

Transfer of fixed nitrogen to bacteria associated with filamentous cyanobacteria in the Baltic Sea

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The large filamentous cyanobacteria *Aphanizomenon* sp., *Anabaena* sp. and *Nodularia* sp. are the three main nitrogen fixers in the Baltic Sea. During summer, these species form massive blooms in the photic zone, gaining the energy required for nitrogen fixation through photosynthesis. Fixation of atmospheric dinitrogen occurs in specialized cells, the so-called heterocysts, and is rapidly transferred to the vegetative cells. Previous studies have reported, that attached and non-attached microorganisms profit from the release of nutrients by the cyanobacteria. However, up to now the transfer of fixed nitrogen from cyanobacterial cells to the associated microorganisms has not been directly shown in the environment. In this study we used a combination of stable isotope incubations, isotope ratio mass spectrometry and nanoscale secondary ion mass spectrometry (nanoSIMS) to measure N and C-uptake by single microbial cells associated with blooming cyanobacteria. By using Halogen in-situ hybridization coupled to nano-scale secondary ion mass spectrometry (HISH-SIMS) we identified the epibionts and the freeliving bacteria and at the same time measured their nitrogen and carbon uptake rates. We showed that the community of profiting organisms is dominated by Alphaproteobacteria, Gammaproteobacteria and Cytophaga as well as single celled eukaryotes which are highly enriched in both ^{15}N and ^{13}C in comparison to the hosting heterocysts and vegetative cells. These results show for the first time that fixed nitrogen and carbon are rapidly transferred to bacteria and eukaryotes in the Baltic Sea.

Skagerrak bottom water exchange in the winter 2010 and possible implications to the deep sea prawn fishery

Jon Albretsen

Didrik Danielssen

The last winter in Scandinavia was relatively cold with persistent cold, dry northeasterly winds replacing the inflow of moist, warm air from the North Atlantic. The subsequent cooling of the North Sea and Skagerrak surface led to a penetration of dense, cold water into the bottom of the Norwegian Trench. This is another mechanism for renewal of Skagerrak bottom water that occurred this winter, besides the inflow of relatively saline and warm water masses with Atlantic origin which gave a renewal for instance in the spring 2009. The monthly cruise between Torungen and Hirtshals across the Skagerrak as a part of IMR's monitoring program is a valuable data set for investigating mechanisms causing bottom water exchanges, and we see that cold bottom water occurred more regularly from the 1950's to the 1980's. The cooling of the bottom water also has implications to the temperature in intermediate levels. For instance the observed temperature in 150 m depth off Torungen has the latest years been approximately one standard deviation above the 1961-90 normal. In April and May 2010 the temperature was about one standard deviation below the normal. In addition the deep sea prawn fishery is concerningly low this spring after several years with good catches. As an example, IMR publications from the 1960s indicate that cooling of the Skagerrak bottom water was an important factor causing the decline in the prawn fishery along the Skagerrak coast after the cold winter in 1963.

Stock structure and local adaptation in marine fish

Carl André

In spite of a seemingly borderless environment, evidence is mounting that many marine fish species are spatially structured into more or less reproductively isolated populations. The recognition of spatial structuring in marine fishes and the understanding of the mechanisms responsible for such population structure is of paramount importance for fishery management and species conservation. Here, I will give examples of recent genetic studies indicating stock structure and local adaptation in cod, herring and sprat in Scandinavian waters.

Modeling kelp forest distribution along geophysical gradients

Trine Bekkby

Eli Rinde, Lars Erikstad and Vegar Bakkestuen

The kelp species *Laminaria hyperborea* constitutes highly productive kelp forest systems hosting a broad diversity of species and providing the basis for commercial kelp harvesting and, through its productivity, the fishing industry. Spatial planning and management of this important habitat and resource needs to be based on distribution maps and detailed knowledge of the main factors influencing the distribution. However, in countries with a long and complex coastline, such as Norway, detailed mapping is practically and economically difficult. Consequently, alternative methods are required. Based on modelled and field-measured geophysical variables and presence/absence data of *L. hyperborea*, a spatial predictive probability model for kelp distribution is developed. The influence of depth, slope, terrain curvature, light exposure, wave exposure, and current speed on the distribution of *L. hyperborea* are modelled using a generalized additive model. Using the Akaike Information Criterion, we found that the most important geophysical factors explaining the distribution of kelp were depth, terrain curvature, and wave and light exposure. The resulting predictive model was very reliable, showing good ability to predict the presence and absence of kelp.

Hidden biodiversity in kelp forests: Bacterial diversity and production on the surfaces on *Laminaria hyperborea*

Mia Bengtsson

Kjerst Sjøtun and Lise Øvreås

The kelp *Laminaria hyperborea* forms extensive underwater forests along the Atlantic coasts of Europe. These kelp forests are hotspots for primary production and biodiversity, and many species of invertebrates, fish and epiphytic seaweed depend on the kelp for shelter, nutrition and as a growth substrate. Invisible but perhaps even more diverse are the bacteria that live in biofilms that coat the surfaces of the kelp. These bacterial communities are believed to be important in the kelp forest food web by making kelp-produced carbon available to animal consumers, yet very little is known about their biodiversity, ecology and functions. The aim of this study was to uncover what regulates the biodiversity of kelp surface biofilms and how it impacts ecosystem function, such as bacterial production. We used deep 454-sequencing of amplicons of the 16S rRNA gene of bacteria to get a detailed view of the diversity and phylogenetic identity of bacterial operational taxonomical units (OTUs). Incorporation of labeled thymidine was used to measure bacterial production. The results show that bacterial OTU richness increases with the age of the kelp surface. There is a "core community" of a few bacterial OTUs that is stable across different seasons and environmental conditions. OTU evenness of the bacterial communities influences bacterial production and confirms that bacterial diversity impacts the kelp forest ecosystem. The findings give important insights into factors that regulate marine bacterial biodiversity in general and suggest exciting new research directions in the field of kelp forest ecology and kelp forest ecosystem.

Size matters – grazer induced chain length plasticity reduces grazing risk in a marine diatom

Johanna Bergkvist

Peter Thor, Hans Henrik Jacobsen, Sten-Åke Wängberg and Erik Selander

Diatoms are among the most important primary producers in the world, responsible for 30% of the carbon fixed in the ocean. Species of the diatom genus *Skeletonema* dominate the spring bloom and drive the biogeochemical cycle of carbon and other nutrients in temperate parts of the coastal ocean. Size is of fundamental importance in the pelagic ecosystem, where grazers are typically confined to size limited range of prey, but size is highly variable in chain forming diatoms. *Skeletonema* can occur as single cells or as long chains consisting of more than 20 cells. The reason why some species of diatoms form chain-like colonies and what determines the length of the chains are not clear. Cues from grazers have been shown to induce morphological changes in phytoplankton and here we show that cues from grazing zooplankton induces the diatom *Skeletonema marinoi* to adjust its chain length to reduce the grazer's capacity to feed on the algae. These changes were triggered without physical contact between the grazer and the diatom and must be due to the algae sensing chemical cues from the grazers. *S. marinoi* also sensed what type of grazer that was present and adjusted the chain length accordingly, also, the change in chain length reduced the grazing pressure. This is the first time that it is shown for diatoms and with their importance for net-production these mechanisms can have consequences for size and quality of the global primary production.

Do seagrasses feel the heat? A common stress garden reveals population-specificity of heat stress gene induction

Nina Bergmann

Gidon Winters, Gisep Rauch, Christophe Eizaguirre, Jenny Gu, Peter Nelle, Birgit Fricke and Thorsten B.H. Reusch

Summer heat waves have already resulted in mortality of coastal communities, including ecologically important seagrass meadows. Gene expression studies from controlled experiments can provide important insight as to how species/genotypes react to extreme events that will increase under global warming. In a common stress garden, we exposed three populations of eelgrass, *Zostera marina*, to extreme sea surface temperatures, simulating the 2003-European heat wave. Populations came from locations widely differing in their thermal regime, two northern European locations [Ebeltoft (Kattegat, North Sea), Doverodde (Limfjord, Baltic Sea)], and one southern population from Gabicce Mare (Adriatic Sea), allowing to test for population specificity in the response to a realistic heat stress event. Eelgrass survival and growth as well as the expression of 12 stress associated candidate genes were assessed during and after the heat wave. Contrary to expectations, all populations suffered equally from three weeks of heat stress in terms of shoot loss. In contrast, populations markedly differed in multivariate measures of gene expression, as indicated by a significant statistical interaction among populations and time points. While the gene expression profiles converged to pre-stress values directly after the heat wave, stress correlated genes were upregulated again four weeks later, in line with the observed delay in shoot loss. Target genes were selected based on functional knowledge in terrestrial plants and 10/12 genes were significantly upregulated at least once during the heat wave in eelgrass. This study underlines the importance of realistic stress and recovery scenarios in studying the impact of predicted climate change.

Feeding ecology of flounder, *Platichthys flesus*, in a shattered environment

Janica Borg

Mats Westerbom and Hannu Lehtonen

Habitat use of predators depends among other factors on food abundance and diet width. According to habitat utilization theories predation is easier in a homogeneous habitat and these will thus be favoured by the predator. We studied the connection between the diet and habitat choices of a predatory species, the flounder (*Platichthys flesus*), in low salinity conditions. The study was carried out on the south-western coast of Finland, at the edge of the flounders range. The habitats in the studied area are becoming more shattered due to eutrophication caused by antropogen activity. This has lead to changes in the fish community; the flounder population is diminishing while cyprinid fishes have increased in number. Still very few studies of adult flounder ecology are made in this area. The study was carried out by gill net fishing and bottom fauna sampling in different archipelago zones and on different bottom substrates. The study showed that the flounder uses the homogeneous hard bottom habitats as foraging grounds to a greater extent than the soft bottom habitats. The most important prey species were bivalves, particularly the blue mussel (*Mytilus edulis*) and the Baltic tellin (*Macoma baltica*). The flounder prefers sessile prey, but also some mobile prey was included in the diet. The diet differs to some extent from that reported from more saline parts of the Baltic, which most likely is an adaptation to the local bottom fauna. This explains why the flounder is encountered also on hard bottom habitats in south-western Finland.

Combined effects of a contaminant and increased temperature in a shallow brackish ecosystem

Clare Bradshaw

Kerstin Gustafsson

Pollutants exert effects at all levels of biological organisation, their effects may be both direct and indirect, and may interact with environmental effects. We investigated how both increased temperature and the flame retardant HBCDD affected ecosystem structure and function, using mesocosms containing comprising both benthic and pelagic components of a shallow brackish water bay. There were alterations in both structure and function of the communities. Overall, there was a stronger effect of increased temperature than of the contaminant. The contaminant effect varied greatly with time and endpoint, indicating a more complex response. There was also evidence of interactions between temperature and contaminant effects. This study highlights the importance of understanding sublethal and indirect ecosystem effects at low contaminant concentrations, and of their interactions with temperature dynamics in an environment where warmer summers are predicted.

MyOcean - the future Marine core service in Europe

Erik Buch

Jun She

The current plan and status of this EU funded project “MyOcean” is presented. MyOcean is the implementation project of the European Marine Core Service, aiming at deploying the first concerted and integrated pan-European capacity for ocean monitoring and forecasting. During years 2009-2011, MyOcean will lead the setting up of this new European service, grown on past investments in research & development, system development and international collaborations. Implementing a European Marine Core Service is one of the top-three priorities of the GMES (Global Monitoring for Environment and Security) program led by the European Commission to enhance the development of new services based on Earth Observation, and organize their long-term sustainability. MyOcean is a direct answer to this priority. Co-funded by the European Commission up to 33 M€, MyOcean gathers a total amount of resources in Europe of 55 M€, and a consortium of 60 partners spread over 28 countries led by Mercator Ocean. More than 350 persons are involved, representing around 200 FTE. The scientific challenge deals with the development and operation of a reliable global ocean monitoring and forecasting service; the technical challenge concerns the transition to full operations at a pan-European level of a distributed system of systems (architecture and organization that integrate and homogenize the existing capacities) made of a dozen of centres on duty in Europe.

Classification and prediction of deep-water habitats in Norway

Pål Buhl-Mortensen

Lene Buhl-Mortensen, Margaret Dolan, Kim Picard and Jennifer Dannheim

The MAREANO mapping programme has mapped 50 000 km² of seabed using multibeam echosounder (MBE), and surveyed 513 locations using high definition video. Detrended Correspondence Analysis (DCA) of quantitative results from processing of the video records provided a classification of seabed sites based on community similarities. The best combination of environmental proxies derived from MBE was selected by using the forward selection function in the analysis software CANOCO. These predictors were used for modeling the “habitat” classes defined with DCA. The predicted habitats displayed a good fit with the actual habitats (82-85% correct prediction). Characteristic species were identified for the habitats and sediment samples from a subset of the surveyed locations provided data on the species diversity and production within the habitats. Together with data on the abundance of fragile and rare species in the habitats, the predicted maps provide a useful tool for assessing the vulnerability of marine areas.

Biological structures as a source of habitat heterogeneity and biodiversity

Lene Buhl-Mortensen

Biological structures exert a major influence on species diversity at both local and regional scales. Some organisms use other species as substrates for attachment, shelter, feeding, or parasitism, but there may also be mutual benefits from the association. This presentation highlights the biotic effects of the habitats provided by epibenthic megafauna to other organisms. Data from video-observations conducted by the MAREANO mapping program indicates that the importance of benthic species as substrates increase with depth, as the complexity of the surrounding geological substrate and food supply decline. Suspension feeding, habitat-forming organisms modify the environment to optimize their food uptake. This environmental advantage is passed on to associated species. Organisms associated with biological structures that provide a firm substratum reaching into the near-bottom benthic boundary layer (BBL) containing bottom currents, will have more food particles and other resources available to them than will be present in the framing habitat. Often propagules and larvae are present but suitable firm substratum is lacking. Thus, organisms that provide an elevated position on a stable substratum represent a scarce habitat, contributing substantially to the species richness of their respective environments. Structures such as tubes, skeletons, tests or stalks of epibenthic organisms protrude from the sea floor, providing a hard substratum that elevates suspension feeders into the BBL flow. The function of these habitat forming organisms and the ecosystem service they provide is poorly understood. Because the epibenthic megafauna is particularly vulnerable to fisheries it represent a key points for management of ecosystems and biodiversity.

An appraisal of the community structure of mangrove forest in Bagonbanua Marine Reserve, Guiuan, Eastern Samar, Summer 2005.

Marianne Camoying

A taxonomic survey and zonation analysis of mangrove species was conducted in Bagonbanua Mangrove Forest during the Summer of 2005. The transect line plot method was applied for establishing sampling plots. Physico-chemical parameters such as temperature, salinity, and pH were noted. Five species belonging to three families were identified. The species were *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera cylindrical*, *Sonneratia alba* and *Aegiceras corniculatum*. The most dominant species and had the highest regenerative capacity was *Rhizophora mucronata*. The least in number was *Aegiceras corniculatum* having the lowest probability to sustain its existence. An evident zonation was observed perpendicular to the shore. The seaward zone which was dominated by *Rhizophora* sp. was the most expansive.

