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Inter-Regional Forum

Second Meeting Report of European Marine Conventions

European Environment Agency

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1. Introduction

The mission of the European Topic Centre on Marine and Coastal Environment (ETC/MCE) is to assist the European Environment Agency (EEA) in improving information on the marine and coastal environment available at the European level. ETC/MCE is, therefore, stimulating the harmonisation of monitoring activities in the European Regional Sea Conventions and collecting information to provide a comprehensive overview of the environmental conditions of these seas in order to enable the Community, the EEA and the member countries to take measures to protect the marine and coastal environment. The ETC/MCE is also developing a methodology for the definition and application of a system of pressure and state indicators and other assessment tools relevant to coastal zone management.

In Europe, there are several regional conventions/action plans with the mandate to assess the quality of the marine and coastal environment. These are: the Arctic Monitoring and Assessment Programme (AMAP), the Black Sea Environment Programme (BSEP), the Helsinki Commission (HELCOM), the Mediterranean Action Plan (MAP) and the Oslo and Paris Commissions (OSPARCOM).

The Scoping Study prepared in the initial phase of the ETC/MCE recognised the important role of these organisations. Therefore, EEA decided to set up an Inter-Regional Forum, organised by the ETC/MCE with two main objectives:

- to facilitate the exchange and possible integration of existing data and information produced by these organisations with the EEA and the ETC/MCE;
- to improve working relations and task sharing.

A small steering group of the Forum, composed of representatives of EEA, ETC/MCE, HELCOM, MAP and OSPARCOM, was set up to decide on the Forum's topics, overall organisation and participation, and to ensure concrete results.

The First Meeting of the Inter-Regional Forum was held in Rome on October 7-8, 1996. It was attended by 41 participants from the major regional conventions/action plans, from other international organisations active in marine and coastal environment, from the EEA and its relevant Topic Centres, from the European Commission and from the European Environment Bureau. The main conclusions agreed upon by the participants were the following:

- there is a need to simplify data collection by national bodies, regional conventions and the EEA, since information and data sources are very limited and have to serve a large amount of assessment purposes;
- work duplication needs to be avoided since national institutions are overwhelmed with requests for information and data and have limited capacities to answer due to limited resources and different work agendas;
- the production of higher quality information and data requires the harmonisation of monitoring designs, assessment methodologies and tools as well as reporting;
- the identification of research priorities common to regional conventions/action plans would stimulate the improvement, at the European level, of quality assurance and monitoring strategies and techniques;
- the need to continue the Forum as a means to co-operate with the EEA was stressed by the regional conventions;
- assessment techniques and tools were selected as the most important topic to be tackled by the Forum's second meeting.

Subsequently, the Steering Group of the Forum decided to also include, as a topic for the Second Forum Meeting in 1997, the identification of research needs to improve assessment.

The Report of the First Meeting as well as the background paper on European Level Arrangements for the Protection of the Marine and Coastal Environment are available from the ETC/MCE Secretariat, ENEA's Marine Environment Research Centre, S. Teresa, La Spezia, upon request to EEA.

2. Summary report of the second meeting

The main objective of the Second Meeting was to stimulate agreement/consensus on common actions by the regional conventions/action plans and the EEA on the following topics:

- activities for the development of common assessment tools (Session I);
- research needs to improve assessments (Session II).

The meeting was chaired by Prof. Philippe Bourdeau, Chairman of the EEA's Scientific Committee.

The meeting was attended by 40 participants, representing the EEA, the main regional organisations /conventions, ICES, the Topic Centres on Inland Waters, on Nature Conservation and on Land Cover, and DGXI and JRC of the European Commission. The National Environment Research Institute of Denmark (NERI), which officially expressed to the EEA its interest to become a partner to the ETC/MCE, was also present as an observer. The list of participants is provided in Annex 2.

It was opened by introductory statements made by Matteo Baradà, Director General of the Central Inspectorate for Sea Protection - Italian Ministry for the Environment, by Francesco Mauro, Director of ENEA, Environment Department, by the Forum's Chairman and by Gordon McInnes, EEA, Programme Manager for Monitoring and Databases. In order to facilitate discussion in the meeting, two sessions were organised.

The discussion of Session I was based on a working paper, presented and prepared by Margarida Cardoso da Silva (LNEC/ETC-MCE), as lead author, and Ben Van de Wetering (OSPARCOM). It presented an overview of available assessment tools, their basic concepts and utilisation experience, as a starting point for development of a longer term process aiming at increasing co-operation and co-ordination on a Europe-wide scale. It covered mostly the experience of OSPARCOM and the EEA. It was followed by presentations of assessment tools within AMAP, illustrated by Lars Otto Reiersen and within HELCOM, by Eeva-Liisa Poutanen. Furthermore, the Barcelona Convention assessment tools (MAP/MED POL Programme) and the design of a monitoring programme for the Black Sea were presented by Franco Saverio Civili and Lawrence Mee, respectively.

In introducing the section on ways and means to compare, harmonise and co-operatively improve assessment tools, Ben Van de Wetering underlined that differences in defining assessment concepts exist among the Conventions. They stem from differences in the political context in which they originate as well as in environmental conditions and, therefore, in environmental priorities, e.g. the impact of fisheries. Although some organisations, e.g. OSPAR, HELCOM, AMAP and ICES enhanced their co-operation in recent years, there is still scope for further improvement.

The following discussion focused mostly on what an assessment should cover, on the process of preparing an assessment, on common actions needed to exchange information and to develop specific tools. Background/reference levels, statistical tools, Geographical Information Systems, ecotoxicological assessment criteria and indicators were considered. The following priority topics were selected for further common work:

- further development of statistical tools;
- Geographical Information Systems.

Decisions were taken to set up a small expert group for each of these topics. The first group will be convened by ICES (Janet Pawlak) and the second by EEA (Sheila Cryan). They were to prepare by the end of February 1998 a draft workplan (including financial implications) to be circulated among the Forum participants for comments and to the Forum's Steering Group for review and submission to the appropriate body of the regional conventions and the EEA.

The full report of Session I is presented in Section 3 of this report. A synthesis of all presentations made in Session I and the set of open questions, to stimulate the discussion, are presented in Section 5.

Session II was based on a working paper prepared and presented by Hein Rune Skjoldal as lead author together with Tor Bokn and other authors from the major regional conventions/action plans. The presentation included a brief review of the extensive research activities conducted within the relevant research programmes of the EC (DGXII) and identified the following priority research areas to improve assessment work by the regional conventions/action plans:

- Ecosystem properties;
- Species and Habitat;
- Transport pathways and processes in marine ecosystems;
- Biological effects of contaminants.

A discussion followed to decide on which common actions to concentrate future attention. The topics of interest varied from remote sensing techniques to biological effects. The need for a “holistic” research approach was also emphasised as well as the importance of diffuse sources of pollution. The need to ensure that marine biodiversity is appropriately considered within a Pan European Strategy on Biodiversity was also stressed.

The main decisions reached by participants were the following:

- the research priorities of the Conventions can provide a useful input to the preparatory process of the 5th Framework Programme on Research and Development for possible incorporation into specific research fields to be reflected in subsequent calls for proposals. Therefore, it was agreed that the background paper, appropriately modified by Hein Rune Skjoldal, with possible additional inputs from the regional conventions, would be forwarded to the European Commission (DGXII), by the EEA;
- a common project proposal will be developed on biological effects of contaminants, to be submitted for EC funding, by a group of experts from the regional conventions and ICES to be convened by the EEA in Copenhagen in April 1998;
- two workshops will be convened jointly by the regional conventions in 1998 on (a) transport models and (b) combined effects of contaminants, with the aim of exchanging information and examining further co-operation activities among the conventions. AMAP offered to verify, at its next regional meeting, the possibility to organise the workshop on combined effects as well as the possibility for one of the AMAP member countries, Norway, to organise the workshop on transport models, through the Institute of Marine Research (IMR) which is also an ETC/MCE partner. The Laboratorio Nacional de Engenharía Civil (LNEC), Portugal, another ETC/MCE partner, indicated its interest in joining such an initiative.

Furthermore, during the presentations and the following discussions reference was made to the possible use of earth observation data for the assessment of the status of the marine/coastal environment. It was pointed out that earth observation cannot provide all the information/data necessary for the description of the marine/coastal environments but it could make a useful and significant contribution. It should, therefore, be worthwhile to consider appropriate activities/ studies in order to support the integration of Earth observation data into the relevant monitoring and assessment programmes. To this effect, it was suggested, as a starting point, that the possibility be investigated of organising a workshop (sponsored by the CEO or Marine Environment Unit of Space Applications Institute) at JRC, on how satellite observation techniques could offer some solutions to meet data requirements by regional conventions. Such a workshop could stimulate constructive CEO/Conventions/EEA interaction on monitoring programmes in the marine and coastal environment, for example through the DESIMA and LACOAST Projects.

The full report of Session II is presented in Section 4 of this report. The presentation made in Session II and the set of open questions, to stimulate the discussion, are presented in Section 6.

The follow-up mechanism to implement the actions agreed upon will remain light and flexible and will be based upon the goodwill and motivation of all participants. The ETC/MCE Lead Organisation will continue to facilitate and stimulate interaction among participants, as appropriate. The results of the activities of the expert groups and the programmes of the workshops will be finalised in consultation with the Steering Group of the Forum, which should include all five regional conventions. These results shall be submitted to the next Forum’s meeting to be held in the Spring of 1999.

Reporting requirements of the regional conventions/action plans were not on the agenda of this Meeting. However, it was deemed appropriate to update the overview table on the Reporting Requirements and Linkages to Political Agendas, produced at the First Forum Meeting. The updated version is provided in Annex 1.

3. Welcome and opening statements

On behalf of the Rt. Hon. Edo Ronchi, the Italian Minister for the Environment, I would like to give you a warm welcome to this meeting, which intends to emphasise the relevance of regional and international co-operation for a successful policy of environmental protection.

The long experience in several international arenas intertwined with the enforcement and implementation of the international conventions and legal protocols relating to the marine environment stresses the importance and the need for public administration officers to rely on accurate and comparable data. To this regard, as global conventions become more and more important, it's evident that data and information sharing among European countries becomes more vital than ever.

To protect the marine environment means to adopt policies to prevent pollution of the sea as well as to intervene whenever it may be necessary to contain and reduce the damage to marine resources and environment due to spillages or inputs by land-based sources of any kind of oil or other noxious and hazardous substances.

The availability of good data and the degree of consensus regarding its quality is also paramount to the process of negotiating international agreements and, even more, of negotiating the implementation of regulatory measures and tools.

The Italian Ministry of the Environment, therefore, supports the efforts of the European Environment Agency to produce objective and reliable data which may be used by both national and European policy-makers in their decision-making process and to gain public consensus on environmental measures and their enforcement.

This approach means a double task for the Ministry of the Environment, which is not always an easy one: ***on the one hand*** we intend to support national inter-agency and inter-institutional co-ordination in collection, control, handling and dissemination of data related to the marine environment in order to appropriately feed our own national data and information into the EEA system; ***on the other hand*** we are also the national users of this information and we must make an effort to improve the use of it, by specifying, as much as possible, our utilisation requirements for the European Environment Agency products in agreement with other European countries and institutions.

We are well aware of the difficulties which lie ahead, but we are firmly engaged in pursuing those tasks, because we believe that benefits may outweigh costs.

Good quality of data which may be commonly shared will not only help to produce better environmental measures and policies, but will have direct effect on improving present guidelines and legislation. This in turn, it is hoped, will influence a policy approach oriented to the sustainability of productive and commercial activities taking into account the need to preserve and improve our environment. In the long term, this goal will be to the advantage of the productive sectors while preserving and improving the quality of life in the interest of the regional national, and world communities.

It may be redundant to stress the importance for Italy of a consistent policy for the protection of the marine and coastal environment, due to the special and sensitive nature of the Mediterranean Sea.

The use of coastal and marine resources of the Mediterranean Sea may represent a proportion of one to ten between dwellers and tourists during the summer season. The sea within this basin does not only represent an area in which to exercise economic or productive activities (fishery, transports, off-shore research or exploitation of sea-bed resources, etc.) but a resource in itself. So much so that any approach to an "integrated coastal management" has been focused in Italy on the marine area and the line of the coast facing inland. The conservation and fruition of the sea is by itself a main topic for a policy of sustainable development with regard to the multiple uses of the marine environment. Of course, it is also important that no negative impact may come from land based sources of pollution.

The Regional Activity Centre for Environment Remote Sensing, which operates within the

Mediterranean Action Plan of the United Nations Environment Programme is situated in Palermo and works in this direction too.

I wish on this occasion to reaffirm that the Italian Ministry of the Environment will also continue to support the efforts of the European Topic Centre on Marine and Coastal Environment in improving its role and impact within the activities of the European Environment Agency.

Let me say that we are proud to host such an important meeting here in Italy and wish you good work.

Dr. Matteo Baradà, General Director,
Inspectorate for the Protection of the Sea, Italian Ministry of the Environment

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Welcome on behalf of ENEA, the Italian Agency for New Technology, Energy and the Environment.

The first Meeting of the Forum, here in Rome last year, marked an important event in the activities of the ETC/MCE.

At that time, the ETC/MCE had been operational for less than a year, following the Scoping Study stage, to which several of you had contributed.

The ETC/MCE has recognised from the very beginning the fundamental role of Regional Conventions and Action Plans in data gathering and handling, in support of policy formulation to their own constituencies, in the north and in the south of Europe. Meeting with them all last year has, therefore, offered the ETC/MCE the opportunity to better understand their working methods, outputs and reporting requirements.

I believe that it also offered the Conventions the opportunity to stimulate co-operation with one another and with the EEA to overcome bottlenecks and gain from each others' work and possible task sharing. In fact, specific agreements with the EEA are being finalised and ETC/MCE experts have attended relevant technical meetings of the Conventions and have consulted extensively with Conventions' experts on products to be produced by the ETC/MCE.

The overall balance in terms of deepening each others' understanding and stimulating discussion on concrete actions seems indeed positive. We can now go beyond this first stage and concentrate on identifying actions in the two topics which you have yourself selected last year, as the most promising to work on together.

You have in front of you two introductory papers which are good starting points to agree on common actions. Appropriate tools are the key to good assessments. Their choice and application methods influence results. Good research is also important to improve monitoring, measurement and quality of data.

I am therefore certain that by the end of the Meeting you will have contributed to tackle important issues and, above all, to identifying who and when, among the participating institutions, can implement follow-up actions.

On the part of ENEA we are honoured to contribute to this process by organising this Meeting and are ready to continue to contribute in the future to the Inter-Regional dialogue through whichever ways may be identified by all of you as the most constructive.

As for the other activities of the Topic Centre, following the initial steps of the ETC/MCE and some undeniable difficulties, some internal and some external, not totally uncommon to other ETCs, ENEA has reconfirmed to the EEA its commitment to carry out the improvements requested by the EEA Management Board.

I now wish you all a good work.

Dr. Francesco Mauro, Director
Environment Department, ENEA

4. Session I - Assessment tools

Ben Van De Wetering/Margarida Cardoso da Silva, Rapporteurs

4.1. Definition-Concept of assessment

The Forum agreed that an assessment should cover:

- environmental state variables (e.g. levels and distribution of contaminants in different ecological compartments and impacts of these contaminants);
- evolution over time and space of the variables;
- factors influencing the variables, the driving forces or pressures, i.e. natural and anthropogenic factors.

The knowledge of these state variables and pressures on the environment is obtained through the observation of the environment (e.g. monitoring activities).

In most cases an assessment implies judgements of the quality of the environment (e.g. whether it is healthy or degrading). The Forum also agreed that tools are required to enable such judgements, e.g.:

- to compare the values of the variables with available criteria;
- to decide on the significance of an observation or a trend;
- to uncover and understand relations in the chain pressures - state - impact.

Furthermore, the Forum recognised that a goal of an environmental quality assessment is to set a basis for decisions on the need for action. As such, a further type of assessment deals with the effectiveness of managerial and political actions or measures. This type of assessment is based on the analysis of the evolution of state and pressure variables but also involves other factors.

