Newsletter No 1 Winter 2001

BIOMARE

Implementation of large-scale long-term MARine BIOdiversity research in Europe

www.biomareweb.org

A concerted action to establish the infrastructure and conditions required for marine biodiversity research at a European scale.
Contract number: EVR1-CT2000-20002

From the Editors

Biodiversity loss and conservation are rapidly becoming important issues on the political agenda. The scientific effort is, however, lagging behind this rise of interest, particularly in the marine sector, which suffers the additional problem of being considered less at risk than the terrestrial environment. With the BIOMARE 'concerted action', the marine biological science community of Europe has an excellent opportunity to organise itself by defining the topics that need urgent consideration in the near future and discussing the implementation of the research required at European level.

BIOMARE is organised around two work packages which address the topics of primary sites and indicators, and it devotes a third work package to the dissemination of results to scientists, politicians and the public at large.

The programme has to be highly organised since BIOMARE is a two-year project only, and the opportunities to launch a European-level research programme as a logical next step in the process will probably be available in a window of one to three years from now.

BIOMARE was proposed to the Fifth Framework Programme as being based on the European Science Foundation (ESF) Marine Board paper *Establishing a framework for the implementation of marine biodiversity research in Europe*. The primary sites will provide the geographical skeleton for the implementation of this research, but the research flesh still has to be defined.

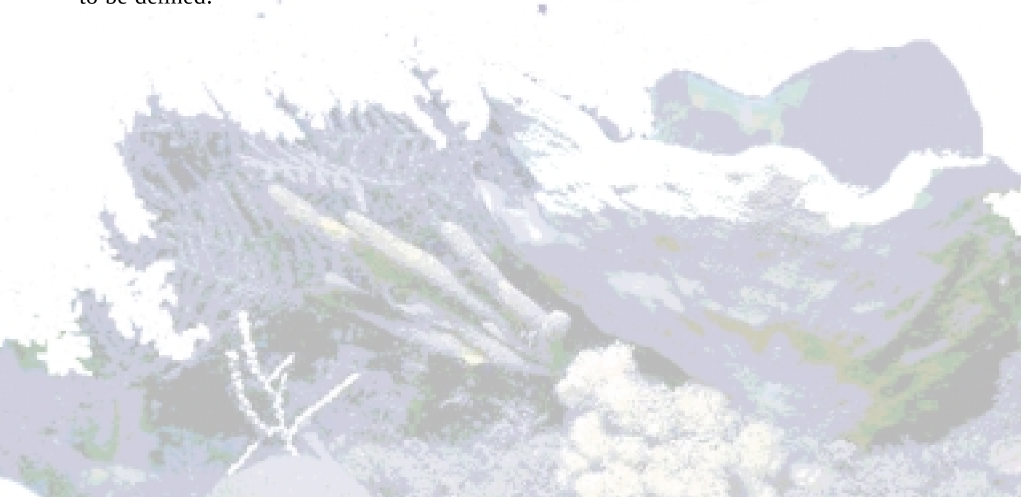
A Eurocores proposal to the ESF is probably the next step and it will be based on the intensive survey of 14 primary sites that will be defined in the coming months. We need to consider the scientific issues now.

We must not forget, however, that the reference sites (as the second list is called) will play a crucial role in future marine biodiversity research in Europe as they will provide the skeleton for the long-term research as well as for comparative studies on selected groups of microbiota, plants and animals. A catalogue of these reference sites as well as a discussion on the mechanisms to support research at these sites for at least ten years will also be crucial.

The work package on indicators sets a difficult mission. This cannot be restricted to the merits of the Shannon-Wiener index or the suitability of spiders to indicate changes in the marine environment. Of course, it is important to make a catalogue of indicators that are used, but another and probably more important goal of this work package is to aptly translate complex biological structures and evolutionary, ecological and biogeochemical processes into more simple parameters and concepts that can be understood by non-scientists. This will require bridging the gap between the rigid language of science and the day-to-day language of the layman. We should not forget that many efforts are being made to define indicators, so a discussion on what BIOMARE can add to these, based on our biological work to date, will be important.

There is, therefore, a very intensive and intellectually interesting year ahead of us. Marine biodiversity science needs upgrading, and marine biologists are perhaps not as well organised on the European level as they should be. We must take the opportunity that BIOMARE, and the MARS network from which it originated, now offers us to do something about this. The BIOMARE community is certainly up to the task, but it also has a great responsibility. We simply cannot afford to fail.

Carlo Heip, Herman Hummel and Pim van Avesaath



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BIOMARE: the kick-off meeting

The Steering Committee of BIOMARE met for the first time at the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology, in Yerseke, The Netherlands, on 13-14 November 2000. The meeting started by reviewing the main goals, perspectives and objectives of the concerted action. In subsequent sessions organisation and finances, the programme of meetings, reports and workshops were discussed. The meeting ended with the formulation of a detailed timetable.

Herman Hummel, Carlo Heip and Pim van Avesaath, NIE-CEMO, Yerseke, The Netherlands

Regional meetings

The first series of regional meetings was organised in spring 2001. The aim of these meetings was to finalise the first comparisons of most suitable and best-studied sites (see Work Package 1 - Primary and Reference Sites) and of indicators (see Work Package 2 - Bioindicators), and discuss the most suitable way for installing a communications network and databases (see Work Package 3 - Capacity Building and Dissemination).

The regional meetings of the Atlantic-Arctic and the North Sea-Baltic were combined and held at IOPAS, Sopot, Poland. The meeting of the Mediterranean and Black Sea took place near Corinth, Greece, and was organised by the IMBC. The organisation of both meetings was excellent.

In total, suggestions for 47 primary sites and 109 reference sites were received, and contributions are still welcome. The high number of candidate reference sites was expected; however, the list of candidate primary sites must be reduced to 14 in total. The participants began the huge task of shortlisting candidate sites. During the meetings a protocol was developed to evaluate the primary sites on the basis of a set of criteria. However, it was not possible to reduce the number of sites based on the information provided by the questionnaire. In order to obtain additional information, the work package leader Richard Warwick has sent a new questionnaire to the institutes that have proposed primary sites.

A number of geographical gaps was indicated, and suggestions for mainly primary sites are requested from: Iceland, the Russian Arctic region, Norway, Portugal, Canary Islands and the Black Sea region. Suggested sites should not include the primary sites already suggested at the regional meetings.