Mitigation measures to relieve the detrimental effects of coastal hypoxia and eutrophication in the Baltic Sea

Daniel Conley

Johanna Stadmark and Jens Kjerulf Petersen

Frustration over the lack of progress in achieving improvements in water quality has led to calls for rapid and radical remediation efforts in the Baltic Sea, which promise immediate improvements in water quality, often at a cost significantly less than the costs of nutrient reductions, and occur on relatively short time-scales compared to the implementation of many types of nutrient reductions. These promises make large-scale, engineered remediation appear quite attractive to the public and to politicians. We risk not making the needed nutrient reductions and we will have to live with an impaired Baltic Sea. The challenge we are addressing in INFORM is to evaluate different mitigation measures to relieve the effects of coastal hypoxia and eutrophication. More specifically, we will evaluate the effectiveness, relative costs and ecosystem consequences associated with different remediation measures and compare them with traditional land-based measures to reduce nutrients. We will present our approach using mussels as an example mitigation measure to reduce nutrients in the Baltic Sea.

The Global Ocean Observing System (GOOS) and its implementation in Europe

Hans Dahlin

Hans Dahlin

GOOS, the Global Ocean Observing System, is designed and being implemented to embrace the oceans as a single entity, to provide a global view of the ocean system. GOOS is designed to: Monitor, understand and predict weather and climate Describe and forecast the state of the ocean, including living resources Improve management of marine and coastal ecosystems and resource Mitigate damage from natural hazards and pollution Protect life and property on coasts and at sea Enable scientific research GOOS serves: Oceanographic researchers, coastal managers, parties to international conventions, national meteorological and oceanographic agencies, hydrographic offices, marine and coastal industries, policy makers and the interested general public. GOOS is implemented by: Member states via their government agencies, navies and oceanographic research institutions working together in a wide range of thematic panels and regional alliances. EuroGOOS is the European Regional Alliance of GOOS. In addition to implement GOOS at the European scale, EuroGOOS also co-ordinates the establishment of a European Operational Oceanography infrastructure.

Nutrient loadings from land: identifying and resolving diverging interpretations of their development

Georgia Destouni

By comparing different model interpretations of nutrient loads to the coast from the Swedish water management district Northern Baltic Proper, we found essential differences in the conceptualization and quantification of the inland pathways and lag times of hydrological nutrient transport to the coast. In the modeling that underlies inland water management decisions, there is in particular a systematic neglect of the possible wide spectrum of very short to very long times of hydrological transport, from the inland sources of nutrients and pollutants, through the hydrological catchments, to the coast. Both independent modeling of hydrological transport times through Swedish catchments, and consistent comparison of nutrient monitoring data from the large catchments of the Mississippi River and the Baltic Sea, provide support for the prevalence of such wide transport time spectra. These are reflected in flow-weighted nutrient concentrations that remain essentially constant in spite of wide inter-annual fluctuations in water discharge and hydro-climatic forcing. Such persistence can be attributed to long-term hydrological transport of anthropogenic inputs, generating long-term nutrient legacy and memory in the catchments. These findings suggest that longer-term water-quality problems in coastal-marine, as well as in inland waters should be anticipated, and point to the need for adopting additional types of abatement measures and strategies than just the currently preferred, source-focused ones.

Combining gut fluorescence technique and spatial analysis to determine grazing effects on benthic bottoms

Eliecer Diaz

Patrik Kraufvelin and Johan Erlandsson

We assessed the applicability of the 'gut fluorescence technique' (GFT) to estimate per capita grazing rates of a common abundant benthic herbivore, *Littorina littorea* under eutrophicated versus non-eutrophicated conditions in a set of mesocosms. Additionally, we carried out a spatial analysis during 24 hours in order to relate clumping behaviour with feeding activity. GFT has widely been used to quantify grazing activity in zooplankton, but not in benthic grazers, while spatial analysis can help to describe spatial patterns of grazers in time. GFT estimates the 'daily ingestion rate' of a grazer. Daily ingestion rate is a function of: (1) the 'gut pigment content', (2) the 'gut evacuation rate', and (3) the 'gut pigment destruction'. These three describe feeding adaptations to environmental conditions. The 'daily ingestion rate' and one of its variables 'gut pigment destruction' did not differ between littorines incubated at different levels of nutrients. In contrast, the two other variables exhibited statistical differences, being larger in magnitude in eutrophicated mesocosms. In addition, 'the gut pigment content' showed temporal variability; guts tend to contain more algal pigments in the evening than in the morning. Similarly, spatial analysis (semivariograms) showed that at midnight littorines tend to disperse randomly respect to mid day. In conclusion GFT can be used for benthic grazers, but the 'gut pigment destruction' method still needs more refinement. The advantages of the GFT in benthic organisms are discussed, and the link with spatial analysis can be a contribution to understand the formation of landscapes on rock bottoms.

Population control of the invasive Pacific oyster in microtidal areas: impact of an ice winter

Per Dolmer

Pia Norling, Mark Wejlemann Holm, Tore Holm, Jens Davids, Elisa Blanda, Benni Winding Hansen, Helle Torp Christense, Pernille Nielsen, Susanne Lindegarth, Åsa Strand, Carlo Nyberg, Bodvin Torjan, Lasse Fast Jensen, Bent Vismann, Stein Mortensen, Lisbeth Harkestad, Kerstin Geitner, Morten Aabrink and Angelica Ardehed

Pacific oyster, *Crassostrea gigas*, is a non-indigenous species that benefit from increasing waters temperatures. The history of the bioinvasion of the species proves the capability of the species to disperse and establish concrete reef structures altering the original habitat. Earlier the native blue mussel was very abundant in many of the areas which are now occupied by pacific oyster. Low water temperatures were previously believed to restrict the establishment of the Pacific oyster in Scandinavia. In 2008-2009 a compilation of a joint Scandinavian assessment of the distribution of *C. gigas* was conducted. The study showed that the Pacific oyster is now established in many areas in Scandinavia. The biomass of oysters in the Danish Wadden Sea has increased dramatically between 2005 and 2007, large numbers were observed along the Swedish west coast from settlement in 2006, and in Norway, populations are established along the southwest coast to 60No. After the icewinter 2009-2010 some of the sites were revisited and the talk presents a review of the impact of an icewinter on population densities of the species. The impact of winter mortality on populations of *C. gigas* is compared to other population controlling factors.

Biological diversity as the central organizing concept in marine conservation and management: Challenges and opportunities

Emmett Duffy

A common argument for biodiversity conservation involves its importance to ecosystem functioning. This justification is based in large part on controlled experiments showing that loss of diversity often reduces productivity, and enhances stability, across a range of systems. But these experiments generally lack context—few studies, theoretical or empirical, have addressed the quantitative importance of such “horizontal” biodiversity effects compared with the well-documented forcing of ecosystem structure and functioning by abiotic drivers, resource supply, and top-down control by consumers. Research also lags in explicitly integrating important components of biodiversity other than species richness—including genetic and landscape diversity—in studies focused on ecological processes. The most fundamental challenge in applying biodiversity research to practical marine management is our still poor understanding of how biodiversity affects functioning of complex, natural ecosystems and their provision of services that directly influence human well-being. Progress on this front will require a more systematic focus on large spatial and temporal scales, interactions among forcing factors, and emergent properties of complex systems. Experiments alone are inadequate to the task and will have to be supplemented with observational approaches and simulation modeling. Here I review recent progress along these frontiers and sketch some proposed paths forward. I conclude with an evaluation of how recent research can inform the focus on biodiversity conservation as the heart of integrated ecosystem-based management.

Evolutionary rules in the brave new ocean

Sam T Dupont

Mike S Thorndyke

As a consequence of anthropogenic CO₂ emissions and climate change, oceans are becoming warmer (global warming) and more acidic (Ocean Acidification, OA). Rates of change are increasingly fast and we can only guess at the kinds of organisms that will suffer (“losers”) or benefit (“winners”) from this mayhem that is radically altering ecosystem structure. OA research is still in its infancy and the increasing amount of data available highlight the complexity of this ecological question. The impact of OA appears to be extremely species- and even population-specific and depends on life-history stages and the processes studied. The current paradigms (e.g. OA will negatively impact calcifiers) are now being revisited making any large scale prediction impossible or over-simplistic. However, sufficient data are now available to move on to the next generation of OA research and start testing hypotheses and predictions. To allow large scale predictions of the impact of climate change on marine ecosystems it is then needed to understand how OA will modify the evolutionary rules shaping marine ecosystems. This presentation will review the literature on the impact of OA on physiology and energetic balance to identify the new evolutionary rules in this changing ocean using echinoderms as models.

Coupled ecosystem engineering and trophic interactions trigger and maintain alternative states

Johan Eklöf

Tjisse van der Heide, Serena Donai, Els van der Zee and Klemens Britas Eriksson

Ecosystem engineers shape communities and landscapes by modifying the physical environment. Such habitat modification can result from positive engineering feedbacks, but also from counteracting feedbacks driven by antagonistic engineers. Since engineering effects typically exceed engineers spatially and temporally, the spatial structure of such ecosystems should be controlled by an interaction between the scale of disturbance and the strength of feedbacks. Here, we investigated how scale-dependent mechanisms shape an intertidal landscape characterized by alternating low tide elevations (hummocks) dominated by sediment-stabilizing seagrass (*Zostera noltii*), and low tide pools (hollows) dominated by bioturbating lugworms (*Arenicola marina*). In summer, seagrasses excluded worms on hummocks but invaded hollows regardless of worm presence and hollow size. In autumn, waterfowl grazing selectively removed colonizing seagrasses in 1 m² clearings, and in 0.25 m² clearings where worms had been added. This effect was caused by erosion – in the large clearings due to lack of seagrass stabilization, in the medium by lack of seagrasses exacerbated by worm bioturbation – which formed hollows large enough to facilitate grazing. Spatial modeling suggests that (1) the hummock-hollow mosaic is temporally self-sustained by the sediment-mediated seagrass-grazer-worm interaction, (2) there is a bifurcation between two alternative landscape-scale states (large vs. small seagrass patches) depending primarily on grazing pressure, but (3) a collapse to a permanently unvegetated state is unlikely, as grazers cease feeding before depleting plant biomass. Coupled ecosystem engineering and trophic interactions thereby maintain hummocks and hollows as alternative states, with clear and interesting management implications.

A multispectral electromagnetic footprint method for determining sediment conductivity profiles

Tim Fristedt

Jan-Ove Hall, Lisa Rosenqvist and Fredrik Silfverduk

The most common technique for (sub)bottom mapping is based on acoustic time travel analysis. In areas where the acoustic properties are such that the sound propagation is impeded, e.g. bottom-trapped gas or in shallow areas, electromagnetic sounding techniques have shown to be an alternative technique. Data is retrieved by transmitting a known signal through the seawater and the underlying bottom and the response is then measured at a specified location. This methodology is known as Controlled Source EM (CSEM) and is based on propagation of harmonic constituents in the ELF/VLF frequency band. The standard technique uses a mobile transmitter and stationary receivers, whereas the current investigation suggests towing of both transmit and receiver instrumentation, where each illuminated spot along the towtrack form a so called footprint. The data is matched to a physical parameterization of the environment via an iterative solution method where the parameters are adjusted until the model fits the data. This is known as model-based inversion and has been used extensively within geophysics and oceanography. The tuning of the model parameters is dependent on the quality of the data, but also on the number of independent observations. This is a key issue for footprint methods since the integration time over each bottom segment becomes limited. The present investigation outlines a technique for maximizing the number of independent data points while keeping the transmit amplitude limited, which results in an enhanced data yield. The technique also avoids beats or DC-frequencies which occurs when mixing harmonic signals.

Monitoring the *Calanus finmarchicus* winter distribution: New possibilities using the Laser Optical Plankton Counter (LOPC)

Frank Gaardsted

Kurt Tande, Sünnje Basedow and Ole-Petter Pedersen

In the autumn *Calanus finmarchicus* descends from surface waters and spends the winter months in diapause at depths below 600 m. Despite the important role of this copepod in marine food webs, relatively little information on its geographical winter distribution is available and the temporal variability remains largely unknown. Most of our current knowledge is based on net sampling, and due to the need for time consuming analyses of samples, and the limited resolution obtained from such sampling, new approaches are necessary to address the challenge of designing monitoring programs that are able to provide data with sufficient spatial and temporal resolution. Because of its high sampling efficiency of large quantities of zooplankton data, the Laser Optical Plankton Counter (LOPC) represents a promising alternative to net sampling. The usefulness of the LOPC as a monitoring tool of the *Calanus finmarchicus* winter habitat is demonstrated by results from four winter surveys (2007 - 2010) in the NE Norwegian Sea. Intercomparison of results from net and LOPC sampling shows that the LOPC provides high quality *Calanus finmarchicus* abundance data. Furthermore, by combining the high resolution LOPC data with simultaneously collected CTD data and current measurements, physical-biological interactions can be studied in greater detail than what has previously been possible with net sampling. As an example, results on the vertical *Calanus finmarchicus* winter distribution and its relationship to hydrography are presented.

Legal implementation of the Water Framework Directive in the Scandinavian countries

Lena Gipperth

Both the Water Framework Directive and the Marine Strategy Framework Directive aims at achieving good environmental status in the aquatic environment and demand the EU member states to take all necessary measures in order to achieve such status by set dates. But how is such status defined in relation to different water bodies and what legal tools can and must be used in order to achieve such status? What are the legal effect in relation to single activities but also in relation to public bodies? This presentation builds on a comparative study of the implementation of some key concepts in the Water Framework Directive in the Scandinavian countries. The study was financed by the The Swedish River Basin District Authorities and conducted in the spring 2010. The aim was to analyse the differences in implementation between different states – how the legal constructions are designed in order to implement the directive and if there is an "over implementation" by some countries. It further draw conclusions about the consequence of such differences in implementation and the challenges facing the Scandinavian countries in relation to the Marine Strategy Framework Directive.

Predicting the natural mortality of marine fish from life history characteristics

Henrik Gislason

John Pope, Jake Rice and Niels Daan

For fish much of the life history is determined by body size. Body size and asymptotic size significantly influences important life history processes such as growth, maturity, egg production, and natural mortality. Furthermore, for a population to persist, offspring must be able to replace their parents on a one-for-one basis in the long run. Otherwise the population would either increase exponentially or become extinct. Combining data on growth and specific fecundity in a size-based fish community model of the North Sea and using the requirement of a one-for-one replacement provides the information necessary to estimate the scaling of natural mortality with size and asymptotic size. The estimated scaling is compared with output from multispecies fish stock models, with the empirical scaling of the maximum number of recruits per unit of spawning stock biomass with body size, and with estimates from a comprehensive compilation of empirical data on the natural mortality of marine fishes. The comparisons are all in agreement with the predictions from the model. We conclude that natural mortality scales with body length raised to a power around -1.6, with the asymptotic length of the species, and with the von Bertalanffy growth parameter K .