4.2. The process of preparing an assessment

The Forum agreed that an assessment must follow an established set of procedures that will allow the design of methodologies specific to each type of problem/issue. This process of assessment is:

- complex, both in scientific terms as it covers several disciplines and in organisational terms;
- time consuming;
- dependent on the cultural, social and political framework.

The methodology must include:

- the tools to be used;
- the criteria for judgement;
- the source of data and how it is processed;
- the frequency of updating the assessment.

4.3. Discussion

With the aim of identifying future work on the development of assessment tools, the Forum identified the following topics for further discussion:

- background/reference levels;
- statistical tools;

- GIS;
- ecotoxicological assessment criteria;
- indicators.

In discussing these topics the following general comments were made:

Background/reference levels

a. background/reference levels are a basic requirement when using any system of indicators;

b. the way to derive background/reference levels should be harmonised and the underlying concept could be expanded to enable a wider use;

c. it is likely that the concept of background/reference levels will be included in the EU Directive establishing a framework for Community action in the field of water policy;

d. the topic was not given priority within HELCOM;

e. the concept of reference stations is being developed for freshwater;

Statistical tools

a. statistical tools are available and are used for several purposes (e.g. detection of trends and analysis of the 'power'[1] of existing marine monitoring programmes). For other purposes (e.g. analysis of eutrophication parameters or the joint effect of various contaminants) further developments are required;

GIS

a. the Conventions clearly indicated a need for the use of GIS systems as an assessment tool but do not have the possibilities to develop such tools;

b. the development of advanced GIS systems is a complicated and time-consuming process involving a high level of expertise but simple systems are also available and relevant to our work;

c. a stepwise approach could be followed starting with the development of tools for visualising data ultimately aimed at full blown GIS systems;

Ecotoxicological assessment criteria (EACs)

a. EACs can play a role as a warning system but do not give an indication about actual biological effects;

b. further work on EACs could be addressed in the context of the discussion on biological effects monitoring (cfr. Session II)

Indicators

a. there is a certain similarity between the concept of indicators (as elaborated by the ETC/MCE) and the concept of Ecological Quality Objectives (being developed by OSPAR);

b. the concept of indicators makes use of many of the tools discussed earlier (e.g. statistical tools, reference values, GIS);

c. developments of such tools should be co-ordinated with the further development of the concept of indicators;

d. the Conventions should be involved in the further development of the concept of indicators.

1. [Power measures the effectiveness of a monitoring programme by quantifying the types and magnitudes of changes that are likely to be detected. Specifically, power is the probability that a specified change is detected (ICES 1994. Report of the ICES Advisory Committee on the Marine Environment, 1994. ICES Cooperative Research Report, No. 204]

4.4. Further action

Taking into account the point made above, the Forum selected further work on statistical tools and GIS as priority topics and nominated Janet Pawlak (ICES) as convenor for the topic of statistical tools together with EEA. Furthermore, the Forum agreed on the following line of action on these two topics:

a. The convenors for the two topics mentioned above prepare draft terms of reference for the work to be carried out for approval by the members of the Steering Group by mid December 1997;

b. The convenor then should arrange a meeting of a small group (max. 5-7 persons) of experts (people with knowledge about the tool and people about knowledge about the need for the tool). This group should prepare by the end of February 1998 a draft workplan (including any financial implications) for further action on the topic;

c. The workplan should be circulated to the members of the Forum for their comments;

d. The Steering Group of the Forum will then review these comments and finalise the workplan for submission to the appropriate body of the four conventions and the EEA for discussion and approval;

e. Taking into account any comment made by the Conventions or the EEA, the Steering Group should decide by June 1998 whether and how actual further work should be started.

5. SESSION II - Major research needs to improve assessment

Gabriel P. Gabrielides, Rapporteur

The background paper was presented by Hein Rune Skjoldal who emphasised the basic challenges and described the main research activities existing at the European level, to improve assessment work.

The priority research fields considered were the following:

a. Ecosystem properties

- research into methods for characterising and expressing the changing states or health of marine ecosystems;
- research into climatic driving forces for ecosystems variability at the regional and European level;
- research on food-webs, interactions and dynamics of marine ecosystems.

b. Species and habitats

- research on methods for mapping and producing inventories of marine habitats;
- research on rare habitats and rare species.

c. Transport pathways and processes in marine ecosystems;

- basic research on transport pathways and processes;
- research on transport models.

d. Biological effects of contaminants

- research on quality assurance of biological effects techniques;
- research on further development of biological effects techniques and bioindicators;
- research on combined effects of contaminants.

The following specific research areas were proposed for co-ordination and concerted action at the European level.

a. A Quality Assurance Programme to be developed for biological effects techniques which have been identified and used in certain monitoring programmes. This could be similar to QUASIMEME which has been developed for the monitoring of chemical contaminants;

b. Transport models. Co-operation between the Conventions could be in the form of a common project or in the co-convening of a workshop;

c. Climatic driving forces. This activity could be linked with GOOS;

d. Combined effects of contaminants. Co-operation through the organisation of a workshop.

At this stage a number of representatives of Conventions and of Topic Centres took the floor to describe their activities.

During the discussion which followed, participants expressed their views on research priorities. As the topics of interest varied from remote sensing to biological effects, it was necessary to set some priorities. All the Conventions included in their priorities biological effects of contaminants which was considered a prime area for inter-regional co-operation. The ICES representative reported on a proposal which has been prepared for the development of a Q.A. Programme for a number of techniques and she asked the support of the Forum which was given.

Decisions

After a lengthy and constructive discussion, the following decisions were taken by the Forum.

a. The research priorities of the Conventions should be made known to the EU (DG XII) which is preparing the 5th Framework Programme for Research. The background paper could be modified accordingly and submitted to EEA which can transmit it to DG XII. Specific ideas for the modification of the paper should be sent by the participants to Hein Rune Skjoldal before November 23, 1997. He would then incorporate the views and send the modified paper to EEA.

b. It was decided to develop a common project proposal on biological effects of contaminants and submit it to the EU for funding.

c. The details of this proposal will be elaborated at a meeting of experts to be convened by EEA in Copenhagen in April 1998. All Conventions and ICES will be represented. The final proposal will have to be endorsed by the Steering Committee.

d. It was decided that the Conventions jointly convene two workshops during 1998. The first one will be on transport models and the second one on combined effects of contaminants. The aims of the workshop would be (i) to exchange information and review the state-of-the-art on the topic in question and (ii) to examine and propose areas for future co-operation between the Conventions.

e. AMAP volunteered to undertake the organisation of the workshop on combined effects. The organisation of the workshop on transport models will be a joint venture between two ETC/MCE's Partners, namely the Institute of Marine Research in Norway, and the Laboratorio Nacional de Engenharia Civil in Portugal.

f. The details of the programmes of the workshops will be finalised in consultation with the Steering Committee. All partners will be invited to attend.

6. Overview of available assessment tools

Authors/Contributors:

Margarida Cardoso da Silva, ETC/MCE/LNEC, Lead Author; Ben Van de Wetering, OSPARCOM; Eeva Liisa Poutanen, HELCOM; Lars Otto Reiersen, AMAP; Franco Saverio Civili, UNEP/MAP; Lawrence Mee, BSEP.

6.1. Introduction

The Oxford Dictionary defines "assess" as: estimate the magnitude or quality of…

In the environmental context, two levels of environmental assessment can be defined:

a. a description/evaluation of the state and development over time of the environmental conditions (e.g. the geographical distribution of contaminants or biota, temporal trends in concentrations) and of the anthropogenic factors/influences that determine these conditions;

b. a judgement of the environmental significance of these conditions and developments (e.g. as to whether the ecosystem is in a healthy condition).

Different kinds of tools and instruments are required for these two levels of assessment, i.e. tools and instruments for a factual description of environmental conditions and for an evaluation of the human impact and tools to judge these conditions.

Tools for an assessment of the effectiveness of environmental management decisions or measures, which could be regarded as a third or intermediate level, are not addressed specifically in this document. However, such tools should be regarded as an essential element in the overall process of an environmental assessment.

Tools and instruments enabling a factual description and evaluation of environmental conditions include statistical techniques, modelling, GIS etc. Also monitoring could be regarded as an assessment tool of the first level.

To have clear-cut criteria enabling a judgement of the environmental condition is a common aim of all environmental scientists. It is also a common demand of politician and managers, who need those judgements as a basis for their decisions. However, such criteria are normally far from universal and scientists tend to be extremely cautious on proposing or accepting dichotomic criteria that would lead to simplistic statements or conclusions between good and bad environmental conditions.

The activities and the assessment tools used by each of the regional conventions which cover the European Seas are stated below:

6.2. Oslo and Paris Commission

6.2.1. What is assessment – Concept and definitions

The two levels of assessment described above are included in the definition of an assessment adopted by OSPAR (OSPAR, 1995):

"… a statement of the whole or part of the current knowledge of the health of the environment of a defined maritime area and its coastal margin. A complete statement includes an analysis of the region's hydrodynamics, chemistry, habitats and biota with an evaluation of man's impact over space and time against this background of natural variability. All aspects of man's influence on the area should be examined including inputs, concentrations and effects of contaminants, nutrients and radioactivity, dumping, transport, and the exploitation of biological and non-biological resources."

6.2.2. Objectives for environmental assessment

The Joint Assessment and Monitoring Programme (JAMP) of OSPAR, states that the purpose of performing an assessment is to provide both managers and scientists with:

- a concise summary of contemporary knowledge and current management;
- an identification of significant gaps in knowledge which can provide an authoritative basis for defining priorities for further scientific and other investigations; and
- a basis for judging the effectiveness and adequacy of environmental protection measures and for making any necessary adjustments.

In view of the objectives of the OSPAR Convention, an assessment should focus on:

- whether and where contamination occurs (descriptive assessment);
- whether and where other adverse effects of human activities occur (judgement);
- whether human health is safeguarded (judgement);
- whether marine ecosystems are conserved (judgement);
- the effectiveness of the measures taken or planned for the protection off the marine environment (descriptive assessment); and
- priorities for action (judgement).

6.2.3. Assessment tools

Descriptive tools and instruments

Monitoring

a. The OSPAR Convention (Annex IV, Article 1) defines monitoring as the repeated measurement of:
b. the quality of the marine environment and each of its compartments, i.e. water, sediments and biota;
c. activities or natural and anthropogenic inputs which may affect the quality of the marine environment; and the effects of such activities and inputs.

For the purpose of the assessment, monitoring for spatial patterns and temporal trends is carried out to determine and describe aspects of the quality of the marine environment. To be able to contribute effectively to the assessment process, monitoring can be expressed as follows:

a. to describe the spatial distribution of a range of physical, chemical, biological and other parameters (including demography, inputs, specific activities);
b. to determine temporal trends, either as a means of assessing the effectiveness of policy measures, or to assess, by the use of suitable indicators, changes and variability in the quality of the marine environment; and
c. to establish relations between anthropogenic activities and observed spatial and temporal trends in the marine environment.

On the basis of a series of questions and hypotheses, OSPAR adopted in 1995 a Joint Assessment and Monitoring Programme (JAMP).

Background /Reference concentrations

The background/reference concentration concept is based on the assumption that it is possible to determine the concentrations of the substances of interest corresponding to a time where no significant human influence on the environment had occurred.

Statistical techniques

Statistical tools can be used to analyse monitoring and other data in a way for instance in order to identify trends in concentrations on environmental compartments. To enable the use of such tools for the wide range of possible purposes, practical protocols or a suite of methods should be developed.

Examples of assessment activities within OSPAR are a temporal trend analysis of available input data of selected substances (tools are currently being developed) or trend analysis of marine monitoring data (using tools developed by ICES).

Mathematical models

Models are used to synthesise information from monitoring data, to make forecasts as a basis for counter measures and to make informative presentations of environmental data. From an environmental administration point of view, models should be developed with the following aims:

1. to provide an integrated picture of the environmental stus of the different parts of the maritime area, combining information on e.g. concentrations, inputs, transport and biological processes and variability;

2. to provide a tool to forecast the effects of proposed measures;

3. to provide a basis for an improved description of causal connections; and

4. to provide a basis for the optimisation of monitoring systems.

The use of numerical models in conjunction with measured data constitutes a powerful tool which generates interpolated data in time and space. However, it should be realised that in applying numerical models to simulate currents and mixing conditions in the sea, it is important to use a model that reflects the major physical forcing functions of the system and which is properly verified and validated. In order to validate a model, there is a need for long-term series of data on physical and chemical variables.

OSPAR does not develop its own models. The focus is on validation of different models using common data sets. Such an exercise was recently carried out using available eutrophication models. Furthermore, an overview of available models and ongoing modelling activities was prepared.

A modelling workshop on the fate and transport of contaminants within the marine environment will take place in November 1997.

Tools to judge environmental conditions an developments

Common Procedure for the Identification of the Eutrophication Status of the Maritime Area

OSPAR in 1997 adopted a "Common Procedure for the Identification of the Eutrophication Status of the Maritime Area" (Common Procedure). The purpose of the Common Procedure is to characterise the OSPAR maritime area in terms of problem areas, potential problem areas and non-problem areas with regard to eutrophication in accordance with a specified assessment procedure. The different types of areas are defined as follows:

a. problem areas with regard to eutrophication are those areas for which there is evidence of an undesirable disturbance to the marine ecosystem due to anthropogenic enrichment by nutrients;

b. potential problem areas with regard to eutrophication are those areas for which there are reasonable grounds for concern that the anthropogenic contribution of nutrients may be causing or may lead in time to an undesirable disturbance to the marine ecosystem due to elevated levels, trends and/or fluxes in such nutrients;

c. non-problem areas with regard to eutrophication are those areas for which there are no grounds for concern that anthropogenic enrichment by nutrients has disturbed or may in the future disturb the marine ecosystem.

A strategy with regard to eutrophication is currently being developed within OSPAR. This strategy will describe the actions required for the different types of areas. In general these actions will be as follows:

1. in the case of non-problem areas with regard to eutrophication, the status of the area with regard to eutrophication will be reassessed by applying the Common Procedure if there are grounds for concern that there has been a substantial increase in the anthropogenic nutrient load;

2. in the case of potential problem areas with regard to eutrophication, preventive measures should be taken in accordance with the Precautionary Principle.

3. Furthermore, there should be an urgent implementation of monitoring and research in order to enable a full assessment of the eutrophication status of the areas concerned. Such an assessment should be carried out within five years of the identification of the area as being a potential problem area with regard to eutrophication;

4. in the case of problem areas with regard to eutrophication:

- measures shall be taken to reduce or to eliminate the anthropogenic causes of eutrophication;
- reports shall be provided on the implementation of such measures;
- assessments shall be made of the effectiveness of the implementation of the measures on the state of the marine ecosystem.

Ecological quality objectives (EcoQOs)

Proposed definitions:

- *Ecological quality reference level*: - the level of ecological quality where the anthropogenic influence on the ecological system is minimal.
- *Ecological quality objective*: - the desired level of ecological quality relative to the reference level. (The purpose of the EcoQO is to ensure that the ecological quality is either maintained or improved).

The basic criteria for selection of parameters or variables to be included in expressions of EcoQ fall into two broad categories, one reflecting basic ecosystem properties and the other reflecting human use or impact on the marine environment.

It is recognised that to describe EcoQ and to set EcoQO is a complex issue which still requires a lot of work in order to overcome existing theoretical, practical and principal difficulties.

The methodology to set EcoQO should follow a stepwise approach , which includes, among others the following:

a. Developing means of expressing EcoQ based on the information content of the chosen parameters.
b. Developing tools for setting objectives for EcoQ – the EcoQO, in a way, that reveals cause-and-effect links. This will help to clarify policy options.

An exercise to express the EcoQ and derive the corresponding EcoQO was performed using the issue eutrophication.

In diagram 1 such methodology is presented.

