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The paradox of the plankton

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Biodiversity has puzzled ecologists for decades. In aquatic ecosystems, the puzzle is particularly troublesome, and known as the paradox of the plankton (Hutchinson 1961). Phytoplankton species are limited by only a handful of resources (e.g., nitrogen, phosphorus, iron, light). Yet a single milliliter of seawater may contain dozens of different phytoplankton species. How can this surprising biodiversity be explained? This presentation will focus on a number of potential solutions for the plankton paradox that have recently been proposed.

First, we tested Tilman's resource-ratio hypothesis, which states that differential utilization of nutrients and light may allow coexistence of species along a nutrient-light gradient. We investigated this hypothesis in chemostat experiments with phytoplankton species. Would differential utilization of nutrients and light generate species coexistence, alternative stable states, or competitive exclusion?

Second, we shift our focus to the underwater light spectrum as a potential axis for niche differentiation. Phytoplankton species often differ in pigment composition, which might potentially favor their coexistence. We tested this hypothesis using competition models and chemostat experiments with red and green picocyanobacteria. Would the reds and greens wipe each other out, or would they be able to share the spectrum?

Third, the complexity of multi-species interactions may generate non-equilibrium dynamics, like oscillations and chaos. Usually, chaos is seen as a destructive force. Or, could chaos promote biodiversity?

Fourth, incomplete mixing can favor species coexistence, especially if species separate in different spatial niches, and thereby avoid intense competition. Climate-ocean models predict that warming of the ocean waters strengthens vertical stratification, which reduces vertical mixing. Could reduced mixing, by global warming, promote phytoplankton biodiversity?

In each of these studies, we make use of a combination of models, lab experiments, and field research. They illustrate how such a multi-faceted research program may shed new light on potential mechanisms that determine the world's biodiversity, thereby providing novel solutions to Hutchinson's classic paradox.

Inventorying the marine biodiversity of the world: what is our rate of progress?

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Twenty-five years ago, scientists believed that the ca. 1.6 million species they had till then inventoried represented about 50% of plant and animal species on this planet. New approaches in sampling insect diversity in rainforests and small macrobenthos in the deep sea have revised this estimate to 1.7-1.8 million described species and 10-100 million species remaining to be discovered, with taxonomists incrementing the known total at a pace of 16,600 new species per year.
Within this grand total, we currently know about 230,000-275,000 species of marine organisms, with rather much grey area due to unconsolidated synonymies. The inventory is growing at a yearly pace of about 1,600 new marine species, ranging from Archaea and picoplankton to fish and cetaceans. A breakdown by taxa both confirms and infirms conventional wisdom. Crustaceans and molluscs together account for nearly half of the new species descriptions, which is expected, and there are five times as many new fish described as there are nematodes, which is unexpected.
The measure of species richness at whatever spatial scale remains a challenge to science, conservation and management. Entomologists have built a predictive model of the number of species of insects on the planet, but such a model is still lacking for marine biodiversity. The global magnitude of marine biodiversity is still a matter of speculation, with microbes and symbionts probably the main 'unknown'.

Knowledge and diversity are unevenly distributed, and the Convention on Biological Diversity has highlighted the imbalance between the distribution of biodiversity and the distribution of knowledge on that biodiversity. The seas around Europe account for about 12% of global marine biodiversity, but authors in the European Union are responsible for 34% of the new marine species descriptions. Most of known and unknown biodiversity is in tropical countries, most of which are developing or emerging countries of the South, whereas most of the pressure to access that biodiversity comes from developed countries of the North. The Convention on Biological Diversity has named "Taxonomic Impediment" the deficit of systematists and support infrastructures to document biodiversity. Of the many factors contributing to this impediment, two can be highlighted.
Within the scientific community, careers, funding, and other resources result from peer reviews that overwhelmingly favor research articles published in high-impact journals. In the real world, only 36% of the new species descriptions are published in journals that have any impact factor at all, and only 12.6% in journals with impact factors equal or superior to 1. The fate of the vast majority of new marine invertebrate and fish descriptions is to be published in journals with a modest impact factor, or no impact factor at all, contributing to the poor success of their authors when competing for employment, grants, or promotions.
Outside the scientific community, it can be argued that the "Taxonomic Impediment" is actually fueled or aggravated by attitudes and regulations both inside and outside the Convention on Biological Diversity. Access to biodiversity – for academic or industrial purposes – has now become strictly regulated under national biodiversity laws implementing international agreements of the Convention. Scientists have championed the economic benefits that would be generated by the discovery of new bio-active compounds, in the hope that this would attract public and private funding for their research. The same scientists are now facing suspicion, if not hostility, from law-makers who want to take no economic or political risk in granting access to biodiversity exploration and bioprospecting. The discovery of new marine species, and indirectly of new marine products, is increasingly being overseen by legal offices, conservation NGOs and Third World activists, rather than driven by academic scientists themselves.

Large scale comparisons and databases
MarBEF: lessons learned from data integration

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Integration is the key issue in the MarBEF network. One of the important integrating activities is the development of databases, containing data and information on taxonomy and biogeography from a large number of partners.

