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*Reports of Meetings of Experts and Equivalent Bodies*

**Health of the Oceans (HOTO)  
Panel of the Global Ocean  
Observing System (GOOS)**

**Fourth Session**

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## 1. OPENING

The meeting was opened at 13:00 hours on 13 October 1997 by Dr CHOU Loke Ming, Director of the Tropical Marine Science Initiative (see Annex III), the National University of Singapore, who welcomed both foreign and local participants. Professor LUI Pao Chuen, Chairman of the Management Committee, Tropical Marine Science Initiative, added his welcome to the participants and laid stress on the importance of the task before the Panel. The Chairman of the Panel, Dr Neil Andersen, then thanked the two representatives of the Tropical Marine Science Initiative for their respective welcomes and provided some background to the decision to hold this meeting in the WESTPAC Region at the National University of Singapore.

Dr Andersen opened the business session of the meeting indicating that Agenda Items 1 through 5 would need to be completed by the adjournment at the end of the first day of the meeting which would have to occur by 1730 hours to allow participants to return to the Merchant Court Hotel in time for the reception being hosted by the Bermuda Biological Station for Research, Inc.

The Chairman continued by providing some historical perspectives on the previous activities of the HOTO Panel and stressing some important topics for the current meeting such as the focus on user demand including deliverables, end-to-end or production-line approach, human health aspects of the HOTO Plan, the issue of potential implementation of HOTO pilot projects in some regions, particularly within WESTPAC, and indicators of sustainable development. Dr Andersen then provided some insights into working procedures such as the designation of discussion leaders, the need for members to work in small groups in the evening or over lunch breaks, etc.

## 2. ADMINISTRATIVE ARRANGEMENTS

### 2.1 ADOPTION OF THE AGENDA

Six additions to the provisional agenda were made: two dealing with GEF programmes/activities [Agenda Items 7.3.6 & 7.3.7], one dealing with indicators of sustainable development [Agenda Item 6.8], one dealing with the UK GOOS Questionnaire [Agenda Item 4.1.4] and two dealing with regional pilot projects [Agenda Items 7.1.7 and 7.1.8]. Reference to "GOOS-1998" was deleted based on a statement of Dr Colin Summerhayes, Director of the GOOS Project Office (GPO), that the draft was not yet at a stage of development to be considered for comment. The adopted agenda is attached at Annex I.

### 2.2 DESIGNATION OF RAPPORTEURS

Drs J. Michael Bowers and Michael Huber had agreed to act as co-rapporteurs for the meeting and this was gratefully accepted by the Chairman on behalf of the Panel. The list of attendees is attached at Annex II.

### 2.3 CONDUCT OF THE SESSION AND ADMINISTRATIVE INFORMATION

Dr Andersen then reiterated the working arrangements for the meeting including the times of bus transport between the hotel and the National University of Singapore.

### **3. BACKGROUND INFORMATION**

#### **3.1 PRESENT STATUS OF GOOS (I-GOOS, J-GOOS AND GPO)**

Dr Andersen noted that during the intersessional period, the GOOS Project Office (GPO) has had a permanent Director, Dr Colin Summerhayes, appointed. I-GOOS continues but it has been decided to reconstitute J-GOOS as the GOOS Steering Committee (GSC). These changes are not expected to alter the way in which the HOTO Panel works. As introduction to the main scientific work of the meeting, background information was provided on the following topics by the GIPME Officers, Drs Neil Andersen and J. Michael Bowers, for which documentation was made available (See List of Documents at Annex IV):

##### **3.1.1 U. S. Coastal Module of GOOS: a Workshop on The Sustainable Healthy Coasts Component**

This item was introduced by Dr Neil Andersen and discussed. The Workshop Report provided a stimulus for the discussion of sustainable development. The results of this discussion are provided in combination with those on the report of the J-GOOS Coastal Workshop and discussion on sustainable development (See Agenda Items 3.1.2 and 6.8).

##### **3.1.2 The International Coastal Module of GOOS: the Report of the *ad hoc* J-GOOS Coastal Workshop**

This item was introduced by Dr Bowers. The Panel reviewed the Workshop Report and noted that the development of the Coastal Zone strategy within GOOS is at a more preliminary stage of development than HOTO. It was further noted that a contrast between the reports of the US Sustainable Healthy Coasts Component Workshop and the *ad hoc* GOOS Coastal Workshop is that the former reflects an appropriate concentration on strategic considerations while the latter appears to be defocussed from strategic matters. The Panel agreed that it was essential that the HOTO Panel be adequately represented in the work of the new Coastal Panel, when formed, to ensure that HOTO aspects of the Coastal Module design were given balanced consideration with those of other perspectives.

##### **3.1.3 Report of J-GOOS-IV**

Dr Andersen drew attention to the report of this meeting noting that one significant development was the creation of Terms of Reference for a Coastal Module Panel.

##### **3.1.4 Report of IOC/UNEP/IMO GIPME Officers' Meeting**

Drs Andersen and Bowers, Chairman and Vice-Chairman of GIPME, respectively, briefly informed the Panel of discussions which took place at IMO, London in May, 1997. Human health issues as they related to ballast water considerations resulted in IMO expressing interest in this aspect of the Panel's work. Other matters relating to HOTO that were considered were sediment quality and mussel watch activities which are addressed in subsequent agenda items below.

### **3.1.5 Report of I-GOOS-III**

Dr Andersen drew the attention of the Panel to the Session Report of I-GOOS-III. He pointed out that this document contained the "GOOS Principles" which would be considered under Agenda Item 4.1.1.

### **3.1.6 Report of XIX<sup>th</sup> IOC Assembly**

The Chairman reported to the Panel that he had received strong support from the IOC Assembly for the HOTO Module to be developed and implemented within the context of the GIPME Programme. This was explained as an agreement to use existing mechanisms and infrastructure available within an IOC Programme to transfer the strategic design elements of HOTO to the implementation phase as appropriate. It was pointed out that the relationship is essentially the same as with the IOC/UNEP International Mussel Watch Project which has been and is being carried out in the context of GIPME.

### **3.1.7 IMO/IOC/UNEP Sediment Quality Guidelines Workshop**

An IOC/UNEP/IMO GIPME Workshop on Sediment Quality Guidelines was held at IMO Headquarters, London, 6 - 9 May, 1997. The Workshop was designed to determine scientific approaches to establishing sediment quality guidelines that might be suitable for a range of management applications such as the London Convention 1972, the Global Programme of Action for the Protection of the Marine Environment from Land-Based activities, and various regional and national purposes. The report of this workshop represents an initial examination of the scientific aspects of guideline setting and an analysis of management requirements. The workshop will probably be followed by subsequent GIPME-sponsored meetings to develop guidance on guidelines for marine environmental management applications. However, even though the workshop was a preliminary effort to address the subject matter, it once again demonstrated the absolute need to fully consider the drainage basin (and therefore GTOS) associated with coastal zones. Further details of the workshop can be found in the IOC Annual Report for 1997.

### **3.1.8 IOC/GIPME Fact Finding Mission to WESTPAC**

Dr Andersen briefly described the fact-finding mission that he and Dr Bowers had made in March and April of this year to Thailand, Singapore, Peoples Republic of China, Republic of Korea and Japan. This mission covered topics related to GIPME and HOTO, as well as GOOS in general, to activities going on and planned for the WESTPAC Region. The hope is to build on the information gained and exchanged in meetings such as this HOTO Session. It was noted that a number of the agenda items coming up would refer to this mission. The full mission report can be obtained from the IOC.

## **3.2 PRESENT STATUS OF THE LIVING MARINE RESOURCES (LMR) MODULE OF GOOS**

Dr Andersen summarized his understanding regarding activities related to the present status of the LMR Module of GOOS. New Terms of Reference are being formulated and a Chairman and members for an LMR Panel are being sought. An LMR Panel meeting is planned for Spring, 1998. All these plans should be fully developed within a month of this HOTO Panel Meeting. The Panel expressed the need to insure HOTO input into LMR planning.

### 3.3 PRESENT STATUS OF THE COASTAL MODULE OF GOOS

Drs Bowers and Andersen provided additional conclusions of the *ad hoc* J-GOOS Coastal Module Workshop held in Miami in March, 1996. Both registered some disappointment regarding strategic planning and lack of specificity. Dr Andersen then informed the Panel of recent developments regarding the GOOS Coastal Panel. Dr Thomas Malone, Center for Environmental Science, University of Maryland, Cambridge, MD, has agreed to chair the Panel. A list of proposed panel members will soon be submitted to the GOOS Project Office for action. It was also pointed out that Drs Malone and Andersen being in the same institution essentially guaranteed the incorporation of the coastal elements and interests of the HOTO Module into the Coastal Module.

## 4. STATUS OF THE STRATEGIC PLAN FOR THE HOTO MODULE OF GOOS

The Chairman summarized information on the following items to facilitate subsequent discussion:

### 4.1 THE GOOS PRINCIPLES AS CONTAINED IN THE I-GOOS-III REPORT DOCUMENT

The Panel reviewed the GOOS Principles annexed to the Session Report of I-GOOS-III and found them to be succinct expressions of sound principles augmented by appropriate explanation.

### 4.2 THE GOOS STRATEGIC PLAN

The Panel reviewed the Draft GOOS Strategic Plan. A single concern arising was the appropriateness of the definition of Module Panels, Specialist Panels and Working Groups as having specifically distinct meanings. It was questioned whether this would constrain the smooth development and implementation of GOOS components by introducing unnecessary rigidity to the administrative structure. The Panel noted that even though the relationship between HOTO and GIPME, referred to in Agenda Item 3.1.6, would minimize this perceived problem for HOTO, it was still a potential problem if the modules were amalgamated for the over-all implementation of GOOS into coastal and basin wide components as is being suggested by some (i.e., the U. S.).

### 4.3 GUIDELINES/PRINCIPLES FOR OBSERVING SYSTEMS (I.E., KARL'S PRINCIPLES)

Consideration was given to "Karl's Principles" (See Annex V) as generalized to the broader GOOS context. It was noted that principle 'iv' (i.e., common data management practices), if applied inflexibly, could preclude the inclusion in GOOS of existing regional programmes since concurrent regional programmes often employ different data management practices (See Agenda Item 7.3.1). Thus, principle 'iv' might in some cases conflict with Principle '1'. The Panel therefore recommended that, in the GOOS context, "Karl's Principles" be treated as guidelines.

With regard to principle 'iv' it was also noted that although common data and information management practices and adequate metadata are both highly desirable, they are not necessarily causally related as is implied by the present language. It was suggested that principle 'iv' be re-stated in two separate principles calling for common data management practices and adequate metadata.

It was also noted that principle '6' of the original set of Karl's Principles (i.e., special consideration for long uninterrupted records) was an important one not explicitly articulated in the generalized set.

#### 4.4 U.K. GOOS DATA REQUIREMENTS QUESTIONNAIRE (Note - this document has copyright rights by the EuroGOOS Office, Southampton, U. K.)

The Panel reviewed the U.K. GOOS Questionnaire (Annex VI) from a HOTO perspective and noted that the section on environmental protection/preservation is weak. It does not include all appropriate keywords, most obviously: ecological risk assessment; hazard assessment; marine ecotoxicology; environmental management; or direct toxicity assessment. The basic and strategic research section should also include marine ecotoxicology and marine biotechnology. It was further pointed out that though the emphasis on commercial users may be appropriate for the developed countries for which the questionnaire was presumably developed, one for developing countries should perhaps place more emphasis on governmental or NGO users (e.g., regulators, policy makers, etc.).

#### 4.5 DELIVERABLES AND USER NEEDS

The Panel strongly endorsed the principle that GOOS implementation should be fundamentally driven by user needs. This is reflected in the HOTO Strategic Plan (p. 22):

*It is absolutely essential that the goals and objectives of any monitoring programme be clearly stated from the outset. The entire design of the programme should flow from these goals.*

The Panel emphasized that the specification of goals and objectives must be undertaken in close collaboration with prospective users of HOTO products.

Specific strategies recommended by the Panel to promote responsiveness to user needs include the development of conceptual models linking HOTO measurements to identified socio-economic outcomes (See Agenda Item 6.8 and Annex XI), the involvement of decision-makers in the design of regional pilot projects (See Agenda Item 7.6), and the inclusion on the HOTO Panel of representatives of the user and donor communities (See Agenda Item 9.3).

### 5. REVIEW THE TERMS OF REFERENCE FOR THE J-GOOS HOTO PANEL

It was agreed that the revised Terms of Reference for the HOTO Panel (Annex VII) would be reconsidered during the course of the meeting and refined to identify more clearly the most important, or core, terms of reference and those of a more routine ancillary nature. The following proposed revised Terms of Reference arose from this discussion:

The HOTO Panel will be responsible for:

1. Ensuring continued updating of the Strategic Plan for HOTO to adequately reflect scientific understanding and technical capability arising from relevant research and development by:
  - maintaining liaison with research and monitoring activities to ensure that assessments and predictions of the health of the oceans are based on sound and contemporary scientific knowledge; and

- developing interactions with other scientific and technical bodies and programmes relevant to the development of GOOS (i.e., ICES, PICES, Euro-GOOS, LOICZ, etc.);
- 2. Analyzing further environmental health criteria or indices that can provide early warning of change in marine environmental quality and threats to human health;
- 3. Co-ordinating with other GOOS Modules to ensure compatible strategic and scientific development of all GOOS Modules;
- 4. Identifying the requirements, nature and availability of models that can facilitate the proper development of HOTO products and/or allow prognostic prediction of potential/future conditions relating to the health of the oceans;
- 5. Identifying the scientific components of training, mutual assistance and capacity building, to undertake regional assessments;
- 6. Examining the content of existing operational systems, both national and international, that deal with the health of the oceans with a view to advancing GOOS; and
- 7. Defining HOTO products and socio-economic benefits relevant to the requirement of specific users and describing the procedures leading from the base variable measurements, through scientifically valid interpretation, to the preparation of such products and benefits.

## 6. UPDATING REQUIRED IN THE STRATEGIC PLAN

### 6.1 HUMAN HEALTH ISSUES

Dr Michael Depledge began the discussion by summarizing the latest state of debate regarding the risks to public health imposed by algal blooms and any association with human disease transmission. This was followed by a presentation by Dr Bo Drasar of the comparative infection rates for cholera and other diseases and the physiology of *Vibrio cholerae*. The Panel felt that the matter of increasing cholera incidence as a result of climate change is speculative and a proper evaluation requires further research. At the present time, the claim that cholera incidence would increase as a consequence of climate change appears to be unsupportable.

***Vibrio cholerae*:** Following the publication of the HOTO Strategic Plan in May 1996, an extensive debate arose among some members of the HOTO panel concerning the relationship between global warming, the occurrence of marine algal blooms and outbreaks of cholera. It has been argued by Dr Paul Epstein and co-workers that this area warrants urgent attention. However, Gray *et al*, (1996) have argued that at present, there is insufficient evidence to justify incorporation of studies to address the above issues in the HOTO monitoring programme. Additional experts have provided information to help clarify the issue. Evidence for global warming remains a matter of scientific debate as does evidence that the frequency of marine algal blooms is increasing (See Agenda Item 6.3). Furthermore, the causal association between global climate change, bloom frequency and risks to human health has not yet been established. However, with regard to the ability of *V. cholerae* to survive in water,

long term survival has been shown in laboratory microcosms at a wide range of salinities ranging from 1 to 30 psu, representing the spectrum from freshwater through estuaries to coastal seawater (Miller *et al*, 1982; Miller *et al*, 1984; Draser and Forest, 1996). Also, survival in fresh waters occurs in association with a variety of freshwater algae (Islam, 1988 and 1990). *V. cholerae* can attach to seaweeds in laboratory mesocosms. However, although it is accepted that *V. cholerae* is a member of the autochthonous microbiota of many estuarine and natural bodies of inland water, there is no evidence that *V. cholerae* fills a similar ecological niche in the open sea or coastal waters. It should also be noted that in context of the HOTO monitoring programme, detection of the very low concentrations of *V. cholerae* in seawater will require major technological developments. At this stage the assembled Panel members believe that *V. cholerae* should not be added to the list of analytes in the programme. The best indicator of the occurrence of significant numbers of *V. cholerae* in the marine environment is the appearance of cholera cases. Cholera is readily treatable by antibiotics (i.e., tetracycline, erythromycin and kanamycin) and rehydration therapy.

With regard to cholera epidemics, it appears that vulnerable individuals will from time to time develop cholera due to the ingestion of contaminated food or water. Such contamination might result from cholera introductions from the marine environment. What is not in doubt is that human epidemics occur largely as a result of poor sanitation. Thus, the initial assertion in the HOTO Strategic Plan that there is little justification for prioritizing this area is upheld.

It should also be noted that outbreaks of cholera in recent years have occurred predominantly in tropical regions, initially in Bangladesh. Historically, however, outbreaks of cholera have occurred world-wide. The most likely explanation for this phenomenon centers on the poor socio-economic conditions and low sanitation standards which prevail in tropical developing countries. Obviously, this fosters the development and spread of cholera.

Other human health issues arising from the marine environment were outlined in the HOTO Strategic Plan. Further research is required to assess the relative risk posed by natural toxins, anthropogenic contaminants (e.g., genotoxins, endocrine disruptors), human pathogens and indigenous pathogens such as *V. cholerae*.

**Endocrine disruptors:** Dr Depledge reviewed the topic of endocrine disruption chemicals because of new concerns since the publication of the HOTO Strategic Plan in May 1996. It is now well established that there are anthropogenic chemicals released to the environment that can disrupt the endocrine systems of a wide range of wildlife species (Medical Research Council (UK), 1995; Danish Environmental Protection Agency, 1995; Umweltbundesamt, 1995; Colborn *et al*, 1996). The reproductive hormone-receptor systems appear to be especially vulnerable. Indeed, changes in sperm counts, genital tract malformations, infertility, an increased frequency of mammary, prostate and testicular tumors, feminization of male individuals of diverse vertebrate species and altered reproductive behavior, have all been reported (Sharpe and Skakkebaek, 1993; Colborn *et al*, 1996).

With regard to environmental management, the problem of endocrine disrupting chemicals is extremely difficult to address. This is because it is not clear:

- i) to what extent endocrine disruption is occurring in aquatic and terrestrial biota;
- ii) whether endocrine disruption is sufficiently severe to cause changes in ecosystem structure and function;

- iii) which of a multitude of chemicals are the most important with regard to endocrine disruption *in situ* and whether endocrine disruption occurs as a result of the cumulative effects of many chemicals;
- iv) what the influence of endocrine disruptors is on invertebrates (the major animal components of all ecosystems);
- v) whether endocrine disruption can be detected at a sufficiently early stage to permit remedial action to be instigated. Early detection of endocrine disruption in organisms *in situ* or in laboratory test systems is not currently feasible;
- vi) which life stages of organisms are most vulnerable to endocrine disrupting chemicals; and
- vii) whether endocrine disruptors give rise to any transgenerational effects.

The importance of these issues was highlighted at a recent meeting of the Committee on Environment and Natural Resources (National Science and Technology Council, Executive Office of the President of the United States) (NSTC, 1996) which concluded that "basic research is required to strengthen the scientific foundation for risk assessment : e.g., baseline studies on endocrine disfunction across classes of animals... to reduce the uncertainty associated with species extrapolations".

An extensive list of chemicals which are thought to be capable of disrupting the reproductive endocrine systems of animals has been assembled. They fall into the following categories:

- i) Environmental oestrogens (oestrogen receptor mediated) (e.g., methoxychlor, bisphenolic compounds);
- ii) Environmental antioestrogens (e.g., Dioxin, Endosulphan);
- iii) Environmental antiandrogens (e.g., Vinclozolin, DDE, Kraft mill effluent);
- iv) Toxicants that reduce steroid hormone levels (e.g., Fenarimol and other fungicides; endosulphan);
- v) Toxicants that affect reproduction primarily through effects on the CNS (e.g., dithiocarbamate pesticides, methanol); and
- vi) Other toxicants that affect hormonal status (e.g., cadmium, benzidine-based dyes).

These and other contaminants are also known to be capable of disrupting thyroid function and adrenal gland function (See Gray *et al.*, 1996 and Agenda Item 6.4 for further details).

With regard to the HOTO Strategic Plan, the Panel's view was that although endocrine disruption is potentially of great concern, further research is required to identify the causal relationships that could be used to define the nature and need for monitoring measurements. Thus, it is proposed that, at this stage, the matter should be periodically reviewed to assess progress. In the meantime, a simple strategy of recording the frequency of feminisation of male fish in estuarine and coastal areas might help to provide some insight into the extent of the problem on a global scale. If funding permits, this effort might be supplemented by use of the vitellogenin biomarker approach which signals exposure to xeneostrogens in fish, and by recording the incidence of imposex in gastropod molluscs worldwide.

Annex VIII contains the references to the citations in the above text and a range of general additional literature on this topic.

## 6.2 BALLAST WATER ISSUES

Dr Anthony Knap introduced the topic with a report on the IOC-IMO-ICES Study Group on Ballast Water and Sediments noting that the next meeting is scheduled for March 30-31, 1998, in the Hague. The HOTO Panel has a legitimate interest in ballast water issues from the perspective of human health risks and the interests of IMO in minimizing environmental hazards associated with ballast water transport. It was the view of the HOTO Panel that the topic of the introduction of alien species by ballast water is of primary interest in a GOOS context to the LMR Panel and, therefore, was not discussed. The Panel concurred with Dr Andersen who had indicated, in discussing the Terms of Reference of the Study Group (see Annex IX) with its Chairman, that they adequately covered the interests of the HOTO Panel. The HOTO Panel agreed to respond, as appropriate, to progress and requests from the Study Group.