Ecotoxicological assessment criteria

Ecotoxicological Assessment Criteria (EAC) are considered to be an essential component in any assessment of data from chemical monitoring programmes, as such criteria are an indication of concentration levels of contaminants below which no harm to the environment is expected.

The data used in the development of EAC included toxicity data for water and sediment, estimates from the Canadian BEDS database, calculated and measured estimates for partitioning coefficients, calculated and measured coefficients for bio-concentration factors as well as toxicity data for birds and mammals concerning contaminants evaluated for bio-magnification.

In 1997, OSPAR adopted a set of EAC for use as an assessment tool in the QSR 2000. These criteria were derived following agreed procedures and using all ecotoxicological data passing pre-defined quality criteria.

The basis of the agreed procedure was the derivation of an extrapolated concentration by selecting the lowest NOEC or L(E)C50 from the accepted ecotoxicological information. Subsequently, an EAC (expressed as a range) is generated by setting an interval around the extrapolated concentration, which depends on the extent of the data set.

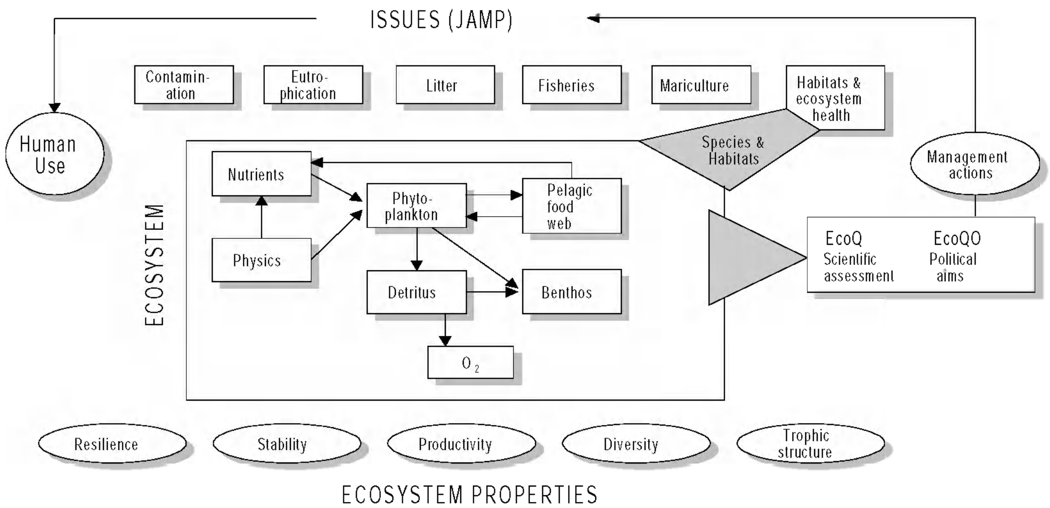
The use recommended for EAC is on the identification of possible areas of concern and to indicate which substances could be considered a priority. EAC shall not be taken as standards or trigger for remedial action. Furthermore, the EAC do not take into account specific long-term effects and do not include combination toxicity.

Another important use for EAC is if, in an integrated chemical and biological effects programme, effects are found then ecotoxicological assessment criteria could be used to diagnose which compounds may be responsible.

Sediment quality criteria

An overview of information from all OSPAR Contracting Parties about their national sediment quality criteria (SQC) and how they are applied in being prepared within OSPAR. However, the development and use of such SQC on a more general level will be hampered as the available national criteria and the related action levels are different depending on local conditions and background levels.

Diagram 1



6.2.4. Experience of use

In the North Sea Quality Status Report (1993) some background concentrations were used for selected substances and in particular cases Ecotoxicological criteria and background values have been adopted to use as an assessment tool in the QSR2000 of OSPAR.

Although the underlying approaches of the tools described above and their applicability are not generally accepted at the national level and their scientific sustainability is often questioned, such tools are currently the best available method to help translating the (imperfect) knowledge of our coastal and marine environment into a basis for decision making and to evaluating effects of environmental protection programmes and policies.

6.3. Helsinki Commission

6.3.1. Introduction

Within the framework the “marine environmental assessment” is collection, analysis and interpretation of information with the purpose of assessing the quality of marine areas. It is a rather comprehensive process comprising the collection of reliable physical, chemical and biological information to assess the impact of human activities against a background of spatial and temporal variability.

Within the HELCOM framework an assessment has never been unambiguously defined. Therefore, two types of assessments have been elaborated:

- A “thematic assessment” of limited scope, concerning evaluation of data on a specific subject, e.g., reporting on pollution load compilation data covering a specific period, or assessing the results of the baseline study of contaminant levels in Baltic Sea sediments, etc.,
- PLC-reports:water 1987(1985), 1993 (1991) and 1997 (1995)
- air 1989 (1983-85 and 1986), 1991 (1986-90) and 1997 (1991-95)
- An “integrated assessment” which implies “bringing together” of information from a variety of sources, and relating these data in a meaningful way. For example, assessing the results of temporal trends in contaminant levels as observed in environmental media in relation to inputs of these contaminants to the respective area over the same period, and considered within the context of implementation of policies and measures aimed at reducing such inputs.

The three periodic assessments of the state of the marine environment of the Baltic Sea (1980-85; 1984-88 and 1989-93) published so far can be classified as “integrated assessments”. The “audience” of the periodic assessments prepared within the HELCOM framework is managers, the general public, and scientists. The aim of the assessments is to provide a compact summary of contemporary knowledge, status and trends in environmental quality and if possible, hints for necessary management actions; to identify significant gaps in knowledge, providing thus a basis for defining priorities for further scientific and other investigations; and to provide a basis for judging the effectiveness and adequacy of environmental protection measures.

The basis for the assessment activities within HELCOM are various monitoring programmes co-ordinated by the Commission.

6.3.2. What is assessed and how?

- In the periodic assessments a so-called “ecosystem approach” has been applied covering the following issues:
- climate (air temperature, precipitation, etc.), ice conditions and hydrology (river-flow),
- hydrography; e.g., effects of saline water inflow/changes in salinity, changes in temperature, oxygen and hydrogen sulphide (few examples)
- hydrochemistry; nutrients (PO4, NO3+ NO2, NH4, SiO4) in the surface layer and in deep waters (seasonal and regional variability, long-term variations),
- pelagic biology; phytoplankton, biomass, chlorophyll-a, and mesozooplankton (seasonal, regional and long-term variations)
- benthic biology; macrozoobenthos and macrophytobenthos (abundance and biomass, regional and long-term variations)
- bacterioplankton (temporal variations in the Gulf of Bothia and Kiel and Meclenburg Bights, spatial variations in other areas)

- contaminants in biota (regional and temporal variations)
  - * halogenated hydrocarbons (PCBs, DDTs, HCHs, HCBs, polybrominated diphenylethers, polychlorinated dibenzo-p-dioxins and dibenzofurans)
  - * petroleum hydrocarbons (only very limited amount of data available)
  - * heavy metals, temporal changes, (biota main matrix, some data in water): Pb, Cd, Hg, Cu, Zn,
- new topics in the Third Periodic Assessment:
  - * artificial radionuclides
  - * fish stocks and diseases and parasites (by ICES)
  - * nature conservation and biodiversity (e.g. marine mammals, sea birds)
  - * harmful algae, sanitary conditions in coastal waters etc.

Hydrographical conditions in various subregions of the Baltic Sea may vary remarkably (e.g., salinity decreases from about 20 PSU in the Kattegat to about 5-7 PSU in the Bothinia Bay). Also seasonal differences, e.g., nutrient concentrations are big. Furthermore, a certain season differs in time in different parts of the Baltic, e.g. in the southern parts spring can be in March/April whereas in the most northern parts it is only late May/early June. Therefore, in the assessment work special care has to be taken when compiling data. Due to large-scale natural variations for the Baltic Sea, it is very difficult to state whether the observed changes are due to the environmental protection measures taken or as a result of natural variation.

To make the situation more complicated, the water column is layered, which makes it necessary to divide the water column into several distinct compartments, all of which are not relevant in all areas. The general division into surface and deep waters, wherever a halocline is present, is supplemented by a winter water layer (or layers) above the halocline and an intermediate layer below, as e.g., the layer from about 100 m down to the beginning anoxia (if present). In some areas there may be reason for a separate treatment of a bottom layer. The surface layer in general defines the nearly homogenous layer from the surface to the halocline or the winter layer. For trend analyses of (winter) surface concentrations and similar considerations this layer is sufficiently represented by the top 10 m. For calculation of mean seasonal variabilities (annual cycles) a description of the hydrochemical situation is considered to be appropriate. These seasonal cycles are the basis for the definition of periods of the year which provide the relevant data for trend calculations. The mean seasonal variability determines the data basis for trend analysis data.

The data from the selected winter period is believed to reflect trends of the anthropogenic load. However, winter nutrient concentrations are much influenced by meteorological and hydrographical conditions which should be accounted for in the trend analyses when possible, and otherwise be considered when interpreting the results of trend analyses.

In HELCOM periodic assessments usually meteorological, hydrological and hydrographic conditions are described first as background information. For hydrochemistry nutrient variability (long-term changes) as well as spatial nutrient distribution is covered. Regarding trends in the open sea the data for a specific assessment period does not allow an evaluation of trends, since a period of at least ten years is needed to get reliable results from trend tests. This is due to the test statistics and the ability to separate short-term variations from changes in the system. In the last assessment work the trend analysis was therefore made for two different periods, one covering the whole period of reliable data (e.g.,1970-93) and the other covering the three HELCOM assessment periods from 1979 to 1993. For practical reasons trends in the open sea and in the coastal zone are considered separately.

6.3.3. Background/reference concentrations

Within the HELCOM framework no specific background/reference values have been set, since as stated above, the natural variations as well as regional differences are so big in the Baltic Sea (e.g. O2 situation). Furthermore, it is very difficult to decide on these values for heavy metals since for example the increase in concentrations of cadmium in organisms towards the north is, at least partly, a consequence of salinity on the bioavailablity of this element (the change in salinity causes change in the chemical speciation of cadmium, which in turn may have an influence on the efficiency with which this element is accumulated by marine organisms). In case background/reference values able to be established they would most probably differ from one sub-region to the other. It is equally difficult to decide what should be the background value for artificial compounds (like PCB, or DDTs).

In 1990 the Baltic Sea Environment Conference decided to elaborate within the framework of HELCOM a joint action programme for the Baltic Sea aimed at reducing pollution decisively in order to assure the ecological restoration of the Baltic Sea, to ensure the possibility of self-restoration of the marine environment and to preserve its ecological balance. The definition of the ecological balance was, however, left open and has afterwards been interpreted as meaning the environmental status of the Baltic Sea in late 1940s or early 1950s.

Nutrients as an example of the situation

It should be remembered that the nutrient concentrations do not determine the eutrophication but the biological response is important. The pronounced regional differences with respect to hydrography, and nutrient loads and budgets, complicate a general assessment of the eutrophication state of the Baltic Sea as a whole. One of the main features involved in budget calculations for example, the residence time, may vary from weeks (estuaries) to a few months (e.g., Kattegat and Belt Sea), to years and even decades (basins of the Baltic Proper).

The level of the primary production is mainly controlled by the concentrations of inorganic phosphorus and nitrogen compounds and of silicate. The majority of the Baltic Sea areas is characterised by a surplus of phosphorus and therefore the phytoplankton production is mostly nitrogen-limited. Phosphorus limitation plays an important if not dominating role in the Bothnian Bay, in the western coastal areas of the Bothnian Sea, in the Gulf of Riga and in some local areas. Taking into account the additional loads of nitrogen from the atmosphere and by nitrogen fixation, this nutrient is the variable of highest concern with respect to considerations on eutrophication in the Baltic Sea. Silicate exhibits pronounced seasonal concentration patterns but seems not to limit the production.

Horizontal distribution - As the dominating sources of nitrogen and phosphorus are land-based, a generally decreasing tendency of nutrient concentrations is found with increasing distance from the coast, and from the inner parts of gulfs and bights towards the open sea. The atmospheric deposition, i.e., mainly wet deposition of NO_x and NH_4, represents a more 'global' load. Marked regional differences occur; nitrate concentrations (winter-surface values) decrease from high levels in the Kattegat/Belt Sea area (6-9 mol dm^{-3}) along a transect through the Bornholm and Gotland Seas (around 4 mol dm^{-3}), while phosphate concentrations are rather uniform (0.6-0.9 mol dm^{-3}) along the transect. Areas influenced by coastal sources exhibit elevated concentrations, e.g., the Mecklenburg Bight, Gdansk Bight, Gulf of Riga, Bothnian Bay and Eastern Gulf of Finland.

Vertical distribution - Vertical nutrient distribution depends strongly on the regional hydrography. In general, haloclines are also ‘nutriclines’, separating surface water with lower nutrient concentrations from bottom water with enriched concentrations. As the mineralization takes place mainly in the deeper layers and at the bottom, the deep layers represent nutrient reservoirs. At low oxygen concentrations nitrate is rapidly removed by denitrification, while phosphate is released from the sediments in the presence of hydrogen sulphide and becomes enriched.

Seasonalities - The annual production of organic material in the euphotic layer is determined by the amounts of nutrients available at the start of the production (spring-diatom bloom), and by the fluxes into the euphotic layer from deeper layers, inputs from the land and from the atmosphere, as well as from internal nutrient cycles (turnover) during the productive season. Except for some local processes, the annual development of the phytoplankton production is rather similar throughout the Baltic Sea, showing a bimodular curve, with a short peak-spring-bloom and a broader maximum at the late-summer to autumn bloom. The spring bloom is dominated by new production, while the proportion of regenerated production is increasing during summer and autumn.

The nutrient concentrations observed in the productive layer are controlled throughout the course of the production cycle. There is a rapid decrease to low or zero levels during the spring bloom. This low level is maintained until autumn when the fluxes of regenerated nutrients into the photic layer exceed the productive consumption. Intermediate increases can be related to short-term events as, e.g., heavy rainfall and run-off, upwelling and advective transport.

Trend studies of these nutrients in the surface layer are therefore restricted to this widely accepted ‘winter period’ before the start of the more pronounced annual biological activity, the spring bloom of the phytoplankton. This happens about mid-February in the Kattegat and Belt Sea, and as late as the end of April/beginning of May in the Northern Baltic Proper. Therefore, the winter period is restricted to 1-2 months only in the Arkona and Bornholm Basins, but to 2-3 months in the Eastern and Western Gotland Basins. In coastal areas and in the western parts of the Baltic Sea, 'winter concentrations' are more difficult to establish.

Long-term variations including trends - As already mentioned, the analysis of long-term trends for nutrients in surface waters should be based on measurements during the less productive season, and must cover periods of more than 10 years to take into account intra- and inter-annual variabilities.

6.3.4. Assessment tools used in HELCOM

Statistical techniques

For contaminants in biota the ICES approach to trend analysis has been applied. During the previous assessment work the possibility of detecting a trend of a specific magnitude - the power - in time series of contaminant levels in biota was investigated by ICES. Since in most cases time series of at least 10 years of annual sampling is needed to reach a reasonable sensitivity, the HELCOM contaminant database is currently inadequate to assess temporal trends in the whole Baltic Sea, except for a few analytes in selected matrices from some regions.

For nutrients and biological data a method for univariate trend analysis, commonly used in North America, was applied. The advantages of the method in comparison with the other methods are:

- it is inherent in the method to handle seasonal variation,
- the method does not rely on normal assumptions, and
- the method is robust to outliers and missing data.

The major disadvantages are that it only tests for monotonic trends and gives a median slope estimate; it is not possible, for example, to test whether a trend is linear.

Statistical analyses of the pelagic parameters were found to be difficult, i.a., due to the fact that most of the pelagic parameters have high seasonal variation that dominates the variation over years and areas.

Modelling

Modelling is considered and also used as one important assessment tool. It is difficult to give a comprehensive view of various mathematical models applied due to the fact that the modelling work is not made by the Commission but by all Contracting Parties. More details about the ecological models in eutrophication studies could be found, e.g., from the Third Periodic Assessment of the State of the Marine Environment of the Baltic Sea, 1989-1993 (Baltic Sea Environ. Proc. No 64B). Therefore, in the following only some examples are highlighted.

