MARBENA

Creating a long term infrastructure for marine biodiversity research in the European Economic Area and the Newly Associated States.

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Deliverable

The status of European marine biodiversity research and potential extensions of the related network of institutes

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General information

Introduction

Europe's marine biodiversity – its biological species, the genes they contain and the habitats in which they live - constitutes a vast but fragile resource of great significance to its people. Europe has the longest coastline of all continents relative to its surface area. Its seas cover millions of square kilometres, encompassing climate zones from arctic to subtropical, and are home to tens of thousands of species of microbes, plants and animals. The seas provide a unique series of goods and services to society, including moderation of climate, processing of wastes and toxicants, protection of the coastline, and food and chemicals. Our coasts and shelf waters provide space to live and directly and indirectly create wealth, including millions of jobs in sectors such as fishing and tourism.

Many of these goods and services are currently used in a non-sustainable way. Numerous threats exist - including over-exploitation of living and non-living resources, pollution, effects of climate change, increasing tourism and introductions of alien species - and their effects have been well documented in many local studies. Large-scale studies are much less frequent. Marine ecosystems, despite their huge dimensions, appear to be particularly vulnerable to external forcing and may go through major changes (so-called regime shifts) where the whole system changes from one stable state to another. The collapse of major fish stocks is one of the most dramatic and well known examples of how human activities can directly change ecosystem structure even on very large scales. Less well understood are indirect impacts due to global change, with their potential consequences for oceanic circulation, temperature, pH and productivity.

Expertise on marine biodiversity in Europe is still fragmented but as a result of a series of smaller projects, integration has been much improved over the last few years. The marine biological community is in a unique position to move forward towards lasting change in the way marine biological science is delivered in Europe, because of the high degree of organization achieved through successfully completed projects under previous frameworks, such as BIOMARE. However, there is now a need to scale up this integration and take it to the next level. Remaining fragmentation can only be overcome by targeted networking to improve communication and discussion between research institutes from many disciplines of science, for instance by focusing on a small number of joint research projects.

Marine biodiversity research in Europe has been slowly developing from predominantly local activities in the middle 90's (Warwick et al. 1998: over 600 projects in Europe, mainly taxonomic, without any international coordination), to a number of national programmes and, finally, to the stage where the foundations for integration have been established but without actual implementation having taken place. This process started with a symposium organised by the EC during the MAST-days in Sorrento, Italy in 1995, where over one hundred scientists recommended to the Commission to look for ways to promote marine biodiversity research at a European level. This was taken up by the Commission and a series of workshops was organized, co-sponsored by the Network of European Marine Research Stations MARS, the Marine Board of the European Science Foundation and the DG XII of the European Commission from which first an inventory (Warwick et al., 1997), then a Science Plan (Heip et al., 1999; http://www.esf.org/generic/626/EmapsPlan.pdf) and finally an Implementation Plan (Heip & Hummel, 2000; http://www.esf.org/generic/626/marinebiodiversity.pdf) were published. The implementation plan led to a successful proposal for a EU Concerted Action BIOMARE (http://www.biomareweb.org) which finished in October 2002 and which established a series of European Marine Biodiversity Research Sites and a list of indicators as a basis for long-term and large-scale research in Europe. The EU programme MARBENA (2002-2006) was a pilot project to discuss policy-related issues via electronic conferences that contribute to the European Platform for Biodiversity Research and Strategy (EPBRS), to develop infrastructure and to network with NAS countries in Europe. MARBENA served as a vehicle to involve NAS countries also more closely with the European marine biodiversity research

Although these concerted actions have made important progress in creating an awareness of the need to coordinate and integrate marine biodiversity research in Europe, these actions have not yet had the impact required to realize the role marine biodiversity research should have on European policy and the sustainable management of European marine ecosystems. The reason being that this impact requires focused, interdisciplinary research with a new balance and dialogue between biologists concerned with the description of marine biodiversity and those elucidating ecosystem functions as well as the socio-economic impact of marine-derived goods and services.
With the establishment of the Network of Excellence 'Marine Biodiversity and Ecosystem Functioning (MarBEF, 2004-, http://www.marbef.org) within the 6th Framework programme the EC facilitated the initialization of a large and long lasting integrating and interdisciplinary research network that aims at the integration of marine biodiversity research at a pan European scale that also operates at the science-policy

interface. It is expected that the new initiative will fill in these gaps and that from this broad initiative new research insights and project-lines will evolve that from an interdisciplinary research perspective will focus on specific marine biodiversity issues.

Box 1. Biodiversity

After the Rio Summit in June 1992 and the adoption of the Convention on Biological Diversity, the term 'biodiversity' has become a component of research policy in many countries and international bodies and initiatives.

The Convention on Biological Diversity (1992) defines biodiversity as:

'The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.'

In its broadest sense the aim of marine biodiversity research is to assess the diversity, distribution, and abundance of living organisms in the marine ecosystem and to understand, explain and predict how it changes over time (sensu CoML research programme), including the three levels of biodiversity: (a) diversity between and within ecosystems and habitats; (b) diversity of species; and (c) genetic variation within individual species.

In order to understand the consequences of change, we need to understand how existing natural processes and anthropogenic stresses alter marine biodiversity at all levels and in all environments, and what changes future alterations in conditions may cause. This does not only involve life and natural sciences but other disciplines as well, such as socio-economics, (cultural) anthropology and history.

How rich is the EU marine biodiversity

The marine biodiversity in Europe (expressed as species richness?) is comparable with, or even somewhat higher than, similar climatic regions of the globe, such as Northern America or Northern Asia. At the moment the European Register of Marine Species counts over 31,000 species and around 600 subspecies (ERMS, 2004). The marine biodiversity varies over Europe: in general the biodiversity increases with decreasing latitude (Figure 1); there are areas with relatively low natural diversity (e.g. brackish water of the Baltic Sea), and biodiversity hotspots.

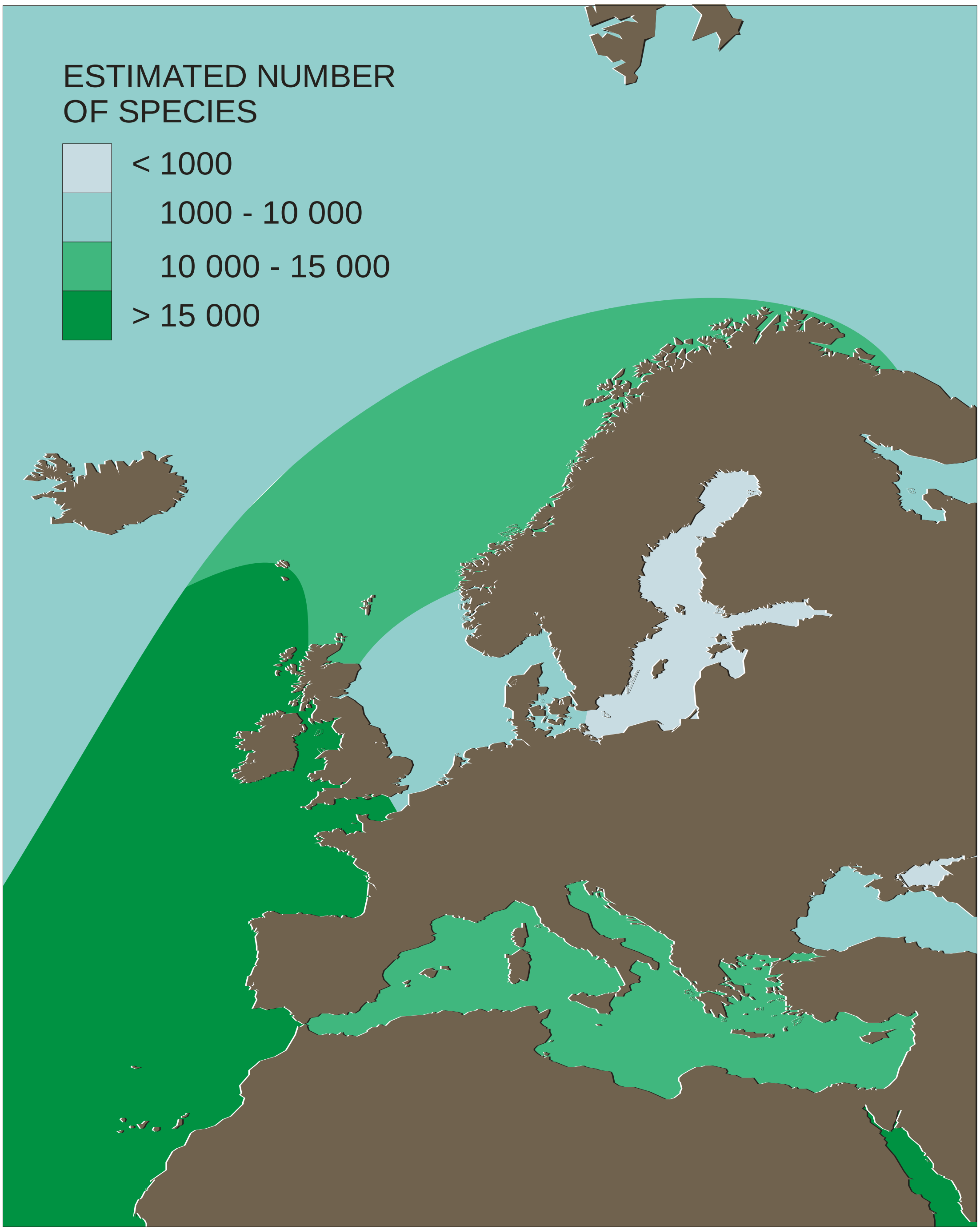

Figure 1. Estimated number of species in Europe.

New species are described every year. The rate of discoveries is the highest in small, inconspicuous taxa, and very low in vertebrates and larger organisms (Figure 2). But still the vast richness of marine biodiversity remains to be discovered, particularly in remote habitats such as the deep ocean.