One of the datasets under development focuses on soft-bottom macrobenthos. A total of over 450,000 distribution records, from 42 different sources, were brought together in a single access database. Integrating data from different sources brought to light several issues. Lack of proper data management procedures with several of the partners made integrating those data a labour-intensive exercise. Lack of standards in sampling methodology made strict comparison of measured densities and biomass across individual datasets difficult. Last but not least, differences in interpretation of taxonomy, differences in identifications, and numerous spelling variations would, if not corrected for, have lead to a serious overestimation of marine biodiversity.

MANUELA: an RMP on meiobenthos. Plans and Progress

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Within MANUELA, scientists 14 institutes from 9 countries are working together on integrating knowledge and expertise on meiobenthos (all metazoans living in the sediment, passing a 1 mm-sieve and being retained on a 38µm-sieve).Within the RMP, three main objectives have been set: (1) To integrate the currently fragmented information on the dynamics and functional role of meiofaunal; (2) To improve understanding of how the activities of meiobenthic organisms, population dynamics and community assemblages are linked to ecosystem processes and (3) To facilitate meiobenthic research within the MARBEF community and stimulate the interest in meiobenthology.

During the kick-off meeting in Gent, organised in September 2006, we decided to dedicate the first months of the RMP on (1) collecting and integrating meiobenthic datasets and (2) setting up structures to facilitate meiobenthic research.

Data collection was performed in close cooperation with VLIZ. At the moment, 42 datasets were submitted, containing information on 1185 species. Some of these datasets were only available as paper version and were transformed to a digital version. The bulk of these species belong to the nematodes and harpacticoid copepods which are the dominant taxa within the meiobenthos. The geographical area covers the NE Atlantic, the Mediterranean Sea and Polar-Arctic Sea. Data originate from the intertidal until the deep sea. At the moment, the species list is being checked for synonyms, typing errors…and corrected. Scientific analysis of this database will be performed on a workshop at Ghent University in January 2007.

Quite some time and effort was spent in providing the scientific community with tools facilitating meiobenthic research. Nematode identification is not possible using classical dichotomous keys: original species descriptions are needed to correctly identify individuals. Since this taxonomical literature is often very old and quite voluminous, access to a complete inventory of species description is limited to only a few institutes worldwide. In order to overcome this problem, all taxonomical literature on nematodes was transformed to PDF and made available on-line (http://intramar.ugent.be/nemys/start.asp?group=2&c=1).

Next to opening the taxonomical literature world-wide, we constructed an easy to use on-line key to marine nematode genera. In some cases, keys to species levels were provided. These keys are polytomic and fully illustrated, providing the user with a relatively easy tool for identification of marine nematodes. Moreover, possible results are linked with the taxonomical literature, a feature offering the possibility to check the identification.

Future activities include an update or ERMS and EUROBIS for nematode species, based on the species list compiled in the MANUELA database. Integration of experimental expertise and planning of experimental work (Theme 2-related) will be done during a workshop in Poland (September 2006), while a workshop in Gent (January 2007) is planned in order to test several hypotheses concerning meiobenthic ecology. Later in 2007, a training workshop on meiobenthic techniques will be organised in Wilhemshaven.

Assessing pelagic faunal assemblages at oceanic sites

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The RMP "Integration of different methods to study patterns and changes in pelagic biodiversity in the open ocean along the Mid-Atlantic Ridge" produced a report on "Strategies, integrated methods and technologies for evaluating pelagic faunal assemblages at oceanic sites".
Priority is given to strategies and methods that provide information relevant to investigations of pelagic *meso-, macro- and megafauna* inhabiting all depths of oceanic sites. The target was *species assemblages,* i.e. not individuals nor higher-level ecosystem components. The geographical focus was on the oceanic North Atlantic, but general assessments and conclusions should be valid for fauna in oceanic waters elsewhere.
The different possibilities as well as the restrictions of the different methods (e.g Net sampling, Acoustic, Optics, Sensors, Samplers and Oceanographic instruments) will be discussed.

Activity Highlights within the MARBEF Fish RMP (MarFish)

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This RMP is investigating the causes and consequences of changing marine biodiversity from a fish and fisheries perspective. Fish and many other marine species are being overexploited and are stressed by human-induced environmental changes including global climate change and eutrophication. The abundance of many species in local areas is changing and in some cases entire local populations have become exinct (Myers & Worm 2003). At the same time, the mean trophic level and sizes of the remaining species has decreased (Steinmetz et al. 2006; see poster at GA).

Changing environmental conditions are also challenging fish populations. Compilations and reconstructions of daily sea surface temperatures measured in the North Sea and Baltic Seas since the 1860s show for example that temperatures are now higher than at anytime since measurements began (MacKenzie & Schiedek 2006; see poster at GA). As a result the geographic distributions (Genner et al. 2004; Poulard & Blanchard 2005; Perry et al. 2005), productions rates (Beaugrand et al. 2004; MacKenzie & Köster 2004), and lifehistories (Greve et al. 2005) of fish species are changing. For example, the anchovy was absent from waters near Denmark for many decades but has recently (2002, 2003) been caught at nearly half the stations occupied during fishery research surveys in the Kattegat and Belt Sea, partly as a result of increasing sea temperatures (MacKenzie & Nielsen 2006; see poster at GA).