During the meetings, the bioindicators questionnaire was optimised. It aims to provide an overview of different types of indicators used to identify the main causes, rate and extent of biodiversity loss, and of indicators used for the evaluation of protective or restorative measures employed in Europe. The results will be used to evaluate the relevance of the indicators and to provide insights into their embedding in national rules and their use within national monitoring networks. This questionnaire is now available on-line at **www.biomareweb.org/wp2.html**

This website was installed shortly after the kick-off meeting in November 2000. It presents general information about the project, the work packages and progress on the concerted action. Links to the member institutes, the news server and other programmes involved in the biodiversity issue are also provided.

Work Package 3 will now focus on the further establishment of the network of scientists and research institutes involved in marine biodiversity research and on the installation of databases providing insights into the current status of marine biodiversity research in Europe.

Euroconference: the scientific highlights

"Biodiversity of Coastal Marine Ecosystems: Patterns and Process"
Corinth, Greece, 5-10 May 2001

This Euroconference was the first of two EURESCO meetings jointly aimed at reviewing and synthesising relevant knowledge on coastal marine biodiversity.

The conference concentrated on clarifying what is known on the three aspects of biodiversity (genes, species, habitats) in coastal areas. A comparison with other ecosystems on Earth was also made.

The audience was exposed for the first time to a description of marine biodiversity that covered all major groups of micro-organisms, plants and animals and the different levels of biological organisation. This generated very lively discussion during the meeting. Only a few of the scientific highlights can be mentioned here:

There are about 500,000 species described from the world's seas and oceans and an estimated 29,000 marine plants and animals in Europe. It is clear, however, that many species still await discovery and scientific description.

It is possible that the total number of marine species will in the end prove to be similar to the number of species on land. The use of species groups as the unit to describe and understand biological complexity to a certain extent requires that at least the common species in certain habitats are known and can be identified.

The problem of disappearing taxonomic expertise has been mentioned many times over the last decade, and it is true that there are few remaining specialists for some of the more obscure plant and animal groups. It is also recognised that the lack of good identification guides poses a large problem.

Another way to aggregate individual species is to look at their ecological function. In the past

Delegates at the Euroconference in Corinth, Greece ***(Photograph by Rafael Sarda)***

few years the concept of ecosystem engineers has gained a lot of attention. Some of these ecosystem engineers are also 'keystone' species, species which determine to a large extent the functioning of an ecosystem. Species which perform similar roles in the ecosystem can be grouped together. This is particularly useful and even essential for ecological modelling which has a limited number of variables.

Many species have very similar DNA and therefore fingerprinting techniques are now widely applied in order to detect their identity, their genetic characteristics and relationships. In this way the population genetics and demography of populations can be assessed and the dispersal and genetic origin of organisms traced. Techniques now at our disposal not only allow us to obtain detailed information on the genetic relationships between individual plants and animals but also to get an informed estimate of the total number of genes within species, or in an area as a whole, and on their rate of dispersal. In this way the concept of biodiversity hotspots, which has recently attracted a great deal of attention in the terrestrial biosphere, can be applied to marine systems.

Depending on the timescale, the driving forces for biodiversity change vary from geological, over evolutionary to ecological. Spatial scales are also very important in determining the number of individuals and species present. Such variability has resulted in a large number of ways to quantify biodiversity. Many of them are based on estimates of species abundance or richness from very small samples representing very large areas. These are labour-intensive and therefore costly and a search for surrogate or rapid assessment methods is of great economic interest. It was illustrated several times at the conference that restricting taxonomic analysis to higher levels does not necessarily lead to a substantial loss of information and may offer one solution.

The impact of marine fisheries on the seabed is a highly controversial issue in Europe. In the Dutch Wadden Sea some scientists claim that the mechanical harvesting of cockles leads to long-term changes in sediments system-wide. About 50 species have become extinct in the Wadden Sea: 25 of these extinctions were due to human exploitation, about 17 disappeared due to habitat loss, while pollution accounted for only three extinctions. Local mass extinctions may be on the increase.

The Euroconference also generated very lively discussion on the problems of applying biodiversity science to the problems of managing the coastal environment. In Europe, the European Environment Agency is now involved in implementing action concerning biodiversity for Europe's waters. For EU countries the protection of the marine environment is only starting, though the legal framework is already in place, including the EU Habitats Directive and to a certain extent the new EU Water Framework Directive. In some countries, such as the UK, a large effort to structure marine conservation has already been undertaken.

Finally, although the international framework is there, the implementation still needs a lot of attention. There are problems of organising the science, both within Europe and globally. Networks such as MARS (European Research Stations Network) and NAML (Assocation of North America Marine Laboratories) are starting to link, also in support of the DIVERSITAS programme. There are still problems of data availability, and some recent projects such as OBIS (Ocean Biodiversity Information System), MarLin (Marine Life Information Network for Britain and Ireland) and their planned link to GBIF (Global Biodiversity Information Facility) will require efforts from the scientific community in the years to come.

Carlo Heip, chair of the conference

This article is based on the presentations made at the European Research Conference (EURESCO) on "Biodiversity of Coastal Marine Ecosystems: Patterns and Process - A Euroconference", held in Corinth, Greece (5-10 May 2001). The conference was organised by the European Science Foundation (ESF) and was supported by the European Commission (Research DG), Human Potential Programme, High-Level Scientific Conferences (Contract No. hpcf-ct-2000-00223), UNESCO, MARS and BIOMARE.

Work Package 1

Primary and Reference Sites

The aim of this work package is to identify sites around Europe that can be used for long-term biodiversity research. A nested approach is being used, identifying a relatively small number of primary sites and a larger number of reference sites.

Primary sites

Primary sites will be areas with a mosaic of habitats that are relatively pristine compared to similar areas and which are therefore expected to have, comparatively, the highest diversity. They will serve as a baseline against which the status of degraded or impacted sites can be assessed and subsequent changes monitored.

The exact criteria for defining primary sites were discussed in detail during the initial phase of the project. Primary sites should meet the following criteria:-

- They should be pristine, free from anthropogenic disturbance and also free from natural stressors, if these are atypical of the region that the site represents.
- They should comprise a mosaic of representative habitats within a well-defined area.
- Some background information on the sites should already be available.
- They should be in areas that are afforded protection by their conservation status, which will ensure the perpetuation of their pristine status.
- An appropriate infrastructure for biodiversity research should be in place.