To determine the response of the marine ecosystem to changing inputs of the eutrophic substances nitrogen and phosphorus, various ecological models have been applied. These models handle input from the land and the atmosphere, export-import fluxes with adjacent sea regions (based on a budget or hydrodynamic module), exchange of nutrients with the seabed (sedimentation and resuspension), and biogeochemical cycling in the water column (hydrodynamic transports, biological consumption and regeneration of nutrients within the food web, sedimentation of organic material, regeneration of inorganic nutrients from organic material, denitrification).

Empirical relationships between inputs of nutrients and conditions in the sea can be found on the basis of long-time series of data. This allows for the development of nutrient budgets and empirical models for the entire Baltic Sea, and for sub-regions. Results from empirical models have been used to develop management strategies for the Baltic Sea. While such models have a good analytical capability, their predictive power is rather limited.

Predictive process-oriented 'mechanistic' models have also been applied. Integrated modelling approaches, combining different models, are under development within the *EU-MAST3* project *BASYS*.

GIS

Several attempts have been made to develop the Baltic GIS. In 1994 a feasibility study was conducted together with several institutes and organisations. According to the needs of organisations involved at that time 14 different data themes were envisaged. Currently a new attempt to get outside funding has been made. The possibilities to use GIS as one tool for analysis and display of the data is acknowledged.

GIS as an information system could be an important part of the future assessment work. Within the HELCOM framework discussion on the development of an information system which could provide up-to-date information has been initiated. Currently both national and regional approaches have been made.

Other matters

Ecotoxicological reference values, ecological quality objectives and ecotoxicological assessment criteria have not been used in HELCOM assessments.

Due to the fact that the whole Baltic Sea is considered to be eutrophied, no common procedure for identification of eutrophication status of the maritime area has been made, but the discussion is focused on limiting nutrients. The eutrophication status is followed within the monitoring and assessment activities.

Furthermore, no sediment criteria has been elaborated or agreed.

6.4. The Arctic Monitoring and Assessment Programme

6.4.1. Introduction

The Arctic Monitoring and Assessment Programme (AMAP) has recently conducted its first assessment of environmental pollution in the Arctic. In the course of this assessment various ‘assessment tools’ were used. In addition, the assessment identified ‘needs for future assessment work’ which can be related to ‘research needs to improve assessment tools’. The following comments summarise the views of The Arctic Monitoring and Assessment Programme (AMAP) based on this experience.

6.4.2. Available assessment tools

- at the scientific level, to facilitate assessment of environmental monitoring data, two main types of tools were employed:

(a) **comparative analysis**, whereby environmental monitoring data were compared with various effects thresholds or guideline values (see example attached). The purpose of such assessments was essentially to provide a ‘**meaningful context**’ for data on environmental contaminant levels, i.e. a basic interpretation of the possible implications of observed levels. Given the numerous ‘caveats’ associated with this type of comparison (see later comments), the (effects threshold/guideline value) levels with which data were compared were not interpreted in the sense of ‘**target values**’ for the environment.

(b) a variety of **models** were employed during the assessment, including**: long-range transport models** - mainly modelling atmospheric transports to estimate depositions within the Arctic (e.g. sulphur, Pb) from compiled (global) emissions inventories (sulphur, nitrogen, Pb, Hg, HCH); **budget models** (e.g. HCH, Toxaphene, PCB) to estimate the (global) budgets in relation to the Arctic Ocean; **statistical models/analysis tools** for assessment of temporal trends, etc.; **food-chain/ web models** to address issues such as biomagnification; **box-models** to describe intercompartment pathways/transports, etc.

- in connection with the ‘decision-making’ process:

the AMAP assessment can be viewed as a two-level process involving (i) the scientific assessment, using tools as previously described, to evaluate the results of environmental monitoring/research programmes, and (ii) the ‘advisory’ component, by which the outcome of the scientific assessment is interpreted in the form of conclusions and recommendations which can be communicated to

Ministers, decision-makers, managers, etc. in an appropriate form (e.g. recommendations on reduction measures, emerging problems, advice at the regional and local level, etc.). In essence, the advisory component was addressed through the preparation of reports (e.g. the AMAP State of the Arctic Environment Report), presentation of this report in relevant international fora, organisation of a Symposium to bring together scientists and environmental decision-makers, representatives of indigenous peoples, etc. In this respect, it is important that the '**delivery tools**' employed are appropriate to the different objectives and target groups involved in ensuring the assessment is received in a manner which achieves the desired results. For example, that Ministers can use the assessment to support international negotiations on reduction measures, or that advice concerning human health issues is communicated to indigenous peoples in a responsible manner.

For specific issues, **risk assessment tools** are desirable. The AMAP assessment is not considered 'an environmental risk assessment', however, certain parts of the assessment (e.g. radioactivity, human health) introduced concepts related to risk assessment analysis and made some first attempts at applying this type of approach.

Risk assessment is seen as a viable tool in developing 'hard' advice from environmental programmes such as AMAP, but often requires comprehensive data which may not be available from basic environmental monitoring programmes.

Similarly, **critical loads and levels**, are concepts which will likely be developed in the future AMAP programmes to provide targeted advice on protection/reduction measures. Critical loads are discussed in the AMAP assessment in relation to, e.g. acidification problems, however, again, there is generally a need for including information which may not be available from a typical regional environmental monitoring programme.

6.4.3. Future needs of assessment tools

All the tools mentioned above have their limitations:

Comparative analysis: the scientific basis for development of applicable effects thresholds and guidelines is generally inadequate. For example:

- effects thresholds typically involve extrapolation of limited data from laboratory experiments or field studies to environmental situations which might be very different and where additional factors may play a significant role (e.g. species differ, exposure levels differ, thresholds for single contaminant exposures are applied to situations where combined contaminant exposures/ environmental stressors are at work, food-web characteristics differ, etc.).

Under these circumstances, whilst **comparative analyses are useful in gaining insight into environmental data and potential problem areas**, they can only be applied as what might be termed 'target values' for environmental management to a limited extent, and only in well-defined situations.

Models: the various models described above are important assessment tools, with a variety of applications, especially in areas such as the Arctic where environmental monitoring will never provide good geographical coverage for logistical/cost reasons. However, models are also subject to inherent limitations (sophistication of the models, assumptions and uncertainty concerning parameterisation and boundary conditions, limited quality of information on inputs, etc., and lack of field data for model calibration/verification). Again models can easily be mis-applied, and without a good understanding of the limitations of the models, their results can be given an unjustified significance in the assessment processes and development of policy advice. Considerable progress in relevant modelling activities has taken place, but the need for further improvements is well recognised; the need for better input data (e.g., emissions inventories) and field data for verifying model results is also recognised, but this 'less glamorous' aspect often receives less attention.

Development of applicable **critical loads/levels**, which can be directly applied in environmental management and policy development, require appropriate progress in both the areas of effects threshold and model development noted above. Such 'target values' are generally not applicable over wide geographical areas such as the entire Arctic.

Risk assessment is a well-defined and well-developed approach in certain fields (e.g. radioactivity), and there is no reason why a similar approach could not be applied to other environmental issues to a much greater extent than it is today. An example could be to conduct formal risk assessments in areas where comparative analyses indicate that the potential exists for adverse effects. However, risk assessment requires availability of detailed information on a number of factors which need to be taken into account, of which 'environmental contaminant levels' is only one; others might include demographic information, dietary information, understanding of food-webs and/or critical path of exposure, and the related effects of exposure. Full application of the approach involves, for example, cost/benefit analysis of remediation measure, and introduces additional data requirements. However, from an environmental management/policy development point of view, such application is required/desirable.

Comparative analysis

The features of comparative analysis as applied within the AMAP assessment, its limitations and needs are discussed above. Comparative analysis can be simply related to the concept of '**indicators**' related to environmental contamination, however, some important points to note are:

- indicators often 'integrate' a number of complex issues, and the more generalised they become the lower the scientific justification for their application;
- even basic indicators such as 'effects thresholds' are subject to so many caveats that their application is questionable in any type of 'target' setting;
- it is probably impossible to identify indicators based on environmental levels that can be applied over wide geographical areas;
- generalised socio-economic indicators (e.g. human birth rate/death rate/life-expectancy, breeding success of wild animals, etc.) can reflect 'environmental health', however, they also integrate numerous other factors and are not addressed in the context of this paper which focuses on the issue of environmental contaminants.

Thus, whilst some 'general indicators' of e.g. human health status, such as life-expectancy, are discussed in the AMAP assessment, indicators of 'environmental/ecosystem health status' are largely qualititative and considered only in the form of examples relevant to specific areas, with full recognition of their limitations and/or explanatory circumstances. For example, species may exhibit levels of contaminants which exceed guidelines for protecting aquatic biota which eat them, but these levels may be unrelated to the environmental situation in the Arctic (e.g. contaminants may be accumulated during migrations to other more contaminated areas). With regard to identifying '1-2 indicators for use in determining the (environmental/ecosysytem) health of coastal areas'; it is difficult to envisage any such indicators which could be generally applied in an Arctic regional context, let alone a wider context. Indicators based on human activity (e.g. tourism) would not be applicable (except in very limited areas); indicators based on environmental levels would need to take into account (significant) specific sub-regional factors. The derivation of 'target values' from such indicators, and their application in terms of, e.g. setting 'environmental quality criteria' possibly with legal/political implications for meeting such targets, would be extremely difficult. They would necessarily oversimplify complex interactions, which are often not fully understood, and could easily be misapplied in a management context, or give rise to misinterpretation the general public if taken out of context and/or not communicated in an appropriate manner.

6.5. United Nations Environment Programme/Mediterranean Action Plan

6.5.1. Introduction

According to the MED POL Phase III Programme, in the framework of the Pollution Assessment and Control Component of the Mediterranean Action Plan (MAP), three basic types of monitoring are organised: compliance monitoring, trend monitoring and monitoring of biological effects.

6.5.2. Trend monitoring

The general objective of the trend monitoring is to provide an assessment of a change with time in the environmental levels of chemical contaminants. In particular, a trend monitoring programme should allow the identification of a specific temporal trend in the contaminant level with a given confidence.

Selection of monitoring stations

A number of fixed coastal stations from the national monitoring programmes will be selected by the MED POL National Coordinators in each country, to be used in the trend monitoring programme.

The following criteria will determine the sites to be selected for trend monitoring:

- The selection of a site will satisfy the managerial objectives of the programme;
- the site will allow the detection of the change in contaminant level that the trend monitoring programme is expected to detect through the selection of a realistic number of samples;
- the site will allow the selection of a sufficient number of biota required for the trend monitoring programme;
- the site will be suitable for sediment down-core analysis, particularly as regards sedimentation rates and bioturbation intensity.

Contaminants to be measured

On a Mediterranean scale and on the basis of the past MED POL monitoring data the following contaminants could be selected for measurement in the temporal trend monitoring programme:

a) - Total mercury in sediment and biota

- Cadmium in sediment and biota

The above may be considered as priority contaminants, for which that trend monitoring would be carried out at most, if not all, selected stations.

b) - Total arsenic in biota

- Zinc in sediment and biota

- Copper in sediment and biota

- High molecular weight halogenated hydrocarbons in sediment and biota

- Polynuclear aromatic hydrocarbons in biota.

Selection of the sampling matrices

Biota and sediments are considered as the primary matrices for the sampling of contaminants for trend monitoring purposes, presenting the advantage of integrating contamination over time. Biota and sediments are primary matrices for the measurement of total mercury, cadmium, zinc, copper and high molecular weight halogenated hydrocarbons.

Polynuclear aromatic compounds are best monitored for trends in biota. Arsenic is a difficult contaminant to be monitored for trends; sediment profiles were proven unsatisfactory while the use of biota is still being studied.

The use of sediments and biota for marine pollution trend monitoring should ideally be part of an integrated monitoring programme which includes otgher compartments of the environment (e.g. SPM, seawater, interstitial water). This will help in the interpretation of the monitoring data.

Biota

The trend monitoring programme will carry out measurements for contaminants in species most closely fulfilling the objectives of the programme while at the same time selecting species adhering to the greatest extent possible to the following criteria:

- A simple relationship exists between contaminant concentrations in the species and average concentrations in the surrounding environment;

- The species accumulates the contaminant;
- The species is sedentary and thus represents the collection area;
- The species is widespread and abundant in the study region, to allow comparisons among different areas;
- The species lives long enough so that more than one year-class can be sampled, if desired;
- The species is large enough to yield sufficient tissue for analysis;
- The species is easy to collect and hardy enough to survive unfavourable conditions or within the laboratory;
- The species exhibits high bio-accumulation factors, to allow analysis without preconcentration;
- The species tolerates brackish water, to allow comparisons between estuarine and offshore sites;
- The species must be easy to identify with certainty.

The following benthic or demersal species were used in the past for MED POL monitoring purposes:

- **Bivalves** (*Mytilus galloprovincialis*, or *Mytilus edulis*, or *Perna perna*, or *Donax trunculus)*

The latter three species were suggested as alternative species if *M. galloprovincialis* did not occur in the area

- **Demersal fish** (*Mullus barbatus*, or *Mullus surmuletus*, or *Upeneus mollucensis)*

The latter two species were suggested as alternative species if *M. barbatus* did not occur in the area.

It must be stressed that, once decided, the same tissue should be used at all times and at all stations.

Sampling of biota for trend monitoring of contaminants could generally take place once every year, while sampling of sediments for trend monitoring of contaminants could take place over a larger time frame, depending upon contaminant influx and environmental physiochemical considerations.

Carrying out sampling of biota during a period in the year when contaminant concentrations are not being significantly affected by changes in physiological mechanisms, is essential for consistency of sampling. Such periods of minimal change are generally related to periods outside the spawning cycle and when food supply is relatively constant. In order to avoid such variations it is recommended that sampling take place in the pre-spawning period.

The number of specimens needed to detect important trends depends on the type of the trend, the magnitude of the trend and the variability in the data. In order therefore to choose an appropriate number of specimens, the statistical power of the monitoring programme should be considered through power studies which examine the types and magnitude of changes that will be detected for a given number of specimens.

The number of specimens in each fish sample collection should be sufficient to allow the sample to be collected in a length-stratified manner (age-related), i.e., the size of the fish should include as wide a length-range as possible and there should be an equal number of individuals in each length-grouping.

It may be necessary to pool (bulk) fish tissues, particularly in the case of fish livers and mussel and other shellfish tissues, in order to provide sufficient quantities of material for chemical analysis.

Sediments

Sediments have an important role in environmental monitoring as they are considered the sink of most contaminants. Marine sediments are closely inter-related to several other compartments of the marine environment. Therefore, their use in monitoring should ideally be part of an integrated monitoring programme which includes other compartments of the marine environment, such as, water, suspended particulate matter and biota. In addition, it is essential to enhance the comparability of results with other sedimentary data sets for the same contaminants. Factors which can be considered include water content, organic carbon, total extractable lipid content, grain size distribution, etc. Apart from the normalization techniques, harmonization of baseline studies as well as strict quality assurance/control programme are also essential.

Quality assurance

Quality assurance of the monitoring programme refers to those procedures which are developed to ensure that analytical results are valid, traceable, reproducible, representative, complete and accurate, i.e. close to the true value; as well as measures developed to assess performance. Methods of quality assurance collectively consist of methods for quality control and quality assessment.

a. Quality control methods will involve the following:
b. Standard sampling and measurement procedures;
c. Data handling procedures;
d. Use of certified reference materials (CRMs) of identical or similar matrix;
e. Regular analysis of reference materials;
f. Regular mandatory participation of the laboratories involved in the trend monitoring programme in intercomparison exercises;
g. Regular calibration, servicing and maintenance of all the equipment.

Quality assessment methods will be developed for the assessment of the performance of individual laboratories participating in the monitoring programme over time and in relation to the other laboratories participating in the programme.