The changes being brought about by fishing and environmental change will have major impacts on fish communities and how fish species interact with the remaining components of the ecosystem (e. g., other fish, benthic invertebrates, plankton). Understanding these changes and predicting the consequences for fish populations, ecosystems and human socieites are therefore two of the key objectives of this RMP.

The presentation during the GA will briefly summarize the participating institutes, work tasks of the RMP and the upcoming activities in 2006-2007. Additional information will be available in an accompanying poster and from the project website (http://www.marbef.org/projects/marfish/index.php) .

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Marine mammals along the Mid-Atlantic Ridge between Iceland and the Azores: What do the whales tell us about this ecosystem?

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Distribution, abundance and aggregations of marine mammals were observed during the MAR-ECO expedition onboard R/V “G.O.Sars” in June 2004 along the Mid-Atlantic ridge (MAR) between Iceland and the Azores (www.mar-eco.no). A total of 1433 individuals and 17 species were observed during the cruise. The most important hot spot area for marine mammals was by far the Charlie Gibbs Fracture Zone (CGFZ) with 282 individuals, constituting 80% of the aggregated hot spot sightings. The highest aggregations of sperm whales (Physeter macrocephalus) were observed north of the CFGC. Sei whales were most common over the slopes of seamounts and rises in waters with depths between 1500 and 3000 m, while sperm whales were common in waters shallower than 2000 m and often above underwater seamount peaks. All three major hot spot areas were found in cold (5°C < t < 9°C) and low saline (S < 35.0) Sub Arctic Intermediate Water (SAIW), while the outside reference areas were characterised by warmer (t > 7°C) and more saline (S > 35.0) North Atlantic Central Water (NACW). The currents from ADCP measeurements showed a tidal current pattern with low average speed of 5 cm/s to the east and a maximum speed of 50 cm/s. Acoustic recordings with Simrad EK-60 echosounder data of possible prey species in the water column using five different frequencies were applied simultaneously with our visual observations from above the bridge (15,5 m). The acoustic densities were significantly higher within the hot spot areas compared to surrounding areas. Zooplankton concentrations were significantly higher in SAIW water masses compared to NACW water. The cephalopods swimming at great depths (> 500 m) could not be detected acoustically due to their extremely low acoustic properties and contrast. Instead, biological data from different deep-water trawl stations catching cephalopods down to 3500 m were used and correlated with the hot-spot areas of concern. Significantly higher concentrations of Gonatus fabricii and related cephalopod species were collected close to our sperm whale hot-spot areas compared to surrounding areas. Thus, sperm whales probably aggregated in these areas due to increased feeding opportunities. Sei whales aggregated in areas with the highest biomass of zooplankton prey in the upper 100-200 m of the water column as documented from meso-zooplankton net hauls in geographically related areas. Favourable topographic features, cold and productive SAIW combined with elevated zooplankton and cephalopod concentrations, probably explain why baleen and toothed whales aggregated in these hot spot areas along the MAR.

Why are diatoms so successful in the modern marine plankton?

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Diatoms constitute one of the most diverse eukaryote microalgal groups in the modern marine plankton. We review their morphology, phylogeny, life history, and ecological diversity and provide an overview of their fossil record to reveal their rise to dominance. Then, we explain the possible reasons for their apparent success. Diatoms belong to a group of chromophyte microalgae resulting from one or more secondary endosymbiosis events giving rise to the haptophytes (coccolithophorids), dinoflagellates, and heterokontophytes (including the diatoms). Chromophytes probably won over the green and red marine phytoplankton because of their superior photo-system, their ability to take up organic material, and, at least partly, their ability to form resting stages. Heterokontophytes may have won over other chromophytes because of their low quotas of trace elements needed and, possibly, their C-4 mode of carbon fixation. The dominance of the diatoms over their heterokontophytan relatives may be thanks to their large central vacuole for nutrient storage, their silica encasing, their advanced biochemical defenses, and last but definitely not least, their ecological diversity. During the course of their evolution several originally benthic lineages adopted a planktonic lifestyle secondarily, over and over again, making use of new designs.