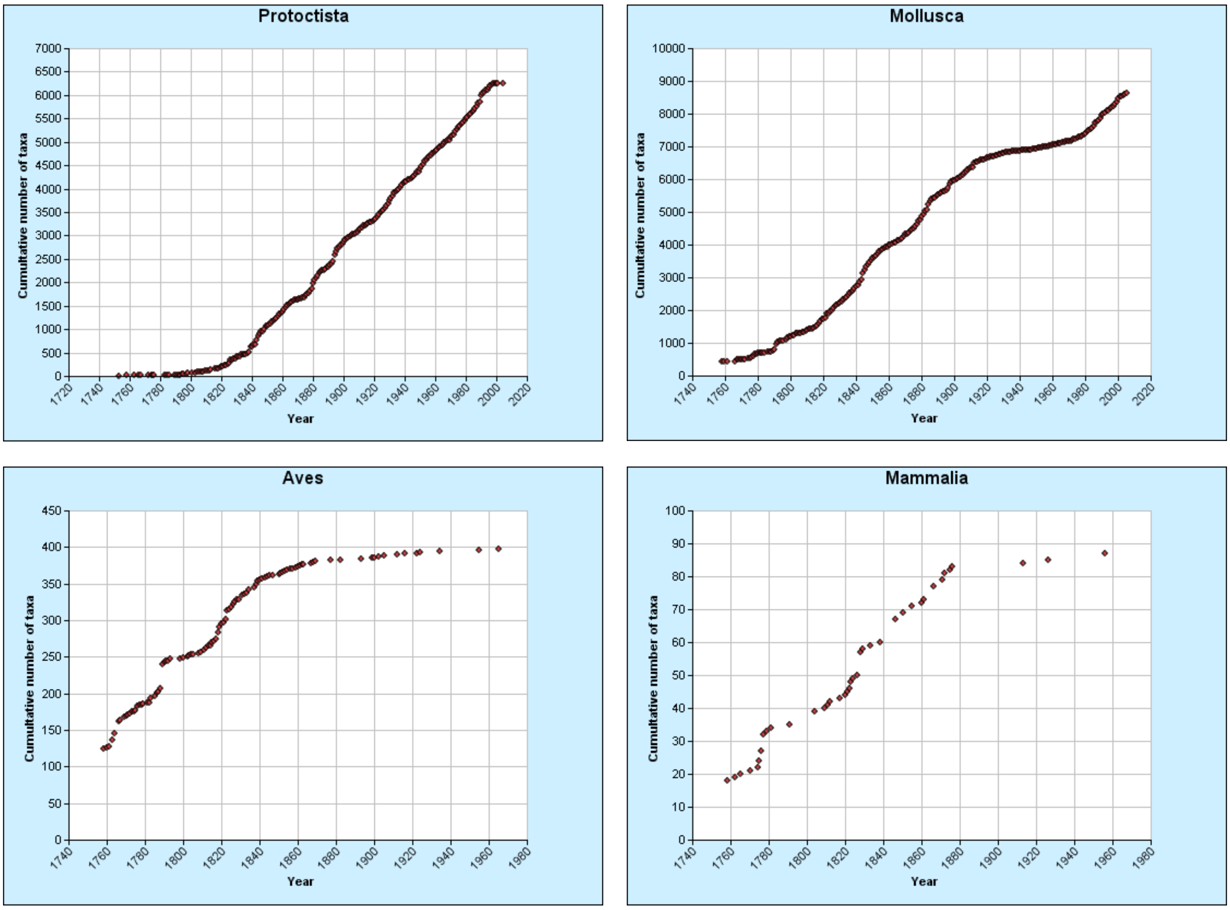

Figure 2. Rate of species discovery of some taxa (Source: ERMS 2004)

Despite the low number of documented extinctions (in Europe only a single report on the extinction of the Great Auk, *Alca impennis,* last recorded in the 19th century), it is a misconception that extinction in the ocean is unlikely because of its huge biogeographical ranges and high connectivity of habitat (Hendriks et al., 2006). Recent surveys and molecular analyses of ocean samples have revealed marine invertebrates with biogeographical ranges as small as 4 km. Marine diversity is much more extensive and vulnerable than previously thought. The reason why there are no more reported extinctions might be caused by the fact that Knowledge on marine biodiversity in Europe is fragmented within and between disciplines and conservationists focus on large conspicuous species to involve the general public at large.

Human resources

Who is contributing to the MBD knowledge
In 1996 the Network of European Research Stations (MARS) carried out an inventory of marine biodiversity research projects in the EU/EEA member states. Of the 610 projects, the majority were carried out in the area Systematic, Inventorying and Classification (DIVERSITAS programme element 3): 185 projects within the EU territory, 137 outside. The inventory showed that despite the impressive number of projects, marine biodiversity research suffered (and is still suffering) from an extremely fragmented approach. In most countries marine biodiversity research originated from a long standing tradition in taxonomy and the existence of Museums of Natural History.
Within this category of marine biodiversity research scientists usually divide themselves in categories of taxonomists and identification experts Taxonomists are experts on specific, usually small taxonomic group, with long term experience, and publication of major taxonomic papers like the revision of a taxon. They focus on the identification of single specimens, the phylogenetic relations and museum collections. Identification experts usually consider themselves as ecologists, used working with organisms in the environmental context (depth, hydrology, geographic position etc), and can properly identify marine organisms, (usually from a larger taxon). They need to consult a taxonomist when they find new or unknown species.
The European Register of Marine Species surveyed the species identification and taxonomic expertise in 1999? The common concern that in the EU taxonomic expertise is vanishing because of the old age of the taxonomic experts, is not really confirmed by the ERMS findings. The average age of the respondents to a questionnaire was 47, and on average taxonomists tended to be older than identification experts (Figure 4). Most of the respondents resided in the UK and Germany (Table 1).
The evidence indicated nut so much a decline in taxonomic expertise, or publication effort, but unaddressed gaps in taxonomy. Closer cooperation with the New Member States (about 15% increase of specialists, mainly from Russia) can help to fill in these gaps.

As traditional taxonomy (underlined by the “species” concept) is rapidly moved to phylogeny (underlined by the “clade” concept), a new generation of taxonomists needs to be developed: the new taxonomist must have skills in a number of disciplines such as traditional taxonomy, genetic analysis, community analysis and phylogenetics.
This has partly started in the context of the MarBEF Network of excellence.

The bias towards taxonomy should not distract from the fact that, despite the improved efforts by MarBEF, the functional aspects of marine biodiversity, and the diversity at the genetic (See also chapter: Research effort allocation on biodiversity) and habitat level remain fundamental areas where only limited efforts are made (Warwick et al. 1997).

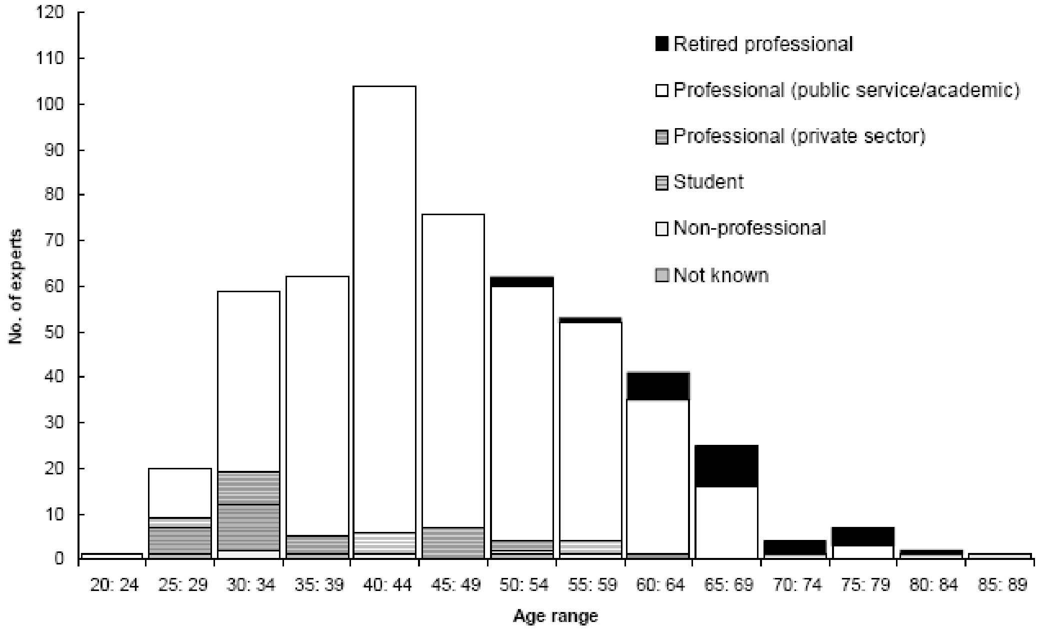

Figure 3. Age distribution in 1999, and employment status, of people with expertise in marine species identification that have responded to the ERMS survey (ERMS 2004).

Table 1. Country and number of respondents in each Country, including (*) countries not completely covered by initial list as they were outside the study area (ERMS 2004)

Australia*	3	Ireland	13	Seychelles*	1
Austria	5	Israel*	7	Slovenia*	1
Belgium	13	Italy	51	South Africa*	1
Brazil*	1	Japan*	1	Spain	95
Bulgaria*	2	Lebanon*	2	Sweden	11
Croatia*	7	Malta*	1	Switzerland	1
Denmark	18	New Zealand*	1	The Netherlands	12
Egypt*	7	Northern Ireland	3	Turkey*	8
Finland	5	Norway	33	UK	65
France	37	Poland	12	Ukraine*	2
Germany	62	Portugal	11	USA*	14
Greece	36	Romania*	3	Venezuela*	1
Iceland	4	Russia*	40		

Box 2. Table of marine taxa and number of species in ERMS 2.0.

Taxa that are currently not covered by a taxonomic expert are indicated in bold. At the moment, the vast majority of the groups and 50% of the protoctista in ERMS are represented by Associate Editors (for a list of the members of the ERMS editorial board see http://www.marbef.org/data/ermspartners.php).

		all taxa	**all species names**	**valid species names**
Biota		52083	35937	31351
Animalia		41080	28389	25303
	Acanthocephala	122	65	64
	Rotifera	172	115	113
	Sipuncula	77	54	44
	Tardigrada	112	78	76
	Annelida	3124	2243	2050
	Arthropoda	11297	7966	7412
	Brachiopoda	52	18	18
	Bryozoa	1209	788	761
	Cephalorhyncha	102	65	65
	Chaetognatha	84	58	42
	Chordata	3308	1999	1968
	Cnidaria	2295	1460	1346
	Ctenophora	94	46	38
	Cycliophora	5	1	1
	Echinodermata	2312	1534	651
	Echiura	35	19	19
	Entoprocta	58	47	47
	Gastrotricha	293	240	240
	Gnathostomulida	48	25	24
	Hemichordata	34	17	17
	Mesozoa	59	38	36
	Mollusca	5658	3913	3779
	Nematoda	2422	1832	1832
	Nemertina	692	524	428
	Phoronida	13	10	9
	Placozoa	5	2	2
	Platyhelminthes	3977	2631	2481
	Pogonophora	40	23	23
	Porifera	3350	2578	1717
Fungi		799	408	391
	Ascomycota	553	302	290
	Basidiomycota	49	10	9
	Chytridiomycota	37	19	18
	Deuteromycota	35	12	12
	Mitosporic Fungi	82	49	46
	Zygomycota	34	15	15
Monera		235	139	109
	Gracilicutes	234	139	109
Plantae		26	6	6
	Angiospermophyta	17	6	6
Protoctista		9936	6995	5542
	Rhizopoda	342	207	174
	Rhodophyta	1413	1040	1027
	Sarcomastigophora	235	175	118
	Stramenopila inc.sedis	152	102	10
	Xanthophyta	28	19	18
	Xenophyophora	32	20	20
	Zoomastigota	32	23	17
	Apicomplexa	14	6	3
	Bacillariophyta	2211	1470	850
	Chlorophyta	537	367	354
	Chrysomonada	4	0	0
	Ciliophora	444	295	205
	Cryptomonada	57	31	16
	Dinomastigota	970	765	720
	Discomitochondria	105	62	41
	Granuloreticulosa	2097	1559	1176
	Haptomonada	73	38	36
	Labyrinthulata	55	34	27
	Myxospora	294	237	212
	Oomycota	89	52	38
	Phaeophyta	651	448	442
	Protoctista inc. sedis	74	45	38

Research effort allocation on biodiversity

Bibliometric study

A bibliographic database was compiled from references obtained from the Web of Science 7.2 (WoS) published by Thomson ISI (http://portal.isiknowledge.com/portal.cgi). The bibliographic search was carried out using the Internet version of the database which runs from 1945 to October 2005, although the years 1945-1954 are pooled and coverage is poor until later years. The WoS database at the time of analysis comprised about 22 million references in the Science Citation Index (SCI). We choose to use only the WoS database, since it had a wide scope and indexed, at the time of analysis, 6100 journals distributed across all scientific disciplines in SCI. Especially for more recent references it has a good coverage, better than e.g. the ASFA database (Gattuso et al. 2005).