## 6.3 HARMFUL ALGAL BLOOM (HAB) ISSUES

The topic of the frequency of harmful algal blooms was then introduced by Dr Youssef Halim who emphasized that the question of whether their frequency had increased was not answerable in any definitive sense without adequate long-term monitoring programmes (see Annex X). Material drawn from the "Manual on Harmful Marine Microalgae" (IOC Manuals and Guides No. 33, IOC, Paris 551pp, 1995) was circulated and discussed particularly as it bore upon the issue of the threats posed by algal blooms and trends that may reflect global change. This was one of the reasons for placing stress on HAB within GOOS. Dr Halim proposed that measures of phytoplankton standing crop variability and community structure be added to the specified HOTO measurements. This resulted in the expansion of the category "phytoplankton pigments" to "phytoplankton pigments and community structure" in the list of HOTO variables as described in the HOTO Strategic Plan. It was also agreed that the distinct issues of:

1. global change in the frequency and diversity of harmful algal blooms; and
2. the more local user demand for early warning of harmful algal blooms that might safeguard marine resource extraction use;

should be approached independently, at least initially. It was also concluded that there was a need for greater cooperation with the algal bloom community especially the International Panel on Harmful Algal Blooms (IPHAB) to develop approaches to these distinct issues without prejudice as to the final responsibility for the topic of global change. Questions were raised about the meaning of the claim in one set of recommendations of the IPHAB (See Annex X) that "there are techniques which permit both detection of long-term shifts in composition arising from decadal climatic variations as well as compositional changes directly attributable to anthropogenic activities." The Panel questioned, in general, whether observed changes in phytoplankton community structure can be unequivocally related to either decadal-scale climate variation or anthropogenic activity.

## 6.4 REASSESSING/REDEFINING THE CONTAMINANTS/ANALYTES

This topic was introduced by Dr Bowers as an opportunity to reconsider the list of analytes and contaminants in the Strategic Plan for HOTO in the light of subsequent concerns and developments, specifically for ensuring continuous updating of the Strategic Plan for HOTO.

Dr Bowers stressed that, with some minor exceptions, the list of analytes and contaminants to be included in aquatic measurements within the Global Terrestrial Observing System (GTOS) largely parallels that contained in the Strategic Plan of HOTO. Subsequent detailed discussion centered around endocrine disrupters and the effects of changing ultraviolet irradiance. While for some endocrine-disrupting compounds (e.g., tributyl tin) adequate scientific information is available, for most, further research is needed (e.g., on environmental pathways and effects) to justify inclusion in a routine monitoring programme such as that proposed for HOTO.

The Panel concluded that the classes of contaminants and analytes in the HOTO Strategic Plan were sufficiently comprehensive to cover all the new issues raised, with the change noted under Agenda Item 6.3. However, it was stressed that the list should continue to be regularly re-evaluated in light of new information and concerns, and the continuing introduction of novel compounds to the marine environment. Greater specificity in the selection of contaminants/analytes within the broad classes will be needed in preparing regional implementation plans.

## 6.5 REQUIREMENTS, NATURE AND AVAILABILITY OF MODELS

Dr T. Oguz presented an overview of models available for HOTO applications. He referred to data interpolation issues in relation to the knowledge of processes that enables the models to be constructed in response to prevailing scientific understanding of the processes controlling the observations being made. It was pointed out that models need to be considered from two aspects: the usefulness of models for interpolation in order to reduce the diversity and frequency of observations; and models, including predictive models, to convert observations into products of direct value to users. The former are likely to have value in the implementation of HOTO Pilot Projects in local and regional areas while the latter will mostly be used for operational purposes according to the nature of user requirements.

Modeling efforts appropriate for HOTO can clearly complement those being carried out or planned within the framework of other GOOS Modules. Since a primary objective of HOTO is to study marine responses to anthropogenic inputs, modeling efforts in HOTO will be focussed primarily on marine contamination and pollution-related issues in the coastal zone and inner shelf with relatively less emphasis on the open ocean. In this respect, modeling for HOTO purposes should be closely linked with the efforts on the development of the Coastal Module of GOOS.

A particular concern of HOTO modeling is to develop forecasting skills. An early warning system for eutrophication, for example, would be useful since eutrophication may lead to increased algal blooms, anoxia, massive fish deaths and major alterations in biological communities. While this requires implementation of sophisticated physical-biochemical-ecosystem modeling that incorporates living and non-living components of the system, somewhat simpler models are adequate to predict the dispersion of passive tracers such as oil spills, other accidental releases of contaminants, radioactive tracers and sediment load. These models should be coupled (on- or off-line) with dynamic models that predict regional circulation. Water quality modeling is another specific HOTO-related activity, which can assist in the development and possibly predict the effectiveness of measures taken to prevent pollution and contamination in the water column. When integrated with risk analysis models, all these models might contribute to assessment of sustainable development of the ecosystem and characterization of human use/activity and other socio-economic parameters.

Since predictive modeling of pollution-related issues is an essential tool for optimum utilization and management of resources, it should be supported by parallel process-oriented modeling to understand the effects of physical and biogeochemical processes on the functioning of the ecosystem in general. Considering the fact that ecosystem models are generally of limited predictive capability due to our poor knowledge of the representations and parameterizations of many biogeochemical processes, knowledge gained by process modeling ultimately helps to upgrade the operational forecasting capabilities of the system.

In addition to event-specific forecasting/prediction models, HOTO is interested in implementing models that may help modify the observation strategy. Models can be used to enhance information derived from the observation network by feeding back information into the observing system, either to assist in its design or to control its operation. Furthermore, an observing system may not provide all the data necessary to initialize and force the models. Under such circumstances data assimilation methods (e.g., adjoint method) are powerful tools which make it possible to estimate some of the model parameters from a limited number of observations under certain constraints and, therefore, complement data obtained by the HOTO observing system.

Numerical forecasting inherently suffers from the intrinsic instability of equations describing the ocean. A numerical model, even when initialized with a realistic oceanic state characterized by the parameters of the observing system, loses the memory of its initial state after a finite time - the predictability time - and diverges exponentially from the observational state. Data assimilation allows periodic updating of the models with new data which constrain the model evolution so that it closely follows the oceanic observational state. The ocean color data from SeaWiFS, and other satellites, for example, as well as time series of data from coastal stations, are particularly useful for this purpose. While the monthly and longer-term prediction of complex biogeochemical processes is presently an area of active research rather than straightforward operational tools, forecasting at weekly time scales should be realistic within the framework of HOTO objectives.

## 6.6 SATELLITE REMOTE SENSING

Dr A Knap opened the discussion with a presentation of remote sensing developments and capacity. This was followed with a presentation by Prof LIM Hock of the National University of Singapore's Center for Remote Imaging, Sensing and Processing (CRISP). These presentations provided a perspective on contemporary capabilities of remote sensing measurements that might be exploited in a HOTO context. It was pointed out that a Global Ocean Observing Systems Space Panel had recently been formed to address the applicability and requirements of remote sensing in GOOS. The HOTO Panel is represented on this group. Dr Oguz also noted the crucial roles of satellite observations to HOTO-related predictive modeling studies.

## 6.7 SCIENTIFIC ASPECTS OF TRAINING AND CAPACITY BUILDING

Dr Chou introduced perspectives on this topic largely from a South-East Asian regional context. There is an ever-increasing need for training and capacity-building, particularly in developing countries.

Training and capacity-building are required to:

- raise the level of "science" itself; and
- increase the input of science to management.

Data analysis and interpretation are as important as data acquisition and management. Drawing from the experience gained in the East Asian Seas Programme, various regional marine science initiatives have increased in recent decades the capacity of the region in general, for marine science research. Dr Oguz reflected similar views on the basis of experience in the NATO-TU Black Sea Project.

There have been activities on inter-calibration exercises and establishment of networks of marine laboratories and of scientists, but continued development of many such activities loses momentum as project funds become exhausted on the completion of projects. The lack of collaboration among funding agencies is also seen to dilute the efforts of participating national agencies.

Dr Chou specifically referred to East Asian Seas Programme intercomparisons that had ceased when funding had been discontinued well before continuing quality assurance procedures had been satisfactorily established. There is a need for improved laboratory-to-laboratory consultation in the region. This might be best accomplished through laboratory director consultative committees similar to those in Europe and North America (e.g., National Association of Marine Laboratories {NAML} and Marine Research Stations {MARS}). There also needs to be increased multilateral development of research projects in the region as a basis for the development of common and sympathetic views to HOTO objectives and activities. It was pointed out that there were two alternative routes to training - either trainees being trained at developed country locations or being trained by experts on site. The view was expressed that inadequate attention had been given to the latter approach. In response, Dr Knap recounted the GIPME history of quality assurance and training activities from which it can be concluded that effective training requires a mixture of on-site and remote activities. Finally, it was argued that at the present state of development of HOTO, the question of training was less critical than other topics of a more strategic nature.

It was stated by more than one of the participants that, often, trained personnel returning to their home countries are not able to put their newly-gained expertise to good use for several reasons. One frequent observation is that the trainee returns to an environment that lacks the infrastructure and equipment for carrying out his/her work. Not infrequently, newly returned trained staff get promoted to positions where they are unable to apply their expertise. Given these eventualities, it is important that appropriate management authorities and administrations be adequately informed and convinced of the usefulness of the GOOS-HOTO Programme. This may help ensure that they implement the HOTO Programme in a meaningful way that guarantees the effective utilization of the training offered. It should be noted here that this echoes similar statements made by Dr Andersen for many years concerning GIPME.

The Panel recommends that attention should be given to the following strategies in the South-East Asian Programme to overcome some of the problems faced by national agencies participating in donor-driven programmes:

1. Establish a regional network of marine laboratory Directors / Deputy-Directors based on models in North America and Europe which are effective in promoting collaboration and cooperation through training and resource sharing;
2. Take steps to convince marine laboratories to plan some of their research programmes in line with the objectives of HOTO;
3. Establish partnerships between marine laboratories of developed and developing countries;
4. Consider on-site training as a more cost-effective approach to sending trainees overseas; and

5. Capacity building should involve direct collaboration with responsible policy makers and other stakeholders. This will increase the usefulness of marine science and improve its support and acceptance.

## 6.8 INDICATORS FOR SUSTAINABLE DEVELOPMENT

Dr Robert Bowen introduced this subject through presentation of on-going considerations of indicators for sustainable development developed from the conviction that the agreed proxy for sustainable development in coastal areas is the successful implementation of integrated coastal management. This presentation distinguished among indicators of social, economic, cultural values and those relating to the biophysical condition of the environment. The Panel agreed that the concepts outlined in this presentation were worthy of further development for applicability to HOTO, to contemporary demands for information and explanation from the GOOS Project Office, the intended analysis of the state of science applicable to ocean management questions adopted by the XIX<sup>th</sup> IOC Assembly and several other purposes.

Given the complexity of the proposed task the Panel was unable to reach a definitive set of indicator recommendations. However, a strategic approach was identified and there was agreement to work on the question during the intersessional period.

The approach discussed at the meeting attempted to integrate various existing efforts of sustainable management practices (particularly, GESAMP Reports and Studies No. 60, 1996), coastal modeling (particularly, HOTO Strategic Plan, 1996; U.S. Coastal GOOS Sustainable Healthy Coasts Component, 1997) and new and ongoing work on the subject by Dr R. Bowen and Ms N. Niedowski at the University of Massachusetts. At the most general level, this approach is described in Figures 1 and 2 in Annex XI. Here, the development of operational measures for sustainable development centers on an effective characterization of the varied uses and activities in coastal areas and an understanding of the relationship between those uses and coastal environmental quality, described as "coastal system dynamics".

Simply, Figure 1 suggests that sustainable development practices (uses and activities) will be driven by the opportunities and limitations imposed by critical socio-economic background conditions (institutional, cultural and economic), which, in turn introduce agents affecting coastal system dynamics. It is asserted that this model affords the opportunity to specify indicators for sustainable development in two different, but mutually reinforcing ways. First, the model asserts that a characterization of sustainable practices (uses and activities) will be directly influenced by critical background socio-economic conditions. Efforts to build operational measures for these conditions can be viewed as partial measures of sustainable development. Indeed, the U.S. Coastal GOOS Workshop on Sustainable Healthy Coasts held in December of 1996 in Bethesda, MD, USA, has already provided a series of such measures (admittedly limited by being considered in a developed country context). That report argued that:

- *the measures described below are designed to serve as indicators of the scale and scope of human activity in the coastal zone at the national level. They provide a means by which to assess national trends, to develop national priority policies and to identify regions where the impact of human activity on coastal systems is, or is likely to be, highest.*
- *... they are primarily designed as broad indicators of human influence on*

*coastal systems (U.S. Coastal GOOS, Healthy Coasts Component, 1997).*

In short, as indicators of human influences on coastal areas they can also be viewed as general indicators of sustainability. The workshop described a total of 24 measures categorized into Core (development) Measures, Waste Disposal Practices, Commercial and Recreational Fishing, Coastal Aquaculture, Coastal Recreation and Tourism, and Dredging Operations. This is an example of how the Workshop on the U. S. Coastal Module can provide input into an international plan, a point made often in GOOS Meetings in 1997, yet seemingly ignored to date.

Second, Figure 1 also characterizes a set of relationships influencing coastal system dynamics (anthropogenic agents, natural variability and episodic events) which in turn affect the level, range and scope of sustainable human practices (uses and activities). A specification of these relationships is illustrated as Figure 2. It is argued that coastal system dynamics could be viewed as comprising eight categories: phytoplankton dynamics, eutrophication, water circulation, geophormological dynamics, turbidity, exotic species introduction, biodiversity, and community structure. Figure 2 illustrates the eutrophication relationships. The effort in Figure 2 is to integrate (i) a general description of the dynamics of eutrophication in coastal waters, (ii) the role of monitoring measures (contained in the lightly shaded boxes) in that dynamic, and, importantly, (iii) the effect of eutrophication on economic and social values (contained in the more darkly shaded boxes). Here, again, one can characterize indicators of sustainable development. It is argued that these measures of economic and social value are effective indicators of sustainability. As such, they provide a direct connection between coastal environmental dynamics, coastal monitoring strategies and indicators of coastal sustainable development.

The Panel viewed this approach as holding some measure of promise. However, the approach, as presented is in early draft form and has not yet appeared in the refereed literature. Dr Bowen and Ms Niedowski are in the process of preparing an article on this work. The HOTO Panel agreed to continue to review progress during the intersessional period through an *ad hoc* HOTO Panel Working Group (Drs Bowen, Bewers, Depledge, Huber and Knap). This *ad hoc* Group is expected to prepare a paper on the topic for consideration at J-GOOS-V.

## **7. IMPLEMENTATION OF PILOT PROJECTS**

### **7.1 FRAMEWORK FOR REGIONAL BLUEPRINTS**

#### **7.1.1 Red Sea**

Dr Youssef Halim presented a HOTO blueprint for the Red Sea which is attached at Annex XII. It was recommended that this blueprint be brought to the attention of the Red Sea and Gulf of Aden Environment Programme (PERSGA). Dr Andersen agreed to take the appropriate action.

#### **7.1.2 Southeast Asian Seas**

Dr Edgardo Gomez noted that a blueprint for a Southeast Asian Seas HOTO Pilot Project had been prepared for the HOTO-III meeting in Bangkok in 1995. The substantive issues covered in the document remain valid and these were briefly reviewed. A slightly revised version that takes into consideration the political/economic developments in the region, was prepared for the Panel meeting and is attached at Annex XIII.

### **7.1.3 North-East Asia Region HOTO (NEAR-HOTO)**

Drs Jing Zhang and Dong Beom Yang provided a presentation of a HOTO blueprint design for the Northeast Asian Seas area which is attached at Annex XIV. It was noted that PICES is planning a practical workshop in Qingdao, China, on early warning measurements as a follow-up activity to the previous IOC/ICES Workshop on Biological Effects Measurements convened in Bremerhaven, Germany.

### **7.1.4 Arctic**

Dr J. Michael Bowers presented a blueprint design for an Arctic HOTO prepared by himself and Dr Robie Macdonald of IOS, Sidney, BC, which is attached at Annex XV.

### **7.1.5 Antarctic**

Although no design of an Antarctic blueprint for HOTO had been developed, there were indications that such a plan might be timely in view of approaches made to the Chairman by the Chairman of the IOC Regional Committee for the Southern Ocean, Dr Max Tilzer. It was noted that GEMSI had earlier responded to a request from the Scientific Committee on Antarctic Research (SCAR) for an Antarctic contaminant baseline study design.

### **7.1.6 Black Sea**

Dr Oguz presented a brief overview of the Black Sea's general environmental characteristics in regard to HOTO-related issues. He reviewed the existing international activities carried out within the framework of the NATO-TU Black Sea Project and GEF initiatives in the Black Sea. A Black Sea HOTO Pilot Project could be regarded as a natural outgrowth of these activities and is included at Annex XVI.

### **7.1.7 Brazilian Coastal Zone**

Dr Michael Depledge described a project entitled "Rapid Assessment of Marine Pollution (RAMP): a HOTO Pilot Project in South America" This project aims to test and provide easy-to-use, inexpensive chemical and biological markers that can be used to assess and improve environmental management in developing countries. The techniques being devised will provide cost-effective screening alternatives to the more complex procedures currently used in Europe and the USA. As part of the project the newly validated techniques are being introduced into Brazil, together with all the necessary equipment and training. In the context of the HOTO Module, the validation of the chemical and biological markers represents an important step in providing a practical means of making some of the measurements identified in the HOTO Strategic Plan.

Specific measurements include the use of immunoassay techniques to detect and quantify levels of PAHs, selected pesticides, herbicides, fungicides and PCBs. Simple measures of biological effects include the Neutral Red lysosomal assay, cardiac activity assessments in bivalves and decapod crustaceans, cholinesterase inhibition assays and a sea anemone bleaching assay.

The approach is currently being validated using comprehensive chemical analyses and standard toxicity test procedures to confirm the reliability of the new procedures. Outputs of the project will include the validated techniques and manuals. This will facilitate their incorporation into other regional approaches within the HOTO.

The Panel believed that the monitoring approach described in this proposal holds significant promise for the future success for the implementation of the HOTO Strategic Plan. If the rapid assessment methods at the core of this programme are shown to produce reliable and valid measures of analyte concentration, they will provide a critical contribution to efforts to achieve a simple and inexpensive approach to global marine monitoring. They will also serve to enhance the level and range of national/regional participation in GOOS.

#### **7.1.8 Caribbean Sea**

Dr Jacobo Blanco described the situation in the Cienaga Grande de Santa Marta, a severely stressed coastal lagoon on the Columbian Caribbean coast and approaches to its rehabilitation as relevant to HOTO (See Annex XVII).

### **7.2 COLLABORATION/INPUT IN THE DEVELOPMENT OF:**

#### **7.2.1 Living Resources Module of GOOS**

See Agenda Item 3.2. The Panel reiterated the need to collaborate with the LMR Module for mutual benefit.

#### **7.2.2 Coastal Module of GOOS**

See Agenda Item 3.3. The Panel again noted the need for collaboration and stressed the point that when the implementation of GOOS is viewed as a basin wide component together with a coastal/shelf/slope component, this collaboration should begin at the very onset of Coastal Module planning.

### **7.3 WESTPAC Collaboration**

#### **7.3.1 SEA-GOOS**

Mr Yihang Jiang reported on the status of SEA-GOOS. Considering the successful development of NEAR-GOOS, a Draft Resolution was suggested to be submitted to the UNESCO General Assembly requesting the necessary resources to develop the project plan and to initiate the project. The Draft Resolution should be submitted by the countries from the region. Indonesia is playing a leading role in developing a Draft Resolution. Further discussion among the countries will be facilitated by the IOC/WESTPAC Secretariat. The Panel resolved to maintain a watching brief until the Draft Resolution has been submitted and approved by the UNESCO General Assembly.

Related Sea-Watch Programmes are underway in Thailand, Malaysia, and Vietnam. These involve bilateral agreements and potential cooperation needs to be established by IOC/WESTPAC.

An apparent lack of coordination between SEA-GOOS and SEA-HOTO was noted by the Panel. This seems to reflect a general lack of coordination within the region. In discussing this issue it emerged that there are a number of national, bilateral, and multilateral monitoring initiatives in the region are developing mutually incompatible databases and information management practices (See Agenda Item 4.1.3). This underscores the need to encourage better coordination of data gathering and management practices at national and regional levels.

The Panel discussed possible steps toward this end and concluded that solutions to this issue are beyond the scope of HOTO, and indeed GOOS, and need to be addressed by sponsoring organizations (e.g., IOC and ICSU). Development of GOOS as currently envisaged will be severely constrained, if not precluded, until the compatibility of data collection and management among component systems is addressed.

### **7.3.2 SEACAMP**

Mr Jiang reported that The South East Asian Center for Atmosphere and Marine Prediction (SEACAMP) Project is a joint effort of WMO and IOC, established to develop and coordinate long term marine meteorological and physical oceanographic monitoring, assessment modeling and prediction capabilities of ASEAN countries, as a regional component of GOOS and GCOS.

At the end of the proposed project, a number of strategically located marine meteorological and physical oceanographic observation stations and facilities will have been upgraded and/or established in the sub-region to provide crucial and high-quality data to ASEAN national meteorological and oceanographic agencies, on a long-term basis. In addition, the project will have assessed, to the extent possible, data from existing networks operated by private companies, such as those involved in off-shore mining operations.