Linking the planktonic and benthic habitat: genetic structure of the marine diatom *Skeletonema marinoi*

Anna Godhe

Karolina Härnström

Dormant life stages are important strategies for many aquatic organisms. The formation of resting stages will provide a refuge from unfavourable conditions in the water column, and their successive accumulation in the benthos will constitute a genetic reservoir for future planktonic populations. We have determined the genetic structure of a common bloom-forming diatom, *Skeletonema marinoi*, in the sediment and the plankton during spring, summer and autumn two subsequent years (2007-09) in Gullmar Fjord on the Swedish west coast. Eight polymorphic microsatellite loci were used to assess the level of genetic differentiation and the gene diversity of the two different habitats. We also determined the degree of genetic differentiation between the seed banks inside the fjord and the open sea. The results indicate that Gullmar Fjord has one dominant endogenous population of *S. marinoi*, which is genetically differentiated from the open sea population. The fjord population is encountered in the plankton and in the sediment. Shifts from the dominant population can happen, and in our study two genetically differentiated plankton populations, displaying reduced genetic diversity, occurred in September 2007 and 2008. Based on our results we suggest that sill fjords maintain local long-lived and well-adapted protist populations, which continuously shift between the planktonic and benthic habitats. Intermittently, short-lived and mainly asexually reproducing populations can replace the dominant population in the water column, without influencing the genetic structure of the benthic seed bank.

Filling in the blanks: Predictive mapping of benthic biotopes in the Koster Fjord area (Sweden) for biodiversity assessment and

Genoveva Gonzalez-Mirelis

Mats Lindegarth, Tomas Lundälv and Per Nilsson

The establishment of the marine Kosterhavet National Park, off the west coast of Sweden, has prompted investigation into the spatial distribution of its marine resources, including benthic diversity, in support of marine spatial planning. Regarding the characterization of the spatial patterns of biological diversity, the main goals of this project were to define, and map benthic biotopes, using spatially-explicit modeling, at a scale relevant for management. To that end, predictive mapping at the community level was carried out, whereby a suite of environmental attributes available as GIS, full-coverage layers, were used to model the distribution of benthic communities, as derived from highly-localized, underwater imagery. In this paper, we report on the model used, as well as the results obtained. The communities modeled included: hard substrate communities of the deep, characterized by various kinds of erect sponges, brachiopods, and tube-dwelling polychaetes; hard substrate communities of intermediate depths, characterized by the soft coral known as Dead Man's Fingers, and the solitary Devonshire Cup Coral; communities associated with the reef-forming, cold water coral *Lophelia pertusa*; and soft sediment communities, associated with the presence of sea feathers, and the (highly valued) Norway lobster. Maps empower planners with a tool to assess representation of biotopes in the different zones within a protected area, as well as highlight underrepresented biotopes in need of particular management provisions. The map obtained was subsequently used to address various management questions, to demonstrate how it can aid in conservation planning.

Halocarbons in Arctic Sea Ice

Anna Granfors

Melissa Chierici, Agneta Fransson, Katarina Gårdfelt, Maria Andersson, Anders Torstensson, Angela Wulff and Katarina Abrahamsson

The Arctic environment is sensitive; with little ability to adapt to a changing climate. Volatile halocarbons play a part in how the ocean interacts with the surrounding environment since they are involved in destruction of ozone and contribute to aerosol formation. A key to the impact of halocarbons to the environment is their transport from the ocean to the atmosphere. In the Arctic the transport of halocarbons in sea ice must be understood to know what influence a change in ice cover will have to halocarbon emission. An understanding of halocarbon transport in sea ice will also help to understand the role of the sea ice-atmosphere interface in halocarbon chemistry. Halocarbons were measured in Arctic sea ice in Ny-Ålesund, Svalbard. The measured halocarbons were both anthropogenic and naturally produced by marine macro- and microalgae. Their concentration and depth distribution in sea ice was studied in ice cores from old ice and in newly frozen ice from recent drill holes. Both the concentrations and depth distributions of the different halocarbons were monitored during 12 days and changes could be seen from day to day.

Empirical modelling for mapping of benthic habitats in the Baltic Sea: what can be predicted and which are the efficient predict

Martin Gullström

Mats Lindegarth

PREHAB is a cross-disciplinary research program aiming at integrating ecological mapping and socio-economic valuation to develop a framework for integrated regional planning and future ecosystem-based management of the Baltic coastal environment. One central theme of the project is that comprehensive maps of biological properties of the benthic habitats are invaluable for rational planning and management of coastal areas. Because most biological variables vary at small spatial scales and are measured using scattered samples, interpolation using empirical models is necessary for comprehensive mapping. Therefore, a primary objective of the program is to evaluate (1) which biological variables can be predicted with sufficient accuracy, and (2) which physical or other variables can be used to predict and map benthic habitats. These questions are addressed using a variety of statistical techniques (GAM, randomForest, MARS, MAXENT and Kriging) and in a range of benthic environments in the Baltic. Initial analyses show that empirical models can be used to successfully map prevalence as well as cover of different types of vegetation in coastal areas. The explanatory power of predictor variables differed among biological response variables, areas and statistical methods, but in general those derived from bathymetry, substrate, exposure and location proved to be important. These results indicate that representative sampling of benthic habitats, combined with predictive modelling is a cost-efficient and feasible alternative for stakeholders in need of maps for decision-making of the Baltic region.

Modelling and mapping green sea urchins – mutual benefits for commercial harvest and regrowth of kelp forests in Norway

Hege Gundersen

Eli Rinde and Hartvig C. Christie

The green sea urchin (*Strongylocentrotus droebachiensis*) occurs in high densities along the northern coast of Norway and is regarded as a big problem due to its ability of turning high-productive kelp beds (*Laminaria hyperborea* and *Saccharina latissima*) into sea urchin-dominated barren grounds of low diversity and productivity. However, the gonad of the sea urchins is also regarded as a delicacy and thus represents a potentially huge resource for industrial and commercial development. We have studied the basis for harvesting green sea urchins commercially by applying GIS models of barren grounds combined with statistical models of density distribution of sea urchins. The statistical models are based on density data from field studies (793 stations covering the coast from 63°N to 71°N). We estimated the environmental gains of “overfishing” the sea urchins resulting in a likely recovery of kelp biomass and production. The recovery of kelp biomass includes an additional positive effect through binding of CO₂, and recovery of kelp associated biodiversity and resources. We discuss the mutual benefits of commercial harvesting of sea urchins in the boundary areas between un-grazed kelp forest and barren grounds with a sufficient effort to cause regrowth of kelp forests on a total of 3500 km² of potential habitat along the Norwegian coast.

Operational oceanography in northern Europe - a dedication to IOC 50th Anniversary

Bertil Håkansson

The BOOS co-operation was formed in 1997 with the aim to promote and develop an operational oceanographic infrastructure including routine collection, interpretation and presentation of in situ and satellite data. This information is necessary in order to improve efficiency of marine operations, reduce risks for accidents, optimise monitoring of marine environment and climate, improve assessment of fish stocks and improve foundation of public marine management. An operational service supporting these activities shall focus on observations and model predictions, analyses and scenarios. Products of high-quality which are timely delivered to users in a sustained manner are key factors to success of services. Present activities ongoing within the Baltic Sea community and at SMHI will be highlighted taking into account the IOC 50th anniversary

Is collaboration plans suitable management for valuable coastal and marine areas?

Jorid Hammersland

Soheil Hagbayan, Lotta Nygård, Ingela Isaksson, Jenny Hertzman and Kjell Schaerling

Collaboration Plans for Valuable Coastal and Marine Areas is a national pilot project initiated by the Swedish Environmental Protection Agency. The project consists of five regional pilot areas that are being conducted during 2008-2010 by the administrative boards of Västernorrland, Stockholm, Östergötland, Blekinge and Västra Götaland counties. Four of the pilot areas are designated as Baltic Sea Protected Areas (BSPA) by HELCOM. Parts of the fifth is designated as a Marine Protected Area (MPA) by OSPAR. The five project areas vary with regard to their dimensions, populations, knowledge, the proportions that are legally protected, and user interests. The objective is to develop plans on conservation, protection and sustainable use in order to provide a basis for long term and sound management fulfilling the requirements according to the regional conventions and conducting the achievement of national environmental objectives. The implementation of the Ecosystem approach and ICZM is guiding the process on the development of governance in the areas. One major challenge in the project is to combine the use and enforcement of current legislative and regulatory frameworks as the Environmental Code, the Plan and Building Act, the Fishing act, the Water framework directive etc., to establish efficient management without developing new regulatory tools or implement stronger enforcement than needed. A strong emphasis is placed on the approval, participation and co-operation of the local communities. Accordingly, the collaboration plans are developed in close co-operation with affected municipalities and organizations, and local inhabitants.

Science and capacity building through IOC

Ulf Lie and Peter M Haugan

From the very start of the IOC, the organization focussed on promotion of ocean science and collaboration between the member states including capacity building. In later years, operational services have come to the forefront with the Global Ocean Observing System (GOOS). In addition the IOC hosts a range of activities to underpin ocean policy. Many national and international organizations today coordinate and run ocean science programs and one may ask if the IOC needs to be involved in ocean science. I will try to review some major achievements of IOC science and capacity building activities over the years and discuss its possible future role as an intergovernmental body within the UN system.

The importance - and limitations - of statistics in ocean acidification research

Jon Havenhand

Gerry Quinn

Our comparatively poor understanding of the effects of ocean acidification on marine species and systems has led to a pressing need for reliable data and predictions. In this context "negative" results are as important as "positive" results, and several key publications claim to show "no effect" of ocean acidification. Here we review the flaws inherent in these, and several other, approaches to the analysis of ocean acidification and make recommendations regarding best practice for future research.

Population fluctuation of seabirds and fish in the Baltic Sea

Mårten B Hjernquist

Björn Hjernquist

Many marine environments are over-exploited, and the Baltic Sea in Northern Europe is no exception. Changes in fish populations can affect the entire ecosystem and organisms at all trophic levels. Marine top-predators such as seabirds are influenced by the abundance and quality of their prey fish. In the Baltic Sea, an increased abundance of Sprat has been argued to be negative to seabirds providing one of the best field evidence for the "junk-food" hypothesis. This because increased competition among sprats supposedly decreases the energy content of each individual fish. Hence, more sprats lead to more food but of less quality. In this study, the role of quality and quantity of sprat on three seabird species (guillemots, razorbills and lesser black-backed gulls) in the Baltic Sea is tested using long term population data. The results support the notion that the abundance of prey fish is of utter importance to piscivore species. Contrary to other studies on seabirds in the Baltic Sea the data do not support the "junk-food" hypothesis and the seabird populations follows the fluctuations in sprat abundance. In the Baltic Sea, more sprat simply seems to mean more food. These results are also important since the junk-food hypothesis is put forward as one possible explanation to changes in other predator-prey systems in the Baltic Sea.

Model species distribution in GIS for coastal management

Martin Isaeus

The aim of the project MMÖG is to produce appropriate GIS layers for the management of the marine area of the county of Östergötland. The GIS layers describe the physical as well as the biological conditions, including layers of classified potential natural values. The project also aims at establishing the quality of depth and bottom substrate layers that have been produced by different methods, and how these quality levels affect the biological results.

Managing Northern Bohuslän for a sustainable use of marine nature resources – a challenge

Ingela Isaksson

The project “Collaboration Plans for Valuable Coastal and Marine Areas” constitute is a national pilot project initiated by the Swedish Environmental Protection Agency and is being conducted as five regional projects where the county of Västra Götaland constitute one. In Västra Götaland the project is integrated in the ongoing “Kustzonsprojektet Norra Bohuslän”. Within these projects five municipalities of Norra Bohuslän including Strömstad, Tanum, Sotenäs, Lysekil and Munkedal work together for a proactive planning and sustainable use of land and water. The primary objective of the project “Collaboration Plans for Valuable Coastal and Marine Areas” is to develop collaboration plans on conservation, protection and sustainable use of the regional areas in order to provide a basis for future management. The collaboration plans are developed in co-operation with municipalities and organizations. Norra Bohuslän harbour more than 6000 marine species, of which 200 are found nowhere else in Sweden. The visitor industry constitute the most important economic sector in the area and together with other activities such as commercial fishing and aquaculture as well as many other ongoing and planned activities high exploitation pressure are placed upon land and water resources and put forward the need for proactive planning. Tools for planning, requires maps also under water! Which has been an important issue throughout the project period together with keeping up the dialogue with stakeholders in the region. Through spatial planning, a well known democratic process for municipalities, we intend to integrate the collaboration plan within the ongoing overview planning process of Norra Bohuslän.

Uptake, distribution and persistence of inorganic and organic tritium in a coastal marine ecosystem

Benedict Jaeschke

Clare Bradshaw, Geoff Millward, John Moody and Awadhesh Jha

Tritium (^3H , T) is a radioactive isotope of hydrogen; it is released in large concentrations from nuclear installations throughout Europe, into the marine environment. The radioactive decay from tritium can ionise molecules in organisms, with sufficient dose this can cause significant cytotoxic, genotoxic and ecotoxic impacts. Tritium is released predominantly in an inorganic form as tritiated water (HTO), and at current levels is treated as virtually benign in the environment. However, there is growing evidence that tritium released in organic forms (replacing hydrogen in carbohydrates, amino acids, DNA, etc.), while representing a small proportion of total tritium releases, has a significantly higher impact due to an increased bioavailability and relative biological effectiveness – achieving similar toxicity to inorganic tritium, at lower doses. We conducted laboratory exposures of Atlantic and Baltic marine organisms to organic and inorganic tritium, and demonstrate a significantly increased accumulation, persistence and toxicity of the organic form. Trends in biokinetics of tritium were contrasted in the blue mussel following acute exposures to organic and inorganic forms through the water and after ingesting organically bound tritium in radio-labelled phytoplankton. Extrapolation of these disparities into a wider context of the marine environment connotes a greater threat to both marine populations and humans who interact with them. This work provides support for the argument that the organic forms of tritium require further attention and separate regulations of releases into the environment.

The challenge of marine biodiversity conservation

Kerstin Johannesson

Biodiversity policy and practice largely focuses on species diversity, and protection of biodiversity is mostly implemented through measures like the Endangered Species Act and Red Lists. At the same time the primary motivation for protecting biodiversity is to secure life-sustaining systems of the biosphere. Reviewing recent research shows that there is no obvious relationship between species richness and ecosystem function in natural ecosystems. Moreover, reviewing comprehensive taxonomic surveys shows that rare species make up 25-45% of all species in pristine ecosystems, and no data exists that show rare species to be important to ecosystem functions. Finally, data from marine habitats shows that costs to monitor a large part of all species present in an ecosystem are extensive. In contrast, biodiversity at the intraspecific level (genetic diversity) has in several recent studies been shown to positively correlate with various ecosystem functions. Furthermore, most common species are substructured into locally adapted populations responsible for decisive functions of local ecosystems. In addition, loss of genetic diversity within species will decrease the potential for evolutionary modifications upon environmental change. The first three observations raise a concern about the current species-action focus in conservation, while the latter three points to the need to protect the genetic part of the biodiversity, and in particular, genetic diversity of functionally important species.

