years in terms of the environment that each life stage inhabits. In addition to a characterization of habitat suitability of the herring, we investigate whether the habitats have changed in recent years. The aim of the investigation is to identify the environmental conditions that are crucial to certain herring life stages. Emerging from the ongoing EU-project RECLAIM, emphasis is hence put on climate change issues: Is the North Sea herring stock vulnerable to climate change due to modification/limitation or expansion of tolerable habitat? Habitat mapping is also one approach that allows us to investigate the causes of poor larval survival since 2002. We combine empirical data on herring abundance from ICES surveys with a coupled hydrodynamic ecosystem model (ECOSMO). Changes and trends in environmental variables in North Sea habitat for each herring life stage can thus be described and interpreted with regard to potential climate change.

Keywords: North Sea herring, habitat, environmental conditions, climate change, life stages.

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**ICES CM 2008/M:06**

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**The dying national wetland case study of Yala Swamp beyond 2020—Kenya**

Roselyne Oduor and Quinter Obeto

Yala Swamp in Kenya lies on the Equator (0°) and has a rich biodiversity over an area of 175 km<sup>2</sup>. Research findings from case studies in relation to property rights management, environmental stewardship, and healthy ecosystems within Yala Swamp are discussed. Yala Swamp is a living museum, providing a home to many fish species. Prior to the introduction of Nile perch in Lake Victoria for the export market, the lake was dominated by over 300 fish species, but now Lake Victoria only supports three fisheries. Yala Swamp could be an important resource for the restoration of the endemic species that were in Lake Victoria, which cannot be found anywhere within the catchments of Lake Victoria. Currently, the Swamp has been leased to an American investor (Dominion Farms) for the purposes of agricultural production without considering the consequences. Within the project, a number of communities have been forced to sell their lands and homes, leading many to question to wisdom of leasing lands to foreign-based developers without conducting environmental impact assessments or considering the socio-economics of wetland reclamation. The integrity of the wetlands is threatened, and, just as with the introduction of Nile perch to Lake Victoria, the lucrative native fisheries are likely to suffer. The paper explores the concept of community participation in managing natural habitat and looks at the impact of free and open trade policy and the consequences of climate change. The study also gives an account of the future potential loss of biological diversity in relation to property rights. In summary, the paper will outline the research needed and give recommendations for action to protect and predict this important wetland and food resource beyond 2020. Also of importance are the satellite lakes within the wetland and their rich biodiversity. [?Q1]

Keywords: biodiversity, conservation, property rights, living museum, endangered, leasing, stewardship, Satellite Lake.

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**ICES CM 2008/M:07**

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**Fish habitat mapping with empirical orthogonal functions**

Pierre Petitgas, Mathieu Woillez, Sandrine Vaz, and Christophe Loots

Fish spatial distributions are controlled by factors external to the populations (e.g. physical and trophic conditions) as well as internal factors (e.g. age structure, density-dependence, learning behaviour). Environmental conditions allow areas of potential suitability for the fish to be estimated; these correspond to habitats. The effective occupation year after year of potentially suitable habitats depends on a variety of factors internal to the population. In this context, mapping the potential is not sufficient to design areas to be protected, as an analysis of the variability in the spatial distribution is required. Empirical orthogonal functions (EOFs) have long been used in meteorology and oceanography to decompose the time and space variabilities of a time-series of maps into principal scales and their amplitudes. The decomposition is a linear factorization of spatial components (eigenvectors) that are constant in time and amplitudes (principal components) and are variable in time. Time-series of fisheries survey data may now offer sufficient space–time information on the spatial distributions of fish populations, making the EOF decomposition adequate for mapping “realized” habitats. The EOF methodology is applied to the time-series of fishery survey data for contrasting case study populations: anchovy in the Bay of Biscay, red mullet in the eastern English Channel, and plaice in the North Sea. The analysis of the temporal variations in the principal components of the spatial distributions leads to the mapping of particular areas as “core” habitats for each case study population.