The search carried out to collect references related to the search string biodiversity. A draft bibliographic database was produced in Endnote 8.0.2 (Thomson ResearchSoft) and duplicates were eliminated. The final database of biodiversity consisted out of 13336 references, of which 1312 dealt directly with marine biodiversity. The bibliographic file was modified and exported to Microsoft Excel. We modified the file to facilitate analysis. Journal names were abbreviated where necessary according to the list provided by Inter Research (http://www.int-res.com/misc/journallist.txt). The country of affiliation of first authors was made consistent, and EU countries identified as such (EU25). Keywords as well as keywords provided by WoS were listed. The realm of investigation was listed (marine, freshwater, terrestrial, general/theoretical, and total). In case of research in overlapping areas (e.g. mangrove systems, salt-marshes), we adopted the habitat on which the focus of the research was put. Other classifications like biological level of the research, experimental approach and ecosystem function addressed were extracted. Screening of the assembled database (n=100) revealed that 6% of organism classifications, 4% of habitat and 8% of the other classifications contained errors, so the error of the present analysis is approximately 5% on most metrics.

World scale Biodiversity efforts

Yearly rate of publications on the topic of biodiversity increases with time (Figure 4A) for combined efforts (total) on biodiversity as well as for all separate realms (marine, freshwater, terrestrial, and general). The drop in publication effort in 2005 is caused by the fact that not all publications were listed for that year at the time of our investigation, therefore we exclude this year from all further calculations. We normalized number

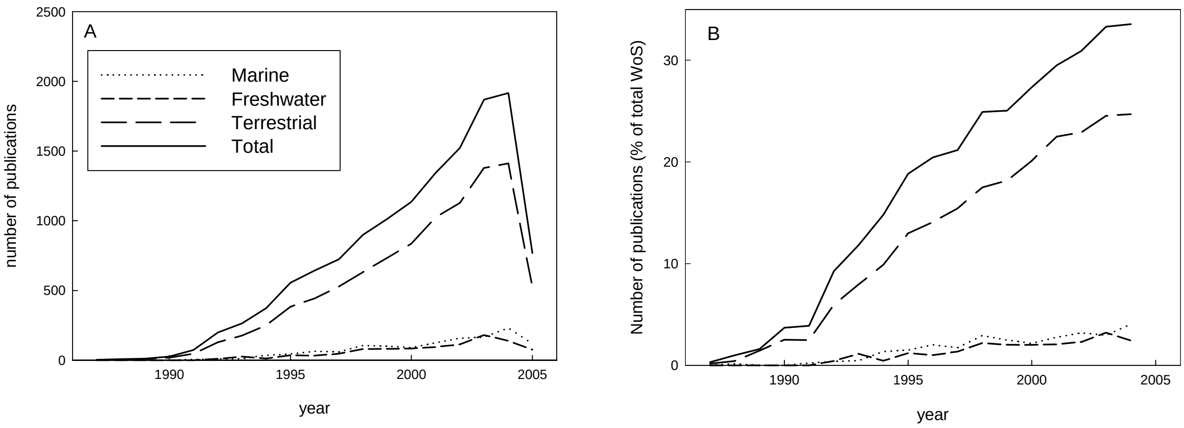

Figure 4. Yearly rate of publication for total, terrestrial, freshwater and marine, realms. (A) Number of publications listing biodiversity recovered from the Web of Science (WoS) database. (B) Biodiversity references expressed in percent of total number of records listing biodiversity and/or ecology archived in the Web of Science (WoS) database.

of publications to the total number of articles within the WoS for each year encountered with the more general search string 'ecology' and/or 'biodiversity' (figure 4B). Generally, aquatic research efforts are more than three times lower than research efforts focused on terrestrial systems. To obtain the growth rate of publications per year until 2004 we fitted the accumulated number of publications for the period 1990-2004 exponentially ($y = a \cdot e^{bx}$) in Genstat, parameters are given in Table 2. When tested for exponential growth rate, only publications of freshwater research grow significantly faster than terrestrial publications (z=2.028).

Table 2. Parameters of function ($y = a \cdot e^{Rx}$) and growth rate b of accumulating publication effort concerning biodiversity.

Habitat	a	R
Marine	39.93	1.2407
Freshwater	27.12	1.2519*
Terrestrial	399.5	1.2215
General	269.8	1.1165*

**growth rate is significantly different*

Level of research

Biodiversity research still focuses mostly on species and functional group level while research on genetic diversity lags behind (Figure. 5). Only 10.68% of marine, terrestrial and freshwater studies were done on this topic, of which the marine component is only 1.05%. Despite constant technical improvements, research on genetic diversity is still representing a minor component of the research effort. However, we expect recent EU projects, such as BIOCOMBE, specific projects within MarBEF and the start of the NoE “Marine Genomics Europe”, to give a boost to the lagging number of publications on the topic.

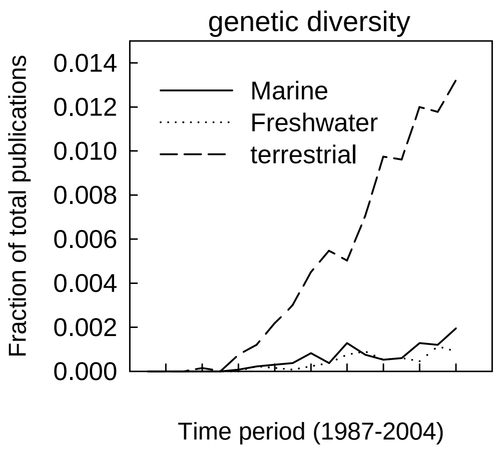

Figure 5. Fraction of total publications concerning biodiversity research which list genetic diversity as focus of the study (keywords, title, abstract) for terrestrial, marine and Freshwater research worldwide.

Experimental approaches of research

Favorite approaches for biodiversity research remain mostly experimental and observational. More than a third (42%) of the experiments in this category is done on land. Modeling studies do not exceed 7.6% of all research (Figure 6).

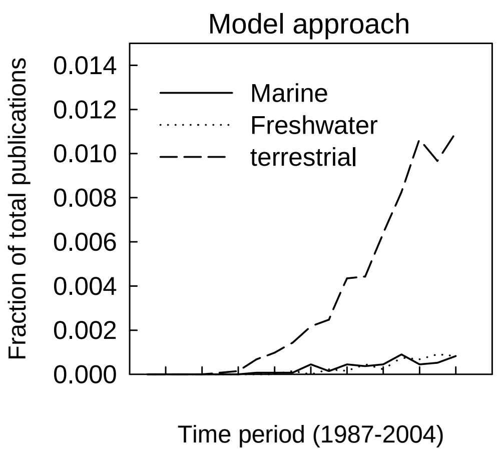

Figure 6. Fraction of total publications concerning biodiversity research which mainly use modeling approaches as focus of the study (keywords, title, abstract) for terrestrial, marine and Freshwater research worldwide.

Dispersal of knowledge

Publication efforts on biodiversity are differently allocated over journals, research on different biomes is disseminated through different outlets, which fragments the community and derived knowledge. Most excellent research (if we classify according to impact factors) on biodiversity is done on comprehensive (conceptual and theoretical) issues where Nature is the preferred outlet (Figure 7). For research on general, comprehensive themes 18.91% of the publications are distributed in the top 5 journals which does not differ much for marine, freshwater and terrestrial where these percentages are 18.37, 22.02 and 16.21

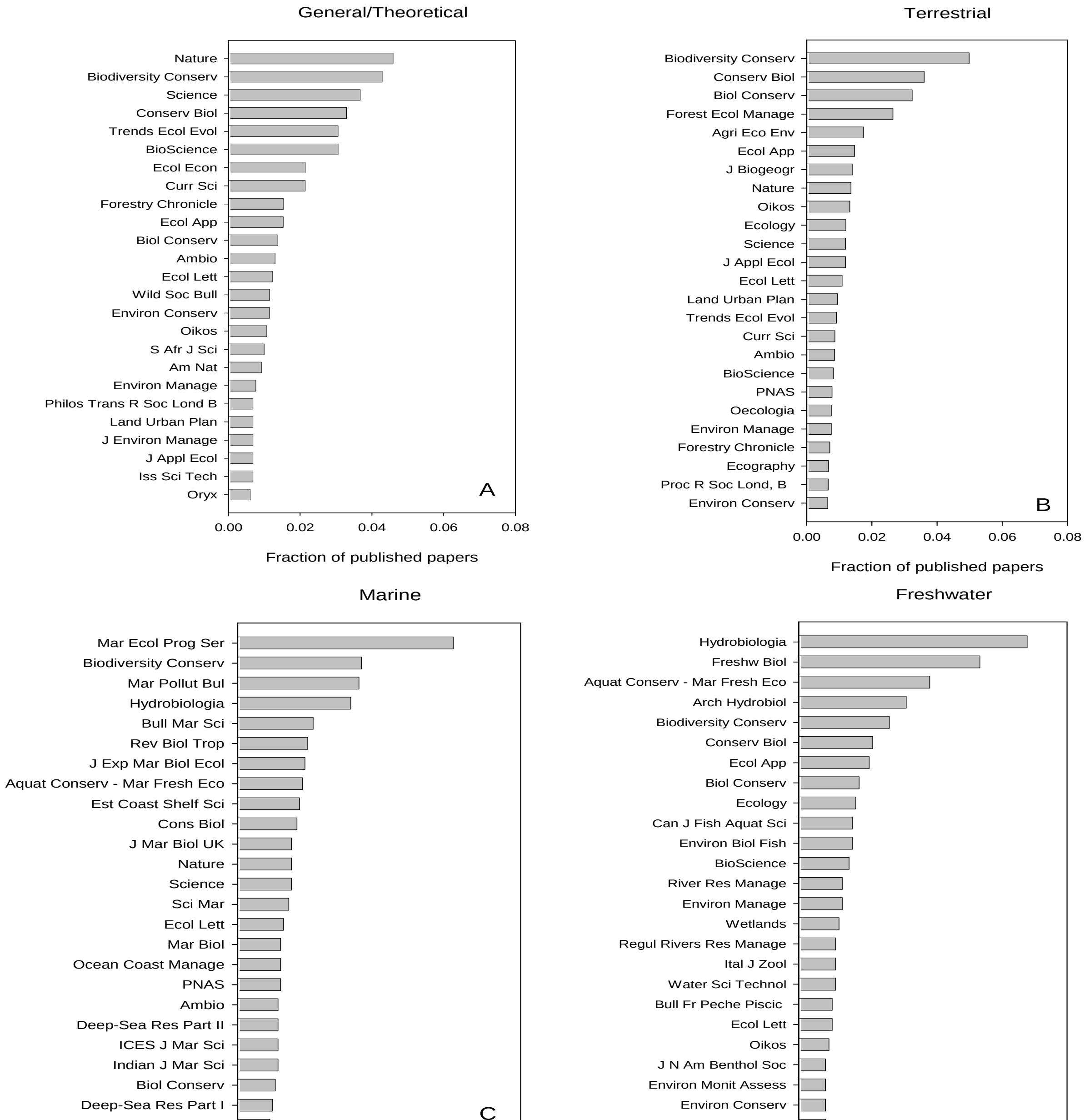

Figure 7. Fraction of papers, within realm studied, published in the 25 most used journals on the topic of biodiversity.

respectively. Average impact factor (SE) for top 5 used journals for these areas are for general subjects 16.37 (6.682), terrestrial 9.76 (0.464), marine 1.28 (0.254), freshwater 1.37 (0.275).