Dispersal in the sea and implications for selection of marine protected areas

Per Jonsson

Martin Nilsson Jacobi

Conservation and management of marine natural resources and biodiversity need improved criteria to select functional networks of marine protected areas (MPA). The connectivity within networks due to dispersal is rarely considered, because dispersal in marine environments is poorly known, but also because it is unclear how connectivity information can be included in the selection of protected areas. We present a novel and general method that applies eigenvalue perturbation theory (EPT) to select optimum networks of MPAs based on connectivity. It is also shown that connectivity is more important than habitat quality when local recruitment is weak, which is characteristic for many marine invertebrates with larval dispersal. Our framework is applied to a population with larval dispersal estimated from ocean circulation models and we demonstrate that for open populations the best strategy is to protect areas acting as both strong sources and sinks. An EPT framework for connectivity analysis could be implemented into existing holistic tools for design of protected areas.

Bio-physical properties of Norwegian coastal cod eggs from different local populations

Kyungmi Jung

Svein Sundby, Anders Thorsen, Arild Folkvord and Olav Sigurd Kjesbu

Vertical distribution of fish eggs and larvae is a key factor for transport and retention of the offspring and for issues linked to mixing/separation between populations. In combination with site fidelity and natal homing of older cod, it serves as a mechanism maintaining genetic differentiation among local populations. The vertical distribution is determined by the combined effects of local salinity structure of the ambient water and by the specific gravity of the eggs. Here we have studied bio-physical properties of Norwegian coastal cod (*Gadus morhua*) eggs from different areas (Porsangen fjord, Tysfjord, and Helgeland) in northern Norway during the spawning season, March to April, 2009. Egg neutral buoyancy was measured during incubation period, and it was observed that fertilized eggs first increase the specific gravity slightly until they complete gastrulation stage, and then become more buoyant. Porsangen cod eggs had the biggest size and the highest water content. Helgeland cod eggs showed a smaller size and contained less water. Interestingly, egg buoyancy was correlated with corresponding water content and chorion volume per egg, but not with egg size. It explained how small size of eggs in Helgeland had high specific gravity. Compared with previous studies, there seemed to be genetic control deciding specific gravity and diameter of offspring. In addition, modeled vertical distribution of eggs varied according to the combination of specific gravity and local hydrographic conditions, suggesting high probability of egg retention in Tysfjord under low-saline brackish water.

Higher diversity of deposit-feeding macrofauna enhances resource utilization in a species-poor system

Agnes Karlson

Francisco Nascimento, Johan Näslund, Sara Blomgren Rydén and Ragnar Elmgren

Animals living in marine sediments, the second largest habitat on earth, play a major role in global biogeochemical cycling. By feeding on organic matter from settled phytoplankton blooms they produce food for higher trophic levels and remineralize nutrients that can fuel primary production. In the Baltic Sea, anthropogenic stresses, such as eutrophication and introductions of invasive species, have altered phytoplankton dynamics and benthic communities. We used isotope tracers to measure incorporation and burial of carbon and nitrogen from simulated phytoplankton blooms by communities of one to four species of native and invasive deposit-feeding macrofauna found in the species-poor Baltic Sea. Both species composition and richness of deposit-feeding macrofauna influenced how much of the phytoplankton bloom material that was incorporated in fauna or retained in the sediment. The mechanism behind the positive effect of species richness was mainly niche differentiation among functionally different species, resulting in a more efficient utilization of resources at greater biodiversity. This was observed even after addition of the invasive polychaete species *Marenzelleria arctica*. The ability of this species to grow fast when supplied old organic matter only, suggests that it is not dependent on newly settled phytoplankton bloom material to the same extent as the native species. This ability has likely been important for the successful invasion of this species, supporting the suggestion that *M. arctica* is using a previously empty niche in the Baltic Sea. In conclusion, higher species richness, including invasive species, may enhance productivity by making resource utilization more efficient.

New developments in SMHI's operational algal bloom monitoring and forecasting in the Baltic Sea and the Skagerrak and Kattegat

Bengt Karlson

Bengt Karlson, Kristin Andreasson, Kari Eilola, Lennart Funkquist, Martin Hansson, Cia Hultcrantz, Marie Johansen, Henrik Lindh, Ann-Turi Skjevik, Patrik Strömberg and Jörgen Öberg

Most algal blooms are beneficent for the marine ecosystem constituting the base of the food web. However, some blooms are harmful in the sense that some phytoplankton produce toxins that may accumulate in e.g. shellfish. Others clog gills of fish, cause anoxia etc. The oceanographic departments of the Swedish Meteorological and Hydrological Institute provide operational services for monitoring and forecasting of algal blooms in general and Harmful Algal Blooms (HAB's) in particular. A new tool for SMHI is the FerryBox system on the merchant vessel TransPaper. The route Gothenburg-Kemi-Oulo-Lübeck-Gothenburg 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. Measurements are made every 20 seconds. Every other week automated water sampling for microscopic phytoplankton analysis is made at a handful of stations. Sampling is also made from research vessels and subsequent microscopic analysis is carried out at least monthly. This provides information about species composition and identification of HAB species. 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 satellite remote sensing, i.e. MERIS (EnviSAT), MODIS (Aqua) and AVHRR. SMHI runs oceanographic models in operational mode. The 3D circulation model, HIROMB, and the biogeochemical model SCOBI, with three types of phytoplankton, have been coupled, aiming at predicting algal blooms in operational mode. The advantages and limitations of the different approaches will be presented.

Genome scanning reveals habitat specific selection among Wadden Sea eelgrass (*Zostera marina*) populations

Katharina Keil

Steven Ferber, Ilka Dankert and Thorsten B.H. Reusch

Eelgrass *Zostera marina* is an ecosystem-engineering species of outstanding importance for coastal soft sediment habitats that lives in widely diverging habitats. We aimed to detect divergent selection and habitat adaptation at the molecular genetic level, hence, we compared replicated habitat pairs of permanently submerged versus intertidal eelgrass populations using genome scans, a powerful tool to detect natural selection in natural populations among a larger sample of marker loci. Three different statistical approaches for outlier identification revealed divergent selection at 6 loci among 46 markers (6 SNPs, 29 EST-derived microsatellites and 11 anonymous microsatellites). These outlier loci were repeatedly detected in parallel habitat comparisons, suggesting the influence of habitat-specific selection. Functionally interesting marker loci were linked to genes involved in osmoregulation and water balance, suggesting different osmotic stress, and reproductive processes (seed maturation), pointing to different life history strategies. The identified outlier loci are valuable candidates for further investigation into the genetic basis of natural selection.

Trait dependent facilitation of macrofaunal communities in sublittoral blue mussel habitats

Maria Koivisto

Mats Westerbom

Blue mussels provide one of the main biogenic hard structures in the Baltic Sea where they aggregate into beds and modify the nature and complexity of the substratum by a variety of processes. They thereby function as important ecosystem engineers in benthic systems. The population structure of these mussel beds fluctuate widely, but the ecosystem effects of these fluctuations are poorly known. In this study, we experimentally and descriptively measured the effect of blue mussel biomass, density and size structure on macrofaunal diversity and body size and tested for the Stress Gradient Hypothesis in rocky shore blue mussel habitats. The Stress Gradient Hypothesis postulates an increased role of facilitative interactions with increasing levels of either physical stress or consumer pressure. We found that biomass and blue mussel size structure are important determinants of species diversity and/or faunal abundance as well as species composition in blue mussel beds, demonstrating that blue mussel traits modify the strength of facilitation in these systems. We also found that the body size of some species groups had a positive correspondence to blue mussel body size, increasing with a growing blue mussel body size. In line with the Stress Gradient Hypothesis, species diversity was more affected by the presence of mussels at the most stressful sites compared to sites with lower stress, indicating that the facilitative strength vary with level of exposure. We suggest that it is of high importance to consider how, when and where individual traits of ecosystem engineers play crucial roles in ecosystem functioning in order to increase the value of the ecosystem engineering concept in ecology and conservation biology.

Multi-decadal to centennial scale North Atlantic SST fluctuations and NW European winter climate - colder in the coming 2-3 decades

Antoon Kuijpers

Marit-Solveig Seidenkrantz, Mads Faurschou Knudsen and Björn A. Malmgren

Multi-decadal to centennial scale North Atlantic SST fluctuations and NW European winter climate - colder in the coming 2-3 decades ? It is well-known that since the late 19th century major regional climatic variations have occurred at multi-annual to multi-decadal time scales. Part of these variations can be linked to multi-decadal changes in Atlantic Sea Surface Temperature (SST) anomaly patterns ('Atlantic Multidecadal Oscillation', AMO) observed in the 20th century, a feature which probably persisted during most of the Holocene. Marine sediment core records from the NE Caribbean and West Greenland Current region covering the past 1500-2000 years show centennial-scale SST fluctuations with warming anomalies marking here the termination of the Medieval Climate Anomaly about AD1200 that persisted during the Little Ice Age. Ensemble simulations with an atmospheric GCM forced with reconstructed SST data for the period 1871-1999 (Sutton & Hodson 2003) confirm linkage between a warm North Atlantic subpolar gyre and weakening of both the westerly winds around 60° N and subtropical NE trade winds. Weaker North Atlantic trade winds and associated tropical North Atlantic positive SST anomalies are likewise typical features of a negative North Atlantic Oscillation index. Considering the actual AMO status characterised by North Atlantic SST warming since 1997, we may infer similar climate development as after the 1930's (positive AMO started late 1920's), with more common cold winters in the coming 2-3 decades. Presumed AMO development in the mid 21st century, possibly enhanced by a global warming trend, may lead to fast and significant (winter) warming.

Reflections on the Intergovernmental Oceanographic Commission

Gunnar Kullenberg

The presentation reflects on the role of the IOC as an intergovernmental mechanism for: ocean research and basic science; cooperation and capacity development; elucidating the importance of the ocean in climate, weather, global cycles, fulfilment of basic human needs and human security; creation of observation, data exchange, forecasting and warning systems; and operational oceanography. Examples include: Climate and ocean processes, role of ocean in greenhouse gas balances, as partner in the World Climate Research Programme, and research on boundary fluxes including coastal and shelf seas. Studies on marine living resources, biological diversity, algal blooms, marine pollution and its biological effects. Initiation of the Global Ocean Observing System in cooperation with several partners and participation in the Global Climate Observing System. Participation in the development of conventions and agreements. Cooperation with other intergovernmental organizations, with non-governmental bodies, in particular the Council of Scientific Unions. The actions are discussed in context of trends, concerns, challenges and changes over the decades since the creation of the IOC in 1960; and with the understanding that IOC is driven by internal forcing from member states and constraints of operating within the framework of UNESCO; and driven by external forcing from other bodies and interests as well as global and regional developments beyond its control.

Stability and forcing of the Iceland-Faroe inflow of heat and salt to the Arctic

Karin Margretha H. Larsen

Bogi Hansen

Stability and forcing of the Iceland-Faroe inflow of heat and salt to the Arctic Karin Margretha H. Larsen¹, Bogi Hansen¹ ¹Faroe Marine Research Institute, Tórshavn, Faroe Islands. Correspondence to: K. M. H. Larsen (e-mail: karinl@hav.fo) The flow of warm saline Atlantic water across the Greenland-Scotland Ridge (Atlantic inflow) is critical for conditions in the Nordic Seas and Arctic Ocean by importing heat and salt. Almost half the total Atlantic inflow is carried by the Iceland-Faroe inflow branch (IF-inflow). After cooling, most of the Atlantic inflow returns to the Atlantic as dense overflow water that feeds the deep branch of the North Atlantic thermohaline circulation (THC). The IF-inflow has been monitored by regular CTD cruises since the late 1980ies and an array of Acoustic Doppler Current Profilers has been moored across the flow since 1997. From these measurements, we have constructed time series of the transports of water, heat, and salt towards the Arctic through this gap. These time series show no statistically significant trend, but temperature and salinity increased during the observational period. Also on shorter time scales, the IF-inflow exhibits a high stability, and satellite altimetry reveals the cause of this to be a continuously maintained low sea level in the southern Nordic Seas. This links the IF-inflow to the processes that generate outflow from the Nordic Seas. The IF-inflow is an important component of the THC, which has been predicted to weaken in the 21st century. Our observations show no indication of weakening, as yet.

Evolutionary impact assessment: Accounting for evolutionary consequences of fishing in an ecosystem approach to fisheries management

Ane T. Laugen

Georg H. Engelhard, Rebecca Whitlock, Robert Arlinghaus, Dorothy Dankel, Erin S. Dunlop, Anne Maria Eikeset, Katja Enberg, Christian Jørgensen, Shuichi Matsumura, Sébastien Nusslé, Davnah Urbach⁴, Loïc Baulier and David S. Bou

Human activity can cause rapid evolutionary changes that are difficult to quantify. For example, while several commercial fish stocks have undergone remarkable phenotypic changes within just a few generations, the extent to which this reflects an evolutionary response to harvesting rather than phenotypic plasticity is the subject of debate. However, increasing evidence supports the premise that intensive fishing exerts strong directional selection on the life history, behaviour, physiology, and morphology of exploited fish. Of particular concern is that fisheries-induced evolution can be much more difficult or slow to reverse than demographic or phenotypically plastic changes. Furthermore, fisheries-induced evolution may change the utility derived from fish stocks, which in turn can modify the ecological services through which living aquatic resources are valuable to society. Therefore, quantifying the evolutionary effects of fishing is important for both economic and ecological reasons. Such assessment may facilitate discussions among stakeholders and assist the management of affected stocks. Here we describe evolutionary impact assessment (EvoIA) as a structured approach for assessing the evolutionary consequences of fishing and for evaluating the outcome of alternative management options. EvoIA will (i) contribute to the ecosystem approach to fisheries management by clarifying how evolution alters stock properties and ecological relations, (ii) support the precautionary approach to fisheries management by addressing a previously overlooked source of uncertainty and risk, and (iii) help realize the Johannesburg summit's commitment to the restoration of sustainable fisheries.