The series of primary sites will aim to cover all the major marine habitats in Europe. Offshore islands may be amongst the favourite locations because they are remote from anthropogenic impacts, not subject to freshwater or fine-sediment inflows from rivers, they have well-defined limits and have a long coastline relative to their area.

Suggestions for research objectives at these primary reference sites will be formulated. These could include:

- an inventory of the biodiversity present, including as complete a range of taxa as possible, the genetic diversity of target species and habitat diversity;
- studies of the underlying phylogenetic pattern of biodiversity;
- development of rapid assessment techniques for (dynamics in) biodiversity;
- development and calibration of biodiversity measures based on relatively coarse data appropriate to the large scales of observation, and the production of indices that are not strongly dependent on standardised sampling effort;
- initialisation of long-term observational information in order to establish patterns of temporal change.

Reference sites

More extensive but less comprehensive studies will be made at a much larger number of sites, called reference sites, covering a range of impacted and non-impacted areas. The criteria for selection of these sites are less rigid, though comparable habitats need to cover a wide geographical range. The objectives of studies at reference sites will be to:

- map distribution patterns of biodiversity on a relatively fine scale;
- assess man's impact on biodiversity;
- undertake long-term monitoring using rapid assessment techniques or biodiversity indicators.

Questionnaire

An initial questionnaire sent out to BIOMARE participants provided an extensive list of primary and reference sites. Unlike other programmes it is clear that, in principle, BIOMARE has strict scientific goals and it is the intention to create an infrastructure for research that does not compete with (non)governmental organisations. Furthermore, the selection of primary sites should be an iterative process between the selection of the sites and the selection criteria. Following discussions at the first two BIOMARE regional meetings the list of primary and reference sites was refined. However, to further refine the list, a second questionnaire has been developed and sent to those who nominated primary sites.

A database and maps of the preliminary candidate primary and reference sites can be downloaded from the BIOMARE website (www.biomareweb.org).

Work Package 2

Bioindicators

The composition and structure of the fauna, flora and habitats of the oceans changes due to climatic and human activity, amongst other factors. Anthropogenic influence is the main reason for much of the deterioration over the last half-century, during which the rate and extent of damage has been unprecedented. Such impacts have serious consequences for biological diversity. In order to manage the marine environment it is necessary to understand and identify causes of biodiversity loss before they become irreversible. The need to develop indicators for biodiversity as monitoring tools is essential given the impossibility of surveying biological diversity in its entirety.

Indicators generally refer to the environmental attributes, often species or species groups, which can be sampled and whose modification is supposed to reflect a change of biological diversity. The objectives of this work package are to:

- survey and critically evaluate different types of bioindicators available in Europe, including so-called indicator and sentinel species, biological indices, biomarkers, lethal and sub-lethal tests, and bioaccumulators;
- provide a tentative inventory of existing national monitoring networks *(e.g.* monitoring of seawater quality indices such as temperature, salinity, nutrients and contaminants, phytoplankton disturbance (especially by toxic, unicellular organisms) and bacteriological contamination of shellfish by coliforms.

Over the duration of the project a number of issues will be discussed at regional workshops, particularly how to:

1. organise a sequence of meetings aimed at securing increasingly inclusive information coverage and defining the sustainable indicators and related techniques at regional and European levels;
2. determine the geographical unit which

must be studied, *e.g.* units having the same biogeographical history and a certain ecological homogeneity;
3. choose the indicator group(s) according to current knowledge, and explore the availability of standardised sampling techniques;
4. express the results in terms of local (α) and landscape (γ) diversity, as well as in terms of β diversity *(e.g.* by quantifying the level of species substitution between communities);
5. produce comparable data, readily available in databases designed for public use.

The outcome of the inventory would preferably be a set of 20 to 30 indicators for monitoring biodiversity. Some of them will be indicator species, some will be biochemical factors, others are likely to be indicators that have been incorporated already into law in some countries. It should be possible to produce a uniform set of indicators for each region that can be adapted for other regions. Where specific regional problems exist, these can be accommodated in the set of indicators.

When determining indicators for biodiversity it should be noted that some indicator types have already been identified, including:

- State indicators which give a description of the environmental situation *(e.g.* concentration of heavy metals, nitrates, bacteria, organic matter);
- Constraint or pressure indicators which indicate the pressure of human activities on the environment *(e.g.* percentage of introduced species per type of habitat; varying extension ratio of *Cymodocea* and *Posidonia* meadows (urbanisation));
- Use indicators which are measures of goods and services provided by ecosystems *(e.g.* percentage of species used for medical or biotechnological use; percentage of endangered native species as against healthy native species);
- Performance or response indicators which are often sectoral and allow an assessment of what is being done to solve an environmental problem *(e.g.* protected areas as a percentage of total area; percentage of doctoral training related to [marine] biodiversity);
- Reference points which provide the means to measure progress and identify needs at political level *(e.g.* thresholds which are used as early warning systems for problems).

A number of questions need to be considered in selecting indicators:

- What is a good bioindicator? By definition, an organism or a group of organisms which, by reference to biochemical, cytological, physiological, ethological or ecological variables, enables the state of an ecosystem to be assessed, and which highlights changes as early as possible.
- Indicators of which biodiversity? Genetic-level biodiversity indicators, although requiring highly qualified staff, sophisticated technical means, time and money, will allow the demonstration of fragmentation of populations or erosion of genetic heritage of threatened species.

Although the impacts of human activity are felt both locally and at regional level, consideration should also be given to biodiversity on a landscape scale. Biodiversity is always structured in terms of space and time, which requires the determination of an initial reference state (the baseline) for monitoring to proceed.

Landscape-scale monitoring is best for analysis of specific diversity, not only as a parameter of the heterogeneity of the biotic and physical environment but also as a reflection of human activity. Such activity, when it induces a disturbance of moderate intensity and frequency, may encourage maximal species richness (the intermediate disturbance hypothesis) which must be analysed in terms of diversity on different scales of space and time.