A focus on Europe

The country of affiliation of the first author conducting biodiversity research is in all cases but for theoretical studies the 25 assembled EU countries, with the United Kingdom (UK) contributing most to the research done in the 25 EU countries (Figure 8). In total 4328 articles had first author affiliations in the EU. Second country with most author affiliations is the USA, in the case of comprehensive studies the country with most

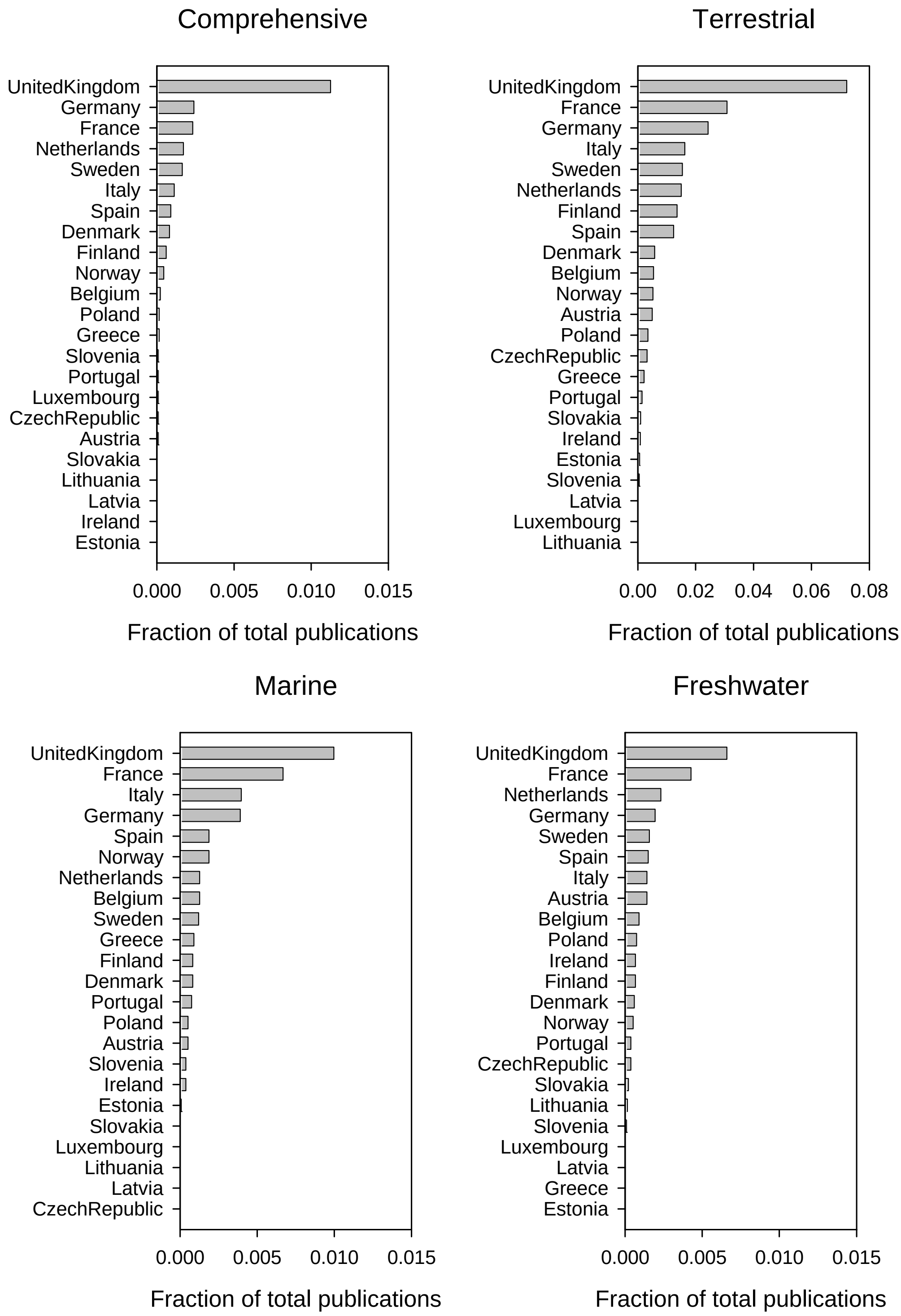

Figure 8. Geographical distribution within Europe, expressed as fraction of total publications within the habitat studied, of the affiliation of the first authors. Note the difference in axis scaling for the terrestrial results.

authors publishing on the subject of biodiversity. However, there is a large fraction of publications without a listed country of origin which is more usual for publications originating in the USA. This fraction ranges from up to 28% for theoretical or generally focused studies to 12% for freshwater research, with values for terrestrial (14%) and marine (13%) studies closer to this lower value. The skewed international distribution of research efforts, with the USA and the EU contributing nearly 90% of the research also signifies that authors from countries most impacted by extinctions and ecosystem degradation only have a minor contribution to this research.

Box 3. Allocation of effort on regional scales

Marine Azorean Publications

In Web of Science Database there are 193 records of scientific publications about the Marine Environment of the Marine Iberian (including the Biscay).". The keywords used were: "(Eco* OR Bio* OR Species) AND (Atlantic OR Marine) AND (Azores OR Azorean)". Of these publications, 94% are scientific papers and 98% are published in English. 36% of the research is produced by Portuguese affiliated scientists, 28% by English and 18% by French and North-Americans. The scientific centres which are publishing the most are the University of the Azores (25%), IFREMER (7%), and Southampton Oceanographic Centre (6%). Publications per year reached a peak in 2000, when 22 publications were edited. This number was repeated in 2001, 2002 and 2005 which might demonstrate a tendency to maintain these figures. The most common publication titles used by the marine biologists that study the Azorean marine area are Hydrobiologia (6%), Fisheries Research (4%), and Cahiers de Biologie Marine (4%). The subjects that these researchers are involved with include Marine and Freshwater Biology (40%), Oceanography (20%), and Ecology (15%).

Marine Iberian (including the Biscay) Publications

In Web of Science Database there are 329 records of scientific publications about the Marine Environment of the Azores. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine) AND (Atlantic OR Biscay) AND (Iberia OR Iberian OR Portugal OR Portuguese OR Spain OR Spanish OR France OR French) NOT (Geology OR Physic OR Physics))". Of these publications, 93% are scientific papers and 94% are published in English. 40% of the research is produced by French affiliated scientists, 29% by Spanish and 12% by English. The scientific centres which are publishing the most are the CSIC (7%) and IFREMER and the University of Bordeaux 1 (6%). Publications per year reached a peak in 2004, when 49 publications were edited. This tendency points towards an increase in publication. The most common publication titles used by the marine biologists that study the Iberian (including the Biscay) marine area are Marine Ecology-Progress Series (8%), Palaeogeograph-Palaeoclimatology-Palaeoecology (4%), and Aquatic Living Resources (2%). The three main subjects that these researchers are involved with include Marine & Freshwater Biology (40%), Ecology and Oceanography (16%).

Marine Icelandic Publications

In Web of Science Database there are 363 records of scientific publications about the Marine Environment of Iceland. The keywords used were: "((Eco* OR Bio* OR Species) AND (Atlantic OR Marine) AND (Iceland OR Icelandic))". Of these publications, 94% are scientific papers and 99% are published in English. 31% of the research is produced by Icelandic affiliated scientists, 20% by North Americans and 16% by Norwegians. The scientific centres which are publishing the most are the University of Iceland (14%), Marine Research Institute (12%), and University of Bergen (5%). Publications per year reached a peak in 2004 and 2005, when 44 publications were edited each year. This numbers might demonstrate a tendency to the growth of publications. The most common publication titles used by the marine biologists that study the Icealandic marine area are ICES Journal of Marine Science (8%), Sarsia (4%), and Deep-Sea Research Part I-Oceanographic Research Papers and Marine Ecology Progress Series (3% each). The subjects that these researchers are involved with include Marine and Freshwater Biology (33%), Oceanography (21%), and Fisheries (18%).

Marine North Sea Publications

In Web of Science Database there are 1300 records of scientific publications about the Marine Environment of North Sea. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine) AND (North Sea))". Of these publications, 93% are scientific papers and 99% are published in English. 23% of the research is produced by Germany affiliated scientists, 19% by English and 16% by Dutch. The scientific centres which are publishing the most are the Netherlands Institute for Sea Research (6%), Alfred Wegener Institute for Polar and Marine Research and the Plymouth Marine Laboratory (4% each). Publications per year reached a peak in 2005, when 147 publications were edited. This number might demonstrate a tendency to grow on scientific publications. The most common publication titles used by the marine biologists that study the North Sea marine area are Marine Ecology Progress Series (10%), Marine Pollution Bulletin and ICES Journal of Marine Science (3%

each). The subjects that these researchers are involved with include Marine and Freshwater Biology (46%), Oceanography (21%), and Ecology (19%).

Marine Baltic Publications
In Web of Science Database there are 838 records of scientific publications about the Marine Environment of the Baltic Sea. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine) AND (Baltic))". Of these publications, 93% are scientific papers and 99% are published in English. 24% of the research is produced by Germany affiliated scientists, 23% by Swedish and 14% by Finish. The scientific centres which are publishing the most are the University of Stockholm (12%) and the Universities of Abo Akad, Gdansk and Helsinki (4% each). Publications per year reached a peak in 2003, when 99 publications were edited. This number might demonstrate a tendency to maintain these figures. The most common publication titles used by the marine biologists that study the Baltic marine area are Marine Ecology Progress Series (9%), Hydrobiologia (5%), and Estuarine Coastal and Shelf Science (3%). The subjects that these researchers are involved with include Marine and Freshwater Biology (45%), Environmental Sciences (20%), and Ecology (19%).