Climate induced alterations of dissolved organic carbon levels in the Baltic Sea; implications on food web efficiency and fish production

Robert Lefébure

Richard Degerman

Climate change predictions indicate increases in precipitation and consequently river runoff levels in the drainage area of the Baltic Sea, leading to a higher influx of terrestrial allochthonous dissolved organic carbon (ADOC) to the marine environment. Elevated ambient ADOC loads has been shown to favor aquatic bacterial growth to such a degree that an uncoupling of bacterial production from primary production might result, yielding a net heterotrophic system. Such a shift towards bacterial dominance is predicted to lower the food web efficiency (FWE) of such systems, as the majority of the bio-available carbon would be channeled through the microbial food web, as opposed to through the classic pathway of phytoplankton-mesozooplankton-fish. To model this potential effect of increased precipitation on the Baltic Sea ecosystem, an indoor mesocosm study was conducted with the aim of investigating differences in FWE and impacts on fish production. The three-spined stickleback (*Gasterosteus aculeatus*) was used as a model fish and placed as top-predator in two contrasting food webs, one with a steady influx of ADOC in the form of glucose and one relying on an autochthonous supply. Preliminary results indicate a higher FWE and consequently a higher net fish growth in systems relying on autochthonous DOC. Pending further investigations, it seems likely that these results can be explained by alterations of zooplankton lipid concentrations combined with a shift to a higher trophic level for fish in systems supported by ADOC.

Biodiversity under stress: Lessons from the deep sea

Lisa Levin

Some of the most extreme environments in the ocean can be found in the deep sea. Exceptionally low oxygen and pH conditions persist in the ocean's oxygen minimum zones, while high temperature and high sulfide concentrations characterize chemosynthetic environments. Muddy deep-sea sediments are well known for their unusually high biodiversity, but strongly reduced diversity is a feature of high-stress settings in the deep ocean. Along strong abiotic gradients of oxygen and sulfide we observe dramatic changes in species composition, species diversity, and size structure. Such systems reveal evolutionary responses to stress and biodiversity consequences for ecosystem functions. Radiation of stress-tolerant taxa, morphological novelty and trophic partitioning of microbial food resources are evolved responses. Low-diversity systems exhibit altered trophic pathways and bioturbation, leading to changes in carbon processing, burial, and sequestration. Continental margin environments in particular are subject to global-change induced warming, acidification and deoxygenation from increased inputs of carbon dioxide and stratification. Understanding derived from natural ecological gradients contributes predictive ability needed to manage environments subject to global change pressures.

Operational oceanographic services at SMHI

Lisa Lind

The Oceanographic Warning and Forecast Service at SMHI is responsible for the government funded operational oceanographic activities at the institute. This includes running and administrating the operational oceanographic forecast models, monitor and charter sea ice, sea surface temperature and algae blooms in Baltic waters, issue warnings related to extreme events, and provide oceanographic expertise and data to other governmental bodies and society. The group is based at SMHI's head office in Norrköping, and possesses expert knowledge in the fields of oceanography, marine biology, hydrography and meteorology. The two main activities within the group are the warning service and the ice service. The proposed presentation aims to showcase the purpose and importance of these services, and to give an insight to the methods, systems and products related to them. SMHI has the national responsibility to issue warnings in extreme weather or water events. Warnings are issued in order to allow time for relevant authorities to take necessary action to avoid damage to people or property. In the field of oceanography, warnings are issued for extreme water levels and ice accretion on ships. The ice service operates daily in the winter season, and use remote sensing to analyse and map sea ice conditions in the Baltic and western seas, and the major lakes. This is to aid shipping and promote marine safety. The ice service work in close relation to the Swedish Maritime Administration and provides forecasts for the planning of the state run ice breaking activities in Swedish waters.

The influence of large climatic decadal patterns on primary production in the Gullmar Fjord, Sweden

Odd Lindahl

Lars Andersson and Andrea Belgrano

Primary phytoplankton productivity has since 1985 been measured by in situ measurements in the mouth area of the Gullmar Fjord, situated on the Swedish west coast. An analysis of five-year running means of the primary production time-series from 1985 to 2008 revealed that the primary production in the Gullmar Fjord increased and peaked during the five-year period 1992 – 1996, followed again by a decrease in production. The increase in production, as calculated from the first annual running mean and compared with the maximal mean, was 19 % and the decrease of the last annual mean was 25 %. It was concluded that there was a direct link between primary production and nitrate concentrations in the mouth area of the Gullmar Fjord. Further, there was no influence from local runoff on the long term development of the primary production. The overall results suggested that the primary production in the Gullmar Fjord during 1985 – 2008 has been controlled by the coupling of large climatic decadal patterns such as the NAO and the subsequent changes in the nutrient regime at a regional scale including the Skagerrak. It may further be concluded that the anomaly of an exceptional flux of nitrate-rich ocean water onto the NW European shelf most likely extended its distribution also to the Swedish west coast and the Gullmar Fjord, which in turn triggered and was the and key variable for the 19 % rise in annual primary production during the mid 1990s.

Survey of off-shore banks - Inventory and habitat modelling as a basis for management

Cecilia Lindblad,

Anna Nikolopoulos

A national survey of 40 off-shore banks has been performed in Swedish sea areas with the aim of providing data and measures for decision making of protection of the marine environment as well as for planning of potential constructions e.g. marine wind parks. The survey include benthic biota, birds and fish. The benthic biota in the Baltic Sea was investigated through diving and underwater video techniques, while ROV, diving and grabs/scrapes were used for the Kattegat and Skagerrak investigations. The methodology for the inventories of fish included hydro acoustic surveys and gillnet-fishing while aircrafts were used for the inventories of birds. Moreover, the results for the biota were supplemented by spatial habitat modelling on predicted distributions of species. One important outcome of the survey is the evaluation of conservation values and a ranking list of investigated off-shore banks.

The Regional Advisory Councils: What is their potential to incorporate stakeholder knowledge into European fisheries governance?

Sebastian Linke

Increased stakeholder participation and knowledge integration are suggested to help European fisheries management dealing with credibility, legitimacy and compliance problems. However, making a science-based management system more integrative and participatory presents challenges in relation to the integration of different types of knowledge into the decision-making process. This paper is concerned with the social dimensions of knowledge conflicts at the science-policy interface for fisheries management in Europe. While the “Common Fisheries Policy” (CFP) is said to be one of the most science-based policy regimes in Europe, it exhibits some dramatic failures of environmental governance. To counter these failures, the EC has reformed the CFP to involve more stakeholders from fisheries, NGOs and other interest groups through so called “Regional Advisory Councils” (RACs) to the policy process. The paper addresses theoretical implications of different social science concepts on science and policy for structuring stakeholder organisations like RACs and their (new) role in integrating different knowledge types (e.g. from fishermen, scientists and NGOs) for the management process. Drawing on theories from Science and Technology Studies, a focus will be on how different knowledge types are produced, communicated and integrated and how the role of values and worldviews in the definition of appropriate knowledge for management could be characterised. The paper will contribute to a new understanding of the relationship between different knowledge types in environmental controversies and how local experiences from fishermen, scientific expertise and transnational policy co-ordination can be brought together for sustainable fisheries management.

Crustacean utilisation in a changing environment in the perspective of juvenile cod

Peter Ljungberg

Anders Persson and Anders Nilsson

Coastal environments are often productive and serve as important nursery grounds for many aquatic organisms. Furthermore, coastal environments are subjected to heavy disturbances and prerequisites for life are continuously altered, potentially influencing trophic interactions between its inhabitants. One species that utilises this environment is Atlantic cod (*Gadus morhua*), which in its early life stages is strongly associated with shallow areas for food and shelter. Long-term changes in habitat distribution might influence recruitment success and population density of e.g. cod. We have tested the ability of juvenile cod to forage in three of the most abundant habitat types in temperate coastal environments; sand, *Zostera* beds and macroalgae. We used two species of crustacean as prey, which both serve as a main food source for juvenile cod during its early life stages. We also tested how cod choose between these two crustaceans depending on habitat type and light regime, this to make predictions of potential trophic effects. Our results along with field data will help us understand how juvenile cod utilises different habitat types in a changing environment with regards to food supply and shelter.

Primary production in the Baltic Sea transition zone – seasonal patterns and vertical distribution today and with a changing climate

Maren Moltke Lyngsgaard

Stiig Markager and Katherine Richardson

Climate change is predicted to increase temperatures and precipitation in the Baltic Sea area. A higher freshwater outflow from the Baltic Sea will change the hydrological characteristics in the area including, strength, frequency and depth of the pycnocline. The position of the pycnocline relative to the depth of the photic zone could be the key factor determining the effects of climate change on primary production (PP) in this stratified area. This study investigates the seasonal patterns and vertical distribution of the PP from 1998 to 2008 in the Baltic Sea transition zone. Pycnocline depth and area primary production were calculated for several stations based on data from the Danish monitoring program including CTD-profiles, water chemistry and PP characteristics from the ^{14}C -technique. Area PP shows highest monthly mean values in spring and summer with inter annual variation highest in spring months (February and March). Furthermore the study showed that 10-15 % of the annual area PP was produced below the mixed layer with the largest contribution (up to 60%) coming from the summer months (May-July). This emphasise the importance of PP associated with the pycnocline and hence its position relative to the photic zone. A sensitivity study showed that small changes in the interpolation of PP characteristics (α , P_{\max}) significantly altered the value for area PP. These results stress the importance of having consensus in the algorithms when analysing PP data in relation to climate change. The results furthermore indicate a great loss of PP if the pycnocline depth increases.

Laboratory benchmarks for nonlinearity and separation of western boundary currents

Thomas McClimans

Ingrid Ellingsen, Stefano Pierini, Pierpaolo Falco and Giovanni Zambardino

Various dynamical aspects of nonlinear western boundary currents (WBCs) have been studied experimentally in the 5-m-diameter rotating basin at SINTEF in Trondheim. A uniform current of homogeneous water over a flat bottom was forced by a piston speed U_p . The flow was directed over a topographic beta-slope to produce the westward intensification. The character of WBCs for various degrees of nonlinearity were studied by varying U_p , flows ranging from the highly nonlinear inertial Charney range down to the “nonlinear Munk range” were simulated and analyzed. In the first range, we obtained the power law $L \sim U_p^{1/2}$, where L is a zonal length scale, in agreement with Charney's theory. In the second range a new power law $L \sim U_p^{1/5}$ is identified which connects smoothly the Charney and linear Munk ranges. This provides an unprecedented coverage of WBC dependence on an amplitude parameter in terms of experimental data. Simulations of WBC separation from a wedge-shaped continent past a cape (e.g. Cape Hatteras) suggested that inertial overshooting (IO) is the cause. The transition to the separation due to IO for increasing current speed was analyzed: a critical behavior is identified according to which a very small change of U_p marks the transition from a WBC that follows the coast past the cape to a WBC (nearly dynamically similar to a full-scale Gulf Stream) that separates from the cape without any substantial deflection, as is the case for the Gulf Stream extension.

Mussel farms as a measure for the implementation of the Baltic Sea Action Plan

Susanna Minnhagen

Odd Lindahl

Kalmar county in southeast Sweden should reduce its annual water-carried nitrogen load to the Baltic Sea by 1000 tonnes (Kalmar County Administrative Board). Farming of the Baltic Sea blue-mussel (*Mytilus trossulus /edulis*) has been identified as a possible measure against eutrophication (Sanchéz et al. 2004, Lindahl et al 2005, Gren et al. 2009). Pioneer farms have been run in the Kalmar Sound, Baltic proper, in pilot scale from 2006-2009. Results have shown that the blue mussels in this area can be harvested every 18-24 months and yields 150 tons of mussel biomass, 1.8 tonnes of nitrogen and 0.12 tonnes of phosphorus per hectare of mussel farm. Nets of rope was found to work best as settling substrate for the mussels, and levels of known algal toxins and perfluorinated compounds (PFOS) were low compared to the limits set by the Swedish National Food Administration. Since 2009 we have two full-scale farms with the total size of c. 2 hectares, and present projects, sponsored by the Baltic 2020 foundation and the European Regional Development Fund, aim to find a market for the Baltic Sea blue mussels as poultry food, substrate for biogas or fertilizer. Based on our present experience and calculations by Gren et al. 2009, the potential to combat eutrophication in Kalmar county with mussel-farming is evaluated and compared to other subsidised measures suggested by the HELCOM Baltic Sea Action Plan.

The role of predators for eutrophication related changes of macrovegetation along Scandinavian coasts

Per-Olav Moksnes

Sonja Råberg, Christoffer Boström, Lena Kautsky and Susanne Baden

Nutrient pollution is regarded as the main cause for the increase of ephemeral macroalgae and decrease of perennial algae and eelgrass in many coastal areas in Scandinavia. However, overfishing may also be important if the loss of large predators has decreased the grazer-control of ephemeral algae via a trophic cascade. We tested these hypotheses in a series of large-scale field experiments along the Swedish west coast and in the Baltic Sea, manipulating predation, grazing and nutrient levels in both eelgrass and *Fucus* communities. Overall, top-down processes dominated in all systems. Nutrient enrichment increased growth of epiphytic algae and decreased growth of perennial vegetation only in areas where the abundance of algal mesograzers was kept low by predation from small predators. If predators were excluded by cages, or in areas where the abundance of mesograzers were naturally high, algal grazers prevented the growth of epiphytic algae, also during nutrient enrichment. Analyses of data from 10 separate cage experiments from 4 different regions showed that local predation pressure from small predators explained a significant proportion of the regional variation in biomass of both mesograzers and ephemeral algae, whereas nutrient levels in the water-column did not. These results suggest that top-down processes play a key role in recent large-scale changes of macrovegetation in the study regions, and that overfishing may be indirectly linked to losses of eelgrass and *Fucus* vegetation. Thus, actions that reduce both nutrient pollution and overexploitation of coastal fish may be necessary to improve the growing conditions for perennial macrovegetation.

Population dynamics and predation impact of the introduced ctenophore *Mnemiopsis leidyi* in the Gullmars fjord, west coast of Sweden

Lene Friis Møller

Peter Tiselius

Lately, waters of northern Europe, including Swedish waters, are facing a new problem with the invasion of the ctenophore *Mnemiopsis leidyi*. Given the rapid growth and high reproductive output of the species, severe effects on its prey populations may be expected. However since the effects on the ecosystem depend on complex interactions in the pelagic community, it is impossible to predict the outcome of the introduction into Swedish waters based on observations from other areas. In the current project we study the development of the *M. leidyi* population in the well documented Gullmars fjord on the west coast of Sweden by sampling the pelagic community for *M. leidyi* and zooplankton approximately once each week. The programme, which also includes, Chl a measurements and CTD casts, has been running from August 2007 and is still ongoing. Results so far has shown a 3 fold increase in the *M. leidyi* biomass from 2007 to 2008/2009 during peak abundances in late summer and the population also remained longer in the water in 2008/2009. Minimum abundances of calanoid copepod prey were observed coincident with peak predation impact in end of August in 2008/2009. This indicates a population regulation effect by *M. leidyi* on copepods. Besides these potential direct predation effects of *M. leidyi*, available data also indicate some indirect effects. Release of phytoplankton from zooplankton grazing-control due to the predation pressure (on zooplankton) from *M. leidyi* resulted in a pronounced phytoplankton bloom - even though the primary production was decreasing during the same period.

The road towards Kosterhavet National Park - A model for participatory conservation planning?