A number of common stages are recommended when selecting indicators, including:

- determining the target public and its information requirements, and clarifying the criteria to be measured;
- determining the geographical unit which must be studied. If the boundaries are unknown, preliminary studies are needed to verify that what is called a landscape has the same biogeographical history and possesses a certain ecological homogeneity throughout;
- choosing the indicator group(s) for these criteria according to one's knowledge of them, but also checking the existence of standardised sampling techniques;
- meticulously testing indicators;
- setting up targets, thresholds and/or marker data that are suitable for selected indicators;
- trying out selected indicators in the field;
- expressing the results in terms of local (α) and landscape, or total (γ) diversity, as well as in terms of β diversity *(e.g.* measurement of substitution of species between differing communities);
- producing comparable data, made readily available through databases designed for public use.

A number of additional considerations could be explored when selecting indicators. Among the species present in a region, one can consider the species as a species in itself and also for the contribution it makes to the architectural, trophic and functional complexity it brings to the ecosystem. Thus the following types could be included in a group of diversity bioindicators:

- rare species;
- threatened species, those becoming extinct and those which are now extinct (locally) as a consequence of the changed environment (whether global change or more local modifications of anthropogenic origin);
- species that are sensitive to pollution;
- biogenic species which, by their existence, large size or durability, contribute to the complexity of landscapes and thus to the diversity of ecological niches;
- species which are 'keystone' species of complex trophic networks or of complex biological cycles (parasite hosts, reproduction sites, nurseries) and which therefore sustain a system or even a whole ecosystem *(e.g. Posidonia)*;
- taxonomic groups with high geographical differentiation, *e.g.* a genus with a high endemism rate. In this case, a taxon may be very vulnerable since a single or several populations represent it. These taxa are of great heritage value.

Questionnaire

The questionnaire on bioindicators is now available for completion from the BIOMARE website http://www.biomareweb.org under bioindicators. The questionnaire has been made to provide an inventory and evaluate the relevance of different types of indicators available in Europe (including bioindicators or sentinel organisms, biological indices and biomarkers). Also being evalutated is the information on recommendations made by national laws and their use within national monitoring networks in order to identify the main causes, rate and extent of biodiversity loss, or to evaluate the benefit of the implementation of protective or restorative measures.

This questionnaire is to be directly filled in online, but it can also be completed in a two-part process:

1. Print a hard copy of the preview and then fill it in once the answers have been found (it is not always possible to have the answers without a little research, which does help when filling in a form online);
2. Return to the website and fill in online.

Please read the instructions carefully prior to completing the questionnaire and direct any questions to Jean-Pierre Feral (email: feral@obs-banyuls.fr).

Work Package 3

Capacity Building and Dissemination

A first step in research on a European scale is making researchers aware of expertise, facilities, study sites and local scientific knowledge in different countries. Mechanisms for the communication of this information throughout Europe are thus essential. The most rapid and lowest cost communication is through the Internet.

The activities within Work Package 3 will in the first instance focus on dissemination via the Internet through several means:

A. News service

To facilitate communication of the project aims to as broad an audience as possible, and to disseminate the results of the project, the **Marine-B (Marine Biodiversity) electronic mailing list** will be utilised by the project.

To join the list

This process will generate a piece of mail inviting you, as the owner, to add yourself to the list. Send an email to listserv@listserv.heanet.ie leaving the subject line blank. In the main part of the mail, type in the command:

subscribe MARINE-B <firstname surname>

Make sure that you do not add a signature at the end of the mail. You will then receive a message saying you are subscribed to the list.

To send mail to the list

When you want to send mail to the list you just enter MARINE-B@listserv.heanet.ie in the 'To:' field and the mail is distributed to the people who have signed on to the list.

If you wish to check the list archives go to:

http://listserv.heanet.ie/marine-b.html

The website http://www.lsoft.com/ may also be useful if you wish to get further information about listservers and the running of the list. If you have any problems please e-mail Chris Emblow (cemblow@ecoserve.ie).

B. Website

A central website for marine biodiversity research in Europe has been constructed at: http://www.biomareweb.org

This website has four main goals:

1. **Introduction of BIOMARE to the public:** it states the goals and provides a description of the rationale behind the project and has brief descriptions of the member institutes.

2. **Dissemination of the results:** this website will show the results of the different work packages and the progress of BIOMARE via the publication of newsletters, reports, *etc*. Furthermore, it will be used to emphasise the applicability and the relevance of the marine biodiversity research for socio-economic and management issues and the existence of an international network of (non)governmental organisations involved in biodiversity research at regional or pan-European level.

3. **Capacity-building:** a database will be incorporated in, or linked to, the website giving insights into the:

   - current state of marine biodiversity research in Europe;
   - identification of gaps in this research in Europe;
   - facilities for training of researchers and students;
   - facilities for marine biodiversity research at European institutes (logistic facilities).

   This survey database will attempt to include institutions with relevance for biodiversity research, such as museums, universities and governmental laboratories outside the project. The regional co-ordinators will be responsible for the survey in their region. The MARS network is currently performing a similar inventory and this will be co-ordinated with the work of BIOMARE.

4. **Links with other organisations:** the website will provide links to other biodiversity programmes (such as the terrestrial biodiversity programmes, the Convention on Biological Biodiversity website, *etc)* and the biodiversity research institutes. Furthermore, these organisations should be asked to link their programme to BIOMARE.

C. Newsletter

The newsletter will be used to inform the public about the progress of BIOMARE. It will be published twice a year. A limited number of hard copies will be sent to a broader audience identified with other projects through the MARS and ERMS network. An electronic version of the newsletter will be put on the website in pdf format and sent to the member institutes and news service(s).

Plans for next 12 months

- The project website will be further developed to:

  - publish project results and distribute dissemination products, including:

    - the details of long-term, large-scale marine biodiversity datasets
    - regional species inventories
    - results of the bioindicator and primary and reference site work packages

  - promote BIOMARE meetings;
  - promote conferences and workshops relating to marine biodiversity.

- Further editions of the BIOMARE newsletter will be published in March 2002 and June 2002.

- A database of researchers and scientists interested in marine biodiversity will be further developed. The results of the database may be published via the BIOMARE website.

- A metadata database of long-term, large-scale marine biodiversity datasets and species inventories will be developed. Initial results were presented at the November 2000 BIOMARE meeting.

- Collaboration with the MARS network will continue to collate and disseminate information on facilities and equipment of European institutes involved in marine biodiversity research and options for training (courses) and mobility of students and researchers.