Adriatic Publications
In Web of Science Database there are 481 records of scientific publications about the Marine Environment of the Adriatic. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine) AND (Adriatic))". Of these publications, 90% are scientific papers and 99% are published in English. 43% of the research is produced by Italy affiliated scientists, 18% by Croatians and 11% by North Americans. The scientific centres which are publishing the most are the CNR (10%), the Rudjer Boskovic Institute (9%) and University of Bologna (7%). Publications per year reached a peak in 2005, when 65 publications were edited. This number might demonstrate a tendency increase the number of publications. The most common publication titles used by the marine biologists that study the Adriatic marine area are Marine Ecology Progress Series (6%), Science of the Total Environment (5%), and Periodicum Biologorum (4%). The subjects that these researchers are involved with include Marine & Freshwater Biology (43%), Environmental Sciences (21%), and Oceanography (16%).

Marine South and Eastern Mediterranean Publications
In Web of Science Database there are 207 records of scientific publications about the Marine Environment of the South and Eastern Mediterranean. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine AND Mediterranean) AND (Morocco OR Libya OR Libyan OR Syria OR Syrian OR Algeria OR Algerian OR Tunisia OR Tunisian OR Egypt OR Egyptian OR Lebanon OR Lebanese OR Israel OR Israeli OR Turkey OR Turkish OR Palestine OR Palestinian OR Cyprus OR Cypriot) NOT (Geology OR Brucellosis OR Alpine))". Of these publications, 93% are scientific papers and 94% are published in English. 27% of the research is produced by Israeli and French affiliated scientists (27%, each) and 15 by North Americans. The scientific centres which are publishing the most are the Tel Aviv University (9%), the National Institute of Oceanography of Israel (6%) and the CNRS (5%). Publications per year reached a peak in 2005, when 29 publications were edited. This number might demonstrate a tendency to grow these figures. The most common publication titles used by the marine biologists that study the South and Eastern Mediterranean marine area are Palaeogeograph-Palaeoclimatology-Palaeoecology (5%), Marine Geology and Marine Pollution Bulletin (4%, each). The subjects that these researchers are involved with include Marine & Freshwater Biology (26%), Multidisciplinary including geosciences (19%) and Environmental Sciences (18%).

Marine North and Western Mediterranean Publications
In Web of Science Database there are 556 records of scientific publications about the Marine North and Western Mediterranean Sea. The keywords used were: "((Eco* OR Bio* OR Species) AND (Marine AND Mediterranean) AND (Spain OR Spanish OR France OR French OR Monaco OR Monegasque OR Italy OR Italian OR Croatia OR Croat OR Montenegro OR Albania OR Albanese OR Greece OR Greek) NOT (Geology OR Aerosol OR Forest OR Brucellosis))". Of these publications, 94% are scientific papers and 96% are published in English. 33% of the research is produced by French affiliated scientists, 27% by Spanish and 25% by Italians. The scientific centres which are publishing the most are the University of Barcelona (5%), the CSIC (5%) and the University of Valencia (4%). Publications per year reached a peak in 2005, when 73 publications were edited. This number might demonstrate a tendency to grow these figures. The most common publication titles used by the marine biologists that study the North and Western Mediterranean marine area are Marine Ecology Progress Series (5%), Palaeogeograph-Palaeoclimatology-Palaeoecology (4%), and Hydrobiologia, the Italian Journal of Zoology and the Marine Pollution Bulletin (3%, each). The subjects that these researchers are involved with include Marine & Freshwater Biology (39%), Ecology (17%), and Environmental Sciences (16%).

Import and export of knowledge to and from Europe

Biodiversity research by European researchers does not always focus on European areas. There is export of knowledge on e.g. coral reefs, and other studies in the tropics. Even though Europe does not have warm water coral reefs, 27% of coral reef research is done by researchers with a European affiliation (figure 9).Many countries have international programs encouraging scientists to exchange knowledge and research. For instance the Netherlands have an active research strategy plan through WOTRO, which focuses on research in the tropics, and many other countries have the same.
Also there is import of knowledge to European study areas, e.g. by American researchers studying European areas like for instance Iceland and the Azores.

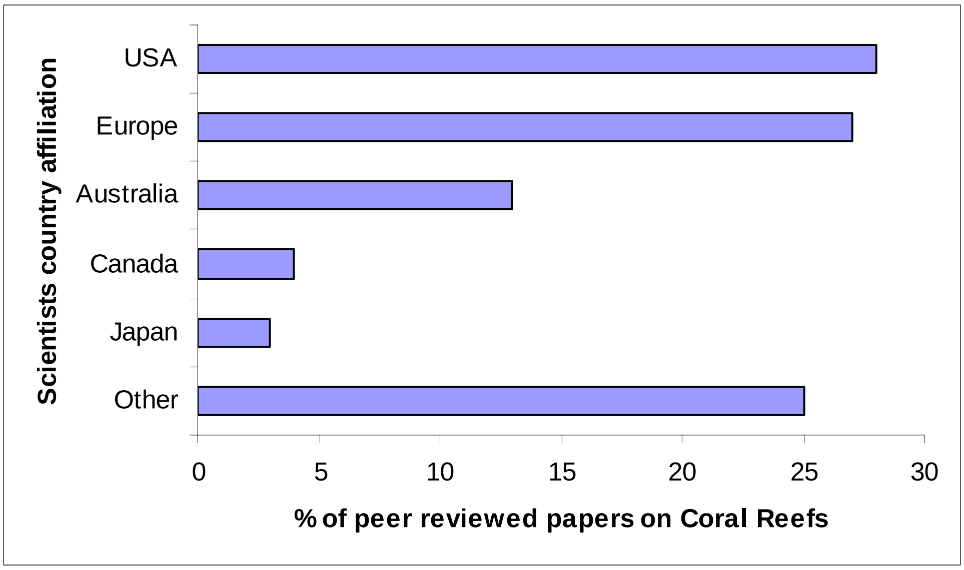

Figure 9. Geographical distribution, expressed as percentage of total publications on war water coral reefs, of the affiliation of the first authors.

How to increase visibility of marine biodiversity papers and average impact factor?

In general, journals dealing with oceanography or marine biodiversity issues are facing a lower impact factor compared to journals on molecular studies or earth sciences. This can partly be explained by the fact that the marine biodiversity research community, the main audience for these journals, is a relatively small group compared to the large earth biodiversity research community or the still new but fast-growing molecular groups. In addition, marine sciences are still very much focused on descriptive natural history, less on ecology and still less on genetics. As a logical result, journals with a focus on marine biodiversity have a lower average impact factor. Nevertheless, it is important to note that, despite not having the immediate high impact (which is measured in terms of the number of citations that follow within two years after publication) they often do have a high half-life value. This is certainly true for taxonomy. If, for example, each time a species is mentioned, also the reference to the original publication would be taken into account by the current citation indexing system, the very first taxonomist, Carolus Linneaus, would undoubtedly be the most cited scientist ever. Hence, comparing different disciplines in terms of impact factor is not entirely justifiable.

In any case, there are certainly some interesting new developments to embark on that ultimately could help us increase our impact and visibility. Very often, the financial barrier to information (installed by publishers) is regarded as a major impediment to enhance dissemination of knowledge, number of citations and research performance (Appeltans *et al.*, 2005). As a consequence, we would like to promote open access journals and open access archives as valuable initiatives to break down this barrier.

An **open access journal** creates an open archive of its own papers by publishing online and making the papers accessible for free, without disregarding a refereeing system. At this moment, there are 11 open access journals within the field of oceanography (although this is still less than 37 in earth sciences), for an overview see table 3. One of the current disadvantages, however, is the fact that these open access journals are still relatively young and cannot yet rely on the recognition of a traditional journal that, through time, has established its impact factor. Nevertheless, we can say that, through open access, the impact factor of an open access journal is likely to increase fast.

Table 3. Directory of Open Access Journals in Earth and Environmental Sciences (URL http://www.doaj.org/ljbs?cpid=78)

Earth Sciences (37 journals)
Ecology (14 journals)
Environmental Sciences (34 journals)
Geography (21 journals)
Geology (39 journals)
Geophysics and Geomagnetism (4 journals)
Meteorology and Climatology (4 journals)
Oceanography (11 journals)

Baltica, Ciencias Marinas, Gayana (Concepción), Marine Drugs, Ocean Science (OS) , Ocean Science Discussions (OSD), Oceanologia , Oceanus, Revista de Biología Marina y Oceanografía, Scientia Marina, Aquatic Invasions

Besides open access journals, there are **open access archives** storing digitized versions of any publication in an online repository. All different kinds of publications are considered, ranging from grey reports to peer-reviewed articles in international journals. The repository is accessible through the internet so that everyone can download the full document or a pre- or post print version without the need for passwords or subscription fees. Whether an open archive is allowed to hold pre-print copies of an article (*i.e.* pre-refereeing) or has green light to self-archive a post-print (*i.e.* final draft post-refereeing), depends on the specific policy of the publisher. At this moment, 93% of the publishers do support the initiative and allow open archives to bring pre- (24%) or post prints (69%) on the web (for a list of these publishers see: http://romeo.eprints.org/publishers.html). Other publishers might allow exceptions to their rules and transfer the copyright to the author. A copyright transfer needs to be explicitly stipulated and inserted as a special clause to the copyright agreement.

The benefits of open access archives are huge. The researcher gets a central archive for all his/her publications, for all to see. A repository is maintained by a specialised data centre or library where proper storage beyond a life span is guaranteed. Open access enables reviewers to view all of the research literature they need and hence makes quality control more efficient. According to Lawrence (2001), articles that are stored in open archives are cited at least three times more than articles that are not freely available. In addition, the institution or region or specific scientific domain gains better visibility and the community gets easy, free and permanent access to publications and scientific output, which in return enhances research performance and decision-making. Nowadays, more and more publishers are joining the initiative and in return, through more citations, experience an increase of their journal's impact factor.

We recommend the marine biodiversity research community to join the Open Archive Initiative (OAI) and create their own open archive. This can be done within, for instance, the context of MarBEF, an EU FP6 Network of Excellence on Marine Biodiversity and Ecosystem Functioning, where articles that are held within the MarBEF Publication Series, *i.e.* articles holding the MarBEF emblem, can be stored in a specific "MarBEF open archive". In this way, the MarBEF Open Archive will be a long-term storage of the network's scientific output in a legal and freely accessible way, where authors can keep control over the integrity of their work and the right to be properly acknowledged and cited, and still can rely on the well-established refereeing system of a scientific journal. Finally, we all win by having easy access to information as this ultimately will lead to greater impact and faster scientific progress.