Marine Biological Valuation:
An integrated view on nature's intrinsic value

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The MARBEF Theme III Responsive Mode Action is aiming at setting up a decision support system (DSS) for a sustainable marine management. By definition such system should take account of social and economic as well as ecological aspects. The workpackage on marine biological valuation aims at establishing a strategy to provide an integrated view on nature's intrinsic value. Biological value is here defined as the value of biodiversity, without any reference to anthropogenic use. As such, the biological value complements the social and economic valuation within a DSS.
Till now, when requested, the biological value of an area was assessed through a basically unguided procedure, primarily based upon a (the available) best expert judgement. Such extremely subjective and arbirarily procedure largely contributed to the general ignorance of biological value within current DSSs. Our marine biological valuation strategy, in contrary, should ideally be (1) scientifically widely acceptable, to avoid an uncontrolled proliferation of valuation strategies, and (2) widely applicable, to maximise its applicability. Only when both criteria are fulfilled, the valuation strategy might be taken into DSSs to quantify nature's intrinsic value. The promising successful application of such strategy was taken from the terrestrial part of Flanders (Belgium)

At first literature, considering intrinsic biological value, was reviewed. Some lessons learned comprised: (1) the high redundancy in valuation criteria used, (2) the high variability in valuation criteria and (3) the frequent confusion between valuation criteria and criteria for MPA selection. A draft paper, drawn from this literature review, was taken as a starting point for an international expert workshop on marine biological valuation. As a result of the workshop a proposition of three first order valuation criteria and two modifying criteria were fixed into a general strategy for biological valuation, taking into account all levels of biodiversity organization (from genes to ecosystems). The valuation strategy is now in the process of review for publication.

Secondly, the developed marine biological valuation strategy is now being tested on the Belgian part of the North Sea (BPNS). For all valuation criteria and organizational levels of biodiversity assessment questions have been described. These were evaluated for the different ecosystem components for which data were sufficiently available for the BPNS (seabirds, macro-, epi- and hyperbenthos). This leads to different maps for every assessment question per ecosystem component. In a last phase of the test all separate maps need to be combined and will result in a marine biological valuation map for the BPNS

Within the MARBEF Theme III Responsive Mode Action the strategy will be tested at six other sites, spread throughout European marine waters: Pico-Faïal channel (Portugal); Puscz Bay (Poland), Scilly Islands (U.K.), Flamborough Head (U.K.), and Sylt-Rømø (Denmark). These tests should provide us with "lessons learned", considering the general applicability of the strategy and its scientifical acceptability (feed back with local experts!) and will thus lead to suggestions for further improvement.

At last, this presentation should be considered as an open invitation for any contribution to the general aim of this work, being an integrated view on nature's intrinsic value. This can be done by both comments on or suggestions for the strategies theoretic outline (paper version on request), but also through participation in the MARBEF Theme III workshop in Ghent (Belgium) on 6-8 December 2006. This workshop aims at (1) a first open evaluation of our proposed valuation strategy (theoretical), as well as (2) linking up the marine valuation strategy with terrestrial (biological valuation) experts. This last aspect will be dealt with in close collaboration with the European Network for Coastal Research (ENCORA).

Goods and Services provided by Marine Biodiversity

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Exploitation of environmental goods and services is essential for human survival. To ensure our utilisation of the marine environment is sustainable, efficient and equitable it is essential that we have a comprehensive understanding of the goods and services provided, and the impact of human activity on all of these functions. Thirteen goods and services are provided by marine biodiversity: resilience and resistance; biologically mediated habitat; food provision; raw materials; leisure and recreation; disturbance prevention; nutrient cycling; gas and climate regulation; bio-remediation of waste; cultural heritage and identity; cognitive values; future unknown and speculative benefits; feel good/warm glow. This research aimed to define each of these functions, and case study areas were then used to validate these definitions and to provide an insight into the difficulties of assessing the goods and services at specific locations. The data available on the goods and services was found to be very variable in quantity and quality. Using present knowledge, it would be impossible to quantify all the goods and services at any given site in a comparable way. To achieve an ecosystem approach to managing the marine environment we need to develop methods to quantify goods and services that are based on the underlying ecological processes.

Information for marine environment protection and management: getting it and using it (a short tutorial)

Keith Hiscock
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Introduction

There is no shortage of information to assist in marine environment protection and management. The problem is:

1. you have to find it;
2. you have to have the skill to use it competently, and
3. it is incomplete and will not therefore provide a definitive answer to many questions.

Whatever you do, don't re-invent information that is already available.
But do keep on improving it.
The below are the sorts of information you should be looking for.

Understanding the issues

The following questions (about biology) are the ones that environmental advisors should be able to answer.

1. What's where, how much is there and how does it change?
2. What do I call them (species and biotopes)?
3. What is 'important' (for marine natural heritage)?
4. What is 'important' (socio-culturally)?
5. What is 'important' (economically)?
6. How do I assess 'quality'?
7. How do I identify 'sensitivity'?
8. How do I identify change that 'matters'?
9. How do I decide what is relevant research to undertake (to inform environmental protection and management)?
10. How do I take account of ecosystem structure and functioning and associated processes?