Marine Biodiversity in Europe

➨ This newsletter aims to publish a series of articles highlighting regional marine biodiversity issues in and around Europe. In the first article (below) Bella Galil from the National Institute of Oceanography, Israel, identifies and describes the range of alien or exotic species which have appeared in the Mediterranean. We are looking for future articles for forthcoming editions of the newsletter, so please contact Chris Emblow (cemblow@ecoserve.ie) if you wish to submit an article on any marine biodiversity issues in your region.

Exotics in the Mediterranean - Bioindicators for a Sea Change

Bella S. Galil
National Institute of Oceanography, POB 8030, Haifa 31080, Israel

Pliny the Elder, the Roman prefect turned naturalist, tells us that "oyster ponds were first invented by Sergius Orata on the Gulf of Baiae ... it was deemed worthwhile to send to the end of Italy, to Brindisi, for oysters". But it was not until the 16th century that the first transoceanic transplantation took place. The Portuguese probably transported the so-called 'Portuguese' oyster, *Crassostrea angulata*, from Japan. Large-scale transplantations of oysters were initiated only in the 20th century: *C. angulata* was introduced along the French Mediterranean coast as well as the Tyrrhenian, Ionian and Adriatic coasts of Italy. The Pacific oyster, *Crassostrea gigas*, native to north-eastern Asia, was introduced to the Mediterranean coast of France by the late 1960s. A decade after *C. gigas* was imported to the Adriatic lagoons of Italy its larvae were collected off Croatia, and it has since been introduced to many Mediterranean locales, from Cyprus to Tunisia. *Saccostrea commercialis*, a native of coastal New South Wales, was introduced to the Venice Lagoon in the mid-1980s and was recently found off Turkey. Manila clam, *Ruditapes philippinarum*, a native of the western Pacific, was introduced into the lagoons of Languedoc (France) in the late 1970s, to the Venice lagoon in 1983, and to other parts of the Italian coast, including Sardinia, in 1985.

The Japanese tiger prawn *Marsupenaeus japonicus* in the fish markat at Jaffa, Israel

Unwelcome introductions

Unrestricted transport of commercially important, alien oysters has resulted in numerous unintentional introductions of pathogens, parasites and pest species: a comprehensive compilation of marine macrophytes that were introduced into the Mediterranean by way of oyster-farming includes 15 species; 10 are native to Japan. The alga *Sargassum muticum*, successfully introduced into the coastal lagoons of Languedoc and northern Spain with *C. gigas*, has rapidly covered artificial substrates and negatively affected native algae. Indigenous species are now nearly absent amongst the dense stands of *S. muticum*. At Thau lagoon, *S. muticum* has locally displaced the indigenous *Cystoseira barbata* by blocking light and thus inhibiting the recruitment of the native species.

The slipper limpet, *Crepidula fornicata*, native to the Atlantic coast of North America, was first recorded in the Mediterranean in 1957 from mussel beds near Toulon; it has since arrived in the lagoons of Languedoc. In high densities it may compete with commercial shellfish crop for space and food and may enhance silting. A recent, small-scale experimental study shows modification of faunal assemblages resulting from settlement of the limpets.

The small mytilid mussel *Musculista senhousia* is native to east Asia. It arrived in the shellfish-farming lagoons of Languedoc in the 1980s and in the Adriatic. The mussel forms byssal mats on the surface of soft sediments, thus altering native benthic assemblages.

Two parasitic copepods, *Mytilicola orientalis* and *Myicola ostreae*, originally from Japanese waters, have been accidentally introduced with *C. gigas*. *M. orientalis*, an intestinal parasite, and *M. ostreae*, a branchial parasite, were recorded from the shellfish-farming lagoons of Languedoc in 1979. Both species are able to infect the indigenous oyster, *Ostrea edulis; M. orientalis* also infects the blue mussel, *Mytilus edulis.*

Mariculture of non-indigenous shellfish predominates in the north Mediterranean lagoonal environments, and these are heavily impacted by exotics, but much of the Mediterranean littoral has its share of exotics. This sea, a hub of shipping, is exceptionally susceptible to ship-borne organisms, whether the non-indigenous species occur in fouling communities or in ballast.

The oldest maritime pathway of dispersal and introduction is the transportation of fouling biota, sessile and adherent, on ship hulls. Many cosmopolitan members of the fouling community are quite possibly older introductions into the Mediterranean.

Serpulid worms of the genus *Hydroides* are frequently found in tropical fouling communities and are among the earliest documented invaders of the Mediterranean: *Hydroides dianthus* was documented in Izmir as early as 1865 and collected in Trieste in 1874; *H. dirampha* was recorded in Naples in 1870; *H. elegans* was found together with *H. dirampha*

Exotics in the Mediterranean....

in the Naples harbour fouling community in 1888. Given the state of marine taxonomy in the 19th century, these three *Hydroides* species may have arrived many years before they were first detected. They are now well-established in ports and lagoons throughout the Mediterranean, where they cause major fouling on artificial substrates. These worms are absent, however, from natural marine habitats.

Of the 61 marine macrophyte species probably introduced into the Mediterranean, 11 came by fouling on ship hulls; five of these entries occurred at least half a century ago.

The interoceanic transport of ballast water in ever-larger, ever-faster vessels has caused a dramatic increase in marine bioinvasions. The American blue crab, *Callinectes sapidus,* was transported into the Mediterranean in ballast tanks. It was first recorded in the Mediterranean in the 1940s, in Egypt, and successively in Italy, Israel, the Aegean Sea, southern coast of Turkey, the Sea of Marmara and the Black Sea.

The veined rapa whelk, *Rapana venosa,* native to the Sea of Japan, was probably introduced into the Black Sea in the 1940s. It was first recorded in 1947 from the oil-exporting port of Novorossiysk; it has since spread to the Aegean, Adriatic and Tyrrhenian Seas. Range extension is probably mediated by ballast transport in early life-history stages. In the Black Sea, *R. venosa* has expanded rapidly and decimated the commercially valuable *Mytilus galloprovincialis.*

Suez Canal entry point

The opening of the Suez Canal in 1869 initiated the invasion of Erythrean biota into the Mediterranean - hundreds of Erythrean species traversed the canal and settled in the Mediterranean.