Interesting links

Self-Archiving FAQ: http://www.eprints.org/openaccess/self-faq/
Open Archive Initiative: http://www.openarchives.org/
List of Open Archives: http://www.opendoar.org
Open Marine Archive (OMA): http://www.vliz.be/EN/Marine_Library/Library_OMA

Interaction and networking

Interaction

Recent development of natural sciences, lead to the closer cooperation, scientist's mobility and multi author collaboration on research papers. This phenomenon is not reflected in marine biodiversity papers, where in last 15 years, the number of co-authors is stable and low: in general 2 or 3 authors (Figure 10). Part of this stability might be associated with taxonomic works, which use to be slow, experience driven, single specialist's efforts. On the other hand it shows, that there are few large scale, cooperative synthesis in our field. The central objective of MarBEF is to initiate encompassing synthesis in biodiversity research.
This indicates either researchers are not collaborating or collaborations do not translate in multiple authored papers.

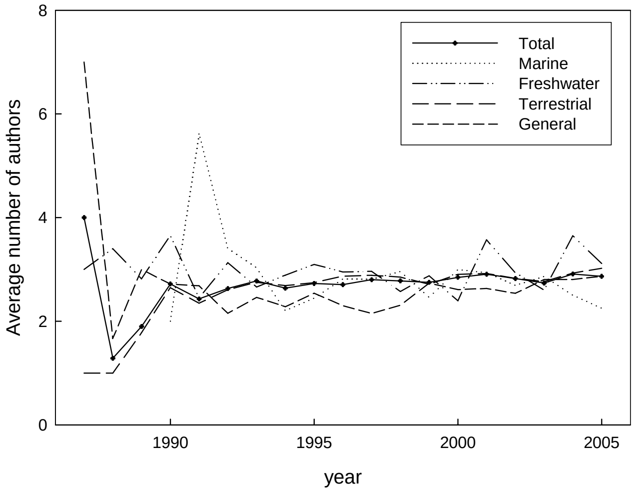

Figure 10. Biodiversity research as a function of collaborative effort: time trends in average number of authors per paper.

The coordinated actions and networks funded by EU resulted in extensive exchange of scientists, workshops and preparation of smaller projects. The level of integration among 15 examined research entities involved in MARBENA shows that most partners are having very vivid contacts (integration on the level above 50% of possibilities offered) and only single institutes were not joining the network actively (Figure 11).

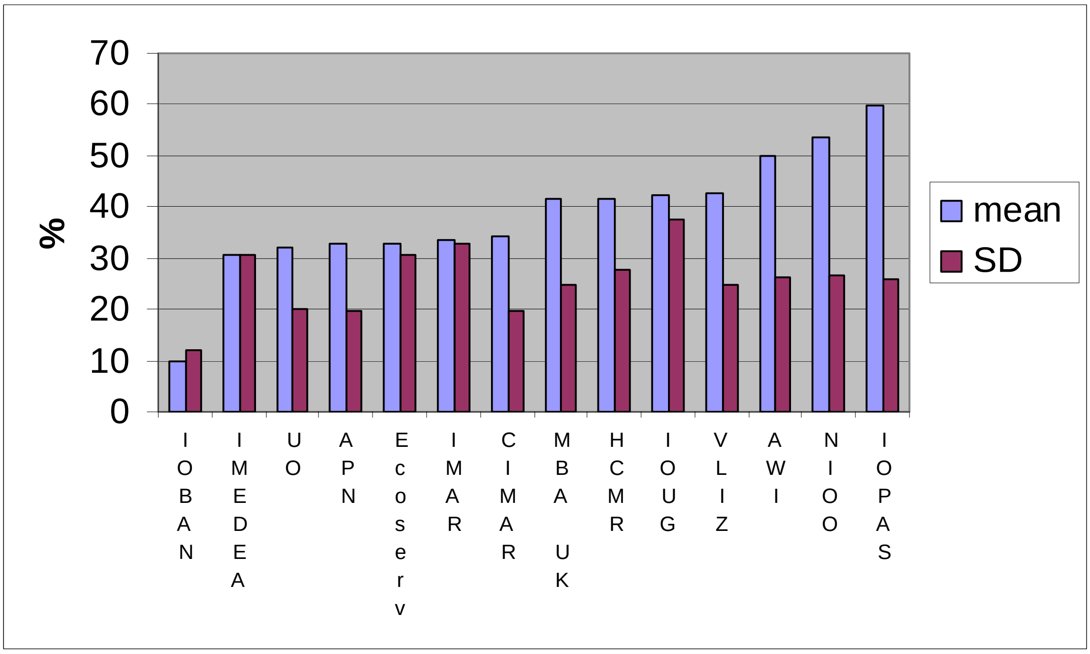

Figure 11. Level of integration amongst some of the MARBENA partners. The level of integration is based on the number integrating activities, such as joint papers, projects, PhDs and visits to and from institutes.

Non- European institutes from the USA, Japan and Canada use to cooperate with MARBENA institutes, but usually with very few selected ones and their level of integration is lower than 25%.
Although marine research institutes from central and northern Europe enjoy long established and strong collaboration, there are still potential partners that need to be incorporated into the existing frameworks. Black Sea and South East Mediterranean is one example, Iceland with extensive recent programs on marine biodiversity and developed facilities is another partner that should be incorporated in the network with respect to the pan- European biodiversity perspective.

Networking

The networking of marine research in Europe started in Paris in 1996 when directors of more than 40 marine research stations decided to create a foundation to coordinate their interests at the European level and to better make use of the facilities at the stations: oceanographic research vessels, specialized experimental laboratories, libraries and collections, and access to specific biological communities in the seas (the European Marine Stations Network (MARS); http://www.marsnetwork.org/). These forty-odd marine research stations cover all the coasts of Europe, from the high Arctic in Svalbard in the north to the Canary Islands and the Azores in the South and Turkey and Israel in the Eastern Mediterranean. In 2000 marine biodiversity was chosen as the first priority issue of the network

The scale of the research efforts needed to obtain adequate knowledge for exploration, conservation and restoration of marine biodiversity demands European-scale collaboration. The European Commission started initiatives as early as 1995 and started cooperation on this issue with the Marine Board of the European Science Foundation and MARS that led to a series of marine policy documents (http://www.esf.org/) culminating in 2000 in the concerted action BIOMARE (http://www.biomareweb.org). The objectives of BIOMARE were to establish a network of research sites and a series of indicators for biodiversity as the basis for long-term and large-scale marine biodiversity research in Europe. Through the International Biodiversity Observation Year IBOY, DIVERSITAS and the Census of Marine Life CoML, three global initiatives, BIOMARE has attracted attention worldwide as a major effort to coordinate biodiversity research at the European scale and beyond.

In the *Fifth Framework Programme* another important networking effort MARBENA ran till 2006 (http://www.vliz.be/marbena/). This project initiated a network of marine scientists with strong links to the different stakeholders in marine biodiversity issues, from the EU-EEA and the New Member States, that adequately prepared and exploited the possibilities of the next framework programme and the European Research Area, and increased the visibility of marine biodiversity issues for science managers, politicians and other end users by feeding directly into EU policy via a series of electronic conferences linked with the European Platform for Biodiversity Research and Strategy (EPBRS; http://www.epbrs.org/).

In the *Sixth Framework Programme* the issue of biodiversity and ecosystems has grown to become one of the main research actions, with well received expressions of interest for networks and projects in marine biodiversity, marine genomics and marine biogeochemistry issued from the MARS member stations, and the installation of three network of excellences dealing with marine biodiversity: MarBEF, dealing specifically with marine biodiversity, Marine Genomics Europe, dealing with genetic aspects of biodiversity and Euroceans, *Box 4. BIOMARE Implementation and networking of large scale, long term Marine Biodiversity research in Europe (http://www.biomareweb.org).*

BIOMARE Implementation and networking of large scale, long term Marine Biodiversity research in Europe. (2003), recommended research focused on carefully selected sites in European waters. Those sites (figure 12) represent different categories. The most important are the ATBI (All taxa biodiversity inventory) – set of just six locations in EU waters, that represent the least human-impacted, pristine level of biodiversity. It turned out, that such places exist on isolated oceanic islands only. In ATBI sites, the full diversity inventory is planned – from microbes to the whales – a task that has never been completed before anywhere. The Long Term Biodiversity Research (LTBR) sites represent another important category of biodiversity knowledge – those are sites with long term tradition in collecting the information, sites, where we can learn how the biodiversity is changing from year to year on the long time run. This would help us in distinction between natural and human mediated changes, modeling and predictions of biodiversity changes. The research postulated by BIOMARE are well on the way in ATBI and LTBR sites, coordinated by EU Network of Excellence MARBEF and sponsored by numerous other programs (e.g. Census of Marine Life, national fundings).

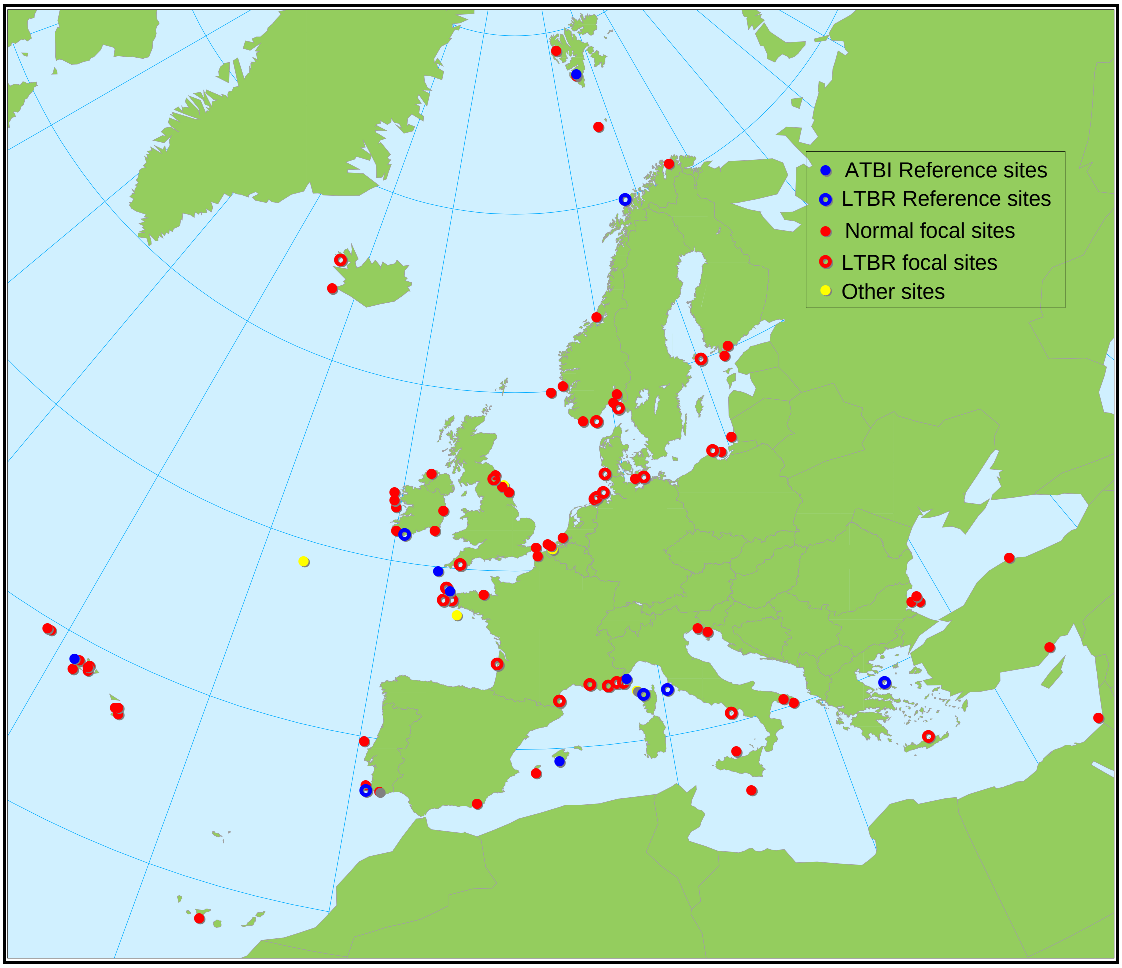

Figure 12 Distribution map of proposed European Marine Biodiversity Research Sites (Warwick et al., 2003).