Keywords: habitat, spatial distribution, EOF, fish stocks, surveys.

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**ICES CM 2008/M:08**

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**Complex assessment of spawning habitat availability for Caspian sturgeons in the Volga River**

Oleg M. Lapshin, Maria G. Dolgikh, and Michael I. Malin

Successful reproduction is one of the major elements for population stability. In the Volga River, natural spawning areas of Caspian sturgeons became significantly reduced after the cascade reservoirs were created in the 1950s. Under changing conditions, such as climate and riverbed changes, navigation, fisheries, and influence connected with the exploitation of hydroelectric power stations, the assessment and conservation of habitats for natural spawning are very important. The majority of data on natural spawning of sturgeons in

this area were obtained in 1953–1973 and since that time systematic inspection of the spawning grounds of the lower Volga has not been carried out. Hydroacoustic methods with confirmation of received results by means of underwater television make it possible to conduct inspection of spawning grounds at a new level, with a higher precision that allows evaluation of suitable spawning areas and the quantification of fish. In September 2007, under low water conditions, six spawning areas classified as sites with highly effective spawning were inspected. We constructed three-dimensional riverbed models, analysed bank conditions and assumed spring-inundated spawning grounds, and determined ground composition using hydroacoustic data and underwater television. We also conducted a hydroacoustic survey of the fish community in the spawning areas. Our studies showed noticeable changes in riverbed conditions and ground composition in the traditional spawning sites over the last 30 years. Classification of habitat availability in the Volga River for natural spawning of Caspian sturgeons has been developed.

Keywords: spawning habitat, Caspian sturgeons, hydroacoustics.

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## ICES CM 2008/M:10

### Does habitat availability affect fish population size? A case study from the Baltic Sea

Göran Sundblad, Ulf Bergström, Alfred Sandström, and Peter Eklöv

Strong and viable fish populations are a prerequisite for ecosystem functioning and sustainable fisheries. Recruitment success is often identified as critical for adult population size, which is available for fisheries and ecosystem services. However, the data needed to quantify habitat productivity relationships is often lacking. For this we need spatial estimates of recruitment habitats together with estimates of adult population sizes from a number of populations. In order to test potential life stage-specific bottlenecks we have modelled the distribution of spawning and young-of-the-year habitats for Eurasian perch (*Perca fluviatilis* L.) within a large archipelago area in the Baltic Sea. Estimates of spawning and nursery habitat availability were based on species distribution models that relate the response variables to environmental variables. Using geographic information systems and generalized additive models, maps of the environmental variables were recalculated into recruitment habitat suitability maps. Within the study area local population size estimates were obtained from standardized gillnet monitoring. The correlation between recruitment habitats and adult population sizes yielded quantitative estimates of how availability of spawning and nursery habitats influences adult population size. These results should be of particular interest for fisheries and conservation managers interested in assessing alternative management scenarios and their potential cost and ultimately addressing the question of “How much habitat is enough?”.

Keywords: species distribution modelling, habitat availability, GAM, GIS, monitoring.

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## ICES CM 2008/M:11

### Assessing the link between coastal wetland loss and white shrimp fishery production in the northern Gulf of Mexico

Ronald Baker, Phillip S. Levin, and Thomas J. Minello

We developed a stage-based matrix population model for white shrimp (*Litopenaeus setiferus*) to examine the links between habitat, stage-specific vital rates, and population growth rate ( $\lambda$ ). The model indicated that  $\lambda$  is far more sensitive to changes in mortality rates of early life stages than it is to changes in adult mortality or fecundity. We are currently applying the model to address a recent paradox in the Gulf of Mexico penaeid fishery. Three indices of white shrimp stock size in the northern Gulf indicate that  $\lambda$  has increased by ~20% over the last decade, despite the continued loss of coastal marshes in this region. However, during early stages of marsh disintegration the amount of valuable marsh-edge habitat increases, and it has been hypothesized that this process could be responsible for the observed increases in  $\lambda$ . To account for this increase, the model estimates adult mortality would need to have reduced by 95%, or fecundity tripled, whereas juvenile mortality would need to reduce by less than 30%. We will combine the model outputs with existing distribution patterns of shrimp in the marsh landscape, habitat-specific mortality estimates, and models of marsh disintegration to calculate the changes in the marsh landscape required to produce the estimated reduction in juvenile mortality. Comparison of these changes with those required in other vital rates will clarify the importance of various habitats and processes that regulate vital rates throughout the life cycle, and provide insights into potential impacts of future changes in the marsh landscape.