Two meetings have been organized to discuss and finalize the implementation plan of the project. These meetings were held at the IOC Regional Secretariat, Bangkok, and in Singapore, respectively. The project proposal was finalized during the Second Implementation Planning Meeting, May 1996, and the proposal submitted to the ASEAN Sub-committee on Meteorology and Geophysics held in Singapore at the end of July, 1997. The meeting was presented with an appraisal report from the ASEAN Co-operation Unit (ACU), which recommended a reformulation of the project into smaller modules with separate budgets. Suggestions from Singapore included: networking; creation of a center; training; and observations. Further comments and formal nominations of contacts were invited from Member States through 31 August, after which Singapore will co-ordinate with WMO and IOC to prepare a reformulated version for resubmission.

Regarding potential linkages between HOTO Regional Pilot Projects in South East Asia and SEACAMP, when the SEACAMP proposal is approved, a regional network on data collection and transmission will be established, similar to the case for NEAR-GOOS. The HOTO Regional Pilot Projects may be able to use this network to a large extent for data transmission and exchange, if technical problems are resolved.

### **7.3.3 NEAR-GOOS**

Mr Jiang informed the Panel about the development and the operation of NEAR-GOOS. The background information on the procedure followed to develop the system was provided to the Panel under Agenda Item 7.3.1 with a view to the future development of HOTO Pilot Projects.

NEAR-GOOS officially started operations in November, 1996. All participating countries are contributing their oceanographic data and some data products to the system.

The parameters specified for measurement are sea surface temperature, salinity, currents, wave and wind fields with an intention to extend the programme to other measurements (e.g., nutrients, dissolved oxygen) in the near future.

The system is providing a useful communication network for the future implementation of a HOTO Regional Pilot Project if some outstanding technical problems relating to data coding and exchanges can be resolved (See Annex XIV).

#### 7.3.4 NOWPAP-3

This topic was introduced by Mr Yihang Jiang. The Northwest Pacific Action Plan (NOWPAP), also known as the Action Plan for Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region, is one of UNEP's Regional Seas Programmes, adopted in Seoul, Korea, at the First Intergovernmental Meeting on NOWPAP in September 1994. Currently Japan, the People's Republic of China, Republic of Korea and the Russian Federation are participating in the implementation of the Action Plan. At the same Intergovernmental Meeting, the NOWPAP Member States identified the following five priority areas:

- NOWPAP/1: Establishment of a comprehensive database and information management system;
- NOWPAP/2: Survey of national environmental legislation, objectives, strategies and policies;
- NOWPAP/3: Establishment of a collaborative, regional monitoring programme;
- NOWPAP/4: Development of effective measures for regional co-operation in marine preparedness and response; and
- NOWPAP/5: Establishment of regional activity centers and their networks.

Among these five projects, IOC has been invited to be the implementing agency for NOWPAP/1 and NOWPAP/3.

Under NOWPAP/3, the purposes of establishing a regional monitoring system have been identified as:

- i. Assessment of the state of the marine, coastal and associated freshwater environments (including land-based sources of pollution);
- ii. Integrated coastal zone management (including freshwater systems);
- iii. Pollution control of sea-based activities; and
- iv. Management and conservation of marine and coastal biological diversity.

The proposed parameters to be monitored on a regional scale should be agreed to among the NOWPAP Member States with due consideration given to the purposes of establishing such a regional monitoring system. The proposed parameters include:

- General sea water quality (nutrients, COD, DO, pH, etc.)
- Pollutants in seawater, sediments and organisms (oils and their derivatives, persistent organic pollutants, heavy metals, etc.);
- Coastal environment (freshwater availability and quality, BOD, land use, agriculture, etc.)
- Biological monitoring (phytoplankton, zooplankton, phytoplankton pigments, flora and fauna, biological effects, etc.)
- Loading of land-based pollutants (point and non-point sources of pollution, etc.); and
- Marine debris.

The project is in Phase I, during which the Member States are to prepare national reports (i) on the state of the marine environment; and (ii) on national monitoring activities, respectively. Based on the national reports, a consultant (recruited under the project) will prepare a regional summary and project proposals for the Phase II (actual establishment of a regional monitoring system). Finally, a workshop will be convened to present national reports and to discuss the proposals to be produced (planned for April 1998, but could be deferred).

In the Northwest Pacific Region, the operation of NEAR-GOOS provided a framework for data collection and exchange among the participating countries. Although NEAR-GOOS is focussing on the physical parameters for the moment, some chemical parameters are planned to be included in the system. The establishment of NOWPAP Projects, in particular NOWPAP/3, will focus on the monitoring of chemical and biological parameters. For countries in the region, this provides a useful infrastructure for the monitoring of the marine, coastal and freshwater environment.

To take advantage of the co-sponsorship of GOOS by UNEP, close cooperation and coordination between IOC and UNEP should be enhanced, in particular at the policy level between the two organizations.

UNEP is in favor of seeking cooperation with the HOTO Panel in several ways. It has been suggested that the following items be discussed at the present meeting:

- i. Potential linkages between the HOTO regional pilot project in the Northwest Pacific and the NOWPAP/3 Project (See Agenda Item 7.1.3 and Annex XIV);
- ii. The HOTO Panel has been invited to review project proposals for the second phase to be produced by a consultant (a small fee may be allocated to this activity from the project fund); and
- iii. Any other relevant activities to consider when NOWPAP/3 is implemented.

### **7.3.5 Bi/Multi-Lateral Programmes under Development**

Dr Yang noted that the Republic of Korea and the Peoples Republic of China will launch a programme on the Yellow Sea in 1998. Development of the basis for this activity, although delayed until 1998, will take full account of the HOTO Strategic Plan and other relevant strategic documents.

### **7.3.6 GEF Projects: East Asian Seas and Trans-Boundary Diagnostic Analysis of the South China Sea**

The IOC WESTPAC Secretariat has been invited to a Workshop in Thailand, November 12-15, 1997, on ICM. One of the objectives of this meeting is to define long-term regional environmental monitoring using common and standardized procedures. As concerns the GEF/PDF for the Transboundary Diagnostic Analysis for the South China Sea, the second meeting of national coordinators and an associated meeting of regional experts is planned for the last quarter of 1997 for the formulation of the Strategic Action Plan. It is anticipated that full implementation of this proposed GEF project will be realized in 1998. Taking note of the discussion under Agenda Item 6.7 and realizing the fixed-term nature of GEF Projects, the Panel proposed that IOC offer the WESTPAC Secretariat to provide a mechanism for continued cooperation in the region, including implementation of regional HOTO activities, after GEF funding ceases in 1998 or 1999.

### 7.3.7 GIWA

Dr Bewers provided information regarding the background and state of development of a GEF proposal for a Global International Waters Assessment (GIWA). This proposal is for a project involving causal analysis of environmental problems in both fresh and marine water areas on a global basis in order to define priorities for subsequent GEF funding. If the project proposal is approved by the GEF Council in November, 1997, there will be urgent administrative planning to conduct a series of up to 65 sub-regional assessments of a variety of freshwater and marine environmental concerns. This project offers the potential benefits of priority definition relevant not only to the GEF, regional marine environmental protection organizations and individual nations but also to HOTO. Steps will be taken to ensure the exchange of information among interested parties and programmes regarding developing GIWA activities. Equally, where appropriate, strategic plans such as the HOTO Strategic Plan will be brought to the table within GIWA project activities.

## 7.4 COLLABORATION WITH THE INTERNATIONAL MUSSEL WATCH PROJECT

### 7.4.1 WESTPAC Region

As mentioned on the Mission Report of Drs Andersen and Bewers, the cooperation with UNU on this project was discussed in Tokyo.

In cooperation with SIDA/SAREC, an IOC-UNU Training Course on Heavy Metal, Organochlorine Pesticides and Polychlorinated Biphenyl Analyses using the Mussel Watch Approach, is now planned in Bangkok, Thailand, March 2-13, 1998.

The objectives of the training course are:

- 1) To train personnel in sampling and analysis of organochlorine pesticides and PCBs in bivalves;
- 2) To develop the level of analytical methodologies to state-of-the-art (proportions) and generate new data pertaining to the coastal marine environment in the region; and
- 3) To promote the intercalibration of analytical methodologies for the environment by utilizing similar analytical techniques in all participating country laboratories for the purpose of sampling accurate basic data on the state of the coastal marine environment in the region.

UNU has expressed its interest in co-sponsoring the training course.

### 7.4.2 Mediterranean Sea

Dr Halim reported that there were plans to initiate a Mediterranean mussel watch programme in the framework of the MAST Programme. It was agreed that the planning of this initiative would benefit from the expertise within GIPME.

### 7.4.3 Black Sea

Dr Andersen indicated that a meeting convened 16 - 17 January in Istanbul, Turkey, which he attended, addressed some of the preliminary actions of a mussel watch activity being carried out in this region. The agenda for this meeting related predominantly to a discussion of the Black Sea

Action Plan for the Istanbul Commission, a body established to undertake follow-on action of the GEF Black Sea Environmental Project. However, this meeting included lengthy discussions of the Mussel Watch Project (i.e., contaminant chemicals and biological effects) supported by the IOC in the Black Sea, being carried out under the direction of Drs Michael Moore of the Plymouth Marine Laboratory and Terry Wade of the Texas A & M University. The discussions focused on what the current status of measurements was and identification of problems, particularly relating to the chemistry, and recommending ways of trying to deal with these problems (e.g. provision of consumables). The role of biological effects measurements coupled with chemistry within the Black Sea Action Plan, was also discussed in some detail.

Participants were informed that the activities pertaining to the Special Pollution Monitoring, which includes Mussel Watch-type activities, would not, as such, form an official regional programme. However, this type of monitoring would be carried out as a related component of the National Programme in each country, alongside the traditional measurements (i.e., nutrients, specific contaminants and microbiology). There were preliminary discussions on a proposal from Prof Valeri Mikhailov (Ukrainian Institute for Ecology of the Sea, Odessa) to act as a co-ordinating center for the future Mussel Watch activities. They would collate the data and prepare it in GIS form and make this material available to all of the other participating regional laboratories. This proposal was viewed positively by Dr Graham Topping, consultant to the Black Sea GEF Project, from the chemical point of view, by Dr Moore from the biological effects perspective, while Dr Andersen indicated that he viewed it as an appropriate step forward in the context of a Global Mussel Watch. In this regard, he informed the Panel that he had subsequently arranged for the transfer of the appropriate software, from the Woods Hole Oceanographic Institution, USA, which was used in the Americas Component of the International Mussel Watch Project.

Dr Andersen further noted that there was also detailed discussion of the EU-TACIS/PHARE Programmes for the training of personnel from the regional laboratories. A series of training workshops in chemistry and biological effects were scheduled at the time to be held in the Autumn of this year in Varna, Bulgaria and Constanta, Romania.

Dr Andersen continued by indicating that a workshop was convened in Istanbul, Turkey, 14 - 17 March 1997, to discuss in detail the biological effects measurements and the chemical determinations that were made as part of the Black Sea Mussel Watch feasibility study. Presentations were made by the groups from all six countries involved in the project. Biological effects measurements using the neutral red lysosomal retention techniques were carried out successfully by all laboratories. Chemical data were available only from Bulgaria and the Ukraine. Some data were available from the Russian Federation which was rather limited because of a power failure of some two weeks at the laboratory in Sochi. It was agreed at this meeting that a second workshop to discuss specifically the chemistry, which was lagging behind the biological effects measurements, would be inappropriate. It was felt that the funding remaining would be better used for a continued biological effects emphasis and the chemistry programme could be a follow-on study. A manuscript is presently in preparation describing the results and should be available from Dr Moore in the near future.

What the Mussel Watch Project in the Black Sea did was to identify those areas that have an adverse biological problem. It is anticipated that these sites should now become the focus of more detailed study of the anthropogenic inputs and contaminant body-burdens in the mussels.

#### 7.4.4 Indian Ocean

Dr Andersen indicated that he had been informed by the IOC Executive Secretary that preliminary action had been taken under the support of SIDA/SAREC to develop a plan for the Western Indian Ocean. However, recent information from the IOC has indicated that this effort has not gone forward as of this date.

### 7.5 COLLABORATION WITH OTHER PROGRAMMES/PROJECTS

#### 7.5.1 Global Terrestrial Observing System (GTOS)

Dr J. Michael Bowers outlined the components of the Global Observing Systems with particular stress on the overlapping zones of responsibility and interest between GTOS and GOOS. There exists "A proposed GTOS strategy to monitor rivers, lakes and estuaries" dated March, 1995, which was circulated for comments within the GTOS community. Only through contacts of HOTO Panel members with GTOS via the medium of the GxOS *In-Situ* Measurements meeting in Geneva in 1995 and the International Hydrological programme of UNESCO in 1996 was it possible to gain information regarding developments in GTOS that might have a bearing on the design of GOOS-HOTO modules. Drs Andersen and Bowers subsequently attempted to arrange a meeting among scientists involved in the strategic designs of GOOS and GTOS to discuss the nature of the boundaries between these two programmes especially at the land-sea interface. As yet these discussions have not taken place but, increasingly as HOTO moves to more detailed design and implementation, the question of the divisions of responsibilities and measurements in estuaries, for example, are becoming more critical. The Panel confirmed the need for interactions with GTOS and recognized that such interaction has not been as great as would be desirable. It recommends that the GOOS Project Office take steps to enhance the interaction between GOOS and GTOS.

#### 7.5.2 Global Coral Reef Monitoring Network (GCRMN)

Dr Michael Huber introduced this item by noting that the GCRMN, which is co-sponsored by IOC, UNEP, and IUCN, is a component of the International Coral Reef Initiative (ICRI). The coordinator, appointed in 1996, is co-hosted by AIMS and ICLARM. The overall goals of the GCRMN are to improve the sustainable management of global coral reef resources and to build local, national, and regional capacities to assess the status of coral reefs and related ecosystems. A related goal is to build the capacity to assess the global status and trends in ecosystems through regional and global cooperation and information sharing.

The GCRMN will at least initially be based primarily upon "low resolution" methodology that requires a minimum of specialized training and equipment. This methodology, largely developed during the ASEAN-Australia Living Coastal Resources project, measures gross change at the community level, focusing on corals and other large benthic forms and on reef fishes. The second edition of a manual of standard survey techniques was published in 1997 and GCRMN has conducted a series of training activities in all GCRMN regions. Parallel methodology is being developed for assessment of social, cultural, and economic data and is expected to be ready for field trials in mid-1998.

The organizational framework for the GCRMN is a hierarchy of national, regional and global nodes. The network includes six regions, the nodes of which are located within UNEP Regional Seas Secretariats. ICLARM, which maintains a central database, REEFBASE, will serve as the

global node. In addition to the low resolution data obtained directly through GCRMN efforts, REEFBASE will incorporate data from moderate and high resolution monitoring methods from areas where these methods are applied.

A related effort "Reefs at Risk", has recently been initiated by the World Resources Institute International Center for Living Aquatic Marine Resources, and the World Conservation Monitoring Center. This project will attempt to identify, on a very broad geographic scale, reef areas most at risk of degradation through a GIS analysis of biophysical and socioeconomic parameters.

The Panel considered that GCRMN is directly relevant to HOTO. In particular, HOTO measurements may have the potential to provide improved early warning of the community-level changes measured by GCRMN. Though it is recognized that a possible relationship between GCRMN and HOTO may be superseded by development of other GOOS modules such as the Coastal Module, the Panel considered that cooperation with GCRMN, especially with regard to early warning of biological change, is essential. The GCRMN Coordinator has indicated that GCRMN data will be freely available to HOTO.

## **7.6 IMPLEMENTATION PLAN; NEED, SCOPE AND TIMETABLE**

In considering all aspects of regional activities relating to HOTO implementation, the Panel prepared recommendations pertaining revising The Revised Terms of Reference which can be found in Agenda Item 5.

The Panel also recommended that future HOTO Panel Meetings should, where possible, be held in conjunction with regional HOTO Pilot Project Design Workshops. These workshops should be organized in order to maximize regional understanding of the HOTO Strategic Plan and foster the development of regionally specific HOTO implementation proposals. Accordingly, they should be convened in collaboration with international organizations, representatives of the regional marine science community, local/regional decision makers and other stakeholders (See Agenda Item 9.4).

The inclusion of local/regional decision makers is considered to be particularly important given the need to expand user perspectives in the development of HOTO implementation plans recognizing that the long-term success of GOOS-HOTO programmes will be largely dependent on local/regional commitments at the policy-level and funding.

## **8. HOTO INPUT TO THE GOOS STRATEGIC PLAN**

The discussions under other Agenda Items deal with the provisions of the GOOS Strategic Plan and conclusions are drawn in the relevant sections of this report.

## **9. FUTURE ACTIVITIES**

### **9.1 INTERACTION WITH OTHER BODIES**

Interactions with other bodies, particularly regional bodies, other GOOS bodies and GTOS have been considered in the discussion of all previous agenda items. The Panel identified and stressed a specific need for closer association with the GTOS community concerned with environmental measurements in the coastal area, especially the aquatic environment, to ensure that both the GTOS and HOTO Strategic designs are comprehensive, coordinated and effective.

## 9.2 FUTURE WORK PLAN AND TIMETABLE

In the discussion of future work for the Panel, an observation was made that the strategic plan can be useful to periodic assessments undertaken by international bodies, regional organizations and national institutions. It was suggested that the Panel may consider how it can assist and guide the undertaking of these periodic assessments of the state of the marine environment (e.g., those of GESAMP) to improve their quality and comprehensiveness.

## 9.3 MEMBERSHIP/COMPOSITION

Given the Panel's considerations pertaining to the development of HOTO implementation plans (See Agenda Item 7.6) and those relating to future panel activities, it was suggested that panel membership should be expanded to include:

- a representative of the policy/user community for which a specific HOTO Project is designed;
- a representative of the international donor community to ensure that an understanding of existing and emerging funding programmes is effectively incorporated into HOTO regional implementation plans; and
- an individual with strong competence in data management procedures, including information and visual display technologies, to ensure that HOTO, and GOOS generally, are able to effectively convey monitoring results to the user community.

Concerning this last consideration of expertise, Dr Andersen reminded the Panel that he had enlisted the services of Dr Adolfo Gil of the Central Oceanographic Data Center, Buenos Aires, Argentina, to cover this area. He also brought to the attention of the Panel a paper that Dr Gil had prepared on this subject. It was pointed out that the reason Dr Gil was not present at this session of the HOTO Panel was due to budgetary restrictions which forced a reduction in the number of Panel Members that could be present. The Panel felt that it was not appropriate to debate Dr Gil's paper without the expertise that he could provide being present.

## 9.4 RESOURCES REQUIRED

The resources required for a future meeting will clearly depend on the venue. In this context it should be noted that subsequent to this session of HOTO, questions were raised concerning the conventional wisdom of convening meetings involving regions in a regional setting. It is suggested that the GPO revisit this issue prior to further meetings to implement GOOS.

Another suggestion arising from discussions concerning resources concerned the possibility of approaching industrial concerns for potential support. For example, at a recent meeting where the HOTO Module was presented, a representative of BHP Corporation expressed interest in the plans being developed by the HOTO Panel. Strategic and operational improvements in the relevance and cost-effectiveness of marine environmental monitoring, for example, are of great interest to the industry. Furthermore, most large industrial developments include environmental monitoring programmes which could contribute to HOTO. The Panel agreed that the potential for private sector contributions to the development of the HOTO Module is an area that deserves further investigation. In fact, the Panel suggested that the GOOS Project Office may wish to follow this suggestion up from a wider GOOS prospective.

Yet another possibility of securing additional resources, particularly with regard to pilot projects, came to light in the discussion of the Brazilian Pilot Project (See Agenda Item 7.1.7). That is, the company producing the kits that are being employed for the simple routine analyses might be interested in providing these kits free of charge in the expectation of the market that would develop with the establishment of a long term monitoring network. Thus, it is suggested that the GPO may wish to develop this idea further as a general guideline for the implementation of GOOS Pilot Projects.

#### **9.5 RECOMMENDATIONS/SUGGESTIONS OF DATE AND VENUE FOR HOTO-V**

The HOTO Panel recommends that the next session of HOTO be convened within eighteen months. It is felt that this interval of time will be sufficient for significant advances to be made on the intercessional work that has been agreed to be conducted. The identification of the venue, however, needs further consideration in light of the concerns that have arisen concerning regional venues as noted in Agenda Item 9.4 above. Since this is a generic consideration for GOOS, it is recommended that this be a subject of discussion at the next GOOS Session.

#### **10. ANY OTHER BUSINESS**

It was agreed that the Chairman would circulate the draft report of the meeting by the end of October. Comments should be received by the Chairman by November 30th. He will then finalize the report and submit it to the IOC Secretariat by mid-December.

#### **11. CLOSURE**

The Panel Meeting was closed by the Chairman at 1400 hours on the 17th October, 1997. However, before closing the meeting, the Chairman, on behalf of the Panel, thanked Dr CHOU Loke Ming for the excellent support provided to the meeting.