Bringing information together

1. How do I make decisions?
2. How do I judge feasibility?
3. How do I judge success?

There are structures and criteria available to process your information to support decision-making. They are mentioned in the paper and emphasis is given to the DPSIR (Drivers, Pressures, State, Impact, Response) approach and to how to take information through an assessment of sensitivity, then importance to decide 'will it matter' in relation to developments and accidents.
The full paper is on:
http://www.marbef.org/modules.php?name=Downloads&d_op=viewdownload&cid=145

Exchange rate between scientific currencies. An application to the marine environment

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Each scientific paradigm tends to devise its own valuation system. Ecologists design maps with environmental values assuming the relevance the ecosystem sustainability. Socio-cultural scientists value things according to their role in the society along space and time. Economists prefer cost benefit analysis where everything can be translated into trade-offs and money. And the question stays open. How to combine the different disciplinary perspectives in a consistent decision support methodology?
The objective of the methodology presented here is to combine different environmental valuation systems in a consistent way. It is assumed that the economic, ecological and cultural valuations complement each other rather. It is also supposed that each one of these valuations could be allocated to some dimensional referential or map. Finally it is believed that public decisions should be consistent so that the trade-offs between similar values must be the same along all the decisions.
If so, in every point of a regulation boundary (f) that limits alternative uses of the environment, the total value for one use (Vfa) must be exactly the same as the total value for a different use (Vfb).

$$Vfa=Vfb \quad (1)$$

On the other hand, each total value (Vfa, Vfb) results from adding up the economic values (Vfea, Vfeb), the ecological values (Vfba, Vfbb) and the socio-cultural values (Vfca, Vfcb) , each one of them multiplied by an Exchange Rate Function. The Exchange Rate Function (p) relates the economic values to the ecological values. The Exchange Rate Function (σ) relates the economic values to the socio-cultural values.

$$Vfa= Vfea + Vfba \times p + Vfca \times \sigma \quad (2)$$

$$Vfb= Vfeb + Vfbb \times p + Vfcb \times \sigma \quad (3)$$

In the boundary (f) the value associated with alternative uses (a, b) are equal. Therefore:

$$(Vfea - Vfeb) = (Vfbb - Vfba) \times p + (Vfcb - Vfca) \times \sigma \quad (4)$$

Notice that the boundary line has many points. Assuming that it is possible to obtain the economic, socio-cultural and ecological values for different alternatives (a, b,….) then it is also possible to estimate the functions (p) and (σ). If these functions are just simple parameters then they can be considered as “Exchange rates between disciplinary valuations”: between economists and ecologists (p), between economists and historians (σ), and also between ecologists and historians (σ/ p).
Notice there each scientific paradigm is more associated with special goods and services provided by the environment (Costanza et al., 1997; De Groot et al., 2002) and some valuation techniques do not cover all those goods and services (Nunes et al., 2004). The proposal is to allocate the valuation of the various goods and services among the different disciplines, and then it is possible to add them up based on the Exchange Rate Function estimated from the revealed public preferences. Expertise of the ecological valuation: resilience and resistance, disturbance prevention, nutrient cycling, gas and climate regulation, bioremediation of waste and biologically mediated habitat. Expertise of the economic valuation: food provision, raw materials, leisure and recreation. Expertise of the cultural valuation: cultural heritage and identity, cognitive values, existence value and speculative benefits.

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A short introduction into ecological network analysis- first steps to model the relation between biodiversity and ecosystem function

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A detailed energy flow model consisting of 56 living and 3 non living compartments was assembled for the intertidal area of the Sylt-Rømø Bight. The model depicts the biomass of each compartment, carbon flow between the compartments, imports and exports, as well as an energy budget for each. The food web was analysed by means of network analysis which showed that about 17% of the total daily flow through the system is recycled through a complex cycling structure consisting of 1197 cycles.
Diversity of benthic communities contributes by different percentages to the cycling and represent separated food webs nested into the food web of the total system. Because of this uneven distribution of the cycling between the different communities the cycling structure of the carbon flow of the system is highly dependent on the community structure and the diversity of the total system.
Comparing several dimensionless system level indices calculated for the Sylt-Rømø Bight and its communities with those of other marine and estuarine ecosystems on a global basis, it showed that the energy is rather inefficiently transferred within the Bight and that most system level indices are lower than those for other coastal ecosystems.
However, flow diversity and food web connectance was higher in the present system. This study has revealed the Sylt-Rømø Bight to be a highly complex system whose energy pathways appear to be sensitive to perturbations especially on the community level.

Experimental unravelling of ecosystem function

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The question of how biodiversity gives rise to functionality (BEF questions) in aquatic ecosystems is not straightforward. The historic approaches developed in terrestrial ecology are now being repeated. However, there are some inherent advantages in using aquatic systems for the development of an experimental approach to BEF problems (Solan 2006). It is often easier to select and measure functional responses that can be contained and controlled under experimental conditions. In addition, the test organisms are relatively small and can be fairly easily manipulated although the logistic strains of collecting and sorting the required biomass should not be underestimated. However, experimental studies will always have their detractors and there are valid criticisms of the experimental approach. Synthetic assemblages do not exactly replicate any real life conditions, the scale and temporal scale of the experiments is a trade-off between resources, time and the desired design. In addition, there are the theoretical problems of low biodiversity, the importance of species identity and potential interactions. For example negative relationships between diversity and functionality may be related to the indirect effects of the species in question (Figure 1). This paper follows a progression of experimental designs used to address the BEF question leading from simple laboratory manipulations (Biles et al 2003a, 2003b), toward more complex systems (Emmerson et al 2001, Solan et al, unpublished data), field manipulations (Dyson and Saunders, unpublished data) toward the ultimate goal of establishing BEF relationships under natural conditions. Interpretation of effects must be carefully considered throughout this gradient to prevent inaccurate conclusions dependant on the experimental protocol.