The state of the present network

MARBENA initiated a database with scientists interested in Marine Biodiversity based on interest in electronic conferences organized by MARBENA and from the networking activities. The database recently has been adopted by MarBEF. The inventory fairly well represents an overview of the number of actors that are currently involved or have an interest in marine biodiversity research in a European context (Table 4). The table shows that marine biodiversity (research) is well anchored in most of the European countries (except for Latvia (0), and a few minor numbers in some new member or candidate EU member states, such as Estonia, Malta and Slovenia). In EU countries there are on average 15 institutions active in marine biodiversity research in some way.

MARBENA succeeded in getting countries bordering the Black sea and south/south-east Mediterranean Sea involved (around 3 institutions per countries). In "Black sea institutions" there is even an equal amount of contacts (~3) compared to "European institutions", whereas in most "south/south-east Mediterranean" institutions there is only 1.5 contact persons on average.

Table 4. Number of institutions and people involved in marine biodiversity research as is recorded in the MARBENA/MarBEF register of resources.

	Country	*Institutions*	*People*		
EU	Belgium	22	71		
	Denmark	16	32		
	Estonia	3	12		
	Finland	12	15		
	France	25	131		
	Germany	21	85		
	Greece	14	37		
	Ireland	19	26		
	Italy	18	89		
	Latvia	0	0		
	Lituania	10	13		
	Malta	1	3		
	Netherlands	14	72		
	Norway	20	47		
	Poland	10	28		
	Portugal	36	58		
	Slovenia	1	10		
	Spain	17	32		
	Sweden	10	16		
	UK	42	146		
Total		**291**	**876**		
Average		**15.3**	**46.1**	**3.0**	**pers/inst**
South and Southeast Mediterranean	Algeria	2	4		
	Egypt	3	3		
	Israel	5	8		
	Lebanon	2	2		
	Libya	1	1		
	Morocco	2	2		
	Palestinian authorities	1	1		
	Syria	3	4		
	Tunisia	3	5		
	Turkey (bordering Black sea)	5	11		
Total		**27**	**41**		
Average		**2.7**	**4.1**	**1.5**	**pers/inst**
Black Sea	Bulgaria	8	16		
	Georgia	2	3		
	Romania	2	7		
	Turkey (bordering Mediterranean sea)	1	8		
	Ukraine	3	22		
Total		**16**	**56**		
Average		**3.2**	**11.2**	**3.5**	**pers/inst**

Regional areas and collaborations

Mediterranean region

Due to new research methods and techniques (in vivo study of biodiversity by SCUBA diving; genetic markers) the knowledge of marine biodiversity in the Mediterranean increased in the past few decades.
The researchers are very interested in biodiversity studies. This is obvious from contributions and papers published on this topic. On the other hand the GO's and NGO's as well as SME's are more interested in topics concerning destruction of habitats and pollution instead of biodiversity.

Policy choices have been hampered by inadequate science. Can our research reduce uncertainties and provide better basis for alternative choices? Sustainable use and conservation of biodiversity requires knowledge of:

- Definition of habitat types in the Mediterranean Sea; lists of habitats and species
- Impacts of most significant pressures (climate change, pollution incl. eutrophication, habitat fragmentation, connectivity, destruction, sea-use change, introduction of non-indigenous species, over-fishing etc.)
- Status and distribution of habitats and organisms (abundances, extent of habitats etc.)
- Trends of habitats and organisms

Some definitions and list of Mediterranean habitats as well as lists of species has been already made. The information on species abundances and biomass (when available) are provided from stations sampled in the Mediterranean and Black Seas. Although in operational mode, it is still under development.

The ELME (European Lifestyles and Marine Ecosystems, at: www.elme-eu.org), funded by the EU under STREPs, is specifically targeted to the impacts of the most important pressures and tries to apply the DPSIR (Driver-Pressure-State-Indicator-Response) model to selected EU habitats, in order to make scientifically sound suggestions for the formulation of the EU policy on the sustainable development.

Among eight MARBENA electronic conferences, three focused also on the Mediterranean Sea: one organized in 2002 (22 April – 3 May), second in 2003 (7 – 20 April) and one in 2004 (6 to 24 September).

MARBENA e-conferences identified the Mediterranean and Black Sea as a unique model region for the marine biodiversity research and monitoring for several reasons:

- this region hosts several traditional marine research centres that possess long-term data sets on environment and biota;
- we may find the whole range of pristine to very impacted areas;
- region has a wide variety of habitats and organisms and high percentage of endemism;
- strong environmental and trophic gradients (south-north, east-west, vertical: oxic-anoxic);
- a range of top predators, some of these are endangered species, while in contrast some increase in numbers (gelatinous predators);
- un-explored or ill-known environments and organisms (anoxic areas, microbiota).

Following major gaps in knowledge of Mediterranean & Black Sea biodiversity were identified:

- deep-sea biodiversity and biodiversity in specific environments;
- biodiversity at different spatial scales;
- long-term biodiversity trends;
- role of physical processes and anthropogenic impacts;
- coupling of biodiversity with ecosystem functioning;
- role of the smallest biological components.

Through presentations and discussion during the MARBENA workshop that took place in Piran from 27 to 30 November 2004 was revealed that in the region there were good observational series (inventories) and datasets at several Mediterranean and Black Sea institutions and, moreover, that UNEP/MAP may offer institutional framework for the future biodiversity monitoring activities.

Future research directions certainly include bio-invasions and the role of large top predators in relation to changes in the trophic status and environmental conditions.
Possibilities to implement recommendations for biodiversity research in the southern and eastern Mediterranean and Black Sea:

- inventory of species and habitats and their distribution, underpinned by significant new taxonomic effort
- develop, test and evaluate indicators, harmonise habitat and landscape classification (providing information on the status, trend of biodiversity and drivers of biodiversity change)

With different search tools on Internet we made inquiries about contributions that contain **“marine biodiversity”**. We got a huge number of hits. But among them we found different kinds of contributions. Like scientific contribution, tourist information, and popular, political contributions….
But we must know that some of the authors use words “species composition” instead of “biodiversity”. So the published material about this theme is even more comprehensive as it looks. We can find contributions about biodiversity of fishes, sharks, invertebrates, jellyfishes, polychaetes, sponges, plankton, macroalgae, sessile epifauna, as well as biodiversity of communities, different habitats and protected areas, genetic biodiversity, different impacts on biodiversity...
On the other hand most of the authors use the term biodiversity but, in the papers we can hardly see more than one ecosystem component (/level of biological organization) or more than one scale of observation, if we want to stick to the original definition of the “biological diversity”.

Another, important gap is the availability of reliable long-term data in the region. Although there are a few labs with long tracking monitoring activities, these data, even the meta-data are hardly available.

Decline of taxonomic expertise is another serious threat for Mediterranean and Black Sea marine biodiversity. Well-trained taxonomists are many times forced to work under monitoring or other relevant projects because this is the only source of funds for their Institutions/Academic Establishments, as well as for their teams. Consequently, this may have serious consequences for the development and continuous maintaining of taxonomic monographs/keys for most of the taxa occurring in the region.

Papers at the molecular/genetic level on species other than the edible ones, referring to either fisheries or aquaculture, are also sparsely found in the relevant literature from the Mediterranean and Black Sea region. Links between taxonomists, ecologists, biogeographers and molecular scientists should be enhanced: this is a *major* gap, partly encountered in the context of the large EU Network of Excellence.

In the recent years, the term “ecosystem approach” has become very fashionable. The term particularly relates to marine biodiversity but so far has been almost *exclusively* used by disciplines like fisheries and modeling. The approaches used, so far, to tackle this new direction are: (i) fisheries and their correlation to the environmental variables (e.g. temperature, fronts); (ii) habitat diversity, deriving from mapping approaches (cartography), thus relating to the potential biological diversity; (iii) top-predator population dynamics under the assumption that if their populations are maintained, then, the quality of the ecosystems they make use of are also maintained. An *ecosystem approach* that encompasses all ecosystem components from the viruses and bacteria to top-predators in benthic, hyperbenthic and pelagic realms, and follows their interrelationships in space and time is *absolutely* absent in the Mediterranean and the Black Sea region. Mathematical approaches to study trends in ecosystem change in relation to climate change and to anthropogenic forcing, under the afore-mentioned context, are also a *major* gap, with the exception of dynamic modelling, which suffers from many “black boxes” describing many of the ecosystem components. Biodiversity modelling, based on niche-based models also exists but it has never been applied to the region.

Among the *major* gaps, one would cite the absence of “environmental probes”, that is the production of reliable and non-expensive tools that can rapidly assess the marine biodiversity/environmental health, especially in the coastal waters. The development of such tools probably involves multi-disciplinary approach and more focused research with molecular/genetic techniques, which can provide with such useful tools. “*Environmental probing*” is a *must* priority for the years to come.

Last, but probably not least in the list of “*demand and supply*”, comes the issue of ISO certified labs in the region, capable of both performing marine biodiversity/environmental health monitoring activities and also providing education to the NGOs and SMEs stuff on this particular subject, consistent with the EU policies, as described by the EU Directives such as the Common Fisheries Policy (CFP) and the Water Framework Directive (WFD).

Baltic region
The four Baltic countries that joined the EU in 2004 are all active in marine biodiversity research, although their potential is diversified. Poland with 40mln inhabitants, and several marine research institutes, employs in total over 1000 persons in the marine science sector (over 200 phD+ scientists in marine research). The other, smaller, countries: Lithuania, Latvia and Estonia (joint population of less than 8 mln) employ in total less than 100 marine scientists, with one marine research institute per country.
The activities of the marine institutes of the Baltic are not restricted to the region (the Baltic) itself. For instance Poland has contributed significantly to the marine biodiversity knowledge in the Arctic and Antarctic

(some 10% of marine biodiversity papers from global list) and in the field of fish taxonomy and biology to the Atlantic and northern Pacific areas.
The strong point of marine researchers from Baltic countries is the orientation in both Western and Russian scientific literature, that permits to us the extensive resources of little known vast taxonomic publications of former Soviet Union. University curricula in Baltics, still contain the basic lectures on systematic zoology and botany, what makes the post graduate students well prepared for the biodiversity studies.