Keywords: marsh loss, habitat-mediated mortality, population persistence, matrix models.

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**ICES CM 2008/M:12****The effect of fishing on habitat functioning: implications for management**

Odette Paramor and Chris Frid

Protecting the functions of ecosystems is demanded by European legislation, but the practical implementation of this approach is still under development. In the UK, three marine landscape types account for 89% of the offshore area. These landscape types are composed of ten habitat types, which all have sedimentary characteristics. Protection of the majority of the ecological functions delivered by the UK offshore area will therefore require an understanding of how these areas respond to changes in human activities. Fishing is known to affect the composition of benthic communities, but few studies have investigated the effects of fishing on benthic ecological functioning. The Dove Benthic Time Series is a 37-year record of benthic communities at two stations in the North Sea: Station P is inside a Nephrops fishing ground and Station M1 is in an adjacent unfished area. We examined the effects of fishing on benthic functioning by analysing the biological traits of the most dominant benthic species at Station P1 and comparing them to the biological traits of species at Station M1. Previous studies on ecological functioning have linked 28 traits to ten broad ecological functions, and these traits are mapped to the most dominant species of the 187 genera recorded at Station P1. The ecological functioning of these benthic communities are then compared over periods of different fishing intensities. The implications of this study for the development of management objectives for habitats are discussed.

Keywords: biological traits analysis, time-series, benthos, sedimentary habitats.

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**ICES CM 2008/M:13****Canada's approach for addressing habitat research needs**

Kim Houston, Ben Davis, and Robert Gregory

In Canada, a suite of interacting Acts and Regulations support the Department of Fisheries and Oceans' (DFO) responsibility to manage human activities so that fish habitats are conserved and protected. Advice from the Science Sector is used in decision-making to resolve issues related to integrated management as promoted by Canada's Ocean Act, Fisheries Policy, Fisheries Management, Oceans Sector Management, as well as the Habitat Management Program itself under the Fisheries Act. To address habitat issues in support of the Department's mandate to conserve and protect fish habitats, the DFO recently established a virtual Centre of Expertise (CoE) on Habitat Research. The CoE will provide strategic leadership to prioritize and address science requirements in fresh-water and marine environments and facilitate informed policy development at regionally applicable scales. The objectives of the CoE include: (i) to quantify and calibrate effects of human-induced and natural changes to habitats and the aquatic resources they support (including sensitivity, resilience, intensity, duration and reversibility of effects); (ii) to develop and test methodologies that link population and community productivity to habitats, including concepts such as critical habitat and habitat-related thresholds; (iii) to develop best practices for measuring habitat impacts, identification of surrogates, and developing indices, models and tools for decision-making; (iv) to develop and assess the effectiveness of mitigation measures; (v) to integrate ongoing surveying and sampling methodologies and to link habitat attributes, productivity, and biodiversity; and (vi) to facilitate data and information sharing across Canada.

Keywords: habitat, centre of expertise, productive capacity, ecosystem resilience.