Andrea Morf

Ulrika Dagård and Anders Godhe

Introducing integrative and participatory management of marine resources to an originally centralist and sector-based system of governance as in Sweden presents challenges. International pressure towards participatory and ecosystem based management, e.g. the Convention of Biodiversity and the European Union's Integrated Maritime Policy, Marine Strategy Directive and ICZM-recommendations, are increasing. One year ago, Sweden has inaugurated its first marine national park comprising the Koster and coastal archipelago in Strömstad and Tanum municipalities. The road towards the park has been long, curvy, and bumpy. Ideas first presented more than 30 years ago met little local enthusiasm. In the end, top-down management has met bottom-up initiative; conservation is no more a "dead hand" but provides potential for rural development through sustainable tourism. Local users are not merely tolerated but an important part in the park's management structure. The park's objectives also include educational and sustainable use-goals. Many participants have become interested to analyse what they call the "Koster Sea Dialogue". From a scientific perspective, the process is a highly interesting case of integrative management of coastal resource conflicts and institutional innovation in conservation. The inclusion of a rural development perspective, the development of multiple forms of collaboration over years, and active individuals on various levels seem to have been important drivers. The case connects to findings from various areas of environmental social sciences. The research is based on Ph.D.- and post-doctoral research and preliminary results from a documentation project with focus on coastal planning, participation, conflict management, and institutional change.

Synergistic effects of temperature and heavy metal pollution on embryos and adults of the brown macroalga *Fucus serratus*

Søren Laurentius Nielsen

Hanne Dalsgaard Nielsen

Fucoid brown algae form extensive populations that dominate the vegetation on temperate rocky shores. The persistence of populations of fucoid brown algae depends on their reproductive ability and the survival and growth of germlings that are more susceptible to stressors than adults. Climate change may lead to changing sea temperatures, and to these effects can be added the effects of anthropogenic pollution. The interaction between temperature changes and anthropogenic pollution as joint stressors on populations of brown macroalgae warrant further investigation due to the ecological importance of these populations in coastal marine waters, especially with the prospects of temperature changes in many coastal marine areas, already strongly influenced by human activities. In this study, the effect of temperature and heavy metal (copper) pollution as joint stressors was studied on both germlings and adult individuals of the brown alga *Fucus serratus*. We studied the effects on growth, photosynthesis (measured as chlorophyll fluorescence) as well as on germling survival. The results clearly show that the germlings are more susceptible to environmental stress than adults. In the germlings all measured parameters are influenced by both temperature stress and by copper stress and the effect of temperature stress is enhanced by copper. In the adult individuals only growth is affected and only by temperature, while no effect of copper was found. We conclude that to fully assess the survival and fitness of brown macroalga populations, the effect of stressors on germlings have to be included, studies only focusing on adult individuals may be misleading.

15 years of Partnership between the IOC and a University - building capacity for research on and management harmful algae

Henrik Oksfeldt Enevoldsen

The last three decades have been marked by an appreciation of the serious impacts of the marine phenomena we now call harmful algal blooms (HABs). These occurrences of toxic or harmful microalgae represent a significant and seemingly expanding threat to human health, fishery resources, and marine ecosystems throughout the world. In the mid 1980s the issue began appearing in the agenda of governing body meetings of international and regional organizations working within marine science, management, aquaculture, and public health. In an example of how science responds to a societal need and how governments can collaborate to address a common hazard, the IOC of UNESCO, over the following years, developed a programme to address the situation. As a mechanism to implement an international programme on harmful algal blooms, and to provide related services to developing nations, the IOC in 1995 entered into a close partnership with Danish research and educational institutions to establish an 'IOC Science and Communication Centre on Harmful Algae'. The Centre, hosted by University of Copenhagen, has now been in operation for 15 years. The Centre coordinates international research activities, provides training and capacity development opportunities, and develops manuals and guides for research and management of harmful algae. The Centre exemplifies how close relationships between national institutions and organisations like the IOC can be mutual beneficial, provide recognition, visibility and results to all partners. It also exemplifies how the involvement in general of such institutions is key to having meaningful and correctly focussed international programme activities.

The effect of temperature, algal biomass and taxonomic group on the growth of *Vibrio parahaemolyticus*

Malin Olofsson

The genus *Vibrio* comprises several pathogenic species where some are lethal or may cause injuries to both human and marine life. In tropical water, where *Vibrio* grows fast, several of the species are known to cause epidemics. More knowledge about how environmental factors affect the growth of *Vibrio* would facilitate predictions of epidemics and thus help people who live in areas with higher risk of infection to know when and where to fish and harvest aquaculture products. In this study, I investigated how temperature, amount of biomass (cells per ml) and taxonomic group affected the growth of *Vibrio parahaemolyticus* by setting up an experiment, in Mangalore, India. The results showed that the growth of *V. parahaemolyticus* are favored by dinoflagellates like *Prorocentrum micans* and could be disfavored by diatoms like *Skeletonema tropicum*. The high (30-32°C) water temperature had a positive effect on the growth of *V. parahaemolyticus*, while a difference between the two cell concentrations (high and low) was not detectable.

Genetic connectivity in seagrass ecology and conservation

Jeanine Olsen

Seagrasses are a unique group of marine flowering plants that form the basis of soft-sediment, coastal ecosystems worldwide. They are among the most productive systems as well as among the most threatened. Successful mitigation, conservation and restoration require that ecological, demographic and genetic processes be considered together. However, this is seldom done because of the widely held belief that ecological factors have more immediate impacts for community structure and function than putatively slower genetic processes. This is not the case. Using two case studies, I will show how population genetic surveys of *Zostera marina* provide important insights about structure and connectivity of meadows that can directly inform management.

Local lobster subpopulations from limited adult migration and high larval retention

Vidar Øresland

Mats Ulmestrand

Detecting the extent of adult migration and marine larval dispersal is crucial to our understanding of connectivity between, and detection of, marine subpopulations, and remains one of the fundamental challenges to bio-physical oceanography. However, there is a devastating lack of bio-physical data at relevant scales which can only be accounted for by applying new methods. Here we show, through tagging of 4016 adult European lobster, *Homarus gammarus*, over 16 yrs within the Kåvra Lobster Reserve on the Swedish west coast, that lobsters have limited migration. By using light traps, we show a tenfold annual variability in larval occurrence, and that larvae at stage 1 have a short peak period of abundance < two weeks, and that the vertical distribution of larvae can be detected at a 1 m scale. By daily tracking the currents in real time during the larval period, using GPS current drifters at mean larval depth of 16 m (below the halocline), we could for the first time infer two exceptionally small local subpopulations and indicate local potential settling areas. The combination of these two methods greatly simplifies detection of local marine subpopulations which is pivotal to population dynamics, genetics and evolution, spread of diseases, the design and understanding of the effectiveness of marine protected areas, and fisheries management.

Climatic effects in seasonal environments-inferences from a growth model on Baltic Sea cod

Anders Persson

Marine environments along coastal areas are characterized by a halocline that divides shallow water with low salinity and deeper water with high salinity. In the Baltic Sea these two water bodies show distinctly different seasonal temperature dynamics and climate change may affect their distributions and profitabilities. Using a size-dependent growth model, I generate predictions of the habitat use by cod over the ontogeny in four areas of the Baltic Sea, representing different temperature regimes, and assess the direction cod growth and habitat use may take under a climate change scenario. First, the model shows that a flexible behavior including seasonal switches between shallow and deep areas is very beneficial in all four areas. Second, the model predicts large differences in habitat use between the eastern cod stock and the three western stocks, where eastern cod are predicted to spend twice the time in shallow habitats compared to western cod. Third, the model predicts less overlap in habitat use between small and large cod in the eastern stock compared to western stocks, suggesting that the importance of cannibalism differs between these marine areas. Furthermore, climate change is predicted to affect both the growth potential and habitat use in the areas, decreasing the use of shallow areas in the three western stocks but increasing the importance of flexible behavior in the eastern stock. Overall, these results highlight the importance of considering local conditions and individual behavioral decisions when projecting even the direction of future climatic effects, let alone its magnitude.

Climate change impacts on fish and fisheries: towards a cause and effect understanding

Hans-Otto Pörtner

The concept of oxygen and capacity dependent thermal tolerance (OCLT) has successfully explained effects of warming on aquatic ectotherms and their abundance in the field. The capacity of physiological functions including those supporting oxygen supply to tissues forms a primary link between organismal fitness and its role and functioning at ecosystem level. The OCLT concept integrates the various mechanisms setting the respective thermal window of performance, which matches the window of aerobic scope. It thereby explains where, why and how thermal windows are positioned on the temperature scale. Loss of performance reflects the earliest level of thermal stress, paralleled by the progressive mismatch of oxygen supply and demand at the borders of the thermal envelope. Transition to time-limited passive tolerance occurs, involving systemic and cellular stress signals like hormonal responses or oxidative stress as well as the use of protection mechanisms like heat shock proteins. Thermal acclimatization between seasons or adaptation to a climate regime involves shifting thermal windows and adjusting window widths. The need to specialize on a limited temperature range results from trade-offs at several hierarchical levels, from molecular structure to energy efficiency and whole organism functioning. Elevated CO₂ levels (ocean acidification) or hypoxia interact with these principal relationships. These factors may elicit metabolic depression supporting passive tolerance to thermal extremes. However, they also exacerbate hypoxemia causing a narrowing of thermal performance windows. An integrative understanding of specialization on climate and of sensitivity to climate change results. The resulting functional relationships likely contribute to shape climate-induced changes in species interactions and thus, community responses at ecosystem level.

Stress responses in clonal and unique *Fucus radicans* individuals –How may this affect distribution in a changing environment?

Sonja Råberg

Helena Forslund, Lena Kautsky, Ricardo Pereyra, Daniel Johansson and Kerstin Johannesson

The recently described *Fucus radicans* is a key species of rocky habitats in the Bothnian Sea sustaining high biodiversity and providing food and shelter for invertebrates and fish species. It is also more grazed by *Idotea* than *F. vesiculosus*, which may be one of the reasons why it does not occur along the Swedish and Finnish coast of the Baltic proper even though it is able to grow at higher salinities. In the BONUS BaltGene program we describe the genetic structure of these two *Fucus* species and study the stress tolerance and adaptation to environmental factors such as temperature, salinity, desiccation and freezing. *Fucus radicans* reproduce both sexually and asexually, with dominance for cloning since ca 80 % of the *F. radicans* population in the Bothnian Sea consists of one female clone. In the present study we compare *F. radicans* with different genetic composition, both clones (i.e. the common clone as well as two other less widespread clones) and unique individuals, and how they respond to different stressors. The study showed that the common clone was not superior to the other clones, or unique individual, when coping with stress factors. Instead the unique individuals tolerated desiccation better than any clone as a result from significantly broader thalli. Furthermore, the results also illustrated the importance of genetic variation since higher variation in stress response was found in the group with sexually reproducing individuals.

Ocean forecasting on yr.no: Challenges

Lars Petter Røed

Ocean forecasting including waves, water level, current and hydrography is available and updated daily at met.no's web portal yr.no. Despite the fact that validation reports shows that the model's producing the current and hydrography forecasts has little skill, the users still find the products to be of relevance and useful. Is some information, even it is incorrect better than none? Examples of validation skill together with forecasts displayed on yr.no will be shown and discussed.

Dissecting the structure of ocean currents

Tom Rossby

Perhaps it should come as no surprise, but the closer we look at the ocean and its currents, the more structured we find it to be. In the past when we were limited to hydrographic surveys we could see how stuff spreads about in the ocean, but with only very general ideas of the mechanisms involved. In fact, ocean currents exhibit a number of striking characteristics: some are transient, others are quite permanent, some act as barriers between water masses, others enhance mixing. Some are long and sinuous, others fold back on themselves as coherent rings and lenses. The overarching aspect of these diverse forms of flow, known collectively as the mesoscale eddy field, is their organization in the horizontal, the most difficult dimension to sample in the ocean. Being able to describe the state of the ocean and how it may respond to future forcing will depend upon having an accurate picture and understanding of these processes. An effective tool for exploring these diverse patterns is the subsurface neutrally-buoyant float. Typically deployed in large numbers, they can be tracked over great distances using the deep sound or SOFAR channel. They can be configured to drift isopycnally with the surrounding waters enabling us to study in considerable detail lateral stirring and mixing processes and thereby unravel or dissect the processes responsible for what was often called 'spreading' in the past. We give a brief overview of the evolution of the technology from the big floats of the past to the tiny fishchip of tomorrow.

Interdependence between interactions among and properties of physical structure, prey and predators

Matias Scheinin

Johanna Mattila and Laura Kauppi

Natural systems are shaped by predator-prey interactions. Their outcome is directly determined by the densities and traits of the prey and the predator. Conversely, those properties are altered by the interactions. Additionally, those properties are shaped by the surrounding environment. It thus indirectly alters the strength and the outcome of predator-prey interactions. Such mediation can be attributable to habitat complexity, often manifested as vegetation density. It is regularly found to co-vary with prey densities. Based on conventional experiments exposing constant densities of prey and predators to varying densities of vegetation, that co-variation is considered caused by the vegetation, through inflictions on predation efficiency. However, this conception may be biased, because the properties of and the interactions among vegetation, prey and predators are interdependent. In many systems, the densities and traits of all the three components co-vary. Thus, interactions among them should be assessed by experiments applying corresponding properties. We compared the conventional and the proposed, experimental approaches with each other using a suite of aquatic species as model organisms. The effect and strength of the triangular interactions depended completely on the density and the traits of the interacting components. Most importantly, vegetation density had a positive impact on predator-prey interactions in the former approach but no impact in the latter one. Thus, our results question the ubiquity of the protective role of habitat complexity. Further, they adduce the critical issue of the bidirectional nature and context-dependence of any biotic interactions.

Genotyping and quantification of the wasting disease pathogen *Labyrinthula* in North European eelgrass populations

Martina Schmidt

Anna Bockelmann

Mass mortality in eelgrass, *Zostera marina*, induced by the protist *Labyrinthula zosterae* was first observed in the 1930s. Since then the wasting disease pathogen has appeared circumpolar and is still a severe threat to eelgrass populations. Despite the ecosystem consequences of eelgrass loss, little is known on distribution and virulence of *L. zosterae* and the environmental triggers for epidemics. We investigate various Baltic and North Sea populations of *Z. marina* on the abundance and genetic diversity of *L. zosterae*. Up to now the impact of *Labyrinthula* on eelgrass has mainly been measured by optical assessment of discoloured tissue (wasting index), however, it is known that the pathogen also occurs in healthy looking tissue. In this project for the first time, we are detecting the presence and quantity of *Labyrinthula* in various eelgrass populations genetically by specific primers. Furthermore, genetic differentiation among *L. zosterae*-strains is identified by microsatellite analysis. Our studies provide strong genetic tools to quantify and characterize the infection status of eelgrass populations.