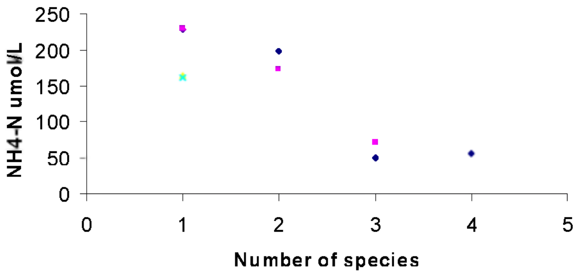

Figure 1. Decreasing ecosystem function with increasing diversity can be attributed to competition/interference between species.

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Genetic Biodiversity: a network cross-cutting themes (RMP 4.1)

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Today, ecological information is available for most keystone species of marine environments while we certainly lack information on the genetic variation of even the most important species and populations, in particular at a European scale. There is a need to resolve the genetic structure of a set of species at a level of detail suitable to make predictions on how global and local perturbations will influence the structuring and the phylogeography of species and their populations.

The main objective of the project is to build a network permitting analysis of the factors influencing the genetic structure of populations of marine taxa to explain the establishment and the evolution of patterns of biodiversity at different scales, local to European (themes 1+2). Such a network is necessary to assess the genetic responses of taxa to short term perturbations and global change (theme 2). Distribution areas are often so wide that a network is the only means to perform the necessary sampling, especially when repeated sampling is required (*e.g.* to study temporal effects in relation to environment changes). This will provide a better understanding of the impact of current biological and anthropogenic processes on the maintenance and sustainability of natural populations and of the processes determining how population structures vary according to ecological and biological traits (life history, reproductive mode, behaviour). It will also provide insights on how the interactions of these traits with physical processes influence population structures (enhancing or restricting gene flow between populations. *e.g.* fragmentation of populations, spatiotemporal compartmentalization over gradients [salinity, temperature], artificial selection due to contaminants, effects of various stresses) and hence the evolution of these populations. The strength of a particular interaction or process (*i.e.* mechanisms underlying functional biodiversity) may vary from one location to another. Such an approach will also permit to detect the signature of historical changes that may explain the present distribution of some taxa, especially the impact of past climate changes on marine life.

The collaborations inside the network will allow comparisons among taxa, which are necessary for a general study of marine communities. Using a multi-species approach across Europe will permit, for the first time, to link the population-species level with the ecosystem function. A European-scale network will also provide the opportunities for using complementary molecular techniques, and also opportunities for training in a context of rapid technical and theoretical progresses.

The role of native and/or invasive ecosystem engineers in explaining biodiversity (RMP 4.2)

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Ecosystem engineering has been defined as a biologically mediated modification of the physical and/or chemical environment that is relatively large. Thus, ecosystem engineers are known to modify habitats, which may facilitate or inhibit conditions to specific members of the community. As a result, many engineers function as keystone species with a large impact on the biodiversity, functioning and stability of ecosystems. However, the mix of facilitative and adverse effects makes that the net effect of ecosystem engineers on overall diversity is not always evident. The net effect may be even less clear in case an invading ecosystem engineer takes over the habitat from a native (ecosystem engineering) species.
Ecosystem engineers can affect biodiversity by two main mechanisms: (1) modifying physical (e.g., ameliorating harsh conditions) and/or chemical (e.g., sediment biogeochemistry) environment, and (2) enhancing the structural complexity of the system. Ameliorating of harsh conditions may affect biodiversity via facilitation processes. In coastal systems, the most harsh conditions are expected at transitions from deeper to more shallow depths. Accordingly, the relative importance of ecosystem engineering may be hypothesised to vary between different elevation zones. The effect of a modified sediment biogeochemistry on diversity may be hypothesised to be related with the level of organic enrichments and oxygen input into the sediment. Modification of structural complexity can affect biodiversity e.g. via shelter from predation. Modification of physical and/or chemical environment may enhance system stability as temporal variations can be buffered. However, an integrative view of the overall net effect of ecosystem engineers on biodiversity is still lacking, due to a lack of good across-system comparisons at a larger scale. The current proposal aims at addressing this gap in our knowledge.

The objective of our RMP is to compare the relative importance of ecosystem engineering for biodiversity and stability across different types of native and/or invasive ecosystem engineers (e.g., coral reefs, seagrass meadows, bivalve banks, algae meadows, salt marshes, etc.), going from:

1) shallow (intertidal) areas towards deeper water
2) cooler Northern latitudes to warmer Southern latitudes and in some cases even tropical areas.