6.5.3. Compliance monitoring

Scope of activity

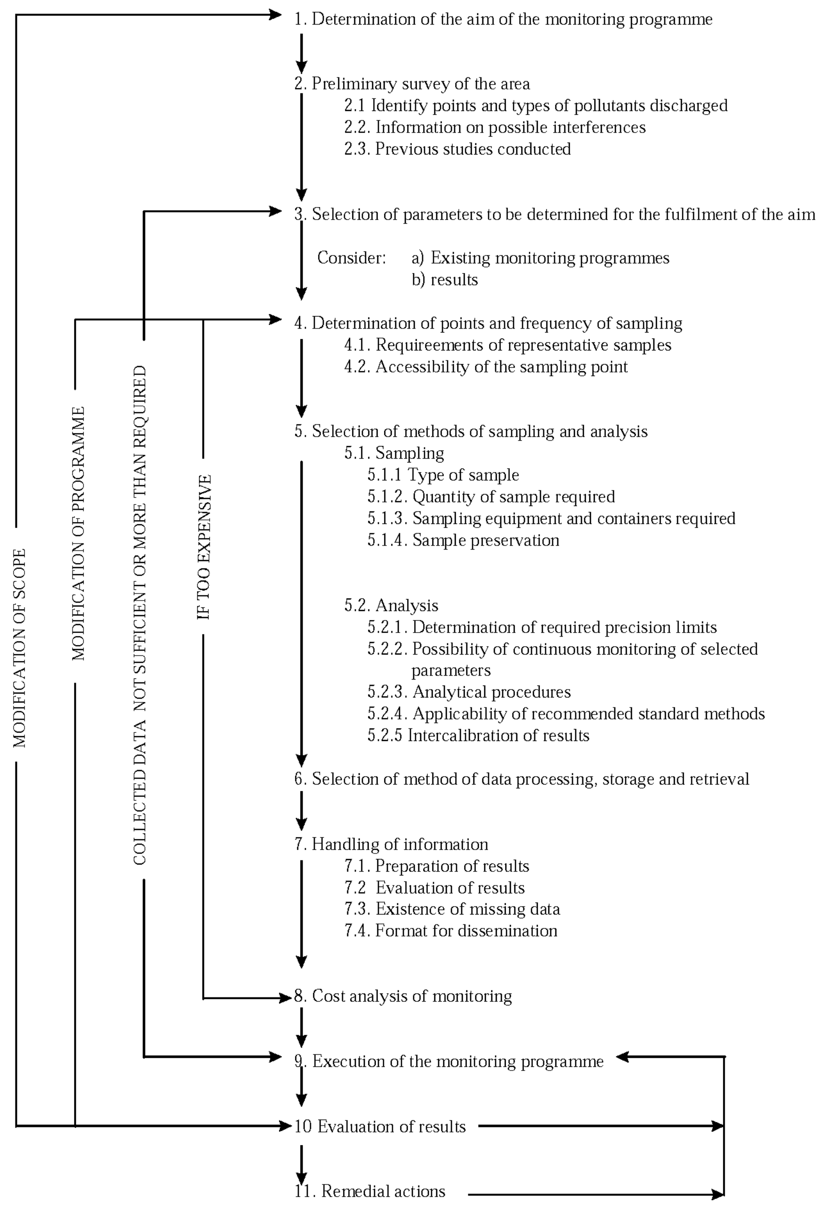
a. The aims of a programme to monitor land-based sources of marine pollution for compliance purposes should be:
b. to complete the baseline studies necessary to survey the types and amounts of pollutants discharged or dumped into the coastal marine environment in any given area;
c. to compile and regularly update an inventory of land-based sources of marine pollution, including data on the probable fate of the pollutants;
d. to carry out effluent quality control where criteria or standards already exist and to assess the control measures being implemented;
e. to compile data on which to base decisions on the promulgation and implementation of control measures where such measures do not already exist;
f. to draw up a database to be used for the environmental impact assessment of any future coastal development.

The outline given in Figure 1 could be followed when planning an effective compliance monitoring programme.

Monitoring area

Prior to establishing the programme, the impact of actual and potential pollution on the various uses of the coastal waters in question should be determined through the acquisition of relevant data (area assessment). The area assessment should include both landward and seaward descriptions of the area, and the data obtained should be noted either on a fact sheet, or on a descriptive map, or on both, depending on the circumstances.

Figure 1. Suggested flow diagram of an effective compliance monitoring programme



General design

Prior to actual implementation of the compliance monitoring programme, it is essential to decide on:

a. the matrices to be monitored;

b. the parameters to be monitored in each matrix;

c. the number and location of sampling points;

d. the frequency of sampling.

The extent of the programme will depend entirely on already-existing resources and on extra resources that can be made available to meet the required demand. These resources consist of:

a. trained manpower for sampling and analysis;

b. laboratory facilities (apparatus, equipment and materials);

c. transport facilities.

Sampling

Sampling techniques should be determined with great care as even with the most sensitive analytical techniques it is not possible to obtain more accurate and dependable results than the collected sample can provide.

The most important principle in sampling is to enable the analysis to be made on samples that are "representative" of the water concerned. In other words, the sample and its source should have the same composition. Furthermore, the sample should be a true representation of the variations in the characteristics of the source over time. Sampling should be performed in a systematic way in order to minimize discrepancies.

Matrices and locations

In programmes aimed at the determination of land-based pollution and compliance, details will have to be determined in the light of the situation existing in each particular locality. These will necessarily differ according to land use and related activities, as well as water use, in the area in question

Point sources

The following principles should be adhered to in relation to the different types of point sources:

- Outfalls

a. urban wastewater: collecting systems, discharges to receiving waters, reference methods, parameters to be measured, limit values etc, necessary for compliance control;

b. industrial effluents: limit values, industrial sectors, frequency of sampling, quality objectives, etc. for cadmium in effluents, as a guide for compliance control.

- Rivers and streams

Monitoring stations on rivers should be established, provided that the river satisfies one of the conditions below:

a. the average flow exceeds 100 m^3/sec;

b. the watershed exceeds 100 km^2;

c. it is thought to be heavily polluted.

A monitoring station on a river should be located outside the limits affected by tides and waves, at a point downstream from the last effluent discharge at a distance sufficient to obtain homogeneous distribution. If the results indicate that the river is of homogeneous character, one position for sampling will be enough, otherwise either the location of the sampling point should be transferred to a location of a homogeneous character or samples should be taken from several additional locations in addition to the original one selected so that the overall characteristics can be represented. For major rivers, even if they are homogeneous, it is advisable for more than one sample to be taken from different depths on the same cross section, forming a sampling point grid if necessary.

Solid waste and sludge disposal

Although it is not recommended practice, solid wastes and sludge can, in some countries, be dumped into a receiving water either legally (with an authorization) or illegally, directly from the coast or from barges used for the purpose.

In the case of authorized dumping, the amount of waste should be determined either by weighing the load on specially allocated scales or, if this is not possible, by estimating the amount by volume.

The only possible way of controlling unauthorized dumping and estimating the possible amount is source control. To achieve this, all sources of hazardous wastes should be obliged to fill in a declaration form giving information about the amount, properties and place of disposal of hazardous wastes.

Diffuse sources

Sampling from diffuse sources is a very complicated process for which a generally acceptable procedure is not available. In such cases, the following approaches are suggested:

a. collection of a representative sample and estimation of the overall effect;

b. determination of the concentrations of selected pollutants in various parts of the receiving marine environment in combination with salinity or other tracers, extrapolating to zero salinity and flow estimations;

c. utilization of information obtained from similar situations for which accurate load calculations are available;

d. in the case of urban waste, calculation of the population equivalent on the basis of previous experience.

As can be seen from the four possible methods outlined above, only the first two require actual sampling, while the other two are based purely on estimates.

Selecting the location of sampling points in the receiving marine environment in order to apply approach (b) above depends entirely on local conditions. However, the following general principles can still be applied:

a. grid of sampling points should be formed covering all the marine environment immediately affected;

b. the depth from which the sample is to be collected should be decided according to local conditions. However, it is recommended that, at points where the depth exceeds 10m, at least three samples (one below the surface, one at mid-depth, and one at 1m above the bottom) should be collected.

Sampling frequency

The following sampling programme should be followed, at least for major sources:

a. hourly sampling during one 24-hour period in each quarter (season) to assess daily cyclic effects;

b. daily sampling during seven consecutive days in each season, to determine any weekly cyclic effects;

c. weekly samples to delineate seasonal effects and to determine how less frequent sampling would have affected the results.

6.5.4. Monitoring of biological effects

In the initial phase of the biomonitoring programme a set of four simple, sensitive, reproducible, and low-cost biomarkers was selected. Among these, two biomarkers, lysosomal membrane stability and DNA damage, were used as general stress indices. These biomarkers reveal a syndrome characteristic of the animal response to a wide variety of environmental stressors i.e. they integrate the effects of the pollutants accumulated into the cells, taking also into account possible negative effects caused by variations of environmental parameters such as temperature, oxygen, salinity, etc.

Two of the biological tests selected are specific stress indices able to reflect the response of the organisms to a particular class of contaminants: (i) Mixed Function Oxygenase (MFO), evaluated as EROD (Ethoxyresorufin-O-deethylase) activity, a biomarker showing the biological responses to xenobiotic aromatic compounds such as PAHs, PCBs etc. (ii) Metallothionein concentration, usually considered a good indicator of the biological response to heavy metal pollution.

A fifth biomarker, the stress on stress response, was recommended to be used in countries where mussels are available.

Initially, another general stress index, that of scope for growth, was proposed. This biomarker is based on such parameters as feeding, digestion, respiration and excretion rates to provide an insight into the growth process. Scope for growth provides a quantitative evaluation of changes in the energy status of the animal, which reflects an integration of a wide variety of responses to environmental pollutants. This parameter has been recently demonstrated to be of great sensitivity for the assessment of environmental pollution levels, being sensitive to low concentrations (in the range of ppb) of hydrocarbons and heavy metals.

Notwithstanding the importance of this biomarker, different MED POL laboratories have found its use not easy for routine applications. This important biomarker was not included in the battery of tests selected to be utilised in the Mediterranean Biomonitoring Programme.

All the biomarkers proposed are sensitive and provide reproducible data. Also the procedures for their determination are simple, low cost and intercomparable. The required equipment (i.e. cryostat and microscope for lysosomal membrane stability; centrifuge and spectrophotometer for metallothionein; centrifuge and spectrophotofluorimeter for EROD activity; light microscope for micronuclei) are moderately expensive but are common basic instruments found in laboratories for biochemistry, cellular physiology, cytochemistry and therefore are presumably present in most of the research centres participating in MED POL.

Mussels (*Mytilus galloprovincialis*, Lam.), where available, represent a suitable sentinel organism. In fact, these lammellibranch molluscs are sessile, intertidal, filter feeding organisms, able to accumulate in their tissues most of the pollutants present in the surrounding water.

However, mussels are not the best organisms for MFO determination and therefore a fish should represent a correct complement to provide a better information on the biological effects of organic aromatic pollutants. Fish from resident populations, possibly with feeding habits related to benthic environments, should represent the best choice. As known, pollutants tend to accumulate in the sediment, therefore, the feeding habit of the selected fish species could be important in terms of chemical compound accumulation.

In field experiments *Scilla cabrilla* was used as the sentinel organism for studies on wild population. However, it must be pointed out that studies utilising caged animals seems to be more appropriate to reduce data variability and to ensure that fish responses are strictly related with the pollution of a well defined coastal area. For this approach, molluscs and fish are usually obtained from commercial farms and the utilisation of mussels and fish of the species *Dicentrarchus labrax* was suggested on the basis of previous experience.

Where the suggested sentinel species were not available, different molluscs and fish should be utilised.

Quality assurance represents the pool of activities devoted to guarantee controlled data of high quality. Therefore, quality assurance must be considered an essential element in a large, international, monitoring programme.

The previous experience developed during MED POL concerning the chemical monitoring of the Mediterranean sea clearly showed that an intercalibration programme is essential to ensure a good level of the quality of the data obtained in the different laboratories involved in the programme, and to provide a correct comparison of the results collected in the different countries, in different seasons or years.

For the same fundamental reasons, before starting the pilot phase of the MED POL biomonitoring programme, an intercomparison exercise was organised.

Three biomarkers, lysosomal membrane stability, metallothioneins concentration and EROD activity (MFO), were intercompared among laboratories participating in the programme.

Genetic stress indices such as DNA damage (alkaline elution and micronuclei frequency) were not included in the intercomparison exercise because most of the laboratories were not yet ready to start the application of these biomarkers, and more work was necessary before this test could be applied widely.

A list of very important points must be taken into account in the future development of the programme.

1. For future activities, basic environmental parameters such as sea water temperature at sampling time must be recorded; a clear indication of the position of the sampling sites is also needed.

2. The size, the number and the sex of animals utilised must be accurately described.

3. A standard procedure for organ extraction and/or the transport of the animals from the field to the laboratory must be accurately described and then utilised in all the laboratories involved.

4. Sample storage procedures in the different laboratories should be similar and always mentioned in the report.

5. Biomarkers for which an intercomparison is possible, should be preferred. Biomarkers which make use of living cells or animals should be added, as an integration to other tests or utilised where not all laboratory facilities are available.

6. Intercomparison exercises are essential for a correct interpretation of the results on a large scale in the Mediterranean area. In the future, the intercomparison exercise must be performed during the period of sample analyses to ascertain the accuracy and comparability of the results.

7. During the biomonitoring programme both mussel and fish must be obtained from the same site and on the same days. Collection of the animals from different sites and in different periods of the year doesn't allow a correct interpretation of the battery of stress indices employed.

8. The caging system is without doubt expensive and it may not always be utilised without an adequate financial support. However, when possible, the utilisation of this kind of approach should be adopted as good results were obtained in the RAMOGE pilot experiment and in other studies in different countries.

9. An accurate choice of the animals to be utilised in the programme must be defined. In fact, the comparison and the interpretation of results will be simplified if the programme utilises a minimal number of widespread different animal species.

10. It must be stressed that only few countries were able to reach the target in the first year of activity. Therefore, in the future, activities must be developed to ensure the involvement of more laboratories from other countries in this programme.

6.6. Black Sea Environment Programme. Design of a Monitoring Programme: Contaminant Levels and Biological Effects[1]

6.6.1. Introduction/background

Much of the waste generated by human activities finds its way into the oceans where some of it may present a threat to marine life and possibly to man as a consumer of seafood. Considerable past

1. Contribution from a paper written by: Michael N. Moore, Plymouth Marine Laboratory, Citadel Hill, Plymouth PL1 2PB, UK , Graham Topping, Marine Laboratory, SOAFD, P.O. Box 101, Aberdeen AB9 8DB, UK, Pia-Elena Minhea, Romanian Marine Research Institute, B-dul Mamaia 300, 8700 Constanta, Romania, Sergei Kiryanov, State Oceanographic Institute, 6 Kropotkinsky Lane, 119838 Moscow, Russia, and Valeri Mikhailov, Ukrainian Scientific Centre for Ecology of the Sea, 89 Frantsuzki Blvd., Odessa 270009, Ukraine

effort in environmental monitoring has focused on the determination of residue levels. Unfortunately, a large gap exists in our ability to either quantify the exposure to toxic chemicals in the environment or to assess the biological significance of such exposure. Exposure cannot always be quantified by measuring the concentration of contaminants in tissues since many toxic chemicals are metabolised, especially in fish. However, this problem is considerably reduced in molluscs which have limited capacity for biotransforming organic chemicals and thus tend to reflect exposure more closely. Even then, measurement of levels at one point in time tells us little about the pattern of exposure that resulted in those levels. In addition, the relationship between tissue concentration and toxic response is complex, as is assessing the significance of exposure to complex mixtures where there may be possible interactions that can invalidate predictions that are based on the toxicity of individual chemicals.