The Scyphozoa jellyfish, *Rhopilema nomadica,* has proliferated in an astonishingly short span of time. This jellyfish was first collected in the Mediterranean in 1977. By the mid-1980s huge swarms were appearing each summer along the south-eastern Levant coast. The massive swarms of these voracious planktotrophs, some stretching 40km, adversely affect fisheries. When drawn near shore, these swarms have blocked water intake pipes of power stations. Swarms of *Rhopilema* may have precipitated the population increase of the commercially important carangid fish *Alepes djeddaba,* whose juveniles shelter among the jellyfish's tentacles.

Other abundant invaders are exploited commercially. An early Erythrean invader, the swimming crab *Portumnus pelagicus,* was recorded from Port Said in 1898. This crab soon became abundant and in the early 1900s

The Scyphozoa jellyfish *Rhopilema nomadica*

it was offered in the markets of Port Said, Alexandria and Haifa. Erythrean fish are now nearly half the trawl-catch along the Israeli coast, and Erythrean penaeid prawns make up most of the shrimp catches along both Egyptian and Israeli coasts. Growth of some invasive populations to the point that they are harvested commercially is an excellent index of how prevalent they have become.

Worrying competition

Though there is no documentation of direct competition between Erythrean and indigenous species, there are many instances of sudden changes in abundance; competition is one explanation. A native penaeid prawn, *Penaeus kerathurus,* was commonly caught by trawlers along the Israeli coastal shelf on sandy or sandy-mud bottoms and supported a commercial fishery throughout the 1950s. This native prawn has since nearly disappeared and its habitat has been overrun by the Erythrean penaeid prawns.

On top of the mariculture, shipping and Erythrean introductions, there is hapless chance: a widely invasive tropical alga, *Caulerpa taxifolia,* entered the Mediterranean courtesy of the Oceanographic Museum of Monaco. This accidental introduction with aquaria outflow probably occurred in 1984. By 1989 it was well-established off Monaco and a year later off Toulon - 150km west of its original Mediterranean colony. *C. taxifolia* has spread rapidly: in 1991 it was collected near the French-Spanish border; in 1992, in Livorno, Porto Maurizio and Mallorca; in 1993, off Elba and Sicily; in 1994, off the Croatian coast; and recently off Tunis.

The Mediterranean strain of *C. taxifolia,* a robust eurythermic, is able to withstand temperatures of as low as 7°C and can settle on sand, mud, rock and native seagrass meadows at depths ranging from 2-100m. Meadows of *C. taxifolia* can have up to 14,000 blades per m^2. The high growth rate of *C. taxifolia* and its exceptionally high densities obliterate the native seagrasses *Posidonia oceanica* and *Cymodocea nodosa.*

Native algal communities are drastically altered when invaded by *C. taxifolia.* Even encrusting algae disappear, and the associated benthic assemblages show reduced diversity: populations of fish, amphipod crustaceans, sea-urchins and polychaetes are all detrimentally affected. The toxic secondary metabolites produced by *C. taxifolia* inhibit growth of native Mediterranean macroalgae such as *Cystoseira barbata* f. *aurantia* and prevent grazing by Mediterranean macro-herbivores, at least during summer and autumn when metabolite production peaks.

The implacable spread of *C. taxifolia* threatens the existence of Mediterranean endemics like *Cystoseira* spp. because their bathymetric distribution is restricted to the infralittoral. Wherever *C. taxifolia* settles it replaces native seagrass meadows with nearly homogenous, species-poor assemblages.

Ranges expanding

Nothing prevents invading species from further travel. The Indo-West Pacific portumnid crab *Charybdis hellerii* was first sighted in the Mediterranean off the Israeli coast in 1924-1925 and has since been reported off Egypt, Lebanon, Syria, Turkey and Cyprus - a spread common to Erythrean invaders. In 1987, *C. hellerii* was collected in Cuba and in rapid succession in Venezuela, Colombia, Florida and Brazil. Transport in ballast tanks is the most probable mode of dispersal because the crab's arrival corresponds with an increase in shipping contacts with the eastern Mediterranean.

The Chinese mitten crab, *Eriocheir sinensis*, a native of east Asia, arrived in Germany with ballast water by 1912; it has since spread through northern Europe, from Finland to Portugal. The catadromous crab traversed the Garonne canal system and has been repeatedly collected in the Languedoc lagoons.

The American blue crab, transported to the Mediterranean in ballast tanks (see above), is found mainly near harbours, estuaries and lagoons. The catadromous euryhaline crab is occasionally caught in the Sea of Galilee, a freshwater lake, where it was accidentally introduced with grey mullet spat collected in the Mediterranean and used to stock the lake.

The pearl oyster, *Pinctada radiata*, was an early Erythrean invader of the Mediterranean. It is now abundant in the Levantine Basin and has spread as far west as the Tyrrhenian Sea, as well as off Sicily and Tunis. Its rapid dispersal may be due to ship-borne individuals, or to marine turtles - it has been recorded as an epibiont on a loggerhead turtle off Lampedusa Island.

Conclusions

Exotic macrophytes, invertebrates and fish are found in most coastal habitats in the Mediterranean Sea. The Mediterranean has been subject to introductions of non-indigenous species by ship traffic since the opening of interoceanic maritime routes five centuries ago. The Suez Canal has been the largest pathway for the entry of invaders: over 300 Erythrean species have established populations. Non-indigenous shellfish farms also serve as gateways into Mediterranean coastal waters for many non-indigenous camp-followers. Some invaders have outcompeted or replaced native species locally, severely reducing biodiversity. Some other invaders are so abundant they are exploited commercially. The rate of these biotic invasions has increased in recent decades; they collectively have significant ecological and economic impacts in the Mediterranean.

The rapid increase in human population density and urbanisation along the Mediterranean's shores has brought about coastal development, dredging and landfills and increased levels of agricultural run-offs and industrial wastes. These changes have caused widespread disruption of the littoral ecosystem and decimation of the biota. Low indigenous biodiversity is certainly a factor in determining the numbers of these biotic invasions.

Much of the Mediterranean littoral is no longer a 'natural' habitat. In order to track and understand the changes in the Mediterranean littoral biota, both its autochthonous and allochthonous components must be studied, and exotic bioindicators may serve as a practical and widely applicable measure of anthropogenic change.