Do fishes care about size? - Assessing the ecological importance of eelgrass meadows in the Western Baltic

Philipp Schubert

Thorsten Reusch

Despite its ecological importance, we currently lack baseline data on eelgrass distribution and meadow attributes (patchiness, epiphyte load, associated fauna) for most regions of the world, even the highly studied southwestern Baltic Sea. Such estimates are mandatory to evaluate the ecosystem services of meadows, as well as future gains and losses. The first goal of this project is to provide the first large-scale yet detailed estimate of the extension and characteristics of eelgrass (*Zostera marina*) meadows along the shores of the Kiel Bight (Western Baltic Sea). For this purpose, we are using a combination of analysis of aerial photography and geo-referenced towed underwater-camera images, and transect surveys conducted on SCUBA. The resulting habitat maps will be a crucial component for further research, such as the role of eelgrass in the global CO₂-cycle or its economic importance as a fish nursery, but are so far not available in sufficient preciseness. Furthermore, recent studies suggest the overexploitation of commercial fish species in the Baltic Sea has resulted in top-down effects on seagrass and its epiphytes, possibly accounting for the loss of eelgrass observed in the Baltic over the last 50-60 years. We plan to assess abundances of small predatory fishes in Kiel Bight and to compare them with historic records of abundances reaching back 40 years. Finally, we will experimentally test the hypothesis that trophic cascades mediated by the overfishing of gadoid fishes affect characteristics of Baltic eelgrass meadows.

Genetic signatures of evolutionary dynamics and range shifts in canopy-forming marine species

Ester Serrão

Canopy forming fucoids are the major ecosystem-structuring component of temperate rocky intertidal zones, and *Fucus* is the most recently diverged and species-rich genus within the brown algal family Fucaceae. As genomic information becomes available through EST projects and marker development (microsatellites, SNPs), it is contributing to a number of fascinating ecological, biogeographic and evolutionary questions. Currently, two main clades are recognised within the genus, but species boundaries are unclear in several cases. In addition to ancestral shared characters (and marker resolution), several contemporary factors likely contribute to the blurring of species boundaries; ongoing hybridization in sympatric assemblages, secondary contact during range expansions, as well as recent divergence in novel habitats (e.g., the Baltic Sea). Several recent and ongoing case studies are discussed. Demographic factors at current range edges/novel habitats may operate to prevent local adaptation and increase susceptibility to abiotic stressors. Extensive genetic “surfing” of introgressed organellar genomes has occurred during post-glacial range expansions. Strong local gradients in abiotic stress maintain distinct phenotypes, despite probable secondary contact and extensive introgression between cryptic invading and local *Fucus* species. Finally, a revised phylogeny of the genus is presented, based on multilocus SNP markers, which provides considerably improved resolution of species relationships.

Modelling of water and nutrient mass flows in the Norrström drainage basin using Soil and Water Assessment Tool

Ekaterina Sokolova

The processes of pollutant transport and spreading in catchments are complex, but their quantification is crucial for mitigation of several important water resource problems, such as eutrophication. This paper investigates nutrient transport in the Swedish Norrström drainage basin, which suffers from eutrophication of its inland water bodies and is also one of the main Swedish contributors of nutrient loads to the Baltic Sea. The water flow and nutrient loads in the Norrström basin are simulated using Soil and Water Assessment Tool (SWAT) which is a semi-distributed, process-based, continuous-time river basin model. The results indicate that SWAT model was successfully implemented to simulate water discharge, total nitrogen and total phosphorus fluxes in the Norrström drainage basin. The multi-variable and multi-site calibration has yielded satisfactory results with correlation coefficients from 0.85 to 0.96 between modelled and observed average annual nutrient loads. However, it was found out that the SWAT model is not designed for large-scale watersheds containing large water bodies, which causes important limitations for its application to the Norrström drainage basin and thus requires modelling of lakes using special water quality models that are linked with SWAT. Several other problematic issues were also identified in the study, such as modelling of in-stream processes, input data demands and extensive parameterization. The possible future scenarios that could be of interest to investigate using SWAT for the Norrström drainage basin in the context of eutrophication, such as climate change, economic development and population growth scenarios, as well as practices intended to mitigate eutrophication are discussed.

Propagation of internal waves from the Drøbak sill in the Oslofjord

André Staalstrøm

The main objective of the actual study is to increase the understanding of how barotropic tidal energy is transferred to energy available for vertical mixing inside a sill fjord. The study focuses on the Oslofjord area, located in the south east of Norway. The area is impacted by the tidal motions prevailing in the North Sea area, causing although relatively moderate, quite high current velocities of up to 1 m/s. The fjord can be divided into an outer and an inner part. The two parts are separated by a long and strait sound, the Drobak sound, with a shallow sill of approximately 20 m depth in the northern end. In contrast to the simple geometry of the Drøbak sound, the geometry of the area north of the sill is rather complicated. The bathymetry north of the sill is quite rough. The basin east of the island Håøya consists of 5 sills that follow each other with depths of 50-60 meters with deep holes of up to 150 meter depth in between. A dedicated field experiment within the Oslofjord area was conducted within summer 2009. During that field experiment, measurements at four moored rigs with current profilers and temperature and salinity chains was undertaken. By using the collected data we try to gain some insight about the relationship between the amplitude of the sea level elevation and the amplitude of the halocline displacement and how much energy is transported by internal waves.

Status and management of the invasive Pacific oyster (*Crassostrea gigas*) along the Swedish west coast

Åsa Strand

Carlo Nyberg and Susanne Lindegarth

In 2007, large numbers of *Crassostrea gigas* were reported along the Swedish west coast for the first time. The origin of *C. gigas* found in Sweden is unknown, but several favorable factors such as unusually warm water temperatures and persistent westerly winds during 2006 may have caused an inflow of larvae from the Wadden Sea region. Since then the geographical distribution and population growth of the oysters has been monitored yearly. Currently, *C. gigas* has been found along the Swedish west coast from Hallands Väderö to Svinesund, with increasing densities from south to north. In many sites, several cohorts can be identified, indicating the occurrence of local reproduction. In general, *C. gigas* prefers more shallow waters than the native European oyster (*Ostrea edulis*), thus competition for space between the two oyster species is not of concern at the moment. However, as *C. gigas* seems to favor blue mussel (*Mytilus edulis*) beds as settlement substrate, negative effects on the mussel population along the coast is to be expected. Winter mortality of *C. gigas* during 2007-2009 has been very low. However, the winter 2009/2010 with a long period of low temperatures and massive ice coverage resulted in eradication of many shallow oyster beds. Preliminary results indicate that the mortality ranges between 50-100 % depending on locality. The continuation of this project will focus on ecological studies to evaluate the effects of *C. gigas* on local ecosystems. Different management options and their costs and benefits will also be discussed in the project.

Recent global changes in plankton community structure

Patrik Strömberg

Observations indicate that the world's oceans are warming and patterns in atmospheric variability are changing, resulting in alterations to oceanic stratification, circulation patterns, sea ice and light supply to the surface ocean. The biological responses to these effects whilst apparent remain uncertain. Changes in aquatic ecosystem productivity both in marine and freshwater have been observed. The details of how changes in plankton community structure will affect the functioning of global ocean ecosystems, impacting both the availability of food for fish and the biological carbon pump remain unknown. Plankton community structure is related to the efficiency of the transfer of energy in pelagic food webs: smaller producers (phytoplankton) result in less food for consumers (zooplankton). Here we demonstrate how macro-ecological theory and satellite remote sensing can be combined to infer changes in community size spectra from estimates of phytoplankton and zooplankton biomass. The resulting global monthly images reveal recent changes in plankton community structure. Over the past decade we show that the community structure has become increasingly dominated by bacteria in large regions of the ocean, especially the gyres. This has implications for both fisheries productivity and carbon drawdown and may provide insight on how marine ecosystems could alter in response to future climate change.

Effects of increased temperature on a shallow-water sediment system: a spring situation

Kristina Sundbäck

Christian Alsterberg and Stefan Hulth

A global-warming scenario on a shallow-water sediment system on the west coast of Sweden was simulated in an experiment for 1.5 months during March-April (ambient water temperature 4–13 °C). Intact sediment cores were connected to a flow-through system, under close to natural light conditions, with the possibility to raise and keep seawater temperature constantly 4°C above that of ambient surface water. Oxygen and inorganic nutrient sediment–water fluxes and bacterial production were measured. Samples for benthic microalgal and meiofaunal biomass and diversity were also taken. Algal mats, consisting mainly of colony-forming diatoms, quickly developed in cores with elevated water temperature, affecting sediment–water oxygen and inorganic nutrient fluxes. Effects on fluxes and bacterial production were mainly observed during the first weeks of the experiment (when ambient water temperature was below 10 °C), with fewer significant effects found at the end. Raised temperature doubled bacterial production. Primary production and uptake of nutrients were stimulated in March, while community respiration increased later. Net oxygen fluxes over 24 hours showed that the sediment system remained net autotrophic throughout the experiment, although the level of autotrophy dropped at higher temperature in late spring. The fact that temperature effects diminished at the end of the experiment, along with increasing ambient water temperature, suggests that functional effects of elevated temperature on shallow-water sediment systems in cool temperate microtidal areas are largest in early spring. Preliminary results from a second, 2-factor experiment (temperature x toxicant), showed diminished toxicant effects at raised temperature.

Marine protected areas for lobsters - why bother?

Andreas Sundelöf

Øyvind Fiksen

Local management is a promising tool in the management of natural resources. The growth and revenue of local stocks becomes the interest of the exploiters and not the managers. In many areas this comes down to a scale issue and identifying the biological scales of species may be very difficult. Apart from reserve size there is a set of variables that the functioning of a reserve will be sensitive to, individual growth rate, mortality rates, recruitment functions etc. I have used an IBM of lobster, parameterized with a large set of data, to assess the possibility of local management options. Lobster adults are predominantly resident to a habitat patch and larvae are pelagic for no more than 14 days, such that they do not disperse over vast areas. This small scale migration and dispersion makes lobster a good model species for testing assumptions and behavior of no-take reserves (MPA) as a local management option. Model simulations show that the proportion of closed habitat need not be large in order to protect a fraction of the population as a larval pump with extensive reproductive subsidies. However, the contribution of larvae produced locally (retention) relative to the total larval pool will be important for the effect of small scale reserves. I conclude that small scale reserves will function well for conservation of lobster size distribution and could render high revenue in archipelago type areas.

Behavioural adaptations to a changing environment - Consequences for pipefish populations in Skagerrak and the Baltic Sea

Josefin Sundin

Anders Berglund, Gunilla Rosenqvist and Tonje Aronsen

The explosive growth of filamentous algae and phytoplankton has in recent years changed aquatic ecosystems worldwide. Increased amounts of phytoplankton alter the environment of marine organisms that have to adapt to changes in pH, oxygen, and visibility. Increased growth of filamentous algae changes marine habitats, which may have consequences for predator-prey interactions, conspecific attraction, as well as the level of interspecific competition, and abundance and quality of a food source. We use the pipefish species *Syngnathus typhle* and *Nerophis ophidion* as model organisms to investigate behavioral adaptations to these environmental changes. Pipefish, which is a seahorse relative, practise male pregnancy, males are also the choosier sex and females compete amongst each other for access to mates. Increased turbidity reduces visibility, which may in turn affect animal behaviour as well as evolutionary processes that are dependent on visual stimuli. In this study the pipefish engaged in mate choice significantly more often when they had access to full visual cues than when visibility was reduced. They also mated at a faster rate in clear water compared to turbid water. The pregnant males are dependent on eelgrass meadows for their protection against predators. In a habitat study the pipefish choose to stay in healthy eelgrass significantly more often than in eelgrass covered with filamentous algae. If adaptive mate choice and healthy locations of eelgrass is vital to population viability, the present-day increase of phytoplankton and filamentous algae may pose a threat to these pipefish populations.

Tests of ecological models: the measure of biodiversity matters.

J. Robin Svensson

Henrik Pavia, Mats Lindegarth and Per R. Jonsson

Arguably, the most fundamental steps in science are the formulation and testing of hypotheses. If models are not specific about the patterns and processes they intend to explain, or if the definition of the response variable differs, formulations of accurate research hypotheses to test the models will be difficult. One such model is the well-known Intermediate Disturbance Hypothesis (IDH), and its extension models, which predicts maximum diversity at intermediate levels of disturbance. Despite that the IDH represents one of few well established ecological theories, still generates scientific papers at an increasing rate, and that the original paper has received more than 3000 citations, it is not yet clear which measure(s) of diversity should be used to test the model. Through a literature survey and two different modelling approaches, we show that the outcome of tests of the IDH depend greatly on the measure of diversity used as response variable. Specifically, species richness showed the predicted unimodal hump-shaped pattern in both models, whereas evenness showed monotonic increases with increasing disturbance frequency. The literature survey revealed that experiments using more than one measure of diversity to test the IDH, rarely report similar outcomes among measures. Furthermore, the logic, and original formulations, of the pattern predicted by the IDH primarily concerns the number of species, and not the evenness of their relative distributions. Hence, the measure of diversity matters, and evenness, and associated indices, may be less relevant in tests of the IDH.

Uncovering cryptic population structure of Baltic herring.

Amber Teacher

Juha Merilä

Neutral genetic studies on Baltic herring have so far shown little or no population structuring within the Baltic region. However it is likely that there is some cryptic structuring, as the Baltic Sea has strong environmental gradients (salinity and temperature), which are likely to impose differing selection throughout the region. In this project we are taking several different approaches to look for hidden structure, and to correlate this to the environmental factors. We will look at wide-scale genome scans, whole mitochondrial genome sequencing, and also focus in on multiple specific adaptive genes (e.g. osmoregulatory genes) that are likely to be under selection. As this project has only recently started, in this talk I will present an overview of the problem and our approaches, and present preliminary progress on the candidate gene work. A more thorough understanding of how populations are structured may help us to evaluate current fisheries management units, and perhaps improve them to make herring fisheries more sustainable.

Öresund, marine environment in change: Experiences learned from 15 years of environmental monitoring

Anders Tengberg

Peter Göransson and Magnus Karlsson

The Swedish city of Helsingborg is located by the Öresund straight. Since 15 years the environmental office has carried out the most elaborate marine fauna monitoring program in Sweden which includes: bottom fauna sampling (two times per year), sediment chemistry including pollutants, persistent toxins in mussels and run-off from land. Starting in 2005 an instrument equipped with sensors for currents, temperature, salinity and oxygen is also measuring at hourly intervals in the bottom water (12 m depth) at one of the stations. Results from the project shows that eutrophication and persistent toxic substances have decreased in the environment while benthic fauna has been impoverished. Results will be presented and discussed. A comparison between monthly water column sampling (done by SMHI and DMU) and hourly measurements will also be done.