An approach to the question of whether or not marine organisms and ecosystems are being endangered has involved the development and deployment of **indices of biological effect and exposure (known as "biomarkers")** as early warning systems of adverse environmental change (Moore, 1985). Biomarkers can demonstrate that environmental chemicals have entered an organism, reached sites of toxic action, and are exerting harmful effects on the organism. In fact, the organisms are functioning as integrators of exposure, accounting for abiotic and physiological factors that can modulate the dose of chemical taken up. Biomarkers can be used to quantify exposure to toxic chemicals and to detect **distress signals** from the organisms. Such methods are being used in combination with analytical chemistry on a rapidly increasing basis and on a world-wide scale (Bayne *et al.*, 1988).

The organisms of choice for this type of environmental monitoring have frequently been sedentary filter-feeding molluscs such as mussels and oysters.

In the Black Sea region, marine laboratories generally have the facility to carry out standard lethal toxicity tests, with a more restricted capability to perform ecophysiological and other sublethal tests (Mihnea, 1995, 1996; Mihnea et al., 1990). Lethal toxicity testing using a variety of animals and plants has been used to determine water quality and for effluent testing. While the deployment of biomarker tests (biochemical and cellular) is not widespread in the region, this capability is being actively developed with the assistance of the UNESCO-IOC/UNEP/IMO Group of Experts on the Effects of Pollutants (GEEP).

Details are provided herein of an integrated programme which will allow scientists to measure adverse biological effects and contaminant levels in the Black Sea using biomarkers and sentinel organisms. In designing this programme, recommendations for monitoring and associated quality assurance work developed by the International Mussel Watch Programme/Caribbean-American Phase as well as work performed from other International Organisations like UNEP and ICES has been used (GESAMP 1994, UNEP 1992 and 1995; ICES, 1992; WGBEC Reports, 1995 & 1996).

6.6.2. Lessons Learned from other International Monitoring Programmes

There has been a tendency to adopt and implement international monitoring programmes with very broad and ill-defined objectives and, as a consequence, the results arising from these programmes were frequently difficult to evaluate. With the exception of the most recent work in the North Sea, most of the co-operative international programmes were conducted along similar general lines and were not designed for specific sub-regional issues and characteristics. In most cases, very little effort was devoted to the design of monitoring by comparison with the effort devoted to the monitoring work.

Other reasons for the lack of a successful outcome of monitoring work have included the lack of adherence to agreed protocols for sampling, quality assurance (QA) work and data assessment procedures. Such protocols are specifically designed to ensure that data collected by different laboratories and countries are comparable and that there is agreement between participants at the outset of the monitoring programme on potentially contentious issues, e.g. "Do the data from individual participating laboratories conform to the required QA criteria and if not should the data be rejected from the set of data to be assessed?" If protocols are ignored, the aims of the monitoring programme are undermined and valuable resources are wasted. It is also clear that only during the data assessment stages were such deficiencies revealed. Had they been detected, and corrected at an earlier stage in the monitoring programme, it would have allowed the organisers to meet their objectives and enhanced the cost-effectiveness of the programme.

6.6.3. Proposed monitoring programme for biological effects and contaminant levels in the Black Sea

Development of a general programme

The working group considered the question of the objectives, generic principles and the implementation of a general programme designed to identify the effects of unknown or unspecified contaminants. Some general principles emerged from the discussion, *viz.*

- in such a programme multiple measures of effect are essential
- measurements used should include those indicative of both exposure and pathology
- he combined suite of measurements should integrate responses across organisational levels
- the combined suite of measurements should be interpretable in terms of cause and effect
- ecologically relevant and sensitive species should be used as sentinels

It was clear from the discussions that there was a need to refine the objectives and implementation plan for this programme. The working group discussed a strategy developed by the ICES Working Group on the Biological Effects of Contaminants (ICES/WGBEC Report, 1996) for implementing a general biological effects programme. This incorporates all of the above points and places them within an environmental management plan which integrates scientific interpretation and management decision-making. The essence of this plan is in defining the “real problem” rather than the “perceived problem” and in testing the outcome at essential points of the process in order to ensure whether the problem has been defined appropriately, and if so whether it has been solved (Figure 2).

This strategy can incorporate biological effects measurements at all organisational levels and is sufficiently flexible to accommodate new diagnostic tests for both exposure and pathology.

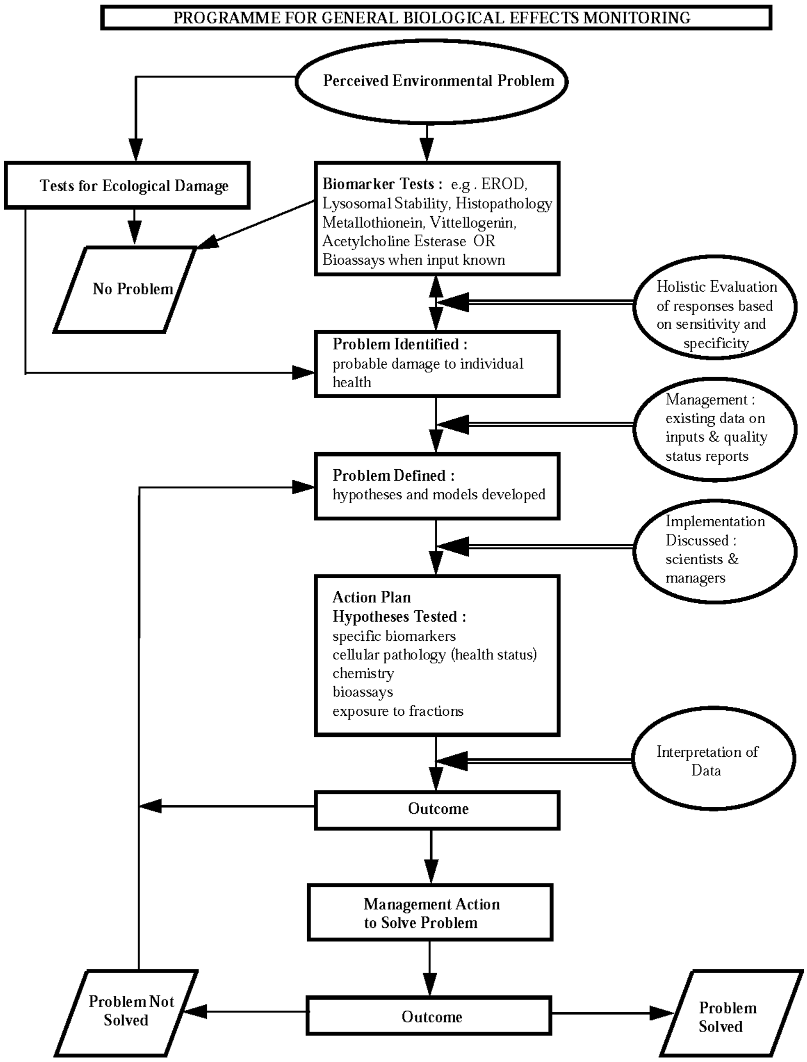
The key feature of this approach is that biological effects measurements are carried out prior to any programme of intensive chemical monitoring. If the initial biological effects measurements identify a real problem then, in addition to more focused biological effects measurements being carried out to further investigate the situation, the source of this problem can be investigated through chemical monitoring work. By working this way, the investigating institute focuses its limited resources to provide a better system for identifying ‘real problems’ from a biological viewpoint rather than ‘perceived problems’ which are often based on simply the presence of chemical substances in the marine environment.

Specific needs for a Black Sea programme

Objectives

1. To determine health status of organisms and ecosystems
2. To reflect exposure to selected pollutants
3. To provide an integrated approach for assessing the quality of component parts of the ecosystem

Figure 2.



Short term objectives

- To identify what can be done by every country at this time, and to agree a programme of work

Criteria

- All countries should use methods which produce comparable data
- One country would act as a focal point for the other countries for each method*
- All countries should agree on the relevant quality assurance procedures

(*This does not mean that each country cannot develop methods to meet their own needs for national monitoring programmes).

Selection of study areas

- Water column
- Sediment
- Surface sediment

Choice of organisms

- Mussels (*Mytilus*) - water column
- Unicellular algae - water column
- Clams (*Mya*) - sediment
- Snails (*Rapana*) - surface sediment

Selection of biomarkers (Table 1)

Table 1. Diagnostic and prognostic value of biomarkers of harmful effect and exposure

Biomarker	Information value
Lysosomal stability* (e.g. in molluscan blood cells and unicellular alga)	Reduction in health status, prognostic for pathology and water quality
ß-Carotene and Vitamins A, E and C (antioxidants)	Protection against oxidative damage by oxyradicals
Metallothionein	Exposure to Cu, Cd, Zn and Hg (also protection against radicals)
Inhibition of acetylcholine esterase*	Exposure to organophosphates and carbamates
Fish liver histopathology	Integrated biomarker of exposure (altered cell foci) and pathological change

*Relatively simple, rapid and low cost.

Sampling

- **Time of sampling**: - avoid periods of active reproduction (known for mussels but not for the other species)
- **Size/age of animals** to avoid problems due to ageing effects (e.g. mussels should be 3-4 cm shell length)
- **Sample size** (minimum 10 animals)
- Tissues archived for detailed chemistry in the event that a problem is identified (whole animal, liver or digestive gland)
- Account must be taken of possible effects caused by differences in salinity and/or temperature

Analysis

- Biomarker tests need to be used according to the appropriate protocols
- Quality assurance procedures need to be established and followed
- One laboratory should be designated to organise regular intercalibrations for purposes of quality control

Interpretation of results

- A statistician familiar with the analysis of biological data should be consulted
- Have the data been checked for normality and will parametric or nonparametric analysis be used?
- Have multivariate analysis been considered?
- Have the data been plotted, and does the anticipated analysis make sense?
- Has all the information needed for interpretation been collected and analysed?
- Are the results consistent with the anticipated outcome?
- How do the results compare with any previous studies?

Reporting of data

A single laboratory should act as focal point for the collation of the results

Regular reports would be prepared by this laboratory on behalf of the integrated international programme

Recommendations

The recommendations for a monitoring programme for the Black Sea are as follows:

- Establish a Black Sea **Mussel Watch** as a pilot study
- Harmonisation of appropriate elements of the national monitoring programmes for the region
- Continued training in analytical chemistry and biological effects procedures through the UNESCO/IOC GIPME expert groups GEMSI and GEEP, with additional support from TACIS and PHARE
- Establish collaborative research projects between the laboratories involved in monitoring to facilitate the creation of a regional network
- Form links with research groups involved in the MEDPOL programme, EERO Environmental Toxicology and Pathology Network and in ICES related activities, in order to encourage capacity building in the Black Sea region

6.6.4. Appendix: The present state of toxicity tests in Black Sea Laboratories.

Marine Laboratories of the Black Sea countries mainly developed Lichfield-Wilcoxon and Bliss lethal toxicity testing or in very few number and/or ecophysiological studies (MIHNEA, 1996).

In Turkey only at **Erdemli Institute,** that is not a Black Sea laboratory, acute toxicity tests in static conditions to determine LC 50 (embryon) and Mac-5 (for phytoplanktonic species) values were performed. Very recently it was introduce DNA alterations in fish as a long term exposure testing.

The other Black sea countries had specialised laboratory but the toxicity was approached by conventional lethal methods.

Russian Federation Centre for Meteorology and Environmental Monitoring of Black Sea and Azov from Sochi developed mainly screening toxicity testing.

Ukrainian Scientific Centre of Ecology of Sea-Odessa performed methods for water quality evaluation using both unicellular algae and marine animals.

Ecophysiological studies were done by the **Institute of Biology of Southern seas Odessa Branch (Ukraine)**. The adverse effects produced by the different pollutants, nutrients or micro-nutrients were assessed in short and long exposure experiments. Unicellular algae and a very large variety of animals (protozoans, ctonophora, coalontorata, worms mollusks, crustaceans, fish) were used as biological models.

The Georgian Scientific Research Institute of Sea Ecology and Fish Industry focused efforts on two types of lethal toxicity testing: water quality and effluent monitoring tests. They established environmental standards by toxicity assessments in acute and chronic exposure.

The Romanian Marine Research Institute performed both lethal and sublethal toxicity testing on a number of organisms: unicellular algae, mussels, soft clams, crabs, shrimps, gobiides, grey mullet, flounder, etc.

In Romania ecophysiological studies in lethal and sublethal exposure were mainly developed on unicellular algae Chaetoceros, Skeletonema, Cyclotella, Platymonas, Chlamydomonas, Chroomonas, etc., using different toxicants present into the discharges, or integral sewage or industrial wastes.

6.7. European Environment Agency

6.7.1. Introduction

Within the European Environment Agency (EEA), a study on Integrated Environmental Assessment (IEA) has been conducted (RIVM, 1995), which proposed a definition for IEA (which also includes the two levels of assessment):

"IEA is the interdisciplinary process of identification, analysis and appraisal of all relevant natural and human processes and their interactions which determine both the current and future state of environmental quality, and resources, on appropriate spatial and temporal scales, thus facilitating the framing and implementation of policies and strategies."

In this context, an IEA covers as much as possible the cause-effect relationship (vertical integration) as well as the cross linkages and interactions between different issues (horizontal integration).

6.7.2. Objectives for environmental assessment

The EEA aims for the assessment of the condition of the European environment are based upon its mandate as stated in the Article 3 of its founding European Council Regulation 1210/90:

"to produce objective, reliable and comparable information for those concerned with framing, implementing and further developing European Environmental policy, and for the wider European public;"

In particular, in the context of ETC/MCE, the focus is on the health of coastal ecosystems and marine water quality.

The objectives for environmental assessment need to be adapted in accordance with the ongoing reporting activities of the EEA.

The update of the 1995 report (EEA, 1995) on of the pan-European Environment (Europe's Environment: The Second Assessment, EEA, 1998), which will present the state of the environment, the pressures that are responsible for the changes in its quality, and the driving forces producing these pressures, takes into particular consideration a series of marine environment issues connected with:

- Land use
- Nutrient enrichment
- Chemical pollution
- Over-fishing.

The aim of the State of the Environment Report 1998, to be published by EEA in 1999, has been stated as "to assess the state of the environment, to focus on specific problems and include hotspots in the EEA countries and the ten Accession countries". The report will also deal with environmental trends from the past up to the present day and, taking into account changes in societal development, will try to give an environmental outlook for the year 2010".

Within the report, several issues with relevance to the marine and coastal environment are covered, either in the chapter on Global Issues or in the Integrated Regions – Coastal, such as: nutrients, heavy metals in the marine environment, wastes, erosion, loss and degradation of habitats, fishing etc.

Some of these issues are also covered in the "Indicator Report" from the ETC-MCE (RIKZ and LNEC, 1997) i.e.: eutrophication/saprobiation, heavy metal pollution, fishing, fragmentation and destruction of habitats.

6.7.3. Assessment tools

Descriptive tools and instruments

EEA GIS Development

EEA, through its European Topic Centres, is developing a series of databases which contain environmental data at the European level. This data is a selection and aggregation of the data collected by national media and source-oriented monitoring systems. The topics covered are marine and coastal environment, air emissions, air quality, inland waters, land cover, nature conservation, soil and waste.

Many of the datasets in the ETC databases have a geographical component. EEA uses the basic reference data provided by GISCO as a common framework for geographical data. This framework is the base for the geographical data used by the European Commission. It is therefore possible to combine data from each of the environmental databases for integrated spatial analysis and for presentation in map format. The compatibility of the administrative and socio-economic datasets from EUROSTAT extend the range and scope of the analyses that can be made.

Currently EEA is producing the spatial information on air emissions for a 50km grid covering the pan European area as required by EMEP. It is also supporting DG VII on the strategic environmental assessment of the TENS. A CD-Rom will be produced in 1999 to make data, information and assessment on land cover and nature conservation available to a wide range of users (NATLAN).

Using copies of selected data from the existing databases at ICES and MEDPOL (and Black Sea?) it would be possible to develop a simple system which would hold data with significance at European level organised in a standard way. The process would be analogous to that which exists between the other environmental databases and national data. Such a system would be compatible with the EEA databases and could be used together with them for the purposes of integrated analysis. Furthermore the result of these applications, based on EEA databases, could be used directly by the Regional Conventions to add value to the work already done.