Across these spatial scales we want to establish:

A. the importance of ecosystem engineering for biodiversity by comparing species occurrence patterns in plots with and without the dominant (invasive) ecosystem engineer. The data will be used to derive assembly rules, showing facilitation and/or inhibition.
B. the relative importance of the 2 main mechanisms: (1) modification of the physical and/or chemical environment versus (2) enhancing the structural complexity of the system. This will be achieved by comparing the biodiversity effect of native and/or invasive ecosystem engineers that strongly vary in this respect.
C. the consequences of ecosystem engineering for ecosystem functioning and ecosystem stability, e.g., by using a (conceptual) modelling approach conform van de Koppel et al. (2002, Am. Nat. 159: 209-218) and van de Koppel & Rietkerk (2004, Am. Nat. 163: 113-121).

Our aim is to use existing databases. For those systems where there are insufficient data to analyse topic B, essential data will be collected.
To further establish the relative importance of the mechanisms by which ecosystem engineers affect biodiversity, we aim for a small collaborative experiment (following common experimental designs) in which we use artificial structures that either result in large complexity, or that result in a large change in physical and/or chemical environment. However, regarding the limited funding, such collaborative experiments must be made compatible with ongoing research programmes of the various participants.

Pan-European gradients in propagation and settlement events (RMP 4.3)

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In this project, we aim to identify the intensity, timing, and temporal extent of production and (primary) settlement of pelagic propagules of benthic plants and animals along large-scale Pan-European transects representing spatial gradients in environmental conditions such as seawater temperature, insolation and seasonality. Studied species comprise both floral and faunal key organisms (e.g. ranging from biofilm communities to bivalve post-larvae). Both representatives of the rocky shore and the soft-sediment communities will be studied. The proposed empirical research on latitudinal gradients in a selection of recruitment characteristics may contribute to the main question how variation in local conditions affects the richness in communities.

Effects of biodiversity on the functioning and stability of marine ecosystems - European scale comparisons (BIOFUSE - RMP 4.4)

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Although documented global extinctions are rare in the marine environment, local extinctions and dramatic changes in abundance are widespread. The consequences of this loss for the functioning and stability of ecosystems are the current focus of intense research activity, partly because of the threat to the goods and services that ecosystems provide to society. Much of the research to date has been controversial, with disagreement over the role of diversity per se as opposed to the roles of individual species or functional groups. Marine environments are potentially very valuable in resolving this debate because they are diverse at higher taxonomic levels than terrestrial systems and have high levels of functional diversity.
The main aim of this project (BIOFUSE) is to quantify the relationship between biodiversity and the functioning and stability of ecosystems with variable regimes of diversity and disturbance.
There are five specific objectives:

1. Quantify stability at sites of naturally differing degrees of diversity under a range of levels of exposure to natural and anthropogenic disturbance
2. Discriminate between effects on ecosystem function and stability of numbers of taxa or functional groups and their identities (while controlling for changes in overall density/biomass)
3. Test effects of loss of diversity at one trophic level on the functioning of others
4. Quantify the main effects and interactions between intensity and temporal variance of disturbance on ecosystem function under different levels of biodiversity
5. Compare outcomes across systems and geographic regions to test the hypotheses that effects of loss of diversity/key species/functional groups vary depending on:
   - the initial diversity of the system
   - environmental conditions (salinity, substratum, nutrient levels, etc.)

Integrated research is required to achieve these objectives. Existing data sets will be compiled to search for general patterns using meta-analysis. Experiments will be used to test explicit hypotheses on the effects of loss of biodiversity on ecosystem functioning. Sampling and experiments will be replicated at the pan-European scale by the integrated activities of participating institutions, following common experimental designs and standardised methodologies. The details of these experiments and sampling programmes have been finalised at two successful workshops and three of the four main studies have been initiated.

Functioning of FOOD WEbs across ecosystems of different BIOdiversity level (RMP 4.5)

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Processes ongoing in the ecosystem and mediated by organisms are determined by interactions among organisms and between organisms and the ambient environment, thus by biodiversity. Diversity of habitats and species vary geographically across environmental and ecological gradients, structuring ecosystems and their functioning at local and global scales. Ecosystem metabolism is intimately linked to carbon and nitrogen fluxes from primary producers to consumers of higher trophic levels. This trophic transfer determines the productivity of ecosystems depending on the efficiency of the food webs. Systems with high diversity and complex trophic interrelations such as the Mediterranean Sea or Atlantic are considered to be stable and productive, while in systems such as the Baltic Sea average diversity is low and food web structure relatively simple. Despite such striking differences in their structures, the productivity of the food web in the Baltic is reported to be similar to that of the Atlantic. This would indicate that biodiversity might not be an essential prerequisite for ecosystem (food web) functioning. However, the number of interactions between species increases with their number and even so does the number of material cycles and pathways within a food web. Therefore the question arises, to what extent food web efficiency of an ecosystem is related to the entire diversity as well as to the species pool of the higher-ranking systems.