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Young Marine Biodiversity Researchers

➨ **This newsletter aims to provide a forum for young researchers to present their work on marine biodiversity in European seas. We are looking for young researchers to offer articles for the newsletter. If you wish to submit an article please contact Chris Emblow (cemblow@ecoserve.ie). The first article (below) in the series is by Martina Orlando from the Marine Biological Station in Piran, Slovenia.**

The Importance of Diving in the Study of Marine Biodiversity in the Shallow Slovenian Sea (Gulf of Trieste)

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The Slovenian Sea represents the southern part of the Gulf of Trieste, which is the northernmost point of both the Adriatic and Mediterranean Seas. It is a shallow, semi-enclosed gulf with a maximum depth of *circa* 33m off Piran. The Slovenian coastline is approximately 46km-long. Research on flora and fauna in the Gulf of Trieste has a century-long history. However, there are several gaps in the knowledge of different taxonomic groups.

A few years ago, a research group was established at the Marine Biological Station in Piran in order to assess the status of fauna, flora and habitat types of the Slovenian coastal sea, to obtain a comprehensive inventory and to identify the factors that are having (or might have) a negative impact on the coastal and marine biodiversity.

The collection of data for this project is being carried out primarily by SCUBA-diving on linear transects along the coastal belt. The fieldwork is recorded with a photo- and video-camera. These techniques have been chosen because they are non-destructive methods - samples are collected only when the identification of organisms is not possible underwater.

The research group has a particular interest in the assessment of infralittoral fish diversity. The accurate estimation of fish populations is a current ecological problem, as long-term surveys of fish assemblages are being developed to study the impact of man-induced changes or to determine the protection status in restricted zones (Harmelin-Vivien & Francour, 1992). With the increasing number of marine protected areas in the Mediterranean, traditional fishing devices - prohibited in protected zones - could well be supplanted by visual count methods.

Small-size marine fish that by definition reach a maximum size of only 10cm have been the object of ecological investigations in several regions of the world (Gibson, 1982). These fish escape from commercial fishing gear and remain undisturbed, especially on rocky substrata. Therefore, it was not surprising that several gobiid and blennioid species of small size were described for the first time during the last 25 years from the European part of the Mediterranean Sea (Miller, 1986; Zander, 1990).

Value of SCUBA-diving

Our SCUBA-diving techniques have revealed that the infrequent capture of small fish in the past is not always an indication of true numerical rarity in the ecosystem. On the contrary, the introduction of such techniques has recently, and repeatedly, demonstrated the abundance and diversity of small fish in the Mediterranean (Ahnelt & Kovačić, 1997).

The blennioids of the Adriatic Sea have been specifically investigated and, from the checklist of Pallaoro & Števčić (1989), it can be seen that in the Adriatic Sea area some 20 species (one Clinidae, 16 Blenniidae and three Tripterygiidae) are established with certainty.

Although some descriptions of the blennioid fauna of the Northern Adriatic are available, there is still a lack of knowledge regarding the species inhabiting the Slovenian coastal waters. With SCUBA-diving, Lipej & Richter (1999) recorded eighteen blennioid species as compared to six mentioned in the first report for this area, when samples were mostly collected with trawling nets (Matjašič *et al.*, 1975).

The first survey of species from the family Gobiidae in the Adriatic Sea was in the last century, by Steindachner and Kolombatovič (Kovačić, 1994). Recently, the interest in this family has increased again. New gobiid species have been described (Kovačić, 1995, 1999; Kovačić & Miller, 2000) and the number of gobiids recorded in the Adriatic area has risen to 45.

With the SCUBA-diving techniques, it will be possible in a few years to have a quite complete inventory of the flora and fauna of the Slovenian Sea, including also the non-indigenous species that are constantly reaching our waters. Although only minor research of this kind has been carried out in the Adriatic, scientists have recorded cases of introductions of alien species that could badly affect the indigenous ecosystems. SCUBA-diving is one of the most appropriate techniques for monitoring the spread of non-indigenous species in order to understand the impact they can have once established in a new area, and to take the right measures to protect the natural biodiversity of local ecosystems.