## **EXECUTIVE SUMMARY AND RECOMMENDATIONS**

### **Statements**

1. The Panel agreed that it was essential that the HOTO Panel be adequately represented in the work of the new Coastal Panel, when formed, to ensure that HOTO aspects of the Coastal Module design were given balanced consideration with those of other perspectives.
2. Even though the IOC/UNEP/IMO GIPME Workshop on Sediment Quality Guidelines was a preliminary effort to address the subject matter, it once again demonstrated the absolute need to fully consider the drainage basin (and therefore GTOS) associated with coastal zones. (See recommendation 10 below).
3. The Panel expressed the need to insure HOTO input into LMR planning.
4. The Panel reviewed the GOOS Principles annexed to the Session Report of I-GOOS-III and found them to be succinct expressions of sound principles augmented by appropriate explanation.
5. The Panel reviewed the Draft GOOS Strategic Plan. A single concern arising was the appropriateness of the definition of Module Panels, Specialist Panels and Working Groups as having specifically distinct meanings. It was questioned whether this would constrain the smooth development and implementation of GOOS components by introducing unnecessary rigidity to the administrative structure.
6. The Panel reviewed the U.K. GOOS Questionnaire from a HOTO perspective and noted that the section on environmental protection/preservation is weak. It does not include all appropriate keywords. It was further pointed out that though the emphasis on commercial users may be appropriate for the developed countries for which the questionnaire was presumably developed, one for developing countries should perhaps place more emphasis on governmental or NGO users (e.g., regulators, policy makers, etc.).
7. The Panel strongly endorsed the principle that GOOS implementation should be fundamentally driven by user needs. This is reflected in the HOTO Strategic Plan (p. 22).
8. The Panel felt that the matter of increasing cholera incidence as a result of climate change is speculative and a proper evaluation requires further research. At the present time, the claim that cholera incidence would increase as a consequence of climate change appears to be unsupportable.
9. The HOTO Panel agreed to respond, as appropriate, to progress and requests from the IOC-IMO-ICES Study Group on Ballast Water and Sediments.
10. The Panel questioned, in general, whether observed changes in phytoplankton community structure can be unequivocally related to either decadal-scale climate variation or anthropogenic activity.

11. The Panel concluded that the classes of contaminants and analytes in the HOTO Strategic Plan were sufficiently comprehensive to cover all the new issues raised, with the change noted below in the 4<sup>th</sup> recommendation.
12. Given the complexity of the proposed task the Panel was unable to reach a definitive set of indicator recommendations. However, a strategic approach was identified and there was agreement to work on the question during the intersessional period.
13. An apparent lack of coordination between SEA-GOOS and SEA-HOTO was noted by the Panel. This seems to reflect a general lack of coordination within the region. In discussing this issue it emerged that there are a number of national, bilateral, and multilateral monitoring initiatives in the region that are developing mutually incompatible databases and information management practices. This underscores the need to encourage better coordination of data gathering and management practices at national and regional levels.
14. The Panel considered that GCRMN is directly relevant to HOTO. In particular, HOTO measurements may have the potential to provide improved early warning of the community-level changes measured by GCRMN.

#### **Recommendations**

1. The Panel recommended that, in the GOOS context, "Karl's Principles" be treated as guidelines.
2. Specific strategies recommended by the Panel to promote responsiveness to user needs include the development of conceptual models linking HOTO measurements to identified socio-economic outcomes, the involvement of decision-makers in the design of regional pilot projects and the inclusion on the HOTO Panel of representatives of the user and donor communities.
3. With regard to the HOTO Strategic Plan, the Panel's view was that although endocrine disruption is potentially of great concern, further research is required to identify the causal relationships that could be used to define the nature and need for monitoring measurements. Thus, it is proposed that, at this stage, the matter should be periodically reviewed to assess progress.
4. The category "phytoplankton pigments" in the list of HOTO variables as described in the HOTO Strategic Plan should be amended to "phytoplankton pigments and community structure".
5. The Panel recommends that attention should be given to the following strategies in the South-East Asian Programme to overcome some of the problems faced by national agencies participating in donor-driven programmes:
  - A. Establish a regional network of marine laboratory Directors / Deputy-Directors based on models in North America and Europe which are effective in promoting collaboration and cooperation through training and resource sharing;
  - B. Take steps to convince marine laboratories to plan some of their research programmes in line with the objectives of HOTO;
  - C. Establish partnerships between marine laboratories of developed and developing countries;

- D. Consider on-site training as a more cost-effective approach to sending trainees overseas; and
  - E. Capacity building should involve direct collaboration with responsible policy makers and other stakeholders. This will increase the usefulness of marine science and improve its support and acceptance.
6. It was recommended that the blueprint for the Red Sea be brought to the attention of the Red Sea and Gulf of Aden Environment Programme (PERSGA) by the IOC.
7. It was recommended that the GPO, along with UNEP, work together in incorporating the blueprint for NEAR-HOTO into NEAR-GOOS and NOWPAP-3.
8. The Panel again noted the need for collaboration and stressed the point that when the implementation of GOOS is viewed as a basin wide component together with a coastal/shelf/slope component, this collaboration should begin at the very onset of Coastal Module planning.
9. The Panel proposed that IOC offer the WESTPAC Secretariat to provide a mechanism for continued cooperation in the region, including implementation of regional HOTO activities, after GEF funding ceases in 1998 or 1999.
10. The Panel recommended that the GOOS Project Office take steps to enhance the interaction between GOOS and GTOS.
11. Panel recommended that future HOTO Panel Meetings should, where possible, be held in conjunction with regional HOTO Pilot Project Design Workshops.
12. The Panel suggested that panel membership should be expanded to include:
  - a representative of the policy/user community for which a specific HOTO Project is designed;
  - a representative of the international donor community to ensure that an understanding of existing and emerging funding programmes is effectively incorporated into HOTO regional implementation plans;
  - an individual with strong competence in data management procedures, including information and visual display technologies, to ensure that HOTO, and GOOS generally, are able to effectively convey monitoring results to the user community.
13. Questions were raised concerning the conventional wisdom of convening meetings involving regions in a regional setting. It is suggested that the GPO revisit this issue prior to further meetings to implement GOOS.
14. The Panel agreed that the potential for private sector contributions to the development of the HOTO Module is an area that deserves further investigation. In fact, the Panel suggested that the GOOS Project Office may wish to follow this suggestion up from a wider GOOS prospective.

15. The company producing the kits that are being employed in the Brazilian HOTO Pilot Project for the simple routine analyses might be interested in providing these kits free of charge in the expectation of the market that would develop with the establishment of a long term monitoring network. Thus, it is suggested that the GPO may wish to develop this idea further as a general guideline for the implementation of GOOS Pilot Projects.
16. The HOTO Panel recommended that the next session of HOTO be convened within eighteen months. It was felt that this interval of time will be sufficient for significant advances to be made on the intersessional work that has been agreed to be conducted. The identification of the venue, however, needs further consideration in light of the concerns that have arisen concerning regional venues.

## **ANNEX I**

### **AGENDA**

- 1. OPENING OF THE MEETING**
- 2. ARRANGEMENTS FOR THE MEETING**
  - 2.1 Adoption of the Agenda
  - 2.2 Designation of a Rapporteurs
  - 2.3 Conduct of the Session and Administrative Information
- 3. BACKGROUND INFORMATION**
  - 3.1 PRESENT STATUS OF GOOS (I-GOOS, J-GOOS AND GPO)
    - 3.1.1 U. S. Coastal Module of GOOS Workshop
    - 3.1.2 International Coastal Module of GOOS (Miami Report)
    - 3.1.3 Report of J-GOOS-IV
    - 3.1.4 Report of IOC/UNEP/IMO GIPME Officers' Meeting
    - 3.1.5 Report of I-GOOS-III
    - 3.1.6 Report of XIX<sup>th</sup> IOC Assembly
    - 3.1.7 IMO/IOC/UNEP Sediment Quality Guidelines Workshop
    - 3.1.8 IOC/GIPME Fact Finding Mission to WESTPAC
  - 3.2 PRESENT STATUS OF THE LIVING MARINE RESOURCES (LMR) MODULE OF GOOS
  - 3.3 PRESENT STATUS OF THE COASTAL MODULE OF GOOS
- 4. STATUS OF THE STRATEGIC PLAN FOR THE HOTO MODULE OF GOOS**
  - 4.1 THE GOOS PRINCIPLES
  - 4.2 THE GOOS STRATEGIC PLAN
  - 4.3 GUIDELINES/PRINCIPLES FOR OBSERVING SYSTEMS (I.E., KARL'S PRINCIPLES)
  - 4.4 U.K. GOOS DATA REQUIREMENTS QUESTIONNAIRE
  - 4.5 DELIVERABLES AND USER NEEDS
- 5. REVIEW THE TERMS OF REFERENCE FOR THE GSC/HOTO PANEL**
- 6. UPDATING REQUIRED IN THE STRATEGIC PLAN**

- 6.1 Human Health Issues
- 6.2 Ballast Water Issues
- 6.3 Harmful Algal Bloom Issues
- 6.4 Reassessing/Redefining the Contaminants/Analytes
- 6.5 Requirements, Nature and Availability of Models
- 6.6 Satellite Remote Sensing
- 6.7 Scientific Components of Training and Capacity Building
- 6.8 Indicators for Sustainable Development

## **7. IMPLEMENTATION OF PILOT PROJECTS**

### **7.1 FRAMEWORK FOR REGIONAL BLUEPRINTS**

- 7.1.1 Red Sea**
- 7.1.2 Southeast Asian Seas**
- 7.1.3 North-East Asia Regional HOTO (NEAR-HOTO)**
- 7.1.4 Arctic**
- 7.1.5 Antarctic**
- 7.1.6 Black Sea**
- 7.1.7 Brazilian Coastal Zone**
- 7.1.8 Caribbean Sea**

### **7.2 COLLABORATION/INPUT IN THE DEVELOPMENT OF:**

- 7.2.1 Living Resources Module of GOOS**
- 7.2.2 Coastal Module of GOOS**

### **7.3 WESTPAC COLLABORATION**

- 7.3.1 SEA-GOOS**
- 7.3.2 SEACAMP**
- 7.3.3 NEAR-GOOS**
- 7.3.4 NOWPAP-3**
- 7.3.5 Bi/Multi-Lateral Programmes Under Development**
- 7.3.6 GEF East Asian Seas and Trans-Boundary Diagnostic Analysis**
- 7.3.7 GIWA**

### **7.4 COLLABORATION WITH THE INTERNATIONAL MUSSEL WATCH PROJECT**

- 7.4.1 WESTPAC Region**
- 7.4.2 Mediterranean Sea**

- 7.4.3 Black Sea**
- 7.4.4 Indian Ocean**

**7.5 COLLABORATION WITH OTHER PROGRAMMES/PROJECTS**

- 7.5.1 Global Terrestrial Observing System (GTOS)**
- 7.5.2 Global Coral Reef Monitoring Network (GCRMN)**

**7.6 IMPLEMENTATION PLAN; NEED, SCOPE AND TIMETABLE**

**8. HOTO INPUT TO THE GOOS STRATEGIC PLAN**

**9. FUTURE ACTIVITIES**

- 9.1 INTERACTION WITH OTHER BODIES**
- 9.2 FUTURE WORK PLAN AND TIMETABLE**
- 9.3 MEMBERSHIP/COMPOSITION**
- 9.4 RESOURCES REQUIRED**
- 9.5 RECOMMENDATIONS/SUGGESTIONS OF DATE AND VENUE FOR HOTO-V**

**10. ANY OTHER BUSINESS**

**11. CLOSURE**

**ANNEX II**

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### ANNEX III

#### TROPICAL MARINE SCIENCE INITIATIVE THE NATIONAL UNIVERSITY OF SINGAPORE

There is a recognized need for a center of excellence in tropical marine science and Singapore is well placed to take advantage of this. Singapore is at the physical center of the Western Pacific region, within South-east Asia and lies only 80 miles north of the equator. South East Asia boasts the world's richest marine fauna. Scientific study of ways of ensuring sustainable development in the coastal regions, where 70% of the world's population lives, is therefore of great importance to the region.

In December 1996 the National University of Singapore launched a new research initiative in marine science: the Tropical Marine Science Initiative. Under this umbrella organization, there are five integrated research programmes:

##### **Marine Biology and Biotechnology Programme**

*Marine information systems*  
*Marine biodiversity*  
*Ecosystem functioning*  
*Environmental management*  
*Biotechnology*

##### **Marine Aquaculture Programme**

*Hatchery production*  
*Reef ranching*  
*Fish health*  
*Environmental investigation*

##### **Cetacean Studies Center**

*Singapore wild marine mammal survey (SwiMMS)*  
*Cetacean communication research*  
*Biosensing*  
*Cetacean captive environment research*

##### **Physical Oceanography Research Laboratory**

*Marine processes*  
*Hydrodynamics*

##### **Acoustic Research Laboratory**

*Ambient noise imaging*

*Marine mammal acoustics*  
*Human-powered submarine*

The Initiative is in the process of developing its full research facilities and buildings on an offshore island. Apart from expanding its research capacity, it aims to fulfill the role of being a regional/international training center in tropical marine science.

## ANNEX IV

### LIST OF DOCUMENTS

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NOWPAP/3 - 2 October 1997 e-mail from IOC/WESTPAC Secretariat.

## **ANNEX V**

### **KARL'S PRINCIPLES GUIDELINES AND PRINCIPLES FOR THE OBSERVING SYSTEMS**

**From "Long-Term Climate Monitoring by the Global Climate Observing System"  
by Karl, T. R, Kluwer Acad. Publ., Dordrecht, 648pp, 1996.**

The abbreviated version:

- (i) Build on existing mechanisms, plans and systems as appropriate;
- (ii) The impact of changed observing practices/technology should be thoroughly investigated prior to their implementation. The sensitivity of objectives, applications and products to the change should be determined;
- (iii) Baseline/reference networks (minimal configurations) provide strength and a foundation for observing system development and evolution;
- (iv) Should exploit common data and information management practices to ensure appropriate and adequate metadata are available on calibration, modifications, etc. (Observing System Information Services); and
- (v) Routine and permanent mechanisms for evaluating and monitoring observing system performance should be put in plan.

Tom Karl's original set is:

1. Prior to implementing changes to existing systems, or introducing new observing systems, an assessment of the impacts of such changes on long [hard-] term climate monitoring should be standard practice.
2. Routine assessments of the long [hard-] term climate monitoring capability of existing systems should be standard practice.
3. Observing systems should be complete, possibly including both "low technology" and "high technology" components and ground truth validation.
4. The transition from research measurements to operational measurements for long [hard-] term climate monitoring must be planned in an orderly and systematic manner.
5. Knowledge of instrument, station, and/or platform history is essential and should be treated with as much care as the data themselves.
6. In-situ and other observations with long uninterrupted record should be given special consideration.
7. Calibration, validation and maintenance are critical to long [hard-] term climate monitoring.

8. Processing algorithms and changes in these algorithms must be well documented.
9. Data management, analysis and diagnostics are a key part of a relevant long [hard-] term climate monitoring system.
10. Data management systems must facilitate access (minimum cost).

## **ANNEX VI**

The U.K. GOOS Data Requirements Questionnaire  
(Copyright held by the EuroGOOS Office, Southampton, U.K.)

6 September 1993

Dear Colleague

### **UK SURVEY OF THE USEFULNESS OF A GLOBAL OCEAN OBSERVING SYSTEM**

The Global Ocean Observing System (GOOS) is an operational ocean observing system which will be developed internationally over the next 10-15 years. Data products will become available progressively during the development period.

The purpose of GOOS is to provide useful services, data, maps, plots, statistics, and predictions. The products should be useful to companies and agencies working at sea and on the coast. GOOS will also provide raw data and model outputs to value-added companies who can generate more sophisticated or specialised products. GOOS will develop archives, climatic records, and long term models and predictions so as to refine data products and increase the period of forecast. Some GOOS products will be used in global climate research, modelling and prediction, with applications on land. Product forecast times will range from weeks to months, with the eventual aim of some climatic predictions extending forward over years to decades.

The design of the observing system, including buoys, ship-deployed instruments, satellite remote sensing, and robotic instruments, will depend upon the need for different services and products expressed by potential users of the data. This Questionnaire is part of a survey to identify the most important applications for GOOS data as specified by UK maritime and coastal organisations, including commercial companies, academic research institutions, Government Departments, operational agencies, and regulatory authorities.

The UK is involved in the design and specification of GOOS through participation in various international committees and UN Agencies, such as the Intergovernmental Oceanographic Commission; and through research programmes such as the World Ocean Circulation Experiment and the North Sea Experiment. The interim focal point for evaluating the importance of GOOS for UK is the International Affairs Committee of the (UK) Inter-Agency Committee for Marine Science and Technology (IACMST). This survey is being carried out at the request of IACMST International Affairs Sub-Committee.

Some aspects of operational oceanography and forecasting will require high resolution models around the UK coast, or on the scale of the European continental shelf. For the purpose of this survey these scales are included within the term "GOOS", although they are strictly local models and products.

This survey is in two parts. Please fill in the part which is most relevant to your organisation, or both parts if you wish.

**PART A:** Survey of your requirements for marine forecasts, data, statistics, and maps, and your preferred medium for delivery of the products.

**PART B:** Survey of organisations wishing to provide equipment or services to GOOS.

Please complete the forms and cover sheet and return as soon as possible to:

Dr N C Flemming, Institute of Oceanographic Sciences Deacon Laboratory,  
Brook Road, Wormley, Godalming, Surrey, GU8 5UB.  
Personal fax no.: (0428) 684847

Thank you very much for your help in this exercise. UK is in a very strong position to influence the design of operational oceanographic systems at the European and global levels, and through this Questionnaire the potential users of GOOS have an opportunity to state their requirements.

A statistical summary of the results of this survey will be sent to all respondents.

Yours sincerely

N C Flemming, OBE, MA, PhD.

**1995 EuroGOOS Survey**  
**RESPONSE COVER SHEET**

**Office use only**  
Form No.....

**1. Respondent to this survey**

Company/Institution .....

Address .....

.....

.....

Form completed by (name) .....

Position in organisation .....

**2. Application of EuroGOOS data and products**

Please list here the activities of your organisation for which you require data or products from EuroGOOS. Table 1 lists a range of industrial, commercial, service, and research activities. Select the activity from Table 1 which most closely describes your organisation, and enter the number, or numbers, in the box. You may add a note explaining your applications in more detail if you wish.

Sector of Application: Number(s) from Table 1

Details of application (optional) .....

.....

.....

**3. Please state below the number of forms A and B you are returning.**

Form A .....

Form B .....

Data will be entered in a confidential computer data base and covered by the regulations of the Data Protection Act.

Please return to: Dr N.C. Flemming  
Institute of Oceanographic Sciences Deacon Laboratory  
Brook Road, Wormley  
Godalming  
Surrey GU8 5UB  
(Fax: (0428) 684847)

Thank you.