Marine Research Station in the 21st Century

Mike Thorndyke

Luis Valdes

A World Association of Marine Stations: It is estimated that nearly a thousand coastal laboratories and institutes can be identified around the world's oceans. Knowledge accumulated for decades by these laboratories are considerable but until the present initiative their joint potential has been far too little used or exploited. Mainly dedicated to marine life, the marine stations, because of their location around most of the world's seas, should be encouraged to play an important role as distributed observatories and infrastructures, for pursuing their pioneering work in fundamental biology and for assessing the impact of climate change on biodiversity and marine ecosystem functioning. In addition they can be central to the collection of data, in depth advanced studies of coastal and deep water environments including: genomics, systematics, ecology and evolutionary biology, stressed and extreme environments, biotechnology, biogeochemistry. These laboratories are of interest as land-based infrastructures for climatologists, physicists, geochemists and specialists in fisheries, aquaculture, biotechnology and biomedicine. Furthermore, the marine research laboratories are a rich resource of experienced scientists and offer unique coverage of many of the World's most important and often vulnerable marine ecosystems and resources. An international meeting held at UNESCO – Intergovernmental Oceanographic Commission, Paris April 13th – 14th 2010 agreed unanimously to establish the "World Association of Marine Stations (WAMS). This presentation will give an overview of the scope, aims and objectives of marine research stations worldwide, with particular emphasis on the Nordic contribution and its leadership.

Submarine landscapes on the North Norway continental margin

Terje Thorsnes

Margaret Dolan and Sigrid Elvenes

The continental margin off North Norway comprises a variety of submarine landscapes, ranging from continental shelf plains in less than 100 meters of water depth, to deep ocean plains extending down to nearly 3000 meters. Repeated glaciations where the ice sheet covered Norway and the entire shelf has been a major factor in the shaping of the margin, creating a favorable physical setting for the living resources. The continental shelf plain includes rich fishing grounds, separated by submarine valleys. The continental slope is heavily dissected by up to 1100 meter deep canyons, and is affected by extensive sliding activity. The deep sea plain is characterized by extensive slide fans, with over 100 meter high slide blocks. A landscape classification, following the new system "Nature types in Norway" has been applied. The basis for this system is "relative relief", aided by other terrain indices for delineating the landscapes. The broad scale landscapes have been combined with landforms such as moraine ridges and sand waves, in order to give a systematic framework for nature type classification on a finer level (eg. habitats or biotopes). The links between landscapes and habitats will be discussed. The data were collected and processed as part of the MAREANO programme, and both basic data (multibeam bathymetry maps) and thematic maps (such as landscape and landforms) are available on the web portal www.mareano.no.

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

Ingrid Tjensvoll

C. Bradshaw, M. Sköld, J. Molvær and H. Nilsson

Soft bottom sediment covers 70% of the world's seafloor and is important for many processes in the marine ecosystem. Sediment's ability to store large amounts of contaminants that can be released during sediment disturbances both due to natural and anthropogenic activities is well documented. The bottom trawl was introduced in the 13th century followed by concerns and protests from fishermen. Since then the trawls and the trawl gears have become larger and more efficient and today they can cover an area half the continental shelf annually. In the past, very limited attention has been paid to the effects of sediment resuspension during trawling. Given the extent and the frequency of bottom trawling and the documented penetration of bottom trawls into sediments, it is likely that resuspension is an important process. We documented large amounts of sediment resuspension during a trawling event in Eidangerfjord, Norway. To sample contaminants in the water column passive samplers (SPMD) and blue mussels were used and the results indicate the bioavailability and the potential effect of this resuspension on aquatic species. The measurements showed that sediment associated contaminants were dissolved into the water column due to the trawling event. The results from this study were compared with published data on dredging activities. Which show how different the management of two human activities can be even though the same environmental impacts are observed.

Functioning along coastal gradients: assigning and assessing biological traits to macrozoobenthos

Anna Törnroos

Katri Aarnio and Erik Bonsdorff

Integrating natural history into ecological studies of biodiversity and ecosystem functioning is shifting the focus from taxonomic diversity towards a trait-based perspective of functioning. The trait concept acknowledges that the levels at which ecosystems function and environmental changes affect them, are components of an organisms' phenotype. Accumulated knowledge of sets of characteristics necessary for maintaining ecological functioning is thus needed. Assigning traits measured in a local environment is essential for interpreting ecological functioning, since taxa can show a varying degree of plasticity in trait expression depending on local conditions. In the low-diverse Baltic Sea, species diversity and composition change dramatically along depth and salinity gradients, hypothetically also affecting trait expression, composition and evenness, potentially influencing functioning of the ecosystem. Hence developing a specific trait set for Baltic Sea benthos is crucial. This study introduces biological trait analysis to the coastal areas of the northern Baltic Sea and contributes to the development and assessment of multi-trait based approaches. We used data included in the Finnish environmental database for coastal zoobenthos, spanning the years 1988-2004 (726 sites, 2080 visits), to develop the trait concept and examine large-scale functional (trait) differences along environmental gradients. We present descriptive and quantitative results from a comprehensive BTA including 25 traits (100 modalities). Preliminary results reveal varying expressions of traits driven on smaller scales by organism abundances and on larger scales by presence/absence of individual traits.

Interaction effects of temperature and carbon dioxide on a sea-ice diatom

Anders Torstensson

Melissa Chierici and Angela Wulff

The ongoing climate change may have profound effects on marine ecosystems. These changes include increased sea surface temperature (SST) and increased partial pressure of CO₂ (pCO₂) in seawater, which are two important factors regulating microalgal growth. The largest pH changes due to oceanic uptake of anthropogenic CO₂ have been projected to occur in Polar surface water. Consequently, the interactive effects of increased temperature and pCO₂ in these areas are important to investigate to further understand the consequences of climate change in the Polar Regions. This study investigates the effects of these factors on a sea-ice diatom. Experimental pCO₂ treatments were 380 ppm (present day) and 960 ppm (projected year 2100). Temperatures were 0 and +4°C. Biological variables measured were photosynthetic activity, growth and photosynthetic pigments. The CO₂ system was described by measuring total alkalinity (AT), pH, temperature and salinity: from these variables for example fugacity of CO₂, DIC, [CO₂], [CO₃²⁻] and [HCO₃⁻] was calculated. There were no interaction effects of temperature and pCO₂ treatments. However, temperature alone had significant positive effects on growth rate and photosynthetic activity. The pigment composition was also significantly altered.

Benthic macroinvertebrate and biogeochemical responses of drill cuttings and organic matter in two sediment habitats

Hilde Cecilie Trannum

Hans C. Nilsson, Morten T. Schaanning and Karl Norling

The present study describes a three-factorial mesocosm experiment conducted to evaluate benthic responses of water-based drill cuttings and organic matter and interaction effects with sediment habitat. Drill cuttings (a mixture of reservoir rocks and drilling mud) are discharged from offshore drilling activities, and when settling on the seabed, benthic organisms may be affected. Two benthic communities were treated with either drill cuttings or natural sediment, and with or without organic matter. The experiment lasted for two months, where fluxes of oxygen and nitrate and oxygen profiles were regularly monitored. Macrofauna was collected after the experimental period. Number of taxa, abundance and diversity were significantly lower in the drill cuttings boxes compared to the natural sediment boxes, while abundance and biomass were significantly lower in the boxes without organic matter compared to the boxes with organic matter. PERMANOVA showed that all three experimental factors were significant for the faunal composition, and that there were no significant interaction effects. Sediment oxygen and nitrate consumption increased and sediment oxygen penetration profiles showed decreased oxygen content and increased fluxes into sediments treated with drill cuttings and organic matter. The risk assessment model for drill cuttings discharges (DREAM) was run for a simulated case of the present experiment, and both the modelled and the observed results indicate a risk above the accepted level of 5%. Water-based drill cuttings have been assumed to affect the fauna through burial, but the present and previous mesocosm studies and DREAM emphasise a risk of oxygen depletion and toxicity.

Baltic Sea chemical management within the EU Water and Marine Strategy Framework Directives

Oksana Udovyyk

Michael Gilek and Mikael Karlsson

Management of the environmental risks of hazardous chemicals in aquatic ecosystems is a complex area of environmental management with a multitude of regulations and management actions at international, country and local levels, as well as involving a large number of stakeholders. However, it is clear that for the Baltic Sea ecosystem (as well as for other European regional seas) the recent development and ongoing implementation of EU regulations are of paramount importance. At the forefront of these developments the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSD) and the new comprehensive European Union regulation concerning the Registration, Evaluation, Authorisation and restriction of chemicals (REACH). We argue that it is important to generate more understanding on the complementarities, overlaps, and potential conflicts of the WFD, MSD and REACH in relation to the implementation of the ecosystem approach of management of chemical risks in the Baltic Sea ecosystem. Knowing that WFD and possibly also the MSD may be hard to implement in regional seas such as the Baltic Sea shared between EU Member States and countries outside the EU, we will also focus our analysis on the new Water Code of the Russian Federation. Although the aims of the study primarily are to describe and analyse the synergies and conflicts among the studies regulations, we will also provide tentative recommendations connected with improving EU-Russian cooperation as well as the ecosystem-basis of chemical management in the Baltic Sea.

Interactions between eutrophication, oil and contaminants in marine ecosystems

Hege Vestheim

K. Hylland, T. Andersen, J. Egge, K. Langford, K. Norling, M. Schaanning, E.S. Stomperudhaugen, J.E. Thain, T.F. Thingstad, K.V. Thomas and H. Vestheim

Eutrophication, oil and contaminant inputs co-occur in most estuaries and harbours. In a range of experimental studies we assess how these stressors interact and affect processes and organisms in the sea surface microlayer, the pelagial, the sediment-water interface and the sediment. Oil may for example modulate the partitioning, accumulation and effects of contaminants, and either increase or decrease bioavailability. And increased inputs of organic material to sediment systems may cause large changes in the physical, chemical and biological characteristics through changes in food input, redox profiles and community composition. Our model contaminant is emamectin benzoate (EMA). It is an aquaculture pharmaceutical and has a selective toxicity to different benthic and zooplankton species and seems to be stable in seawater and sediments; in range-finding experiments we found that EMA could be detected in the water even 10 days after exposure (= end of experiment), though the concentration in water dropped markedly already after 1 hour. We have so far a.o. performed experiments assessing how organic material and oil affects the transfer of EMA from sediment as well as nutrient fluxes between water and sediment, and sediment related processes, including the role of bioturbators. Both factors have an effect and oil and organic material further influence the oxygen levels in the sediment. Results from pelagic microcosm (100 L) and mesocosm (2.5 m³) experiments indicate that ecological processes, e.g. species composition, zooplankton numbers and composition, are affected by both oil and EMA.

Potential flexible behavior of marine larval fish: consequences in a changing environment

Knut Vollset

Integrating and scaling from observed individual behaviour to field distributions is a daunting task across disciplines in marine ecology, and is an expanding field in the study of early life history of marine fish and invertebrates. Perhaps the most important task at hand is to understand how behaviour will create non-linearity between environmental variables and survival on measurable scales. Here we revisit two years of field data and apply an individual based vertical model that includes state dependent flexible behaviour according to predation and starvation mortality. Our data suggest that larval fish distribute shallower after a period of consistent low prey availability, and that this coincides with an increase in stomach fullness in relatively poor prey conditions. This is qualitatively replicated by the model that includes state-dependent behaviour and thus lends support to the hypothesis of flexibility in behaviour at early stages of larval fish creating non-linear relationships between prey concentration and stomach fullness across temporal and spatial scales of field collected samples. We suggest that field data that seeks to study the physical environment's effect on the functional response of larval fish preying on plankton, must either include the former environmental conditions and state of the larval fish, or integrate over a temporal and spatial scale that incorporates the time-lag response of state-dependent behaviour.

Estimation of N, P budgets in the Baltic Sea using a linear inverse method based on in-situ data and outputs from a 3D ecosystem

Zhenwen Wan

Marie Maar, Jun She and Lars Jonasson

Goals: 1. to synthesize the time series of total N, P budgets in the Baltic Sea by incorporating the in-situ data and model outputs; 2. to estimate the time series of the budget items: (1) biological fixation, (2) detritus remineralization, (3) river source input, (4) exchange with open sea, (5) atmospheric dry deposition, (6) outgassing, and (7) exchange with sediment using a linear inverse method, i.e. adapting the modes of the budget items to the synthesized time series of total N, P budgets; 3. to further validate the model on the basis of budgets.

Why is the recruitment of eels declining?

Håkan Westerberg

The recruitment of the European eel has declined since the 1980-ies and is now down to one or a few percent of the historical level. A parallel decline is seen for both the American and Japanese eel species. There are several possible explanations. Climate, overfishing, loss of freshwater habitat, pollution have all been considered but the question is still open. The ongoing European FP7 research project EELIAD (<http://www.eeliad.com/>) aims to resolve some of the mysteries of eel biology, and to use this information to help conserve European eel stocks. The projects focus is on the oceanic phase of the eel life cycle. Satellite tags and data storage tags are used to study the spawning migration from the European coast to the Sargasso Sea. The return of the eel larvae is modeled and investigated using analysis of the core of the otholits. A possible population structure is studied by screening microsatellite loci of eels from the whole distribution range and chemical analysis of the otholits of eel larvae. Examples of preliminary results will be presented and discussed.

Airborne laser as a tool for mapping of underwater vegetation and habitat types

Sofia Wikström

Michael Tulldahl

MMÖG is a joint project by AquaBiota, the County administration board of Östergötland, the Swedish geological survey (SGU) and Norrköping municipality. MMÖG is financed by the Swedish Environmental Protection Agency, who also participates in the reference group of the project in together with the administrative boards of a number of other counties. AquaBiota coordinates the project and models and produces maps of e.g. bathymetry, currents, salinity, presence of benthic biota and classes of expected natural values. (Read more about spatial modelling at www.aquabiota.se.) The Swedish Maritime Administration delivers point data on depth, and the Swedish Geological Survey models bottom substrate. The County Administrative Board of Östergötland develops methods for classification of potential natural values of modelled biota in collaboration with the Municipality of Norrköping and AquaBiota. Data on presence of benthic biota have been compiled from previous studies by the County Administrative Board of Östergötland. Supplementary data have been collected through drop video surveys by AquaBiota and field the county administration board. The project runs 2009-2010.

Scientific advice and resilience in marine governance: lessons from European fisheries

Doug Wilson

While spending the past 25 years failing to sustain Europe's fish stocks, the Common Fisheries Policy has also become adept at making the lives of its scientists miserable. Now it is being confronted by the complex challenge of an ecosystem-based approach to fisheries management. The interface between science and policy that supports the CFP has been a part of this overall failure, but not in a way that can be simply reduced to the often heard "managers fail to follow scientific advice". Based on a five year study of ICES this talk traces the power dynamics and patterns of institutional communications and that have influenced the creation and use of fisheries science advice under the CFP. It discusses the critical role that ICES scientists are play as reformers as well as advice givers. The ICES network offers many independent opportunities for scientists to play different roles and to offer and withdraw support for initiatives. This "polycentricity" is proving to be an important source of institutional resilience that is making an important contribution to the slowly emerging efforts at long term reform of Europe's fisheries and general marine policy.