The Baltic, as an enclosed brackish sea, has a relatively long history of international scientific collaboration in monitoring and research. Here the ICES and HELCOM play crucial roles, with emerging new initiatives like the pan-Baltic European Research Area (ERA) project BONUS. Regular, annual meetings of Baltic scientists (Baltic Marine Biologists, Baltic Oceanographers, Baltic Geologists) provide a good working platform for a large population of marine scientists (some 500 from Scandinavia, 200 from Germany, 200 from Russia and 500 from Poland, Estonia, Latvia and Lithuania). The Baltic marine research is however strongly leveled towards environmental problems – eutrophication, toxic blooms, overexploitation of fish resources, and true biodiversity studies are not very common. Still, the long term observations on macrozoobenthos, zooplankton and phytoplankton regularly carried out in all Baltic countries, give a good ground for Long Term Biodiversity Monitoring. Special issue of interest are the non- native (invading) species, not less than 50 of macrofauna species recently established stable populations in the Baltic, their spreading and ecological consequences are closely followed by number of Baltic marine biologists.

The South-eastern Mediterranean region
Regional cooperation in the Mediterranean Sea represents a major challenge of the XXI century towards a better understanding of biodiversity-related issues at the basin scale. This requires a major effort in enhancing the collaboration among scientists in the entire Mediterranean region, especially between northern and southern countries, to share similar and coordinated efforts. The MARBENA project has contributed to such integration by sustaining an active interaction with several scientists from various south-eastern Mediterranean countries working on marine biodiversity.
As a follow-up of the large and active participation to the 7th MARBENA electronic conferences, which focused on the south-eastern Mediterranean region, various contributions south-eastern Mediterranean colleagues were received for the implementation of the MARBENA final report. Several aspects related to the current status of marine biodiversity in the south-eastern region, identification of strength and weakness, possibilities for regional integration were highlighted (annex x, contributions).
There is a clear desire of regional cooperation, networking and integration with EU-Mediterranean countries from south-eastern Mediterranean colleagues. A balanced (i.e., not biased towards the north-western Mediterranean) network should be put in place to evaluate and integrate all the work done at the regional level, taking into account the experience of north-western Mediterranean countries. At the same time, there also is a need to enhance more debate (dialog) among scientists with different backgrounds in order to create appropriate roles that are applicable to the south-eastern region. Thus, a partnership process with normative to be established and agreed by all partners on an equal level of responsibility. In the south-eastern Mediterranean region, there also a need to reduce infrastructural and publishing gaps, whereas there is a weakness (gaps, lack) in having reliable long-term scientific data, as compared for instance to the North Sea and the Baltic Sea, which mainly come from scattered (i.e. individual, not coordinated) research programs. It also appears, however, that this effort should go in parallel to a better integration at the sub-regional (e.g., North Africa, Eastern countries) and even national level, as in several cases there are not concerted actions and programs even within an individual country.
Due to a weaker economic situation, funding for conducting research on marine biodiversity seems to be a major problem, while it would also help to reduce brain-drain in south-eastern Mediterranean countries. Along this line, while research is mainly a domain of public Universities, there is a need to involve other institutions and organizations including private Universities, local municipalities, NGOs and stakeholders at large.

Box 5. Example of successful collaboration through monitoring series in North western Europe

The North Sea
The coastal areas of the North Sea are some of the busiest in the world in terms of shipping, exploitation of marine resources and as local amenity areas. North sea coastal areas are now also increasingly the sites for large offshore wind farms. This heavy use also makes them extremely vulnerable to pollution, effects of global change and overfishing. The North Sea is therefore a very good example for a maritime area where reliable biodiversity assessments are particularly crucial for the detection, monitoring and where possible amelioration of the effects of global warming and different types of pollution. To do this, several steps are necessary: **1.** collection of comprehensive data, i.e. all components of the marine food webs and if at all possible both the benthos and pelagic

areas, **2.** temporally very long-term data that can identify reliable trends in the community under study. Detailed long-term data are necessary to make such assessments and many data series have therefore been started in laboratories bordering the North sea (see list below). Good examples for comprehensive sampling exist in the North Sea. The measurements at the Helgoland Roads long-term monitoring station, encompass measurements of physico-chemical parameters as well as counts of phytoplankton (counted workdaily since 1962, full quality control), zooplankton and bacteria (see special issue of the peer reviewed journal Helgoland Marine Research, 58, 4).
However, use of these data particularly for comparative studies still suffers from problems, e.g. in methods related to sampling and counting techniques.

In addition to data collection, efficient dissemination is vital for facilitating collaborations. Again, the Helgoland Roads data are a good example for effective and open archival practice. The Helgoland data have been stored in the online database system PANGAEA (http://www.pangaea.de) and are available for researchers. In addition, to holding the Helgoland Roads and other AWI data, PANGAEA also serves as a repository for other institutes and individual researchers, wishing to make georeferenced data publicly available online. Many close collaborations with institutes such as the GKSS (Institute for coastal research) have been created to model the data and will produce the multiauthor papers resulting from multidisciplinary research projects, the lack of which was criticised elsewhere in this report (….).
Data from long-term monitoring series are also being made available online by NIOZ (http://www.nodc.nl/datasets/welcome_uk.html), including nutrient and phytoplankton data from various parts of the North Sea (Table…). However, there are still deficits with respect to the dissemination and accessibility of quality controlled taxonomic information and existing systems are rarely comprehensive, meaning here, taxonomic records containing both images, descriptions and biogeographic information.

Applications for reliable long-term data
Climatic shifts/ phenology
Analysis of the Helgoland Roads Long-term data series has revealed a 1.1. degree increase in surface water temperature over the past 40 years. Additionally, and connected to the rise in water temperatures a delay in the spring diatom bloom (calculated as the mean diatom day) has been demonstrated.

Species invasions/ introductions
The importance of temporally detailed data sets and the comprehensive sampling of food web components becomes particularly clear in the study of species invasions and introductions. Invasions of the North Sea by exotic species is stretching across a range of taxon groups, including phytoplankton (*Coscinodiscus wailesii* (Rick and Dürselen 1995; Edwards et al. 2001) and possibly the dinoflagellate *Gymnodinium chlorophorum*), siphonophores (*Muggiaea atlantica*), molluscs (the Pacific oyster *Crassostrea gigas*), which was introduced intentionally for aquaculture purposes but is now spreading) and fish (e.g. blue mouth, *Helicolenus dactylopterus* and striped bass). These invading species can, as shown e.g in *Crassostrea gigas*, which can completely swamp and eventually obliterate musselbeds have profound effects on local ecosystems. To make matters worse they can also act as vectors for additional species (Wolff and Reise 2002).
In case of species such as *C. gigas* and *C. wailesii* the existence of the many long-term data sources covering the North Sea has not only facilitated the identification of invasive species but also their route of establishment, which provides an opportunity for framing hypotheses as for the mode of establishment.

These studies clearly demonstrate not only the need for long-term data but also for efficient data dissemination and collaboration, because only then will it be possible to identify species introductions/ invasions correctly (and to avoid errors e.g. due to misidentifications or different taxonomic names being used in different data sets, (Elbrächter 1999) and to assess possible changes they might cause shifts?? in local ecosystems. Such collaborations will need to be multidisciplinary in nature including both trained taxonomists, ecologists and data managers/ statisticians. Such collaborations can be facilitated by the large scale collaborations such as Marbef. Most of the institutes listed in Table 1 are members of the Marbef network and the responsive mode project Largenet (including 6 Marbef partners) in particular has already recognized the continued need for existing long-term data t be examined both data collection and data analysis techniques as a prerequisite for joint analyses of these data sets. This process will require a range of different skills.

Table 1: Examples of long-term monitoring series covering parts of the North Sea

Data Series	Country	Species cover	Duration (since..)
AWI Helgoland AWI Sylt	Germany Germany	phytoplankton zooplankton bacterioplankton phytoplankton	1962 1987
NIOZ	The Netherlands	phytoplankton- Southern North Sea phytoplankton- Central North Sea	1975 1986
Ifremer (Rephy)*	France	phytoplankton	
NERI**	Denmark	phytoplankton, zooplankton, zoobenthos, macrophytes	1989
Plymouth	England	E1, L5: Phytoplankton, zooplankton L4: Phytoplankton	 1902-1987, restarted 1990s
Dove Marine Lab	England	Z: Zooplankton P, M1: Benthos	1968 1971/72
SAHFOS	England	CPR survey on several routes in the North Sea	from 1946

***French seashore phytoplankton monitoring, **National Environmental Research Institute**

Recommendations:

Networks already exist that aim to integrate the Marine Biodiversity data held by different laboratories (e.g. BIOMARE, MARS). One aim of these networks is the harmonization of existing data sets and the methodologies needed. These efforts have to lead to durable schemes (not limited to the 3 or 5 year duration of a funded project) for sharing resources and expertise to conserve funds and therefore make collecting and analyzing the data viable in the long-term.

These efforts have to be intensified, particularly on the data dissemination level and in data rescue.

The greatest problems however are presented by the older data sets that are not fully digitized but still only exist as hard copy. This situation still has to be remedied if we want to be able to make reliable assessments of European, marine biodiversity and therefore an assessment of the state of the environment.

Future needs in European marine biodiversity research

There is a requirement for long-term and broad scale monitoring to track change and to be able to separate short-term variability from long-term trends and impacts of localised human activities from climate change. The design of monitoring and decadal research networks needs to be further developed.
There should also be a meaningful assessment of status and health of existing systems focussing on local and regional perspectives, as well as the identification of pressures adversely affecting marine and coastal biodiversity (e.g. fisheries activity) so that action to reduce the pressure can be prioritised.
This needs to be carried out together with process-orientated research on the underlying mechanisms enabling better predictive ability of rates and scales of likely future changes. Experimental studies (laboratory and field) should be carried out to test the reaction of organisms to likely effects of climate induced change and therefore better understand what aspects of climate change are most important in threatening ecosystem structure and functioning. Specific experimental studies could include the assessment of the rate of atmospheric CO2 conversion into biomass, impacts of temperature and saturated CO2 levels on carbon fixation of individual species and the influence of temperature and salinity at organizational and functional levels of different species. Another very serious gap in knowledge at present is the rate of ocean acidification and the impacts it will have on biodiversity.
Predicting climate change impacts on biodiversity in marine and coastal ecosystems will necessitate the development of new tools, and ways to constantly update and integrate new methods and technologies as they develop. In addition the multi-trophic responses that need to be considered over a range of spatial and temporal scales will need the integration of current research efforts.
Summary of priority activities:

- Long-term broad scale monitoring
- Assessment of current status of marine biodiversity and pressures impacting biodiversity that could be reduced
- Process-oriented research in to key drivers of change and response of ecosystem structure and function
- Better understanding of the impacts of ocean acidification
- Integration of current research efforts
- Socio-economic aspects of biodiversity

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