See Table 1 over

**1995 EuroGOOS SURVEY**

**TABLE 1 APPLICATION OF GOOS DATA AND PRODUCTS**

**SECTORS OF APPLICATION:** Please enter on the Response Cover Sheet

|                                                                    |                                                                   |                                                                    |                                          |                                           |
|--------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------|-------------------------------------------|
| <b>00. Transport (excluding military)</b>                          |                                                                   |                                                                    | 36. Placer minerals, diamonds, tin, etc. | 76. Data transmission, telecommunications |
| 01. Shipping operations                                            | 37. Salts extraction, magnesia, bromine                           | 77. Diving, including suppliers                                    |                                          |                                           |
| 02. Hovercraft operations                                          | 38. Desalination                                                  | 78. Inspection, maintenance, repair                                |                                          |                                           |
| 03. Hydrofoil operations                                           | 39. Phosphate                                                     | 79. Insurance                                                      |                                          |                                           |
| 04. Submersible/submarine operations/ROVs                          | 40. Coal, subsea                                                  | 80. Metocean survey, mapping, hydrographic surveys                 |                                          |                                           |
| 05. Tunnel subsea operations                                       | <b>41. Food from the sea</b>                                      | 81. Project management, non-defence, consultancy                   |                                          |                                           |
| 06. Barrage roads                                                  | 42. Fisheries, catching                                           | 82. Remote sensing                                                 |                                          |                                           |
| 07. Causeway                                                       | 43. Fish farming                                                  | 83. Salvage, towing                                                |                                          |                                           |
| 08. Bridges, sea channels                                          | 44. Shellfisheries                                                | 84. Ship routing                                                   |                                          |                                           |
| 09. Navigational safety, lights etc. Electronic charts             | 45. Shellfish, crustacea, farming                                 | 85. Weather forecasting                                            |                                          |                                           |
| 10. Safety services, rescue, life preserving, fire                 | 46. Fishing gear                                                  | <b>86. Equipment sales</b>                                         |                                          |                                           |
| 11. Port operations                                                | <b>47. Defence</b>                                                | 87. Marine electronics, instruments, radar, opto-electronics, etc. |                                          |                                           |
| <b>12. Energy production</b>                                       | 48. Military vessels, surface and submarine                       | 88. Sonar                                                          |                                          |                                           |
| 13. Oil and gas production (Oil companies only)                    | 49. ASW, oceanographic applications                               | 89. Buoys                                                          |                                          |                                           |
| 14. Oil and gas exploration and prospecting, and drilling services | 50. Underwater weapons                                            | <b>90. Tourism and recreation</b>                                  |                                          |                                           |
| 15. OTEC                                                           | 51. Navigation, position fixing, etc.                             | <b>91. Basic and strategic research</b>                            |                                          |                                           |
| 16. Wave energy                                                    | 52. Defence sales, equipment, components                          | 92. Acoustics, electronics                                         |                                          |                                           |
| 17. Tidal energy                                                   | 53. Operations and efficiency, logistics, controls, computing     | 93. Civil engineering                                              |                                          |                                           |
| 18. Wind energy, offshore installation                             | <b>54. Building, construction, and engineering</b>                | 94. Climate change                                                 |                                          |                                           |
| <b>19. Environmental protection/preservation</b>                   | 55. Coastal defences                                              | 95. Climate forecasting                                            |                                          |                                           |
| 20. Clean beaches                                                  | 56. Port construction                                             | 96. Coastal modelling                                              |                                          |                                           |
| 21. Oil pollution control                                          | 57. Dredging                                                      | 97. Data centre                                                    |                                          |                                           |
| 22. Non-oil pollution control                                      | 58. Land reclamation                                              | 98. Environmental sciences                                         |                                          |                                           |
| 23. Estuarine pollution                                            | 59. Barrage construction                                          | 99. Estuarine modelling                                            |                                          |                                           |
| 24. Health hazards                                                 | 60. Tunnel construction                                           | 100. Fisheries                                                     |                                          |                                           |
| 25. Marine reserves                                                | 61. Outfalls/intakes                                              | 101. Marine biology                                                |                                          |                                           |
| 26. Species protection                                             | 62. Consulting engineering                                        | 102. Marine weather forecasting                                    |                                          |                                           |
| 27. Environmental forecasts                                        | 63. Components, hydraulics, motors, pumps, batteries, etc.        | 103. Ocean modelling                                               |                                          |                                           |
| 28. Flood protection                                               | 64. Cables, manufacture and operations, laying                    | 104. Oceanography                                                  |                                          |                                           |
| 29. Safe waste disposal                                            | 65. Corrosion prevention, paint, antifouling, etc.                | 105. Polar research                                                |                                          |                                           |
| 30. Amenity evaluation                                             | 66. Heavy lifting, cranes, winches                                | 106. Remote sensing                                                |                                          |                                           |
| 31. Environmental quality control                                  | 67. Marine propulsion, efficient ship, automatic ships, DP, props | 107. Shelf seas modelling                                          |                                          |                                           |
| 32. Environmental data services                                    | 68. Offshore construction, platforms, etc.                        | 108. Shipping/naval architecture                                   |                                          |                                           |
| <b>33. Mineral extraction</b>                                      | 69. Pipelaying, trenching, burial                                 | <b>109. Hinterland</b>                                             |                                          |                                           |
| 34. Aggregate, sand, gravel                                        | 70. Ship-building, non-defence, all kinds                         | 110. Agriculture                                                   |                                          |                                           |
| 35. Deep ocean, Mn, hydrothermal muds, crusts                      | <b>71. Services</b>                                               | 111. Land use planning or zoning                                   |                                          |                                           |
|                                                                    | 72. Certification                                                 | 112. Urban management                                              |                                          |                                           |
|                                                                    | 73. Climate forecasting                                           | 113. Local government                                              |                                          |                                           |
|                                                                    | 74. Data consultancy                                              | 114. Wetlands management                                           |                                          |                                           |
|                                                                    | 75. Data services                                                 | 115. Public health                                                 |                                          |                                           |
|                                                                    |                                                                   | 116. Algae Collection                                              |                                          |                                           |
|                                                                    |                                                                   | 117. Algae Culture                                                 |                                          |                                           |

## **1995 EuroGOOS SURVEY OF REQUIREMENTS**

### **NOTES FOR COMPLETING FORMS**

#### **PART A GOOS DATA AND PRODUCTS GRADING**

If you might use data products and services from GOOS, please read Part A and complete Form(s)A. Refer to Table 2 for key terms and lists of variables. Partially completed forms are welcome if your requirements cannot be specified in this amount of detail.

##### **Required data types and products**

Table 2 lists most of the raw data variables proposed as properties of the ocean which could be measured operationally either globally by GOOS, or in coastal and regional sub-programmes or modules of GOOS. "The Case for GOOS" p. A15 Annexe 5 lists typical products.

The objective of Part A of the survey is to provide the following information:

- 1) What parameters or variables in the ocean or coastal seas are of use to you?
- 2) What types of products, scales, spatial resolution, and accuracy do you need?
- 3) For what period into the future is it most useful to have forecasts?
- 4) What medium for delivery of information would you prefer?

Your organisation probably only requires a small number of the possible data types shown in Table 2. For each data type or combination of data types which you require, please complete a survey Form A 'Product Grading'. Select from Table 2 the relevant variable(s) and enter in column 1 on the Form A. Then tick or grade the various accuracies, product types, and delivery media which you require. If you require data from a number of variables, you may group or aggregate them onto single forms, provided that you require all the variables on that form with similar levels of accuracy, resolution, latency, geographical coverage, etc. Data which require different sampling and treatments must be entered on different forms.

Photocopy as many extra copies of Form A as you need. Three forms are provided.

##### **Column 1 - Variables**

The variables and parameters which describe the physical state of the ocean, and a range of biological, chemical, and geological factors, are listed in 13 groups in Table 2. Certain concepts such as heat flux or currents appear in different groups, e.g., surface layers, deep ocean, boundary currents, etc. When entering your choice of variable(s) in Column 1 of the Form you need only enter the number(s) of each of the variable(s) from Table 2.

Some data types which are very dependent upon particular instruments, such as satellite remote sensed sea surface temperature, XBT, CTD etc., are listed as separate variables, but in each case only once.

The data are listed in Table 2 as basic physical and environmental variables in most cases because these are the lowest levels of information which are likely to be needed by users operating assimilation programmes for descriptive and forecasting models, conducting research, or acquiring data to develop specialised multi-parameter products. If you generally require combined products such as combined 10 day forecasts of wind speed, wave conditions, currents, and ice conditions, list the numbers of the most useful combination of variables in Column 1. If there are two or more such groupings which are likely to be useful, please enter them on separate Forms A.

In many cases the unit or dimension of the variable is obvious, e.g. C or PSU or  $\text{m s}^{-1}$ . If possible, state the preferred or most generally used unit for the data type, e.g.  $\text{g l}^{-1}$ , ppm, km/day, megawatts  $\text{km}^{-2}$ , or units of radioactivity, etc. This information will ensure that the accuracy and precision required are unambiguous.

At the end of Table 2 the following categories occur:

- Year-long or multi-year time series
- Decadal time series
- Multi-decade time series
- Climatic statistics
- Spatial statistics
- Past model outputs
- Composite multi-parameter products
- Spectra or other reduced statistics

These category numbers can be used in combination with the Variable or groups of Variables to qualify further the type of products which you need.

**Grading:** For Column 2 and subsequent columns you have the option to either tick the values which you consider to be useful, or to grade the options on a scale of 1-5. The grade scale is:

- 5. An ideal product which would meet the highest requirements.
- 4. A good product which would be very useful.
- 3. A useful product.
- 2. This might be useful, but it falls short of what we need.
- 1. Marginal. Might have some occasional use.
- Blank. This is of no interest to my organisation.

If you do not wish to grade your choices, please make only one entry as a tick against the value which you consider useful. This will be valued as a Grade 3 mark in analysis of the Forms.

**Allocation of Grades:** The objective is to rank products in order, from those which are most useful to those which it would be pointless to develop. When allocating grades, please start at the coarse/low resolution/low value end for each characteristic and consider the values which would not be useful. Work upwards to values or products of greater use to you. When you reach a value or type of product which would be useful, give it a grade or tick. Allocate grade 5 to the accuracy/resolution/ delivery etc. which would satisfy your requirements. Please do not mark higher levels of accuracy/resolution/etc. than are needed. This would tend to delay development of an operational system. It is assumed that higher levels of accuracy/resolution/faster delivery etc. would satisfy your requirements

You can skip grades, marking one as '1', the next '3', and the next '5' if you wish.

In making your choice, do not be constrained by what you know to be available or measurable in 1993. In 10 years time it may be possible to create the product at the accuracy and speed you really need.

## **Column 2 - Geographic Coverage**

Grade the typical areas of geographical coverage which you are most likely to require. There is no need to indicate actual oceans or sea areas, although this information can be added in Column 12 as an option. Coastal seas are defined as including wetlands and coastal waters out to a distance of 10-20km. Shelf Seas are defined as full continental shelf width, or out to 200 nautical miles. Ocean basin means North Atlantic, Southern Ocean, etc.

## **Column 3 - Product Type**

This column allows you to grade the type of products or level of processing which you are most to require.

Raw data defines a stream of observational data with time and geographical co-ordinates plus quality control information. Such data could be delivered operationally for assimilation into models, or for hazard or alert warnings.

Processed data implies that a form of statistical treatment, contouring, averaging, gridding, has been applied, or that variables have been combined or corrected to obtain derived parameters. These data have not been assimilated into operational or research models.

Hindcast data describes data sets which have been processed through a numerical model to provide the best possible description or approximation to a past state of the ocean. Hindcast model output would resolve or detect details and process not shown by the raw data, and present fields at a higher resolution.

Nowcast products are model outputs which seek to provide the most accurate and rapidly available description of the state of the ocean at the time of data distribution.

Forecast products will be concentrated on periods of 10 days or longer. See column 10 for detailed grading.

Statistical products include a wide range of climatic and engineering summaries of data such as spectra, occurrence and exceedance diagrams, predicted maxima and minima, percentage probabilities, recurrence intervals, variability, co-occurrence probabilities, inter-annual changes, anomalies as departures from multi-year mean values, etc.

## **Column 4 - Variable Accuracy**

Data or derived data products have an accuracy determined in part by the accuracy of the original observations, and in part by the subsequent transmission, processing, assimilation, and modelling. If the product which you require is a set of raw data prior to assimilation, the accuracy you stipulate will define the accuracy of observation. If you require a processed or modelled output, the accuracy refers to the accuracy of the product or data set provided to you as compared to a check of the predicted value subsequently observed in the field.

For those physical variables which are expressed in numerical fields, contours, or vectors, the accuracy is expressed as an error % of the typical mean value or range. For chemical concentrations, this is also the case. For characteristics or variables which are themselves composite, or are usually described with several component variables (e.g. time of arrival, phase, amplitude, position, direction, etc.) it is not possible to show all the components in Table 2. Biological data often consist of qualitative, descriptive, and numerical data in combination. Please assume that the necessary species information is included in the product, and apply the accuracy criteria to the quantitative data. Comments on important criteria, species information, units, expected range of values, etc., may be added in Column 1 or Column 12 of the Form. Please note that commercial fisheries data and fisheries monitoring and stock assessment are excluded from the observing system of GOOS as these activities are conducted by other agencies.

#### **Column 5 - Variable Precision**

Grade the precision required as a % of range or mean value for each variable.

#### **Column 6 - Spatial Resolution**

If you require raw data prior to modelling or processing, grade the lateral spatial resolution of field data sampling which would be required. Horizontal spatial resolution of products resulting from diagnostic and forecasting models can be significantly finer and contain more detail than the original observing scheme. Grade the spatial resolutions required.

#### **Column 7 - Vertical resolution**

Assuming a data set consisting of profiles or sections showing variable values and properties at standard depth intervals, or a fully 3-dimensional data set, grade the vertical resolution which you require for each variable. Table 2 allows you to select variables which are specified as sea surface, upper layer, or deep ocean, and you may specify different vertical resolutions depending on the depth. Where Table 2 does not present the same variable in different depth ranges, but you wish to specify variable vertical resolution, please add notes in Column 12.

#### **Column 8 - Temporal Resolution**

Temporal resolution of an observing scheme or data product defines the time interval of observational data sampling or the time step of output data presentation at a single point, or within a defined standard area. It is therefore linked to spatial resolution. If you require unprocessed observational data, grade the temporal resolution which you would require within a square of the preferred spatial resolution indicated in Column 6. If you require processed, assimilated, or model output data, the product may either include data sets repeated at the time step of the model, or reduced or averaged products, fluxes, velocities, etc., based on integrations of the model. In either case, please grade the temporal resolution you require.

#### **Column 9 - Latency of Delivery**

The latency of delivery defines the time elapsed between observation of the last variable value at sea which is included in the data set, and the delivery of the data or product to the user. Thus a 10-day forecast which is computed rapidly and delivered within 6 hours will have a maximal value; the same forecast delivered after 5 days has less value. Long period forecasts will require a great deal of data and computation, and it would be reasonable to allow a latency of 1 month for a 1 year forecast.

#### **Column 10 - Forecast Period**

GOOS will concentrate on providing data sets describing oceanographic physical, chemical, and biological processes with periods of variability longer than atmospheric weather. There may be some overlap of interest with conventional marine meteorological services, but the intention is to provide a continuity of services, and to avoid duplication. Most GOOS forecasts will be for periods of 10 days or more. Accuracy and temporal and spatial resolution will tend to degrade with increased period of forecast

#### **Column 11 - Delivery Medium**

GOOS data and data products may be delivered through any global communications system, satellite links, academic networks, or dedicated operational links. Users requiring large volumes of data for operational models should select appropriate media for data delivery. The prioritised method of data delivery should be chosen for higher level data products. Very high data rate links may exist in a few years time, together with improved versions or additions to the WMO Global Telecommunications System.

Thank you for completing Form A. If there are further details of your activities or requirements which would help in the design of GOOS, please add them in the space for supplementary notes on the back of Form A.

# 1995 EuroGOOS SURVEY

## FORM A

**PRODUCT GRADING** Please read notes Part A before completing this form

Office use only

Company ID.....

Sheet No.....

| 1                          | 2                   |       | 3            |       | 4                 |       | 5                  |       | 6                  |       |
|----------------------------|---------------------|-------|--------------|-------|-------------------|-------|--------------------|-------|--------------------|-------|
| Variable(s) [from Table 2] | Geographic Coverage | grade | Product Type | grade | Variable Accuracy | grade | Variable Precision | grade | Spatial Resolution | grade |
|                            | Estuarine           |       | Raw data     |       | 0.01%             |       | 0.01%              |       | <0.5 km            |       |
|                            | Coastal seas        |       | Processed    |       | 0.10%             |       | 0.10%              |       | 0.5 km             |       |
|                            | Shelf seas          |       | Hindcast     |       | 1.00%             |       | 1.00%              |       | 1.0 km             |       |
|                            | Ocean basin         |       | Nowcast      |       | 10%               |       | 10%                |       | 10 km              |       |
|                            | Hemisphere          |       | Forecast     |       | 20%               |       | 20%                |       | 100 km             |       |
|                            | Global              |       | Statistics   |       | 30%               |       | 30%                |       | 500 km             |       |
|                            |                     |       |              |       |                   |       |                    |       | 1000 km            |       |

| 7                   |       | 8                   |       | 9                |       | 10              |       | 11              |       | 12    |
|---------------------|-------|---------------------|-------|------------------|-------|-----------------|-------|-----------------|-------|-------|
| Vertical Resolution | grade | Temporal Resolution | grade | Latency Delivery | grade | Forecast Period | grade | Delivery Medium | grade | Notes |
| 1 m                 |       | 1 hour              |       | 6 hour           |       | 10 days         |       | Tape            |       |       |
| 10 m                |       | 6 hour              |       | 12 hour          |       | 30 days         |       | Disc/CD         |       |       |
| 50 m                |       | 1 day               |       | 1 day            |       | 3 months        |       | Network/e-mail  |       |       |
| 100 m               |       | 10 days             |       | 5 day            |       | 1 year          |       | Shipboard       |       |       |
| 500 m               |       | 1 month             |       | 1 month          |       | 10 years        |       | Fax             |       |       |
| 1000 m              |       | 3 months            |       | 6 month          |       | 20 years        |       | Hard copy       |       |       |
|                     |       | 1 year              |       | 1 year           |       |                 |       | Other*          |       |       |
|                     |       | >1 year             |       |                  |       |                 |       |                 |       |       |

- Notes:
- 1) The characteristics defined by this form refer to the product delivered to you the user, not to the original observations carried out.
  - 2) If you cannot give precise details in all columns a partially completed form will be appreciated.
  - 3) The information on this form will be held on a computer and will be covered by the Data Protection Act.

\* Please state preferred mode of delivery

Tick here if you wish to be kept informed of the development of GOOS products described on this  
**Supplementary Notes to Form A**

form: P.T.O.

**1995 EuroGOOS SURVEY**

**TABLE 2 DATA VARIABLES AND PARAMETERS IN GOOS DATA PRODUCTS**

Please select from this table to complete Column 1 of Form(s) A

|                                     |  |                                 |
|-------------------------------------|--|---------------------------------|
| <b>A. SURFACE FIELDS</b>            |  | 43. Carbon inventory            |
|                                     |  | 44. Carbon budgets              |
| 1. Sea surface temperature          |  |                                 |
| 2. Sea surface Wind stress          |  |                                 |
| 3. Velocity                         |  |                                 |
| 4. Direction                        |  |                                 |
| 5. Heat flux                        |  |                                 |
| 6. Moisture flux                    |  |                                 |
| 7. Precipitation                    |  |                                 |
| 8. Sea surface salinity             |  |                                 |
| 9. Wave spectrum                    |  |                                 |
| 10. Wave direction spectrum         |  |                                 |
| 11. Waves Hs                        |  |                                 |
| 12. Wave Period                     |  |                                 |
| 13. Wave swell                      |  |                                 |
| 14. Sea surface CO <sub>2</sub>     |  |                                 |
| 15. Sea surface GHGs                |  |                                 |
| <b>B. SEA SURFACE TOPOGRAPHY</b>    |  |                                 |
| 16. Hourly mean sea level           |  |                                 |
| 17. Marine geoid                    |  |                                 |
| 18. Monthly mean sea level          |  |                                 |
| 19. Sea level anomaly               |  |                                 |
| 20. Oceanic tides                   |  |                                 |
| 21. Geostrophic currents            |  |                                 |
| 22. Meteorological forcing          |  |                                 |
| <b>C. UPPER LAYER FIELDS</b>        |  |                                 |
| 23. XBT sections                    |  |                                 |
| 24. XCTD sections                   |  |                                 |
| 25. Tropical upper ocean, structure |  |                                 |
| 26. Upper ocean heat content        |  |                                 |
| 27. Upper ocean salinity            |  |                                 |
| 28. Upper ocean fresh water         |  |                                 |
| 29. Upper ocean heat transport      |  |                                 |
| 30. Upper ocean heat flux           |  |                                 |
| 31. Fresh water transport           |  |                                 |
| 32. Fresh water flux                |  |                                 |
| 33. Salt transport                  |  |                                 |
| 34. Salt flux                       |  |                                 |
| 35. Buoyancy flux                   |  |                                 |
| 36. Upper ocean velocity fields     |  |                                 |
| 37. Momentum fields                 |  |                                 |
| 38. Surface currents                |  |                                 |
| 39. Upwelling velocities            |  |                                 |
| 40. Downwelling velocities          |  |                                 |
| 41. Eddies, jets, fronts            |  |                                 |
| 42. Carbon transport                |  |                                 |
|                                     |  | <b>D. SEA ICE</b>               |
|                                     |  | 45. Extent, boundary, leads, %  |
|                                     |  | 46. Concentration               |
|                                     |  | 47. Surface ice state           |
|                                     |  | 48. Surface ice roughness       |
|                                     |  | 49. Thickness                   |
|                                     |  | 50. Temperature                 |
|                                     |  | 51. Air, sea, ice, temperatures |
|                                     |  | 52. Ice motion                  |
|                                     |  | 53. Albedo                      |
|                                     |  | 54. Snow on ice                 |
|                                     |  | 55. Water on ice                |
|                                     |  | <b>E. ICE SHELVES</b>           |
|                                     |  | 56. Extent, boundary            |
|                                     |  | 57. Topography                  |
|                                     |  | 58. Roughness                   |
|                                     |  | 59. Surface state               |
|                                     |  | 60. Bottom topography           |
|                                     |  | 61. Snow line                   |
|                                     |  | 62. Mass balance                |
|                                     |  | 63. Albedo                      |
|                                     |  | 64. Surface temperature         |
|                                     |  | 65. Surface ice velocity        |
|                                     |  | 66. Sub-shelf ocean circulation |
|                                     |  | <b>F. ICEBERGS</b>              |
|                                     |  | 67. Numbers                     |
|                                     |  | 68. Distribution                |
|                                     |  | 69. Trajectories                |
|                                     |  | 70. Area, volume                |
|                                     |  | <b>G. DEEP OCEAN</b>            |
|                                     |  | 71. CTD sections                |
|                                     |  | 72. Deep ocean salinity         |
|                                     |  | 73. Deep ocean ht storage       |
|                                     |  | 74. Deep ocean carbon storage   |

- 75. Deep ocean water storage
- 76. Ocean tracers
- 77. Ocean boundary currents
- 78. Inter-basin straits currents

#### **H. SEA BED**

- 79. Bathymetry
- 80. Surface outcrops
- 81. Surface sediments
- 82. Gridded bathymetry
- 83. Gravity
- 84. Magnetism
- 85. Heat flow

#### **I. COASTAL & SHELF**

- 86. Coastline map
- 87. Hinterland topography
- 88. Coastal bathymetry
- 89. Shelf bathymetry
- 90. Tidal constants
- 91. Tidal ellipses
- 92. Stratification
- 93. River runoff
- 94. Land non-river runoff
- 95. Sediment transport
- 96. Wetlands characteristics

#### **J. BIO-GEOCHEMICAL**

- 97. Chlorophyll
- 98. Nitrate
- 99. Phosphate
- 100. Oxygen
- 101. Silicate
- 102. Iron
- 103. Biological pigments
- 104. Pathogens
- 105. Synthetic organics
- 106. Artificial radionuclides
- 107. Petroleum hydrocarbons
- 108. Pesticides & Herbicides
- 109. Trace metals
- 110. PAHs
- 111. Pharmaceutical wastes
- 112. Phytoplankton
- 113. Zooplankton
- 114. Carbon dioxide

- 115. Tritium
- 116. Aquatic toxins
- 117. Human health risks
- 118. Suspended sediments

#### **K. OPTICS**

- 119. Incident light spectrum
- 120. Depth of photic zone
- 121. Transmissivity
- 122. RS reflected light spectrum
- 123. Phosphorescence
- 124. Bioluminescence
- 125. Secchi disk depth

#### **L. ACOUSTICS**

- 126. Sound velocity profiles
- 127. Sound ray paths
- 128. Acoustic scattering
- 129. Reverberation characteristics
- 130. Ambient noise spectrum
- 131. Anthropogenic noise
- 132. Seabed acoustic prop's
- 133. Acoustic tomography
- 134. Acoustic thermometry
- 135. Acoustic models (shelf)
- 136. Acoustic models (oceanic)

#### **M. DATA STRUCTURE**

- 137. Year-long time series
- 138. Decadal time series
- 139. Multi-decade time series
- 140. Climatic statistics
- 141. Spatial statistics
- 142. Past model outputs
- 143. Composite multi-parameter products
- 144. Spectra or other reduced statistics

#### **N. HINTERLAND**

- 145. Coastal land use
- 146. Vegetation cover
- 147. Agricultural crops
- 148. Urbanisation
- 149. Population density
- 150. Industrial characteristic

**1995 EuroGOOS SURVEY**

**NOTES FOR COMPLETING FORMS**

**PART B EXPRESSIONS OF INTEREST IN EQUIPMENT AND SERVICES**

If you are interested in supplying services or equipment during the development and operation of the Global Ocean Observing System (GOOS) please complete Form B. These notes will help in completing the Form.