To address this question, the *FOODWEBIO* project investigates the relations between diversity of habitats and species, and the functioning food webs in European coastal waters that differ in biodiversity. The objectives of the project are:

1) to define the structure and functioning of the food webs and inter-relations between various trophic levels in ecosystems of different biodiversity level based on key taxa
2) to compare the structure of the food webs among systems based on the selected BIOMARE flagship sites across a range of geographical and environmental gradients
3) to assess the effect of changes in biodiversity on the efficiency of food web at a pan-European scale.

Two methodological approaches are integrated: (1) $\delta^{13}C$ and $\delta^{15}N$ ratios to identify the origin of organic matter in various components of the systems studied and define trophic relations and (2) Network Analysis to unravel the interactions between the living and non-living components of ecosystems and energy flow within them.

The project was commenced in November 2005 through a kick-off meeting in Hel, Poland for a period of nearly four years (until 2008) within the activity of EU Network of Excellence Marine Biodiversity and Ecosystem Functioning (*MarBEF*). The project gathers nine partners representing six European countries bordering the Baltic Sea, North Sea, Bay of Biscay and Mediterranean Sea.

Microbes: problems and ways for linking diversity and ecosystem functioning when dealing with planktonic bacteria (RMP 4.6)

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There is a general agreement that the major ecosystem functions (e.g., decomposition, mineralization, nutrient cycling, bioremediation, community respiration etc…) are carried out by microorganisms. These encompass organisms of the two prokaryotic domains *Bacteria* and *Archaea*, but in a variety of ecosystem functions also many protist groups (within the *Eucarya*) are involved. The functions are not only related to heterotrophic metabolisms but include as well autotrophic and mixotrophic modes of growth (e.g., primary production). The facts that many environmental processes impacting the whole biosphere are driven by prokaryotic microbes, that prokaryotes comprise the hugest metabolic diversity, and that their phylogenetic diversity probably far exceeds that of eukaryotic organisms suggests that an analysis of microbial diversity and functions is of crucial importance to advance our understanding of the relation between biodiversity and ecosystem functioning and sustainability.

However, this can not be done at the same level that it is commonly done for large eukaryotic organisms. In the communication we will discuss the arguments that have been put forward to distinguish the peculiarities in the biodiversity study of bacteria as compared to that of other organisms. we will also show several different ways of linking biodiversity with function for pelagic microorganisms, through correlation analyses, through single-cell analysis techniques, through analysis of genomic information or through analysis of cultured microorganism information. For example, I will show how linking the use of specific radiolabeled tracers to specific groups of bacteria allow us to understand the changes in carbon and sulfur cycling that occur during a summer event at a Mediterranean coastal station in Blanes.

ROSEMEB: Integrating Chemical Ecology Research in Europe

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ROSEMEB aims at developing and applying novel and ecologically relevant methodologies to studies of allelopathy, antipredation, anifouling, antimicrobial, and other possible functions of marine secondary metabolites. The project is designed so as to exchange information about metabolites in terms of structure, function, and biosynthetic pathways within the RMP participants. The project involves 8 MarBEF institutes, representatives of which met at the kick-off meeting in Ischia on 3-4 November 2005. At the meeting we decided that a better integration of research activities on chemical ecology within Europe could be achieved through a series of training courses and workshops as well as other activities such as the writing of position papers and exchange of biological samples and standardization of chemical and bioassay methods.
There are several research projects involving MarBEF participants, two of which will be described at the Lecce meeting. The first involves studies on diatom-copepod and diatom-diatom interactions. Traditionally, diatoms have been regarded as providing the bulk of the food that sustains the marine food chain to top consumers and important fisheries. However, this view has recently been challenged on the basis of laboratory and field studies showing that these small, unicellular algae possess anti-mitotic properties similar to the cytotoxic compounds isolated from numerous marine and terrestrial higher plants. In fact, when copepods, the principal predators of diatoms, are fed certain diatom diets, they produce abnormal eggs that either fail to develop to hatching or hatch into malformed nauplii that die soon afterwards. The compounds responsible for this anti-cell growth and teratogenic activity are short chain unsaturated aldehydes. Recently these compounds have also been shown to have allelopathic effects on diatoms and other phytoplankton leading to growth reduction and cell death (apoptosis).

Another research project within ROSEMEB is the study of secondary metabolites in molluscs, one of the richest marine phyla for the production of these metabolites. Studies currently under way are addressing the natural function of these compounds that include feeding deterrence and growth inhibition of potential predators.

ROSEMEB is also involved in the training of young scientists and the first of a series of training courses on bioassay methods in chemical ecology is planned for September 2006 in Tjärnö, Sweden. A second course on chemical isolation methods will be organized in association with the European Conference on Natural Product Chemistry which will be held in Naples next year in September 2007.

Theme 2 summary and overview of biodiversity research

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In this presentation we give an overview of MarBEF activities (mostly) within Theme 2, and present specific Theme 2 activities in the new JPA. Most developments have been within the RMP projects, which have been discussed in D. Patersons overview, while here we focus on SCP/JPA activities. Next to this update on progress made within the program we present a short overview of biodiversity research worldwide, on marine research in Europe specifically, identifying trends and gaps were MarBEF as consortium could direct future attention.