The system would contain the following ‘layers’:

Basic data

The geographic location of the Conventions and their respective areas covered.

For each convention area:

Internal regions e.g. Arctic Waters or Greater North Sea within OSPAR, socio-economic data, major river catchment areas, protected areas, remedial action areas, digital Elevation Model of land areas, bathymetric data if available from the Convention

Meta data

For sampling points: Locations, methods used, legal basis

Measurement data

For sampling points: Substance, time series

Derived data

Areas showing results of existing thematic assessments, locations of identified ‘hot-spots’

If the analytical applications which are used to produce the thematic assessments and to identify ‘hot-spots’ are made available, it would be possible to produce up-to-date maps as soon as data becomes available from the countries (maybe a regular cycle like the CORINAIR reports or Ozone reports).

A second stage application would be to identify areas of vulnerability and eventually to simulate European level responses to major accidents.

Tools to judge environmental conditions and developments

A system of indicators, with the associated reference and objective values for each environmental variable, is an assessment tool in itself, as well as a way of synthesising data. A preliminary list of a set of indicators to use in the European context was proposed in the report from the ETC previously mentioned (RIKZ and LNEC, 1997).

Table 2. The following table summarises the proposed indicators.

Environmental issues	Pressure indicators	State indicators
Eutrophication Saprobiation	- Total load of N + P - total load of BOD	- Total concentration of - P, N in winter (μmol/l) - % DO saturation - Concentration of chlorophyll - Transparency
Heavy metal pollution	- Total Loads of Pb, Cd, Hg.	- Concentration of (Pb, Cd, Hg) in sediments and or biota
Fishing	-*Fishing mortality*	- Spawning stock biomass
Fragmentation and degradation of habitats	- Land use change in coastal zone - artificialization of coast *line*	Accelerated sea level rise Recession of shore in M/year.

In the same report a methodology to estimate the trends on the pressure and state indicators and the criteria to define reference and objective values for the selected indicators were included.

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6.9. Questions to be answered

- What kind of assessment tools do we need to assess the state of the marine environment?
- What do the Conventions need?
- What does EEA have to offer?
- How are the Ecological quality and the Framework Directive connected?
- Tools like the Common Procedures of the OSPARCOM may be used by the other Conventions. Can we all agree and develop the same principle?
- Can the GIS system developed in the EEA, together with other environmental information help in this direction? How?
- GIS was not used for assessing the marine environment. Could it be done? If yes, how could it be developed? Are the Conventions able to use it? Do they have the capacity? If not, how can EEA help? Could EEA/ETC and the Conventions discuss the collaboration of the GIS in a more formal workshop?
- What are the parameters that define the Ecological quality in the different Regional Seas? Could these parameters (or part of them) give the same picture for each of the regional seas? Should it be in close connection with the Framework Directive from DGXI?
- Could the EEA/ETC, use the data from the Conventions to improve the indicators that have been developed as a tool?
- What else do the Conventions want from EEA? Tools can be identified for the coastal issues (indicators, thematic maps etc.). Which tools can be identified for the marine waters that needs more work to be done? Priorities have to be applied.
- There is a need for improving cooperation. How can this be done? Through smaller meetings/ workshops? Through larger meetings, like this Forum?
- If the answer to the point above is to have smaller action oriented meetings, EEA is ready to provide the ground for this. It could assist the Conventions and invite them all for specific needs to small workshop. Where? Would that be enough?
- Are there differences in assessment tools between the Conventions, but which can lead into the same result?
- They are often used for each one on the basis of the agreement that they have with the Member States. Would it be possible to agree on common tools?
- Can EEA take the responsibility to identify these common tools for the Conventions? Would that improve monitoring capacities?
- Reporting of EEA will be based on yearly indicators. Every 5 years a Report on the EU State of Environment Report will be produced. Can these assessment tools be used in the next 5 year reporting phase from EEA? Big issue: Harmonisation of Reporting.

7. Major research needs to improve assessment

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7.1. Introduction

7.1.1. Basic challenges

Environmental assessment involves assessing the state, condition and health of marine ecosystems. This requires an overall holistic approach with focus on the structural and functional integrity of the ecosystem on the one hand, and the sum of effects from the totality of human uses or impacts on the other. The marine ecosystems undergo natural changes and fluctuations in response to e.g. climatic variations. A basic requirement of an environmental assessment is to be able to distinguish changes due to anthropogenic influence from changes which are due to natural variability. If this can be achieved a further requirement is to be able to distinguish changes due to a particular human activity, e.g. fishing, from those from other human activities, e.g. eutrophication. This would be required as a basis for decisions on remedial actions.

A thorough environmental assessment is a great challenge which requires a high level of general and detailed knowledge. At present the knowledge base is fragmented and insufficient, and there is therefore a great and long-term research need to improve the situation. Priority areas of research to improve the assessment work of the international Conventions are identified and discussed in this document.

7.1.2. Main existing European-level research activities to improve assessment

There are extensive research activities in research programmes under DG-XII of the European Commission with varying degrees of relevance to environmental assessments. Two major programmes are Marine Science and Technology (MAST-III) and Environment and Climate.

The MAST-III programme has programme areas on marine systems research, regional sea projects, coastal and shelf sea research, generic technologies, and operational oceanography. Two of the regional sea projects deserve special mention. The Mediterranean Targeted Project phase III aims to examine the function of the Mediterranean Sea in all its aspects, applying a strong multi-disiplinary approach. The results can be used to monitor the whole Mediterranean environment and provide a basis for better environmental assessment. The Baltic Sea System Study (BASYS) applies a system approach and has as its goal to help understand the susceptibility of the Baltic Sea to natural and man-made causes.

Environment and Climate has four programme components:

a. A. Research into the natural environment, environmental quality and global change.

b. B. Environmental technologies.

c. C. Space techniques applied to environmental monitoring and research.

d. D. Human dimensions of environmental change.

The area of Environmental technologies addresses the following three issues:

1. Instruments, techniques and methods for monitoring the environment.

2. Technologies and methods for assessing environmental risk and for protecting and rehabilitating the environment.

3. Technologies to forecast, prevent and reduce natural risks.

7.2. Research activities carried out by the Conventions

OSLO AND PARIS COMMISSION (OSPAR)

OSPAR is in a similar situation as HELCOM in that it does not carry out or co-ordinate research. Supporting activities are however carried out mainly in co-operation with ICES. OSPAR requests scientific advice on specific topics from ICES in an annual work programme. Topics for advice have included guidelines and procedures for sampling and analyses of contaminants in monitoring programmes, nutrients and eutrophication, and environmental impacts by fishing activities and mariculture.

HELSINKI COMMISSION (HELCOM)

Due to the fact that HELCOM is not a research organisation, no real research activities are co-ordinated by it. Some of the activities may, however, be considered as supporting activities.

- HELCOM has acknowledged the importance of quality assurance (QA) issues, and two ICES/ HELCOM Steering Groups on QA of Chemical and Biological Measurements in the Baltic Sea have been working since 1990 and 1991, respectively, with the aim:
- to co-ordinate the development and implementation of a QA-programme for laboratories participating in the Baltic Monitoring Programme,
- to give guidance on practical questions relating to QA and how QA data should be used in relevant assessment work, and
- to give advice on the revision of the monitoring programme and to prepare relevant QA guidelines for measurements.

Several workshops on specific topics have been arranged during the past years and all these activities are seen as an essential support for the monitoring and assessment work. Since the chemistry sector is somewhat ahead of the biology, the main emphasis has been during the last years on biological QA aspects.

Application of the best possible analytical methods does not, however, guarantee that the monitoring data is good for assessment purposes. Sampling strategy and selection of parameters to be monitored are also extremely important for a successful monitoring programme. In the recent revision of the Baltic Monitoring Programme (BMP) special emphasis has been given to these issues. The old strategy of the BMP was based on sampling at fixed stations using research vessels. This resulted in a very low frequency for data collection both in space and time. In the highly fluctuating and patchy Baltic Sea this has caused severe problems in. e.g., trend analysis of the biological variables.

In the revised programme automated systems such as automated buoys, ship-of-opportunity technique, and remote sensing are emphasised. Numerical and statistical models should become an elemental part of the monitoring system on equal terms with the actual field measurements. Observations must be closely coupled to modelling in an iterative way. Models could be used to efficiently direct and interpret observations. Models could also be used to interpolate and extrapolate observations both in space and time. Coupled observational modelling strategies of this kind have been well developed in the International GLOBEC and GOOS programmes.

As a special service the updating and running of the HELCOM Bibliography could be mentioned. Since 1975 bibliographic material has been collected and distributed to the Contracting Parties. First the distribution was made through paper copies and microfiches but later on through on-line or Internet services. (http://otatrip.hut.fi/vtt/baltic/intro.html or, http://www.helcom.fi/special.html -HELCOM homepage).

Co-operation with ICES, which is based on a Memorandum of Understanding between ICES and HELCOM, is important for HELCOM. In practise HELCOM agrees annually upon a set of specific requests which are forwarded to ICES. The advice by ICES is delivered by the ICES representative to the appropriate meetings of the subsidiary bodies of HELCOM as well as in the reports of the ICES Advisory Committee of Marine Environment. For this co-operation HELCOM pays annually an agreed amount of money.

The actual scientific work is carried out by the Contracting Parties. HELCOM is not involved in the planning and possible selection of the research topics of the Contracting Parties.

ARCTIC MONITORING AND ASSESSMENT PROGRAMME (AMAP)

The aim of the first phase of the AMAP programme was to produce a QSR for the Arctic region, and for that purpose a monitoring programme was designed building on existing monitoring activities with emphasis on levels and geographical trends of contaminants. Although limited research has been carried out or co-ordinated by AMAP, the results from research activities have provided an important source of information for the environmental assessment in the QSR.

A phase II of AMAP is now being planned with stronger emphasis on research to allow better description and evaluation of transport routes and biological and ecological effects of contaminants.

UNITED NATIONS ENVIRONMENT PROGRAMME /MEDITERRANEAN ACTION PLAN (UNEP/MAP)

Monitoring is the main assessment tool used within MED POL. Phase III of MED POL, which now is being implemented, provides for the initiation of monitoring programmes of temporal trends of levels of chemical contaminants mostly in biota, and of biological effects of pollutants in marine organisms.

Very little research is supported directly by MED POL. A number of laboratories have been assisted to develop the suite of biomonitoring techniques which have been recommended provisionally on a regional basis. Since this is a new field, research is carried out to test their suitability. In parallel, a number of species are tested especially for EROD activity to identify the most suitable ones for inclusion in monitoring.

In the field of trend monitoring some work is going on to identify suitable species and also to test different designs of monitoring schemes. Work on eutrophication continues and the emphasis now is on the proper treatment of the data to assist decision making. Microbiological work on testing of methodologies, survival and degradation of microbial contaminants will continue, but emphasis will be given to factors affecting the discharge pattern of wastewater, as well as to the development of environmental quality criteria and common measures for microbial pollution.

BLACK SEA ENVIRONMENT PROGRAMME (BSEP)

A monitoring programme has been proposed, focusing on biological effects and contaminant levels in the Black Sea. The proposed programme draws upon experiences gained in other international monitoring programmes and is based on a strategy developed by ICES for implementing a general biological effects programme. The objectives are to determine health status of organisms and ecosystems, to reflect exposure to selected pollutants, and to provide an integrated approach for assessing the quality of component parts of the ecosystem.

A research component to the monitoring programme has been suggested. Since the programme is still under development, this research component has not yet been specified and implemented.

7.3. Priority research fields

7.3.1. General research needs

Ecosystem properties

An assessment of the condition, state or health of a marine ecosystem requires basic knowledge about the properties of such ecosystems. This includes knowledge about the structure and function of marine ecosystems, their biodiversity and stability properties, including resistance and resilience to external stress and driving forces for ecosystem variability. Such knowledge is generally scarce at present and there is a need for research activities to improve the basic level of knowledge. While this research area is intellectually challenging, encompassing, and resource demanding, specific research efforts could be directed at the following items to improve the basis for environmental assessments at the regional and European levels.

- ***Research into climatic driving forces for ecosystem variability at the regional and European level.*** We know that for many Large Marine Ecosystems (LMEs) physical forcing through climatic variability is a primary driving force for ecosystem variability (Sherman 1994). Focused research on the role of climatic variability for the variability in the regional marine ecosystems of the European seas would greatly benefit the difficult task of distinguishing impact by man from natural variability. Research on the climate system at the European level would provide basic information for the environmental assessments carried out by the regional conventions. There would also be a need for research to lay the foundation for a harmonised system for monitoring, assessing, and forecasting the ocean climate of the European seas. This would be of relevance not only for environmental assessments but also for the assessment and management of living marine resources, coastal zone management, and maritime operations. This should be seen as a European level component of GOOS which would provide a framework for co-operation to fulfil the needs of the regional conventions and other international organisations such as ICES.
- ***Research on foodwebs, interactions and dynamics of marine ecosystems.*** Several aspects of environmental assessments, e.g. effects of contaminants, eutrophication, fishing activities, and introduction of alien species require knowledge about foodwebs and biological interactions in marine ecosystems. There is a need for ecosystem focused research on the marine ecosystems of the European seas. One system of need for such research is the North Sea. Despite being perhaps the most studied sea area in the world, it is still only fragmentarily understood as an ecosystem as is quite apparent from the North Sea QSR 1993 (NSTF 1993). The North Sea is a strongly exploited and stressed ecosystem. It should be a priority research area to provide the necessary insight into the properties of the North Sea LME to provide the scientific basis for an ecosystem approach to its future management. While achieved results would provide specific insight into the North Sea ecosystem, they would also provide general knowledge transferable to other regional seas in general and comparative contexts. Ecosystem focused research should also be carried out in other European seas. Priority could be given to other areas such as the Black Sea which is an impacted and distressed ecosystem.
- ***Research into methods for characterising and expressing the changing states or health of marine ecosystems.*** This could include theoretical considerations of the information required, harmonised collection and management of information and data from a number of national and regional institutions, and the expression of ecosystem state or health based on this information by e.g. statistical and multivariate techniques or by the use of indicators. Work carried out by the ETC-MC under the 1995 and 1996 Subventions provide relevant background information to this research area.

Species and habitats

Protection of species and habitats is an overall aim for the work on environmental assessments by the Conventions. Biological effects, impacts and disturbances by different human activities affect species and habitats in the marine ecosystems. The OSPAR JAMP (Joint Assessment and Monitoring Programme) issues 6.2 and 6.3 address the roles of different habitats for the functioning of marine ecosystems and their areal extent, connectedness and rarity within the ecosystems. There are important issues related to species diversity and roles of different species within ecosystems. Going from an era with emphasis on flows of energy and matter in ecosystems, there is now a recognised need to move towards greater emphasis on species population dynamics, habitats, and marine "landscape" ecology. This is a vast research area which will require extensive and long-term research commitments. Some specific research areas are identified which could benefit the work of the Conventions:

- ***Research on methods for mapping and producing inventories of marine habitats.*** The seafloor consists to a lesser degree of uniform mud and sandflats than is often conceived, but contains a number of geological and sedimentary structures that produce a mosaic of smaller or larger biotopes or habitats. There is a need to more thoroughly map the seafloor of the European seas in an ecologically meaningful manner as a basis for producing distribution maps of species and maps of biotopes or habitats. This is an extensive and long-term task. There is a research need to develop strategies and cost-efficient methods and technologies to survey and map benthic habitats.

- ***Research on rare habitats and rare species.*** The revealed species richness of an area depends on the extent of sampling and the size of the sampled area. Often there is a considerable selection involved in the types of habitats and species which can be sampled with conventional benthic sampling gear. We may therefore have biased information and impression of the species and species richness in marine ecosystems. Habitats of restricted spatial extent may contain special biota which may not have been revealed in conventional sampling. Such habitats and their biota may be particularly vulnerable to impact by human activities due to their restricted spatial extent. There is a need for research of both theoretical and practical nature to explore the issue of rare habitats and rare species.