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**ICES CM 2008/M:15****Exploring the effects of exploitation, season, and temperature on abundance-occupancy relationships for the Georges Bank finfish and shellfish community from 1963 to 2006**

Michael G. Frisk, Daniel Duplisea, and Verena Trenkel

Abundance-occupancy (A-O) relationships were estimated for 38 species representing the Georges Bank finfish and shellfish assemblage from 1963 to 2006 using the National Marine Fisheries Service's annual bottom-trawl survey. Occupancy was considered the proportion of stations with at least one individual present and abundance was estimated as the mean annual number of fish captured per station. Intraspecific relationships were estimated to provide information on use of space by a species in relation to environmental

and community metrics. In addition, interspecific relationships over all species for a single year were fitted to estimate assemblage structural changes over time in relation to environmental and anthropogenic factors. A-O relationships were fitted using two models whose parameters are indices of the strength of the relations and goodness-of-fit statistics represent the quality of the annual fits over the time-series. Fits suggested that relatively sedentary species showed a weaker relationship (i.e. their occupancy increased with abundance more linearly), whereas mobile species tend to show stronger relationships (i.e. occupancy decreases more steeply with decreasing abundance). The quality of the fits over species within years decreased over the time-series and correlated significantly with fishing effort and total groundfish landings. Environmental variables also can be important forcers on the relationships that further vary with season.

Keywords: Georges Bank, abundance–occupancy relationships, community ecology, exploitation.

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## ICES CM 2008/M:16

### Topographic and tidal influenced foraging behaviour of top predators and prey

Clare B. Embling, Eric Armstrong, Janine Illian, and Beth E. Scott

The distribution of fish prey is patchy both in space and time, making marine spatial planning for the conservation of fish stocks and biodiversity challenging. This study investigated topographical and tidal influences on the spatio-temporal dynamics of sandeel (*Ammodytes* spp.) and top predator (seabirds and marine mammals) foraging behaviour in order to define and predict critical marine foraging habitats. Multidisciplinary surveys were carried out in the North Sea, Scotland, during June 2003 as part of the EU IMPRESS study. Surveys took the form of three “mini-surveys”, in which the same oval area was repeatedly surveyed 12 times during set tidal speeds over a 25-hour period. A Simrad EK500 echosounder operating at 38, 120, and 200 kHz was used to collect data on the distribution and relative abundance of sandeels. Top predator data were collected using standard line transect methodology during daylight hours. The results indicate that sandeels were aggregated in areas over shallow banks where there was evidence of strong internal wave activity. Schooling behaviour varied both over diurnal and tidal cycles: with sandeels forming columnar schools distributed throughout the water column 2–3 hours after sunrise and becoming aggregated into larger schools close to the surface at maximum flood currents. Kittiwake (*Rissa tridactyla*) foraging behaviour corresponded to that of the sandeels, with highest foraging aggregations at maximum flood. This importance of topography and tidal speed on the foraging behaviour of sandeels and top predators should allow for the definition and prediction of critical marine habitats.

Keywords: sandeels (*Ammodytes* spp.), kittiwakes (*Rissa tridactyla*), tidal oceanography, topography, foraging behaviour, North Sea, Scotland.

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## ICES CM 2008/M:17      Poster

### The role of pelagic fish in abundance of immature sturgeons in the southern part of the Caspian Sea

K. Haddadi Moghaddam, Z. Pajand, and F. Chubian

Sturgeons are one of the most important and valuable species in the Caspian Sea. The objective of this study was to determine the major and minor food species of sturgeon in the continental shelf and their role in the biodiversity of the southern part of Caspian Sea. The feeding of sturgeons was investigated using a trawl net 9 m wide and 24 m long with 8 mm mesh size with sturgeons caught by motor boats in depths of 2–10 m during various seasons over the period 2004–2006. The average minimum and maximum length was 10–40 cm; 281 were Iranian sturgeon (*Acipenser persicus*) and 13 were *Huso huso*. The abundance of polychaetes in the stomach contents of fishes from areas over 10 m deep show the importance of these organisms in the food of sturgeon (under one year old). The abundance of polychaetes was related to increases in water levels of the Caspian Sea up to 2.2 m in 1977–1992 which caused these animals to transfer to shallow regions. Findings show that herring are a major food for sturgeons of 2 and 3 years old.

Keywords: sturgeon, pelagic.

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