GOOS is in the early stages of planning and development, and will require collaboration between agencies in those countries which are already most active in oceanography and marine services. Developing countries will be involved, since many observations will need be taken within their EEZs, and the benefits of the data and modelling will be provided to all countries in the world.

Operational activities will be conducted by existing national agencies, and some countries are already considering revised departmental structures or terms of reference to support national participation in GOOS. As the development of GOOS progresses there will probably be an increased demand for operational instrumentation, improved deployment and coverage, greater reliability, simpler field maintenance and preparation of instruments, simpler calibration, longer endurance, etc. Additionally there will be a need for technical services, data telemetry, data quality control, deployment and maintenance of instruments or moorings, etc.

Through this survey I wish to contact companies and organisations which have a potential interest in providing equipment or services as part of their business, or as research contracts etc. The potential market for service and equipment within the framework of GOOS is not exclusively British, and there could be considerable opportunities at the European scale, or globally.

Please identify the areas of business or contract research which would interest your organisation from Table 3, and list the item numbers on Form B. Return the form with the Cover Sheet.

Thank you.

**1995 EuroGOOS SURVEY**

**FORM B**

**ACTIVITIES OF ORGANISATIONS RELEVANT TO GOOS**

**Office use only**

Form No.....

Sheet No.....

My organisation is interested in marketing the following products or services during the development and implementation phases of GOOS. (Please list item numbers from Table 3 below):

Activities from Table 3: .....

Notes:

1. Please list any supplementary information below. You may enclose company brochures or equipment fact sheets or specifications with your reply.
2. Do you wish your organisation to be kept informed of the development of GOOS?

The information provided on this Form will be treated as commercial in confidence.

4. The information which you provide to this survey will be held on a computer, and will be covered by the Data protection Act.

**Supplementary Information**

## 1995 EuroGOOS SURVEY

**TABLE 3 SERVICES AND PRODUCTS WHICH MAY HAVE INCREASED MARKETS DURING THE DEVELOPMENT AND IMPLEMENTATION OF GOOS**

Please select from this table to complete Form B

| <b>00. Subsea instrumentation</b>                      |                                                         | <b>44. Data Telecommunications systems</b>                |                                                            |
|--------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|
| 01.                                                    | XBT                                                     | 45.                                                       | Acoustic data telemetry systems                            |
| 02.                                                    | CTD                                                     | 46.                                                       | Data storage and retrieval systems                         |
| 03.                                                    | XCTD                                                    | 47.                                                       | Global data transmission services                          |
| 04.                                                    | Towed undulating systems                                | 48.                                                       | Local or regional data transmission services               |
| 05.                                                    | Moored Current meters                                   | 49.                                                       | Data management, quality control, and processing           |
| 06.                                                    | ADCP, moored                                            |                                                           |                                                            |
| 07.                                                    | ADCP, shipborne                                         |                                                           |                                                            |
| 08.                                                    | Water bottle rosettes                                   |                                                           |                                                            |
| 09.                                                    | Thermistor arrays                                       |                                                           |                                                            |
| 10.                                                    | Sound velocity instrumentation                          |                                                           |                                                            |
| 11.                                                    | Sonobuoys                                               |                                                           |                                                            |
| 12.                                                    | Fluorimeter                                             |                                                           |                                                            |
| 13.                                                    | Plankton detectors                                      |                                                           |                                                            |
| 14.                                                    | Biological trawl nets                                   |                                                           |                                                            |
| <b>15. Surface instrumentation, buoys and drifters</b> |                                                         | <b>50. Data processing services, computing, modelling</b> |                                                            |
| 16.                                                    | Marine meteorological instrumentation                   | 51.                                                       | Oceanographic data bank                                    |
| 17.                                                    | Wave measuring buoys                                    | 52.                                                       | Modelling and forecasting centre                           |
| 18.                                                    | HF radar, waves and currents                            | 53.                                                       | Model development and testing                              |
| 19.                                                    | Tide gauges                                             | 54.                                                       | Data assembly centre                                       |
| 20.                                                    | GPS buoys for sea level altimetry                       | 55.                                                       | Image processing                                           |
| 21.                                                    | Salinometer                                             | 56.                                                       | Marine biological species identification and data assembly |
| 22.                                                    | Drifting instrument buoys                               | 57.                                                       | Sea ice modelling                                          |
| 23.                                                    | Moored buoys, buoy system and moorings.                 | 58.                                                       | Marine biological modelling                                |
| 24.                                                    | Unmanned vehicles                                       |                                                           |                                                            |
| 25.                                                    | Remote operated instrumented vehicles (ROVs)            |                                                           |                                                            |
| 26.                                                    | Automatic unmanned vehicles (AUVs)                      |                                                           |                                                            |
| 27.                                                    | Satellite sensors and services                          |                                                           |                                                            |
| 28.                                                    | RS data centre and services                             |                                                           |                                                            |
| 29.                                                    | RS data quality control and merging                     |                                                           |                                                            |
| 30.                                                    | Satellite sensor design and calibration                 |                                                           |                                                            |
| 31.                                                    | Ground truthing                                         |                                                           |                                                            |
| 32.                                                    | RS Algorithm development                                |                                                           |                                                            |
| 33.                                                    | Oceanographic RS data product development               |                                                           |                                                            |
| 34.                                                    | Deployment, leasing and maintenance services            |                                                           |                                                            |
| 35.                                                    | Charter or operation of research vessels                |                                                           |                                                            |
| 36.                                                    | Charter or operation of vessels for operational surveys |                                                           |                                                            |
| 37.                                                    | Charter or operation of research or survey aircraft     |                                                           |                                                            |
| 38.                                                    | Deployment or maintenance of moored instruments         |                                                           |                                                            |
| 39.                                                    | Equipment leasing                                       |                                                           |                                                            |
| <b>40. Optical instruments</b>                         |                                                         | <b>59. Basic and strategic research</b>                   |                                                            |
| 41.                                                    | Light transmissivity equipment                          | 60.                                                       | Acoustics, electronics                                     |
| 42.                                                    | Spectral measurements                                   | 61.                                                       | Civil engineering                                          |
| 43.                                                    | Albedo                                                  | 62.                                                       | Climate change                                             |
|                                                        |                                                         | 63.                                                       | Climate forecasting                                        |
|                                                        |                                                         | 64.                                                       | Coastal modelling                                          |
|                                                        |                                                         | 65.                                                       | Data centre                                                |
|                                                        |                                                         | 66.                                                       | Environmental sciences                                     |
|                                                        |                                                         | 67.                                                       | Estuarine modelling                                        |
|                                                        |                                                         | 68.                                                       | Fisheries                                                  |
|                                                        |                                                         | 69.                                                       | Marine biology                                             |
|                                                        |                                                         | 70.                                                       | Marine weather forecasting                                 |
|                                                        |                                                         | 71.                                                       | Ocean modelling                                            |
|                                                        |                                                         | 72.                                                       | Oceanography                                               |
|                                                        |                                                         | 73.                                                       | Polar research                                             |
|                                                        |                                                         | 74.                                                       | Remote sensing                                             |
|                                                        |                                                         | 75.                                                       | Shelf seas modelling                                       |
|                                                        |                                                         | 76.                                                       | Shipping/naval architecture                                |

**77. Standards and calibration services**

- 78. Standard seawater
- 79. Standards for nutrients and trace metals in seawater.
- 80. Instrument calibration services
- 81. Pressure vessels for instrument calibration.
- 82. Field trials for instrument standardisation
- 83. Bathymetric surveying
- 84. Electronic chart services
- 85. Bathymetric surveying
- 86. Swath bathymetric surveys and data processing
- 87. Deep ocean digital cartography
- 88. Swath bathymetry equipment
- 89. Precision echo-sounding equipment

**90. Acoustic equipment and systems**

- 91. Tomography

**92. Chemical sensors and services**

- 93. Laboratory services for salinity analysis
- 94. Laboratory service for trace metal analysis
- 95. Operational pollution modelling
- 96. Radioactivity detection, nuclide analysis
- 97. Oxygen measurement systems
- 98. Nutrients, nitrate, phosphate, silicate measurement systems or services
- 99. CO<sub>2</sub> sensors or pCO<sub>2</sub> measurements
- 100. Analysis of organics in seawater
- 101. Shipboard chemical analytic systems
- 102. Remotely operated subsea chemical sensors and recording systems

**103. Other (please specify)**

## **ANNEX VII**

### **REVISED HOTO TERMS OF REFERENCE**

**From Report of the Third Session of J-GOOS (Annex VIII)  
23 - 25 April 1996, Paris, France**

The HOTO Panel will be responsible for:

- Ensuring a continuing up-dating of the Strategic Plan for HOTO to adequately reflect development and understanding arising through relevant research and technology;
- Further analyzing the nature of marine processes and vectors for human disease transmission to ensure that the most appropriate variables relating to threats to human health are included in the HOTO Module design;
- Developing specific HOTO Module designs for several marine regions, including spacial and temporal resolutions of sampling, to test the validity and comprehensiveness of the Strategic Plan for HOTO and to determine the specific measurements/variables required from other modules/programmes to support HOTO measurements and their interpretation;
- Identifying the scientific components for training, mutual assistance and capacity building, where necessary, for undertaking the regional assessments;
- Examining the content of existing operational systems, both national and international, dealing with the health of the oceans with a view of advancing GOOS;
- Co-ordinating with other GOOS Modules for the purposes of ensuring compatible strategic and scientific development of all GOOS Modules. In particular, identifying the requirements, nature and availability of models that can facilitate the proper development of HOTO products and/or allow prognostic prediction of potential/future conditions relating to the health of the oceans;
- Maintaining liaison with research and monitoring activities to ensure that assessments and predictions of the health of the oceans are based on sound and contemporary scientific knowledge;
- Developing interaction with other scientific and technical bodies having relevance to furthering the development of GOOS (i.e., ICES, PICES, EURO-GOOS, etc...); and
- Defining HOTO products relevant to the requirements of specific users and describing the procedures leading from the base variable measurements, through scientifically-proven interpretation, to the preparation of such products.

**ANNEX VIII**  
**REFERENCES FOR HUMAN HEALTH ISSUES**

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## **ANNEX IX**

### **TERMS OF REFERENCE**

#### **ICES/IOC/IMO STUDY GROUP ON BALLAST WATER AND SEDIMENTS**

The ICES/IOC/IMO Study Group on Ballast Water and Sediments recommends that it meet from 30 - 31 March 1998 in The Hague, The Netherlands to:

- a) continue work on international intercalibration of ballast water and sediment sampling methods;
- b) Discuss cooperative research programmes and databases;
- c) discuss the results of on-going research on new ballast management technologies;
- d) continue to address other ship-mediated vectors in addition to ballast systems; and
- e) work closely with WGHABD to monitor the introduction, via ballast water transport, of phytoplankton organisms that can toxic and harmful algal blooms.

## **ANNEX X**

### **THE IOC-HAB PROGRAMME**

(This annex was prepared by Dr Halim, who is also a member of the IOC-FAO Intergovernmental Panel on Harmful Algal Blooms (IHAB), and serves as the HOTO linkage with that Panel)

There is growing concern over the extent to which worldwide reports of HAB events represent an actual global spread of such blooms. Various evidence seem to support this view, correlating the apparent increase of HAB with the coastal alterations caused by the development of mariculture, the intensified coastal urbanization, the introduction of exotic species through ballast water and the potential effects of climate change.

Such outbreaks of HABs are symptomatic of health deterioration of the coastal oceans and seas affecting marine resources and human health. Their monitoring, therefore, is central to the objectives of the HOTO Module and possibly other GOOS Modules as well and provides societal justification for the GOOS Programme.

A global network of long-term monitoring sites is needed to address this issue. Such a network is presently lacking. A global programme on HAB should be designed to assess the geographical spread, the frequency and magnitude of such blooms with the ultimate goal of providing an early warning system. It will focus on the monitoring of trends of variability in the standing crop and shifts in species composition, on the vertical oxygen gradient and the micronutrients. The programme should be accessible to both developed and fund-limited countries.

Phytoplankton pigments are a low-resolution measurement and moreover, an indiscriminate index for community structure and the occurrence of potentially harmful algae.

It is proposed to introduce the assessment of the "Phytoplankton standing crop and community structure" to the specific HOTO monitoring measurements required to assess the health of the marine environment. Advantage will be taken from technological advances such as the PC based taxonomic identification keys and the automated equipment for phytoplankton counting.

At its fourth meeting (30 June - 2 July 1997) in Vigo, Spain, the IHAB recommended that the provision of information on the timing and magnitude of HAB should be articulated as part of the GOOS Programme. It also recommended that the long-term monitoring of water quality and phytoplankton species composition be included as a routine part of monitoring programmes throughout the world, including GOOS and LOICZ.

The IPHAB-IV (See attached recommendations) took note of the report from the HOTO Panel Representative and recalled the recommendation of its last meeting, in 1995, concerning the linkage between the HAB Programme and GOOS.

**Recommendation IPHAB-IV.8**

**LONG TERM OBSERVATIONS OF HARMFUL ALGAE**

**The IOC Intergovernmental panel on Harmful Algal Blooms,**

**Recognizing** that the provision of information on the timing and magnitude of blooms of harmful algae represents an essential ocean service for protection of living resources and public health that should be articulated as part of the IOC-GOOS Programme's societal justification,

**Noting** the report from the HOTO Panel of GOOS,

**Recalling** Recommendations IPHAB-III.6 on the linkage between the HAB Programme and GOOS,

**Noting** that long-term monitoring of water quality and phytoplankton composition as an extremely effective tool in determining long-term responses to climatic variation as well as anthropogenic-induced shifts in species composition, including proliferation of HAB species,

**Noting** also that in some regions, long term taxonomic studies have produced decade to several decade-long plankton collections that provide excellent resources for detection of long-term shifts in composition arising from decadal climatic variations as well as compositional changes directly attributable to anthropogenic activities,

**Noting** also that there are techniques which permit both detection of long-term shifts in composition arising from decadal climatic variations as well as compositional changes directly attributable to anthropogenic activities,

**Recommends** the continuation of on-going long-term studies,

**Recommends** also the inclusion of long-term monitoring programmes for phytoplankton species composition as a routine part of monitoring throughout the world, including GOOS and LOICZ.

**Recommendation IPHAB-III-6 (1995)**

The IOC-FAO Intergovernmental Panel on Harmful Algal Blooms,

**Recognizing** that the provision of information on the timing and magnitude of blooms of harmful algae represents an essential ocean service that should be articulated as part of the IOC-GOOS Programme's societal justification,

**Recommends** that the IOC secretariat and the Chair of the IPGAB work with the IOC-GOOS Programme, its subsidiary bodies (I-GOOS and J-GOOS), and the Health of the Ocean and Coastal module working groups, to incorporate during planning and implementation, monitoring facilities to acquire long-term, high resolution observations on the occurrence, distribution, impacts, and densities of harmful and noxious algae and associated environmental parameters;

Also **recommends** that efforts be made to place a member of the Panel on the GOOS Health of the Oceans Panel (and other GOOS panels as appropriate) who has expertise in aspects of the biology of HABs; and

Further **recommends** that the IPHAB member of the Health of the Oceans Panel specified above report progress on GOOS activities related to HABs at the IPHAB-IV.

**ANNEX XI****INDICATORS OF SUSTAINABLE DEVELOPMENT****Eutrophication**

This issue area is closely tied with the Phytoplankton Dynamics Coastal System Dynamics issue area. Indeed, these areas are designated separately solely to acknowledge the importance of examining early warnings of eutrophic conditions, rather than taking the retrospective view once eutrophication leads to excessive blooms, anoxic waters, and fish kills. At the center of the Eutrophication issue area, then, are the marginal shifts in nutrient concentrations occurring in coastal waters which may first result in blooms of toxic and/or nuisance species, and subsequently, to overall blooms which overload the system with organic matter and deplete the water column of oxygen—with ramifications throughout the food web.

*Monitoring Needs:*

- Nutrient concentrations — the speciation, concentrations, and trends in concentration of nutrients in coastal waters should be closely monitored for managing the Eutrophication Coastal System Dynamics area. Spatial profiles of nutrient concentrations should also be taken, both for this issue area, and for assisting the Water Circulation area.
- Primary production — this monitoring variable, coupled with light penetration and organic matter concentration, helps to determine the status of bloom conditions in coastal waters.
- Light penetration — a decrease in light penetration may affect primary production in deeper waters; also, low penetration of light may be an indication of high levels of organic matter, a precursor of hypoxic or anoxic conditions.
- Organic matter concentration — see above; also, the presence of organic matter in the water column will influence the speciation, bioavailability, mobility of trace metals and other anthropogenic pollutants.
- Metals — should be monitored as hypoxic or anoxic waters, and especially bottom waters and sediments, may exhibit different redox characteristics, changing the speciation and bioavailability of essential, non-essential, and toxic trace metals
- Community structure variables — monitoring variables related to community structure is important in terms of Eutrophication because marginal changes in nutrient loading may cause substantial shifts in planktonic community structure. Both the type and abundances of the phytoplankton, zooplankton, invertebrate predator, and planktivorous fish species should be monitored for this issue area.