Transport pathways and processes in marine ecosystems

Marine ecosystems are open systems with considerable flows and transports of water and associated transports of organisms, organic material, sediments, and contaminants. Such transports are important with regard to descriptions and understanding of the functioning and variability of the natural ecosystems. They are also important for assessment of fates and effects of input of contaminants to the marine ecosystems. There is a wide range of research topics of a both general and contaminant-specific nature. These include physical transport of contaminants by water, suspended solids and sediments; biological uptake, bioaccumulation, biomagnification and biotransformation of contaminants in marine food chains and food webs; and contaminant transport mechanisms, pathways, and cross-media interactions.

- ***Basic research on the topics of transport pathways and processes.*** Such research may be co-ordinated and conducted at the European level without a specific regional focus. The gained knowledge may be applied at the regional level or provide the basis for further more focused research to apply it to regional problems, taking into account as required the specific regional conditions.
- ***Research on transport models.*** Input of persistent contaminants to marine areas follows to a considerable degree atmospheric transport routes as well as transport with seawater and suspended matter from one regional sea to another. There is therefore a strong case for co-operation and co-ordination among the Conventions and other international organisations dealing with contaminant transport and environmental assessments. Rather than independent model development for each region, generalised transport models at the European or hemispheric scales could be developed, using consistent sets of contaminant input data. Such models could then be further refined by e.g. increased resolution for application at the regional level. There is a research need in the further development and refinement of such contaminant transport models and in their validation.

Biological effects of contaminants

There is a multitude of contaminants with different properties with regard to transport, toxicity, and biological and ecological effects in marine ecosystems. Assessment of the effects of contaminants is therefore a difficult and challenging task. Development and use of ecotoxicological assessment criteria rest on the accumulated evidence from experimental studies trying to establish relationships between exposure levels or body burdens of contaminants on one side and biological effects on the other. Contaminants can occur in different forms and interact with other chemical substances. There is a range of exposure ways and a multitude of different species and life stages of species which may have different sensitivities and responses to contaminants. Contaminants occur commonly in complex mixtures which are likely to cause combined effects by different contaminants. Establishing relationships between concentrations or doses of exposure of contaminants and biological or ecological effects is an important but very demanding task.

Basic research on biological and ecological effects of contaminants is a prime area where international and inter-regional co-operation can be developed. Results gained from experimental work will typically be of a general nature and contribute to the information basis for establishing and refining ecotoxicological assessment criteria. Research instigated within one organisation and region can generally be utilised in other regions. Some specific research topics which could be priority areas of co-operation are listed below.

- ***Research on Quality Assurance (QA) of biological effects techniques.*** Several biological effects techniques have been identified as potentially useful for inclusion in environmental monitoring programmes (ICES ACME 1995 report). Related to chemical measurements in monitoring programmes there has been a special EU-supported QA programme (QUASIMEME) to ensure comparability of results. There is now a great need for a similar international QA project for the biological effects techniques which have been identified and recommended for use in monitoring programmes. The QA requirements have been outlined in the ICES ACME 1996 report, and a project proposal to implement a programme to develop details of these QA procedures and co-ordinate intercomparison activities will be submitted to EC DG-XII.
- ***Research on further development of biological effects techniques and bioindicators.*** A number of biological effects techniques have been identified as potentially useful for application in monitoring. There is a need for further research to clarify their usefulness and evaluate their limitations and strengths. There is also need to explore new techniques to widen the suite of methods which should be available for future applications to strengthen the basis for assessments of ecological effects of contaminants.
- ***Research on combined effects of contaminants.*** Contaminants may have additive, synergistic or antagonistic effects. The typical environmental situation is one of long-term exposure to low levels of a range of contaminants. Assessment of possible effects of single contaminants are done by comparison with ecotoxicological criteria or concentrations which have or have not produced effects in experimental studies. There is now a need to start addressing the combined effects of multiple contaminants. This is an issue of common interest and relevance to all regional programmes and Conventions. There is much to benefit from close co-operation as there is limited expertise available and since basic knowledge would be applicable to all regional programmes. It is suggested that this research area should be given high priority, and that a joint workshop of experts should be convened to further assess the state of knowledge and to make specific research plans.

7.3.2. Priority research areas for the Conventions

OSLO AND PARIS COMMISSION (OSPAR)

OSPAR has not prepared any separate list of priority research needs for monitoring and assessment. Research needs are however identified in the assessment process. In the North Sea 1993 Quality Status Report a number of gaps in knowledge were identified which are candidates for research activities. In the Joint Assessment and Monitoring Programme (JAMP) a number of environmental issues have been identified under the categories of contaminants, eutrophication, litter, fisheries, mariculture, and ecosystem health and habitats. For each issue a work programme has been made which outlines the activities to be undertaken. For some of the issues research is identified as the appropriate activity. JAMP therefore provides an overview of research needs for the OSPAR work on environmental assessment.

One item can be singled out as a priority issue for concerted action. This is the topic of quality assurance for biological effects monitoring techniques. Several techniques have now been recommended by ICES ACME and by ASMO for inclusion in monitoring and assessment work. There is a need to develop adequate QA procedures for these techniques to ensure comparable results from their use in monitoring and research programmes.

HELSINKI COMMISSION (HELCOM)

The quality of an assessment report depends very much on the quality of the data itself and on the quality and design of the monitoring programme. To improve the quality of the data, main attention has been paid, by tradition, to analytical QA (development of methods, intercalibrations/intercomparisons, etc.). ICES has had an important role in this analytical work over the past decades. Between 1993 and 1995 the European Union supported the development of a holistic quality assurance programme for marine environmental monitoring information in Europe (QUASIMEME), which has afterwards expanded from this initial EU project to include additional determinands and is now open to all laboratories which make chemical measurements in the marine environment through a subscription scheme. More recently a QA programme of sampling and sample handling (QUASH) has been set up. Some of the "HELCOM laboratories" (for sea moni-toring as well as for pollution load monitoring) have been able to benefit from the Europe-wide activities but unfortunately several of the Contracting Parties to the Helsinki Convention have always been left out.

Although monitoring programmes are revised periodically, there is an insufficient amount of data to allow adequate assessment of the state of the Baltic Sea. This could most probably be improved by applying biological effects techniques which can integrate the effects of a wide range of stress factors. For the Baltic Sea there is an increasing need to develop a coherent monitoring programme on the biological effects of changing environmental conditions (contamination, eutrophication) on organisms. Presently, the studies have been more or less sporadic, or mere case studies.

Due to the special environmental and biological characteristics of the Baltic Sea, studies performed in other sea areas cannot directly be applied in this area. Furthermore, regarding the Baltic Sea organisms that are potentially suitable for monitoring, relatively little information exists on the basic characteristics and suitability of the physiological parameters. Thus, a joint programme involving several Baltic Sea countries on the applicability of these parameters is called for.

Taking into account the results of the periodic assessments the following issues are considered as priority research fields within HELCOM:

1. Biological effects of contaminants, in more detail, inter alia:

- bioassays, biomarkers, liver histopathology, community structure, fish diseases;
- oil hydrocarbons in sea water, biota and sediments;
- survey of TBT concentrations in potentially endangered areas;
- contaminant burden of salmon tissue and salmon feed, and linking the contaminant levels to possible effects;
- studies aiming to give information on effects of contaminants on Baltic top predators;
- measurements of contaminants in seawater and suspended particulate matter.

2. Remote sensing and automated systems, in more detail, inter alia:

- satellite imagery, as a tool for monitoring the spatial distribution of phytoplankton biomass in the surface layer, especially the accumulations of blue-green algae, distribution of water masses etc;
- development of automated systems, such as automated buoys and ship-of-opportunity technique;
- development of new techniques to estimate primary production (e.g. fast repetition fluorometry, to record primary productivity with high resolution;
- flow cytometry, to describe the plankton community with an automatic method, HPLC pigment analysis, to get fast information of the phytoplankton pigment composition as indicator of the taxonomical composition.

3. Development of models

- Observations must be closely coupled to modelling in an iterative way. Models could be used to efficiently direct and interpret observations. Models could also be used to interpolate and extrapolate observations both in space and time;
- application of new tools for information spreading (information data base linked with www-presentations).

ARCTIC MONITORING AND ASSESSMENT PROGRAMME (AMAP)

In AMAP assessment work a number of gaps in knowledge and deficiencies in different approaches have been identified. On this basis the following priority research fields in need of additional research are suggested:

- Basic research on effects of contaminants (both laboratory and field studies) to improve the knowledge base for establishing effects thresholds and environmental guidelines. Especially there is a need for research concerning ‘combined effects’ (both effects of combinations of different contaminants/types of contaminants, and combinations of contaminants and other environmental stressors such as UV-B).

- Model related research including: improved data on sources; improved models for specific regions (e.g. the Arctic where special environmental conditions such as low temperatures, ice, etc. are not taken into account in existing models); research into contaminant transport mechanisms/pathways and cross-media interactions which are poorly understood at present (e.g. sea ice); food-web research and related topics associated with biological pathways modelling.

Basic research on the effects of contaminants on the environment and ecosystems is a prime area where international and inter-regional co-operation can be developed, and where research instigated within one forum can be utilised in others.

Similarly, all regional programmes face similar problems in relation to the issue of 'combined effects'. Combined effects are effectively ignored in current assessments due to the complexity of the problem and lack of basic research into this topic. Situations leading to acute exposure to contaminants (e.g., industrial exposures) are not the main focus of most regional environmental programmes, as these situations are largely covered by national regulations and bodies. In most areas, the typical environmental situation is one of long-term chronic exposure to low levels of environmental contaminants. Whilst regional assessments are beginning to consider 'single contaminant effects' in their assessments (e.g. comparing levels with effects thresholds, assessment of data from biological effects monitoring, single contaminant trend studies) the implication of the 'combined effects' issue is that it can change the conclusions from such assessments.

In the future work of AMAP there is a strong desire to begin to tackle the problem of combined effects and their relevance to environmental assessments. AMAP would like to propose that the inter-regional forum adopts the subject of combined effects of contaminants as a primary focus for a co-ordinated and jointly-sponsored activity. This is because:

- the problem should be of considerable common interest/relevance to all regional programmes (OSPAR, HELCOM, EEA, etc.);
- basic research/knowledge is equally applicable to all such programmes;
- limited expertise on this subject exists (in terms of accessibility to a given regional programme) and this could be more effectively utilised by bringing together experts who would normally work in isolation.

This would be an area where a priority research need is strongly linked to its direct relevance to environmental monitoring and assessment needs. A joint workshop on this topic would be an appropriate activity to bring together relevant experts, assess the status of existing knowledge, and initiate a programme for co-ordinated future development of the research and its application.

UNITED NATIONS ENVIRONMENT PROGRAMME /MEDITERRANEAN ACTION PLAN (UNEP/MAP)

At a meeting of MED POL National Co-ordinators (20-23 May 1997) it was agreed that during MED POL Phase III the following subjects should be given priority as far as target-oriented research for pollution assessment and control is concerned:

a. eutrophication

b. biomonitoring techniques

c. atmospheric deposition

d. biogeochemical studies

e. evaluation of the standards applied and establishment of quality criteria for recreational waters, and

f. methods and techniques for pollution prevention

BLACK SEA ENVIRONMENT PROGRAMME (BSEP)

There will be distinct advantages to be gained if the Black Sea monitoring programme contains a research component. This will help maintain the scientific interest of the scientists involved in implementing the monitoring programme. Furthermore, such a research component will help to develop the regional technical capability for future monitoring and also stimulate and motivate the scientists. Studies on other organisms (both animals and plants) with regard to antioxidant defences, lysosomal membrane stability, histopathology, and histochemistry would also be appropriate, in order to be able to derive information from several levels of organisation within the ecosystem.

An improved research capability will also provide additional tools which will help to address the problem defining and solving elements of the programme for general biological effects monitoring.

A further consideration that falls within the area of research is human health concerns. In the context of the Black Sea the main identifiable issues are as follows:

- Persistence of cholera;
- potential of some algae to produce toxic blooms related to ecological changes and interventions;
- bioaccumulation of toxic contaminants which may be transferred through the food chain to humans (e.g., cadmium, PAHs and organochlorines).

An active culture of research in contaminant chemistry, biomarkers and microbiology, linked with mussels, would facilitate the eventual inclusion of a module for human hazard identification and risk assessment in the monitoring programme for the Black Sea.

7.4. Questions to be answered

- The paper is too ambitious, but it is meant to be ambitious. Focusing down, which research issues should be tackled?
- Which are the concrete actions to be taken from this exercise?
- Can we prepare a pan-European project? On what? Biological Effects Monitoring?
- What are the priorities for monitoring? How can these comply with the specific heading from the paper (Ecosystem properties, species and habitats, Transport pathways, Biological Effects).
- What can be done in short, medium and long term? How can the ETC be involved?
- How can we perform a more concise monitoring programme using the same but fewer parameters? Which issues should be involved? What kind of research is needed for this? Who is going to perform it?
- How can we organise it? Workshop with experts on the specific issue to be identified by the Conventions? Proposals by the ETC partners?
- Programme under EU? ESF? Concerted actions of specific programme to start the process? MAST? Environment? UN?
- Working groups from countries (ETC partners? Others?) to address the following issues:
    * Size of a project
    * Number of countries from the different regions to participate. Pilot Study?
    * Areas to be covered
    * Financing possibilities
- Could the pilot study be on a pan European Programme on e.g. Biological Effects Monitoring from all the Conventions involved but only 2 to 3 countries per each region (including countries from Black Sea from the southern and eastern Mediterranean and PHARE countries from the Baltic)? (12 countries could be involved in the pilot study)
- What would be the benefit of improving monitoring? First step on harmonisation of data, first approach to solving common problems.

Annex 1. Reporting requirements and linkages to the political agendas of regional conventions/action plans and the EEA

Regional Conventions and EEA		1997	1998	1999	2000	2001	2002	2003	2004	2005
HELCOM Annual reporting of data for the BMP, Airborne Pollution, Radioactive Substances; PLC reporting of aggregated data (5 years)	Reporting	PLC3 (based on 1995 data) 3rd Periodic Assessment available early 1997	Report on implementation of MD of 1998 on 50% reduction goal			4th Periodic Assessment (1994-98)				5th Periodic Assessment (1999-2001)
	Linkages		MC							
OSPARCOM	Reporting			Holistic assessment for 5 regions	Holistic assessment based upon the 5 regional assessments					
	Linkages		MMC				MMC (to be agreed upon at MMC 1998)			
MAP	Reporting		Final Report on MEDPOL Phase II	State of Environment				State of Environment		
	Linkages			MCP 1999				MCP 2003		
BSEP	Reporting	GIS Package - Monographs Biological Diversity in the BS Report	State of Pollution of the BS Report National BS Action Plans		Public Progress Reports		State of BS Environment			
	Linkages	Steering Committee Meeting BS Commission Meeting	BS Basin Intersectorial Workshop							
AMAP	Reporting	AMAP Assessment Report The State of Arctic Environment Report	Progress Report on 2nd Phase of AMAP	Progress Report on Monitoring and Assessment Activities of AMAP	Progress Report on Monitoring and Assessment Activities of AMAP					
	Linkages	Ministerial Meeting (June '97-Alta-Norway)	Ministerial Meeting (Canada)							
EEA	Reporting	Annual Report Monographs	3 years Reporting (Dobris+3 EU 98)	Annual Report Monographs	Annual Report Monographs	Annual Report Monographs	Annual Report Monographs	5 years Reporting	Annual Report Monographs	Annual Report Monographs
	Linkages		Aarhus Pan European MC							

<u>KEY:</u>
MC: Ministerial Conference
MD: Ministerial. Declaration
MMC: Ministerial Meeting of the Commission
PLC: Pollution Local Compilation
MCP: Meeting of Contracting Parties
TDA: Transboundary Diagnostic Analysis

Annex 2. Second meeting of the Inter-Regional Forum

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