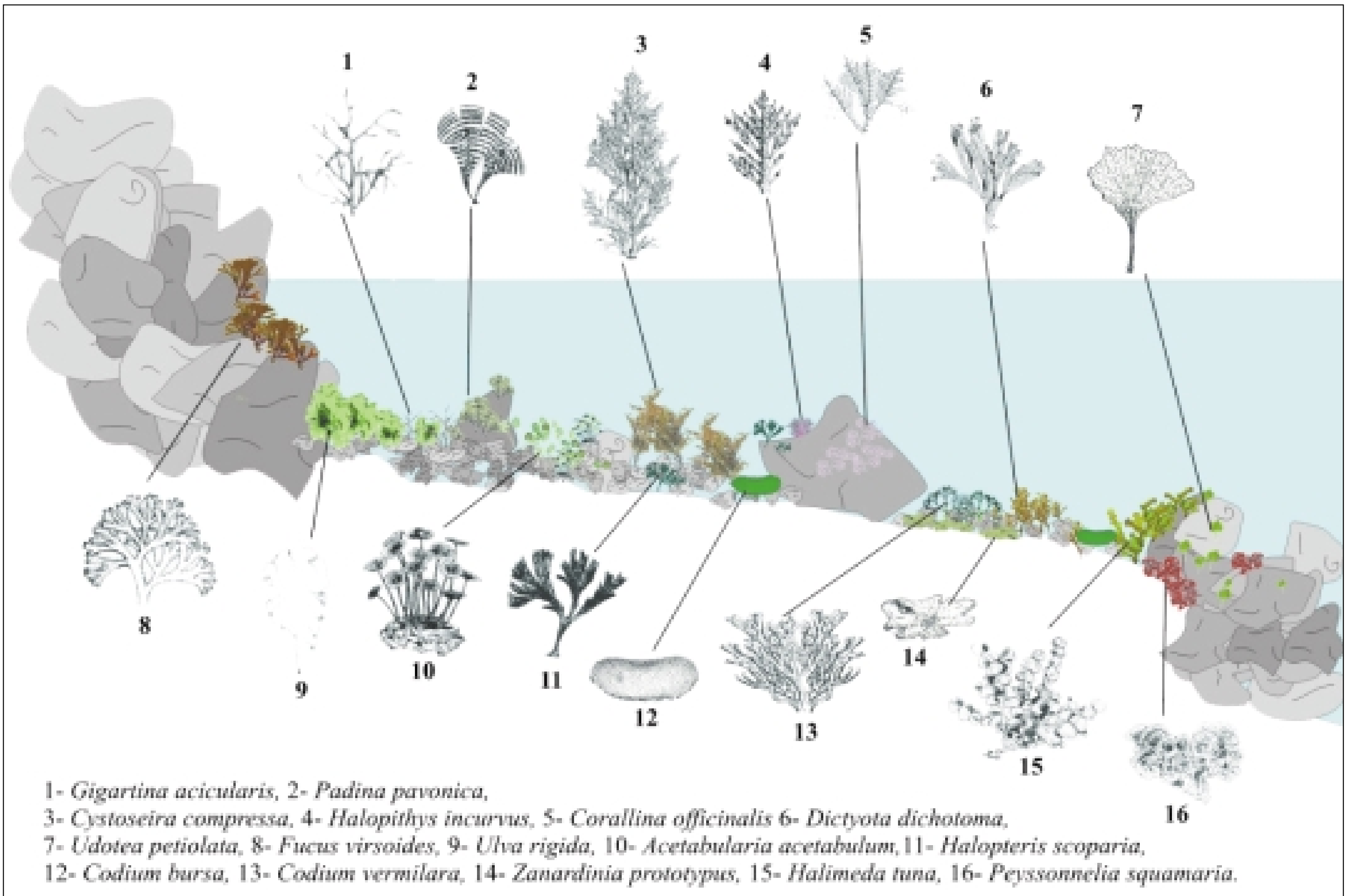

Figure 1. Some inhabitants of the Slovenian coastal area (from Lipej *et al*, 2000)

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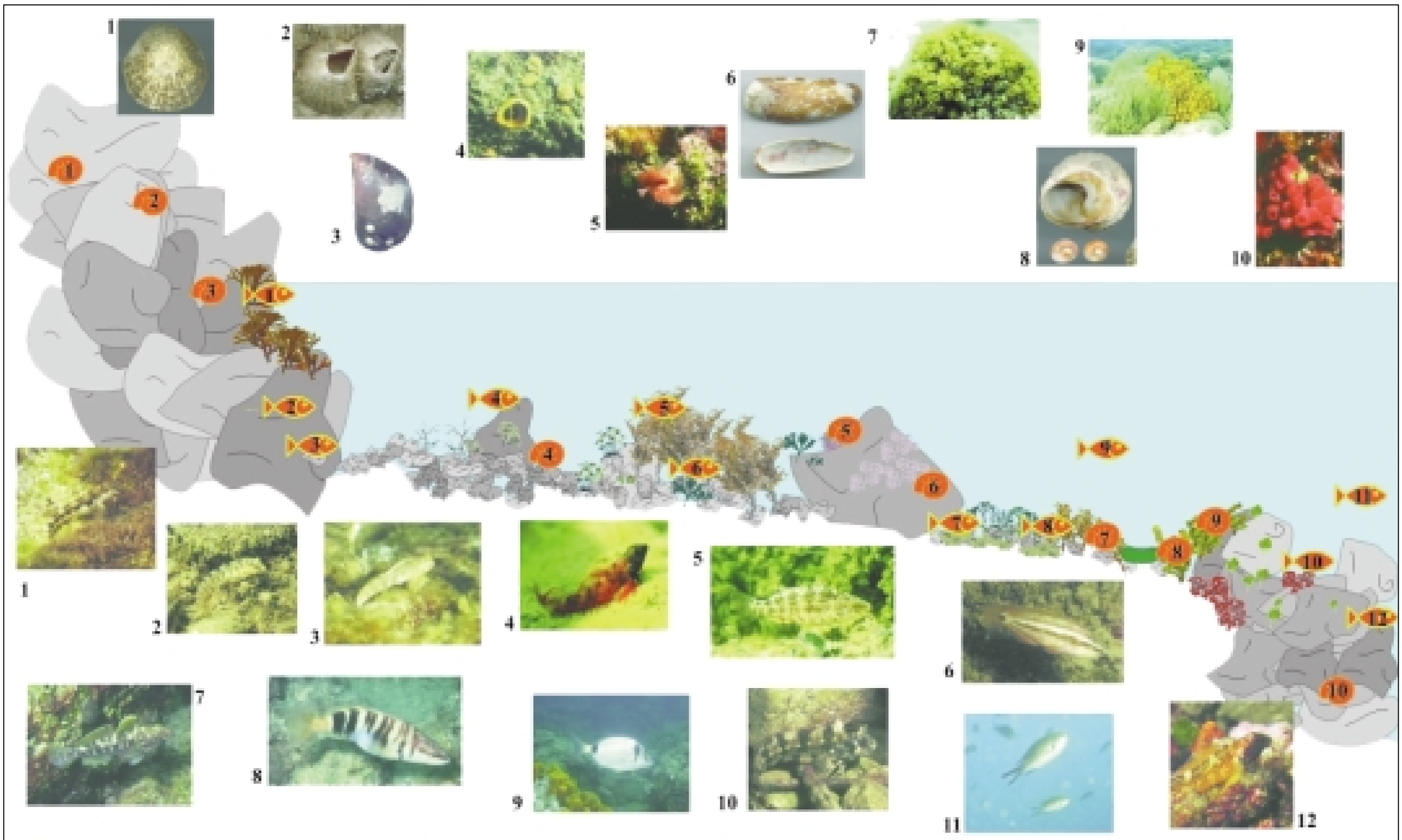

Invertebrates: 1 - *Patella caerulea*, 2 - *Chthamalus stellatus*, 3 - *Mytilus galloprovincialis*, 4 - *Cliona viridis*, 5 - *Serpula vermicularis*, 6 - *Lithophaga lithophaga*, 7 - *Cladocora caespitosa*, 8 - *Astrea rugosa*, 9 - *Verongia aerophoba*, 10 - *Haliclona mediterranea*.

Fish: 1 - *Lipophrys adriaticus*, 2 - *Lipophrys dalmatinus*, 3 - *Aidablennius sphynx*, 4 - *Tripterygion tripteronotus*, 5 - *Symphodus roissali*, 6 - *Symphodus ocellatus*, 7 - *Gobius cruentatus*, 8 - *Serranus scriba*, 9 - *Diplodus vulgaris*, 10 - *Parablennius gattorugine*, 11 - *Chromis chromis*, 12 - *Tripterygion xanthosoma*.

Figure 2. Some inhabitants of the Slovenian coastal area (from Lipej *et al*, 2000)

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