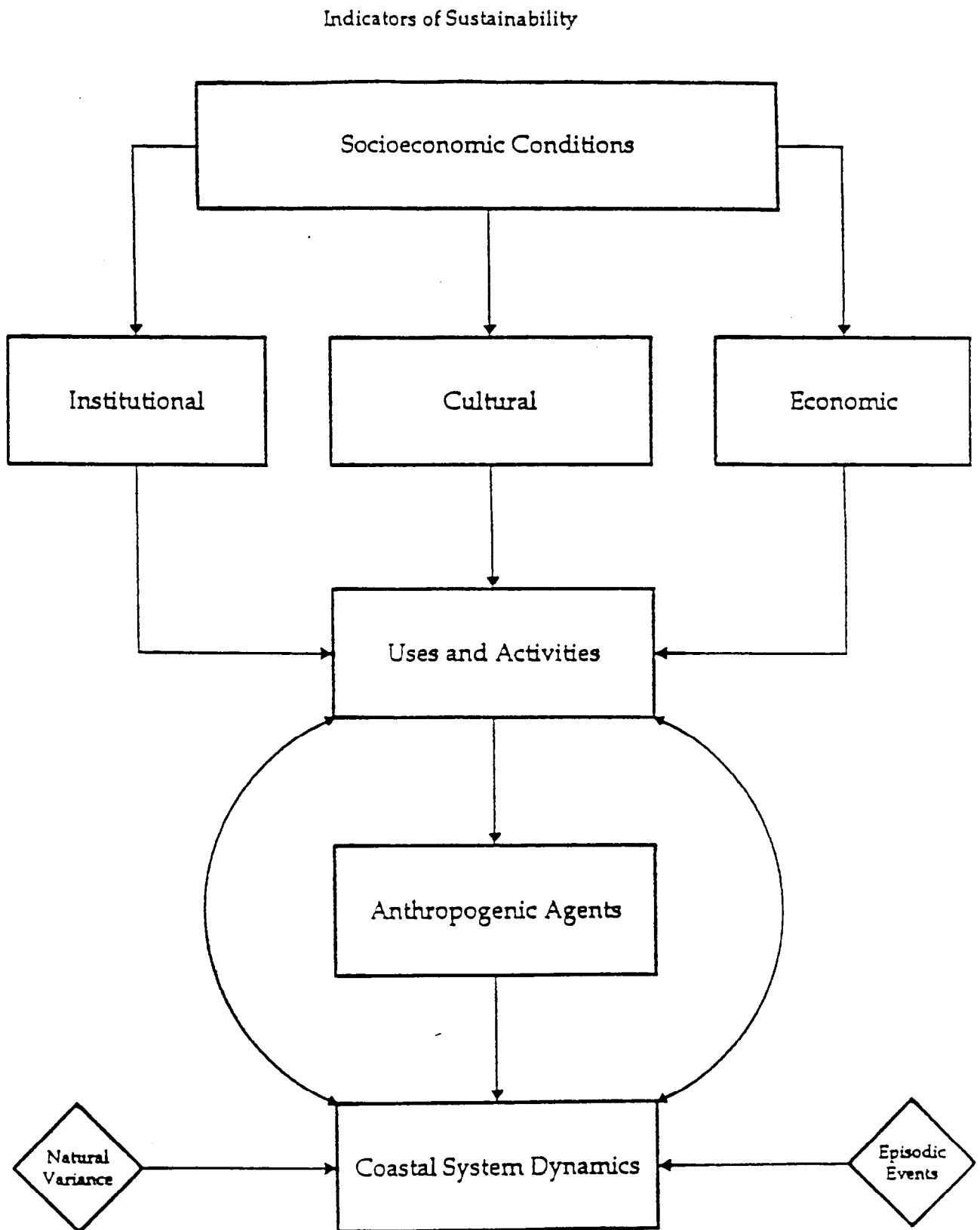
*Use/Activity Costs:*

- Tourism/Recreation — these uses of the coastal zone may be impacted as a result of the prevalence of aesthetically-displeasing nuisance species (e.g., algal “foams”); toxic

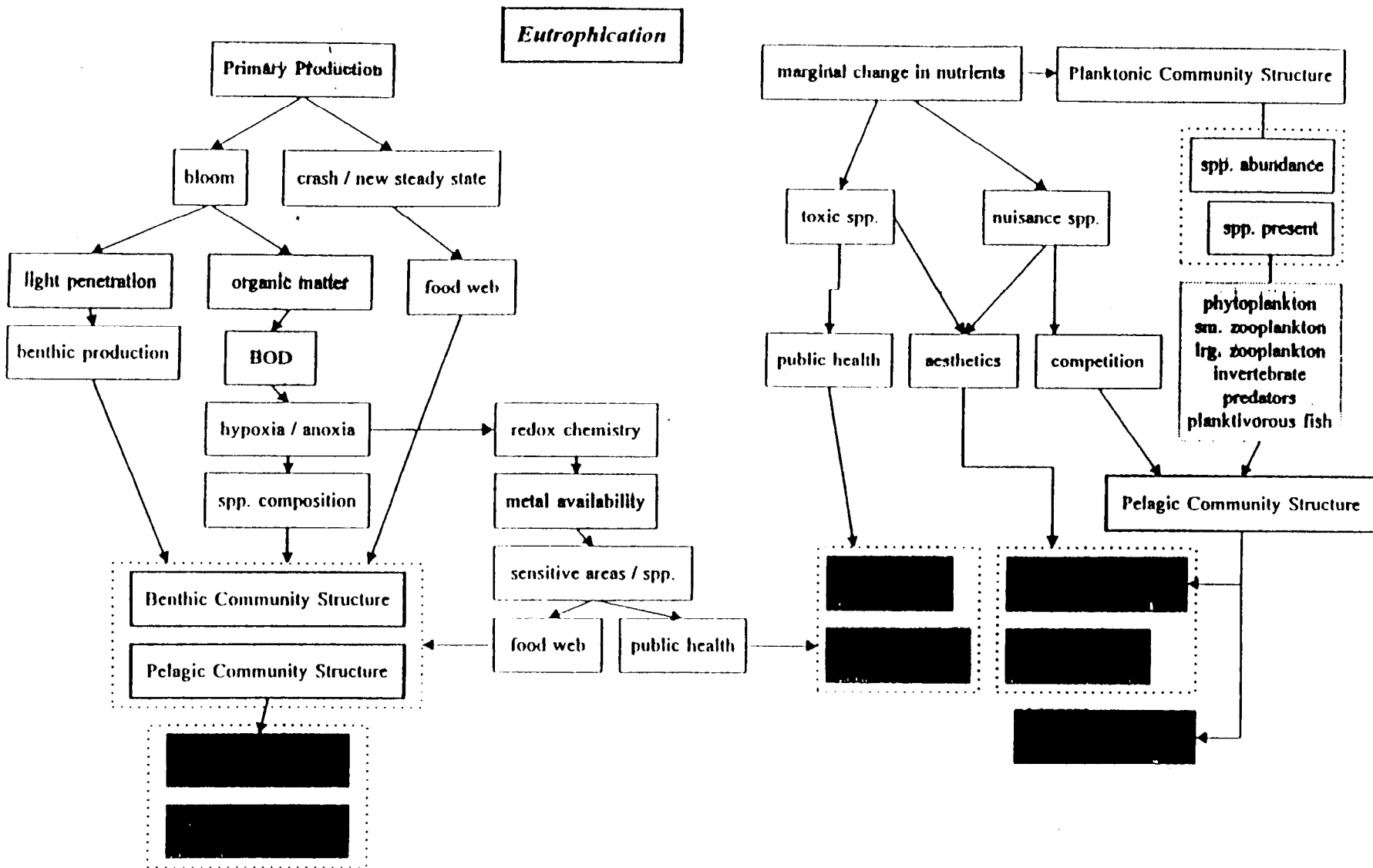
species that pose a public health threat (e.g., red tides); and the loss or decline of important touristic or recreational species through the ramifications of eutrophic conditions (e.g., fish kills, infected shellfish).

- Property value — aesthetically-displeasing nuisance species may affect coastal property values and impact waterfront development decisions.
- Sickness cost — the possibility of human sickness or cancer exists as a result of eutrophication either from toxic species that infect shellfish and seafood, or from contaminants that are remobilized when contaminant speciation changes due to eutrophic conditions. Costs are incurred in quality of life, medical treatment, and parameters such as lost working days and/or worker productivity declines.
- Prevention cost — there is a social and/or economic cost associated with attempts to prevent the above sickness, e.g., inspection man-hours, loss of income due to shellfisheries closure.
- Commercial species — because of its ties to the primary producer level of the trophic web, Eutrophication will surely impact a variety of commercial species because of subsequent ramifications at higher trophic levels. However, commercial species are impacted by Eutrophication primarily due to anoxia leading to mass fish kills.

FIGURE 1



## FIGURE 2



**ANNEX XII****REGIONAL BLUEPRINT AND PILOT PROJECTS FOR THE RED SEA****Background****A. Description**

The Red Sea is a deep semi-enclosed and narrow basin connected to the Indian Ocean by a narrow sill and extends northward to almost temperate latitudes. In this sea, tropical habitats and communities, coral reefs, mangroves and sea grasses reach their northernmost limit.

In the Red Sea, the physical system, as well as the biological trends, are to a large extent governed by the monsoon pattern over the Indian Ocean, in addition to the aridity of the climate and the semi-isolation of the basin.

Circulation in the northern Indian Ocean, as driven by the winter monsoon, introduces nutrient rich surface water from the Gulf of Aden into the Red Sea. Winter is the productive season in the Red Sea. It is also the season of recruitment for a large number of pelagic species and of planktonic larvae of benthic organisms. Both productivity and biological diversity, therefore, are subjected to the monsoon cycle. On the other hand, there is a south to north decreasing gradient in both diversity and productivity. The fish and shrimp stocks are significantly more abundant in the southern Red Sea, off Yemen and Eritrea, than elsewhere in the basin. The gradient is no less distinct for other physical and biological characteristics. Surface salinity rises with distance from the Indian Ocean, reaching exceptionally high values (e.g., 42 psu) in the north, a salinity to which biota are adapted (Halim, 1969 and Morcos, 1970).

The pattern described above is likely to become altered, with unpredictable consequences, following any disruption in the monsoon cycle resulting from climate change. A northward shift of the rainy zone in association with potential climate change would increase precipitation and runoff, reducing salinity and disrupting the ecosystem. The increased nutrient and suspended matter inputs with runoff would add their impact.

**B. Demography and Population Distribution**

The Red Sea is bordered by seven countries: Egypt, Eritrea, Israel, Jordan, Saudi Arabia, Sudan and Yemen. The population is very evenly distributed. There are two large industrial cities having commercial harbors (i.e., Jeddah and Suez), two other industrial centers in Saudi Arabia and several smaller towns (i.e., Aqaba, Jordan; Eilat, Israel; Horghada, Egypt; and Port-Sudan, Sudan. In between the urban centers extend large sparsely populated coasts, with the exception of the Egyptian coast which is now being developed rapidly for tourism.

**C. Resources**

As a shipping lane, the Red Sea and Suez Canal provide an important service for the transport of oil and oil derivatives from producer to consumer. Commercial, artisanal and subsistence fisheries (e.g., fin fish, shrimp, crabs and molluscs, including cephalopods) provide a living for a large sector of the coastal population in Egypt, The Sudan, Eritrea and Yemen.

Shells, broken pieces of coral and other marine materials are used for the manufacture of curios and souvenirs for the tourists. Some bivalve shells are collected for the mother-of-pearl industry (e.g., *Pinctada* and *Trochus*). The black coral *Cimipathes anguina* is sold for prayer beads and jewellery. The edible giant clam *Tridacna* spp. is threatened to a point of extinction in the northern Red Sea. Offshore oil production is mainly concentrated in the Gulf of Suez, where there are about 30 fields.

The ecotourism infrastructure is continuously developing along the Egyptian Red Sea. More and more new resorts are being established in new areas along the coast. Large scale resorts also are underway in Eritrea. Healthy coral reefs with their colorful and diverse marine landscapes represent the main asset for ecotourism and are a major resource in this sea.

#### D. Monitoring and Management Activities in the Red Sea

The Programme for the Environment of the Red Sea and Gulf of Aden (PERSGA), with its Secretariat in Jeddah, represents the regional organization for cooperation and coordination between the countries in this region within the framework of the Jeddah Convention.

GEF is currently supporting the following programmes in the Red Sea:

- ◆ The development of a "Strategic Action Plan for the Red Sea and Gulf of Aden" for PERSGA.
- ◆ In Egypt, the "Red Sea Coastal and Marine Resource Management Plan" (World Bank; \$4.75 million).
- ◆ In Yemen, a programme on the "Protection of the Marine Ecosystem in the Red Sea" (UNDP; \$2.8 million).
- ◆ In Eritrea, a preliminary feasibility study of a programme on "Conserving Coral Reefs in the Red Sea".

#### Regional Management Goals

Although the volume of trade and shipping through the Red Sea has seen a turning point since the opening of the Suez Canal in 1868, the rate of coastal and marine activities has intensified considerably in the last two decades. This has resulted in a multiplicity of impacts on the marine environment and the coastal ecosystems (IOC, 1995). Except for oil, however, the land based sources of pollution remain localized and far apart.

#### A. Oil

Oil hydrocarbons and PAHs are pervasive but oil contaminations more critical in some locations. Loading at pipeline terminals, offshore oil extraction, contaminated cooling water from refineries, tanker ballast water and accidental oil spills contribute to the contamination of the Red Sea (Figure 1). The Red Sea environment receives more oil per square kilometer than any other regional sea. More critical areas are the shipping lanes and where the coast of Saudi Arabia between Jeddah and Yanbu and the Gulf of Suez, the beaches are heavily tarred in places.

## B. Coastal Development, Urban and Industrial Activities

### Sewage

The open Red Sea is still clean but the sewage and treatment facilities in the larger cities are inadequate. As a result, raw and partially treated sewage is disposed of near Jeddah (2 million inhabitants), Suez (one half million inhabitants), Aqaba, Eilat and Horghada. The density of coliform bacteria in adjacent waters is significantly increased. Plans to build more adequate treatment plants are said to be underway.

### Industrial Pollution

Airborne dust with heavy metals is released from cement factories in Suez and Jeddah and ammonia from fertilizer plants. Power plants cause thermal pollution. Desalination plants generate brine having 1.3 times the ambient sea water salinity at a temperature about 10 degrees higher than the maximum sea water temperature. The brine also contains some heavy metals

### Coastal Engineering

Large scale in filling for coastal reclamation has destroyed fringing coral reefs along Horghada and Jeddah. Building activities generate cement dust and other particulates, causing silting and smothering of coastal habitats.

### Mining

There are three main phosphate ore mining centers; Aqaba (Jordan), Safaga and Qoseir (Egypt). Tone pf phosphate ore dust spill over into the sea during shipping. Although the ore is insoluble, phosphate contamination is believed to affect reproduction and the rate of calcification in corals.

## C. Tourism Development

Tourism development concerns exclusively the western coast of the Red Sea, including the Gulfs of Suez and Aqaba, and extends south down to the border with the Sudan. Although there is growing awareness of the significance of the natural environment as an asset for tourism, the development activity has serious impacts.

- It creates an incentive for over fishing to meet the increased demands for sea food, leading to local depletion;
- The coral communities are often impacted and sometimes damaged by sports divers;
- Nesting beaches for marine turtles are reclaimed as recreational beaches;
- Small sea crafts and yachts cause fuel oil contamination and noise pollution;
- Litter and garbage accumulate on the sea shore and on the near shore sea bottom; and

- brine from desalination plants and domestic waste water are released, in some case, to the sea.

### Priority Measurements and Observations

Apart from oil, the physical aggressions on coastal habitats, often with irreversible consequences, appear to be of greater significance than the introduction of contaminants into this sea.

Oil hydrocarbons need to be monitored throughout the basin with more focus on the critical areas. This should be done in parallel with the impacts of oil contamination on coral reef, mangrove, mud flat and rocky beach communities.

Areas of concern for trace metals appear to be localized downstream from the desalination plants and industrial effluents. Tributyl tin (TBT) would presumably be of significance in and around commercial harbors and marinas. However, the Red Sea provides an example of natural contamination with metals. The trace metal levels for deep sea benthic shrimp are consistently higher than for most coastal invertebrates. This is suspected to be related to the emissions from the deep Red Sea hot brines. A baseline survey of selected trace metals in selected biota needs to be carried out in the hot spots at relatively large time intervals.

The Red Sea is comparatively poor in nutrients. Nutrients as contaminants occur near fertilizer plants and sewage outfalls. Phosphate ore dust is sparingly soluble but, as noted above, is believed to cause "phosphate poisoning" in corals. No eutrophication, however, has been reported in the Red Sea and no heavy algal blooms have been observed. Nutrient levels and their potential impacts should be monitored in spite of this in water and sea food in the hot spots, together with human pathogens.

Suspended particulate matter occurs naturally as an effect of wind blown sand and flash floods. Their occurrence is increased in the vicinity of cement factories and where coastal engineering work is taking place.

**TABLE 1**

#### Priority Measurements and Observations and their Perceived Ease of Measurement

*1 - Routinely made in the region*

*2 - More difficult but can be made in the region*

*3 - complex with limited competence in the region*

| <b>HIGH</b>          | <b>MEDIUM</b>                                       | <b>LOW</b>                |
|----------------------|-----------------------------------------------------|---------------------------|
| Oil (1)              | Human Pathogens (1)                                 | Herbicides/Pesticides (3) |
| SPM (1)              | Trace Metals in Biota (2)                           | Radionuclides (2)         |
| PAHs (2)             | Nutrients (1)                                       | Oxygen (1)                |
| Litter/Tar Balls (1) | Phytoplankton Pigments &<br>Community Structure (1) | Toxins (3)                |
|                      |                                                     | Synthetic Organics (3)    |

## Sampling Strategy

Sampling and monitoring in the open basin waters can be done seasonally for oil and its derivatives. In the hot spots (i.e., downstream from large urban centers, tourist resorts and oil fields), sampling for oil, turbidity and nutrients can be carried out monthly; litter and tar balls seasonally; and human pathogens in water and sea food weekly. Measurements of trace metals in selected biota can be made once a year.

## Proposed Pilot Projects

### A. Pilot Project I

- Review and Assessment of Existing Information Relevant to the Health of the Marine Environment in the Red Sea.

All data and information available should be assembled, evaluated and the need for further data acquisition and quality control identified. The existing valid data and information should then be integrated and interpreted to provide a preliminary assessment of the health of the marine environment of the Red Sea. A review, assessment and recommendations should then be delivered to the countries of the region.

### B. Pilot Project II

- Biological Monitoring of the Health of the Marine Environment of the Red Sea at Different Levels of Biological Organization.

This pilot project should be designed for assessing changes at the community/ecosystem level but also employ the use of biological procedures at the organism and sub-organism levels, such as biomarker and physiological techniques. The pilot project should be coupled with a training and capacity building programme for the region.

### C. Pilot Project III

- Modeling

A hierarchy of models is needed for the region.

- Site specific habitat and community sub-models (e.g., mangroves and coral reefs in differently exposed sites) should be attempted;

- A basin-wide model for the Red Sea basin ecosystem should be developed to evaluate the impacts of climate variability and long-term climate change on the physical and biological systems and on the resources of this sea. This model required collaboration with other GOOS Modules (i.e., specifically the Coastal and LMR Modules) which may be engaged in a similar effort. Also, this pilot project should evaluate the extent to which the combined ecosystem/physical model for the Black Sea, which has been developed within the NATO-TU Black Sea Project, can be employed and or expanded upon.

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FIGURE 1

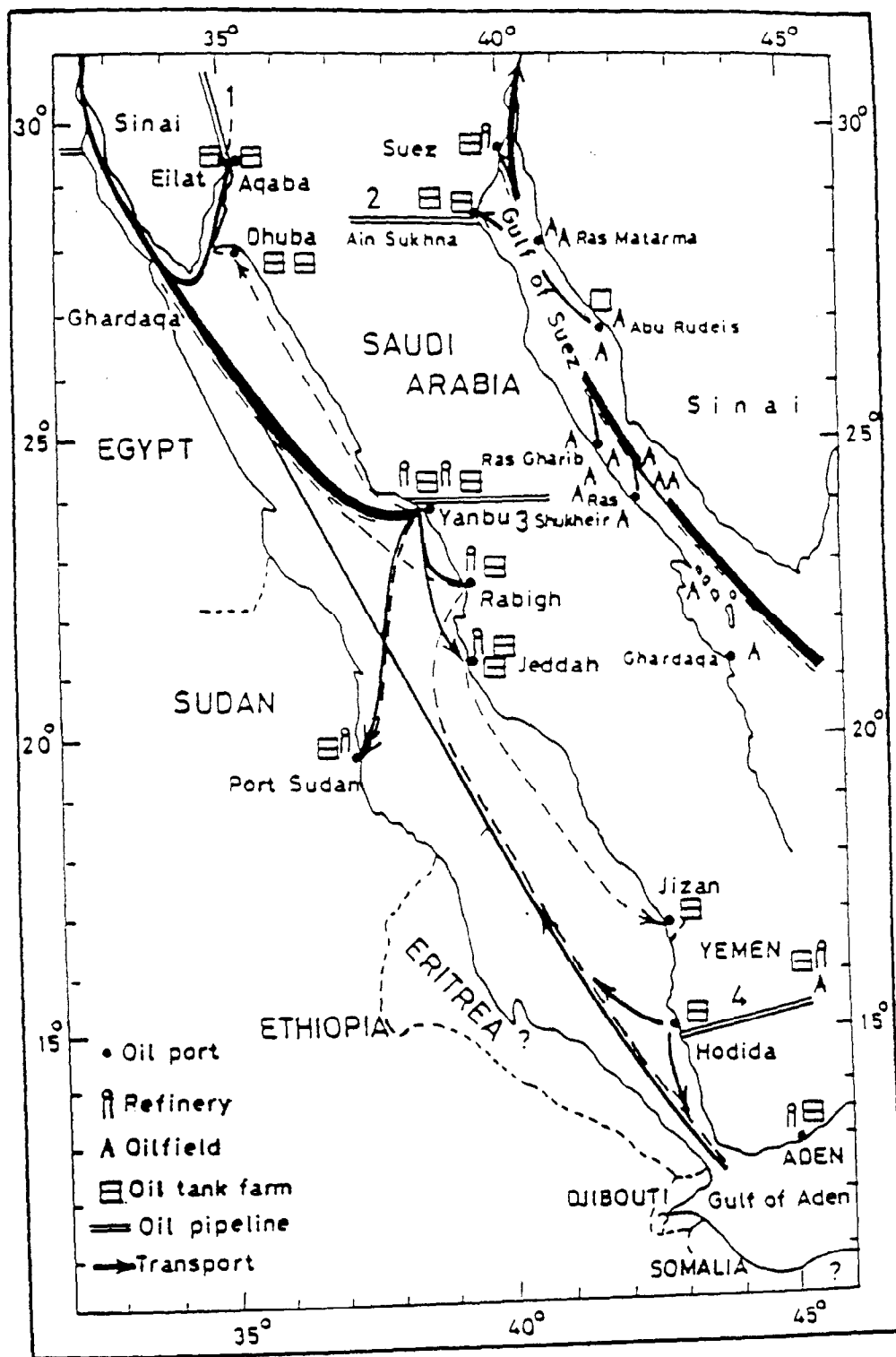


Fig.1-Main oil activities in and around the Red Sea (Awad, 1989 )

1-Eilat to Mediterranean Sea (25 mta) 3-PETROLINE from Arabian Gulf (160 mta)  
2-SUMED to " " (80 mta) 4-from Yemen oilfield (10 mta)

## ANNEX XIII

### REGIONAL BLUEPRINT AND PILOT PROJECT FOR THE SOUTHEAST ASIAN SEAS

Southeast Asia represents a fast developing area with a burgeoning population. The majority of the population is coastal since much of the land mass is insular. This maritime character of many communities emphasizes their dependence on both the marine environment and the marine resources. Consequently, the condition or health of the ocean is of primary concern to the region.

#### I DESCRIPTION

##### A. Physical and Biological Setting

The Southeast Asian Seas may be defined as the marginal seas bordering insular Southeast Asia, the Indochinese and Malayan peninsulas and the Burmese coast. The countries concerned include the eight coastal Member States of ASEAN, viz., Brunei, Darussalam, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam plus Cambodia (Laos is the only land-locked country in S. E. Asia).

Insular Southeast Asia includes more than 20,000 islands principally grouped into the Indonesian and Philippine archipelagoes. Continental Southeast Asia represents the extreme tropical extension of the Asian mainland consisting of two peninsulas. Subtidally this land mass extends to the Sunda shelf which includes the western half of the Indonesian islands and reaches the southwestern Philippines through Borneo. This fragmented land mass represents the nexus of the Pacific and Indian Oceans and experiences a varying monsoon regime.

Given this physical setting, the Southeast Asian Seas are endowed with abundant living marine resources that are heavily exploited. In addition, these marine waters harbor the most diverse shallow coastal ecosystems, with many taxa of fish, invertebrates and marine plants having their center of distribution here. Of particular note are the coral reefs and mangrove forests.

Fish protein may represent some 50% of the protein intake of Southeast Asians. Hence, capture fisheries and aquaculture represent major industries. Additionally, a flourishing ornamental trade in marine products exists. Although major rookeries of marine turtles are found in the region, the exploitation of these species are contributing to their endangered status.

Non-living resources are extracted from coastal waters in several countries, notably oil and gas, tin and aggregates.

##### B. SOCIO-ECONOMIC OVERVIEW

As previously mentioned, the population of Southeast Asia is predominantly coastal. The littoral communities continue to grow vigorously both from the natural increase and migration. There is rapid industrialization in the coastal area due to better accessibility of contracts both local and international. Consequently, the major population centers, including several capitals, are coastal.

The development of the coastal zone is not limited to population and industrial centers. Many wetlands of the region, particularly the mangrove swamps, have been transformed into area for agriculture and aquaculture, leaving less and less existing in their natural state. However, due to the natural beauty and attraction of some areas, coastal tourism is a growing industry that both prevent and destroys the environment. As a consequence of these trends, land-use conflicts often arise.

### C. MANAGEMENT ISSUES

Among the management issues of concern that may be addressed by the HOTO Module of GOOS are the following:

- harmful algal blooms and eutrophication;
- sewage discharge and shellfish contamination;
- over-exploitation and marine resources;
- destruction of coastal ecosystems;
- marine pollution; and
- suspended particulate matter and sedimentation.

### D. REGIONAL ARRANGEMENTS

Many of the countries in the region adhere to international conventions such as the London Convention (1972), MARPOL (1983/1986), UNCLOS (1982) and the Convention on Biological Diversity (1993) which relate to the marine environment and marine resources. However, there is no uniformity in membership. There is no single regional agreement to which all are party. However, many states take part in the following regional programmes:

- UNEP Regional Seas (COBSEA);
- IOC WESTPAC; and
- GEF/UNDP/IMO Marine Pollution Prevention and Management.

In addition to the above, there have been a number of regional projects concerned with coastal resource management that have involved more than half of the countries. The following projects, completed and on-going, have contributed greatly to capacity building and in fostering regional collaboration:

- ASEAN/Australia Marine Science Project;
- ASEAN/US Coastal Resources Management Project;
- ASEAN/Canada Marine Science Project; and
- ASEAN/Korea Marine Science Project.

In spite of the above, the Association of Southeastern Asia Nations (ASEAN) has shied away from evolving a regional convention or protocol for marine pollution prevention, although the majority adhere to the non-binding regional seas action plan.

## E. REGIONAL CAPACITY AND REQUIREMENTS

As mentioned above, several regional marine science projects have contributed to capacity building over the past decade. Needless to say, there is a diversity of capability among the nine coastal countries, with some of the ASEAN Member States more advanced than others. There is also a wide diversity in the economics and, hence, financial resources of the nine countries, with the newly industrializing countries (NIC's) of Singapore, Malaysia and Thailand having better conditions in this regard.

In spite of the above, even the better endowed countries will need assistance in mobilizing a HOTO Pilot Project. This need will be best met in terms of additional technical training in QA/QC and also in the acquisition of supplementary equipment for monitoring. In the case of a few countries a fair number of trained manpower exists so that their needs will be more in terms of financial assistance. For several countries the requirements are more substantial both in terms of training and infrastructure.

## II REGIONAL MANAGEMENT GOALS

The maintenance and, in some cases, the rehabilitation of a desirable marine environment in Southeast Asia became important from the perspective of public health, food supply, tourism and other economic considerations.

The dependence of many people in the region on seafood for protein highlight the public health and food supply issues. Edible shellfish and finfish must be safe for human consumption in all places at all times. This points to the need to monitor and, if possible, eliminate contamination of living marine resources by both harmful algal blooms and microbial contamination. These blights also adversely effect the quantity of food supply. Over and above these negative influences on the food supply, the integrity of coastal habitats must be preserved from both physical and chemical stresses in order to ensure favorable conditions for secondary production.

The conservation of both coastal ecosystems and coastal resources is also favorable for economic development particularly where coastal tourism is involved. The exotic nature of tropical coasts and the marine life found there make the countries of the region prime tourist destinations for the developed countries of both the West and the East.

## III PRIORITY MEASUREMENTS

In the assessing and monitoring programme envisaged for a HOTO Pilot Project, the following contaminants are suggested according to priority concern:

| HIGH                         | MEDIUM                | LOW                |
|------------------------------|-----------------------|--------------------|
| algal toxins                 | herbicides/pesticides | synthetic organics |
| human pathogens              | oil                   | pharmaceuticals    |
| nutrients                    | litter/plastics       | trace metals       |
| phytoplankton pigments       | PAHs                  |                    |
| suspended particulate matter | dissolved oxygen      |                    |

In addition to the above, there must be monitoring of the condition of coastal ecosystems particularly coral reefs and mangrove forests. In this regard, the Global Coral Reef Monitoring Network (GCRMN) is of particular relevance to this region. The abundance of marine life, both in terms of fish stocks and ornamental species, should also be monitored.

#### **IV SAMPLING STRATEGY**

##### **A. LOCATIONS**

Participating countries will designate critical habitats near population centers and in remote areas:

- traditional fishing grounds;
- coral reefs; and
- mangrove forests.

##### **B. TEMPORAL CONSIDERATIONS**

- dry season; and
- wet season.

#### **V DATA PRODUCTS AND USES**

Due to the high degree of variability in data management and archiving in the region, this is an area desperately in need of attention to bring into agreement the disparate data reporting activities presently in practice.

#### **VI RELATIONSHIPS**

The concerns of the HOTO Module clearly interact with those of the Living Marine Resources and Coastal Modules. This is particularly true with respect to the food supply concerns and the condition of coastal ecosystems, particularly coral reefs. With respect to the latter, the Global Coral Reef Monitoring Network may be considered as a common system relevant to two or more modules of GOOS.

## ANNEX XIV

REGIONAL BLUEPRINT AND PILOT PROJECT FOR THE NORTHEAST ASIA REGION  
(NEAR-HOTO)

## Background

The geographic coverage identified by NEAR-GOOS is the area also being identified for NEAR-HOTO. In this region, Kuroshio water moves northward at the eastern side and has an important influence on the water circulation and renewal, environment and ecosystems (See Table 1).

Table 1

| Sea                     | Area<br>x 10 <sup>6</sup> km <sup>2</sup> | Volume<br>x 10 <sup>6</sup> km <sup>3</sup> | Mean Depth<br>meters |
|-------------------------|-------------------------------------------|---------------------------------------------|----------------------|
| Yellow Sea              | 0.38                                      | 0.017                                       | 44                   |
| East China Sea          | 0.77                                      | 0.285                                       | 370                  |
| Japan Sea<br>(East Sea) | 1.008                                     | 1.361                                       | 1350                 |

Several large rivers, including the Changjiang and Huanghe from China, empty themselves into the region with various water/sediment loads and contaminants (e.g., nutrients, new synthesized compounds, trace metals, pesticides, etc.) which largely affect the local and even regional marine environmental issues and biodiversity (See Table 2).

Table 2

| River         | Drainage<br>Area<br>km <sup>2</sup> | Water<br>Discharge<br>x 10 <sup>9</sup> m <sup>3</sup> /y | Sediment<br>Load<br>x 10 <sup>6</sup> tons/y | Country             |
|---------------|-------------------------------------|-----------------------------------------------------------|----------------------------------------------|---------------------|
| Yanlujiang    | 62,630                              | 32.8                                                      | 1.1                                          | China & D.P.R.Korea |
| Huanghe       | 752,443                             | 41                                                        | 1,100                                        | China               |
| Changjiang    | 1,808,500                           | 928.2                                                     | 500                                          | China               |
| Keum          | 9,886                               | 7.0                                                       | 6.0                                          | R. Korea            |
| Han           | 34,473                              | 19.0                                                      | 18.4                                         | R. Korea            |
| Qiantangjiang | 41,700                              | 35.8                                                      | 6.7                                          | China               |
| Minjiang      | 60,992                              | 58.4                                                      | 7.5                                          | China               |

This is also a densely populated region. The people living within 150 - 200 km of the coast total up to several hundreds of million people. The anthropogenic pressure on the region comes from various pathways such as waste drainage, over fishing, mining/exploration, coastal and marine engineering activities, commercial shipping, aquaculture and dumping. Since the region is a traditional fishing site for the Chinese, Koreans, Japanese and Russians, the anthropogenic impacts mentioned above have resulted in some unpleasant consequences. For example, the stocks of several fishery species of high economic value have declined dramatically over the last two or three decades. As a result, traditional fishing is being replaced more and more by coastal

aquaculture, which, in turn, unavoidably increases waste drainage into shallow water areas.

The region also is characterized by rapid economic growth in the surrounding countries. For example, the GNP could increase by 5-10% per year. Like the southern and eastern countries of Asia, the agricultural activities are very extensive, including rice, corn and wheat. However, there is little treatment of municipal and industrial waste discharges and very limited control capacity for the monitoring of non-point source drainage in some areas of the region.

Consequently, marine environmental pollution has become more and more a serious threat in the last several decades, creating problems such as eutrophication and harmful algal blooms, toxicity in benthic fauna, oil spills following well-lock and ship accidents, and regional diseases. For example, harmful algal blooms in the Yellow and East China Seas increased ca. 1 - 5 events per year in the 1970's to 20 -30 events per year in the 1990's.

There are intensive monitoring programmes of both national and international scales. In terms of surface and sediment water discharges from rivers, data for some large systems are available from the 1920's - 1930's. Marine environmental monitoring practices are currently undertaken in the Yellow, East China and Japan/East Seas by means of coastal land-based stations, standard section surveys, buoys, aircraft and remote sensing. Several countries in the region (e.g., Japan, Rep. Of Korea and China) have established nation-wide monitoring data bases, but an agreement on coordination has not yet been reached. In 1987 a forum on transboundary environmental issues was held in Hawaii, USA, and another convened at Dalian, China, in 1991. In 1995 a joint oceanographic research center (i.e., Chinese-R. Korea Joint Oceanographic Research Center) was established in Qingdao under the agreement of the Chinese and R. Korean governments. This research center serves as a research and monitoring organization for both bi-lateral and multi-lateral programmes in development.

#### Monitoring Objectives of Health of the Ocean (HOTO) Pilot Projects

Since intensive coastal activities are being undertaken in the NEAR-HOTO area, monitoring programmes should be designed to adequately address all serious environmental concerns in the area.

Fisheries, aquaculture, natural habitat and tourist resources could be better protected and effectively managed by means of proper assessment of the marine environment. In this concern, monitoring programmes should include not only measurement of contaminants in water/sediments but also real-time data acquisition from ocean observing buoys and satellite images.

#### Priority Measurements and Observations

| HIGH                   | MEDIUM                   | LOW                |
|------------------------|--------------------------|--------------------|
| Algal toxins           | Herbicides/Pesticides    | Synthetic organics |
| SPM                    | Trace metals             | Pharmaceuticals    |
| Nutrients              | PAHs                     | Human Pathogens    |
| COD/BOD                | Artificial radionuclides |                    |
| Phytoplankton pigments |                          |                    |

## Sampling Strategies

### 1. Locations

During the pilot stage, sampling locations should be chosen where massive riverine inputs and adverse biological effects are anticipated. Screening methods for contaminants and biological effects could further identify the locations where intensive measurements are needed.

### 2. Frequency

It is suggested that the cruise survey be undertaken 4 times per year in order to cover seasonal variations in the region.

### 3. Buoys

It is also suggested that nitrates, O<sub>2</sub>, SPM and phytoplankton pigments should be measured on a real-time basis using existing observing buoys.

### 4. Biomarkers

Easily applicable biomarkers should be employed as an early warning distress signal to detect adverse effects of contaminants on marine biota.

### 5. Methods

All monitoring activities should be based on common methodologies as recommended in the Strategic Plan of HOTO and from GIPME.

## Regional Activities and Collaboration with other International Bodies

- Northwest Pacific Action Plan (NOWPAP)

NOWPAP is one of UNEP's Regional Seas Programmes which covers the seas bordered by China, Russia, Japan, R. Korea and D.P.R. Korea.

NOWPAP/3 is a collaborative regional monitoring programme of this Action Plan. During the first phase of this Project (1997-1998) Member States are invited to collect information on marine environmental monitoring systems, monitoring results, data quality control methods and data analysis methods. Regional monitoring programmes will be set up and proposed through a workshop that will be held during the first phase.

- Asia-Pacific Economic Cooperation (APEC)

Collaboration among scientists of APEC economies are being undertaken through workshops on "Harmful Algal Blooms" and on "Coastal Zone Management organized by the Marine Resources Conservation Group (MRC).

- The North Pacific Marine Science Organization (PICES)

PICES is preparing a practical workshop in Jiaozou Bay, Qingdao, China that is aimed at harmonizing approaches and methodology among PICES for assessing ecological impact of pollution. The format of the workshop is being designed along the lines of the IOC/GIPME-GEEP Workshop convened several years ago in Bremerhaven, Germany. Biological responses to be evaluated will include benthic community structure, demersal fish health, oyster chambering and other biological distress signals.

- IOC/WESTPAC

Within the framework of the IOC-WESTPAC Sub-Commission, there are several on-going projects that can incorporate NEAR-HOTO activities, including projects on "Harmful Algal Blooms" (HAB), "Riverine Input" (RI), "Atmospheric Input" (AI) and "Mussel Watch" (MW), etc.

There have been several training programmes addressing HABs within the West Pacific Regions in which scientists from the NEAR-HOTO Region were involved. In addition, China, R. Korea and Japan have national monitoring systems and nation-wide on-going projects. For example, the National Science Foundation of China (NSFC) has provided RMB 5 x 10<sup>6</sup> yuan recently for a national HAB Project between 1900 - 2000.

Large rivers emptying into the NEAR-HOTO Region have been extensively studied over the last twenty years through both national and international cooperation (cf., Table 2), which form an important contribution to the RI Project of IOC/WESTPAC. There are at least three national and international projects such as the NSFC supported project "Yangtze River Estuary Nutrient Fluxes" (1998 - 2001), the Sino-Japanese joint study on the "Riverine Drainage and Environmental Capacity and Influence on Marine Ecosystems in the East China Sea" and the Korea-China joint study programme on the "Circulation and Material Budgets in the Yellow Sea".

The close cooperation of the AI Study in the NEAR-HOTO Region can be traced back to the 1970's, or even earlier. The AI Project was accepted by the IOC-WESTPAC Sub-Commission as one of its key projects in 1993. There will be a workshop on the atmospheric input of natural material and pollutants to the West Pacific Region in Qingdao in 1998, in which some key laboratories of the NEAR-HOTO Region will participate.

"Mussel Watch" Studies are being undertaken at both national and international scales. The preliminary data from R. Korea, Japan and China were reported and summarized at the Third IOC/WESTPAC Scientific Conference convened in Bali in 1994. A training programme will be conducted by the IOC-WESTPAC Sub-Commission in March, 1998, which scientists from the NEAR-HOTO Region will attend.

## **Recommendation**

The J-GOOS HOTO Panel strongly urges that HOTO Pilot Projects, designed along the lines noted above, be incorporated into planned and on-going activities, also noted above. Sponsoring agencies and regional organizations in the NEAR-HOTO Region are encouraged to bear the blueprints of HOTO Pilot Projects in mind when developing plans for new monitoring endeavors. It is recommended that NEAR-GOOS, presently a monitoring activity concentrating on physical variables, incorporate a HOTO component as soon as possible.

## ANNEX XV

### REGIONAL BLUEPRINT AND PILOT PROJECT FOR THE ARCTIC MARINE ENVIRONMENT

by

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#### Introduction

One of the modules of the Global Ocean Observing System (GOOS) is the Health of the Oceans (HOTO) Module. The design of this module has been the subject of three meetings of the HOTO Design Panel, two in an ad hoc capacity and the last as a formal Panel commissioned by the Joint Scientific and Technical Committee for GOOS (J-GOOS). At the most recent of these three meetings, held in the WESTPAC Secretariat in Bangkok, Thailand, the design of the HOTO Module was completed for consideration by J-GOOS during its 1996 session. On the assumption that the HOTO Module design would be accepted by J-GOOS, the HOTO Panel (1996a) decided to take initial steps towards identifying a marine region in which the HOTO Strategic Design (HOTO Panel, 1996b) could be tested through a pilot implementation phase. Several candidate regional marine areas were identified, one of which was the Arctic. Members of the HOTO Panel undertook to examine the nature of policy and environmental protection and resource management concerns in the selected regions and to translate these into embryonic regional HOTO Pilot Programme designs. This document undertakes this task for the Arctic.

The following analysis is based largely on contemporary concerns and assessment activities among the Arctic states that are parties to the International Arctic Environmental Protection Strategy Agreement (AEPS) concluded in Rovaniemi, Finland, in 1991. The authors are involved in the current process that is expected to lead to the preparation of an Assessment of the State of the Arctic Environment in 1997 (see AMAP, 1996). They have also prepared a scientific evaluation of the contemporary situation in the Arctic marine environment regarding damage and threats posed by a wide range of contaminants, partly as input to a document on the Protection of the Arctic Marine Environment also being prepared under the aegis of the AEPS, and for publication in the open literature (Macdonald and Bewers, 1996). This provides them with some insights to contemporary issues of public and political concern and the probable direction of, and priorities for, future scientific and regulatory activities within the States Party to the AEPS (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the United States). It is from these perspectives that the following analysis is conducted.

The following sections examine in greater detail the nature of management concerns regarding the Arctic, deficiencies and uncertainties in scientific understanding that limit the ability of the natural and social science communities to determine the validity of perceived threats to human health and the environment, and the types of environmental measurement necessary to address outstanding management concerns regarding the Arctic marine environment. Finally, the paper advances a measurement scheme that could be instituted, as a HOTO Pilot, to satisfy these issues.

## Management Concerns

This section is intended to identify contemporary concerns within the public/political sectors of the Arctic countries and to attempt to place these in some perspective of relative priority to enable associated measurements that might form part of a Health of the Oceans pilot programme. Initially, the easiest manner in which to approach this task is to define each of the major classes of contaminants or human influences and identify measurements in relation to each of these and, then, to make relative priority assignments.

### Anthropogenic Influences and Contaminant Classes of Management Concern

**Ozone Depletion:** Concerns in this category relate primarily to UV radiation changes as a result of ozone depletion at polar latitudes. These include: changes in the UV spectrum and radiation intensity at the surface and subsurface (marine and freshwater environments); the potential effects of enhanced UV irradiation on humans and animals and their resistance to such effects; and induced changes in the limnological and upper ocean microbiological communities as a consequence of increased UV irradiation.

**Climate Change:** Concerns in this context relate to changes in sea-level, sea-ice cover and glaciological and hydrological balance and their respective consequences, and the general climatic conditions that have a direct influence on long-term (sustainable) development in the Arctic. One subset of these concerns would be alterations to marine biological productivity resulting from hydrologic changes (e.g., changed nutrient influxes); temperature changes and irradiation changes (as discussed under Ozone Depletion). Another subset of concerns involve the consequences of climate change, especially sea-level rise, seasonal ice cover and sensitivity to autumn storms, in affecting the traditional habits of native inhabitants of the Arctic such as access to, and the prosecution of, fishing and marine mammal hunting.

**Shipping Activities:** The major concerns here are twofold: the effects of accelerated offshore hydrocarbon resource development; and the effects of consequently increased shipping traffic in the Arctic (and adjacent, more temperate, areas). Both of these concerns relate primarily to changes in the release of hydrocarbons and combustion products to the Arctic environment. However, there are ancillary concerns about increased noise, physical disturbance and release of antifouling preparations, such as tributyl tin, associated with enhanced shipping in the Arctic and any impacts on coastal areas caused by the development of supporting infrastructure and transshipment facilities.

**Persistent Organics (excluding PAHs):** Persistent organic compounds in the Arctic environment are generally lower than corresponding levels in temperate areas, such as the Baltic Sea. This view has been confirmed by the information acquired during the course of preparing the relevant chapter of the State of the Arctic Assessment Report under the Arctic Monitoring and Assessment Programme (AMAP) under the AEPS. Nevertheless, there remain valid concerns about the effects of animal and human exposures to these compounds because of the exceptional dietary habits of northern inhabitants, both animal and human. Accordingly, the focus is on levels and trends in high lipid tissues that form major components of the diets of top trophic consumers (e.g., marine mammals, bears, birds and indigenous peoples).

**Metals:** The concerns about metals and their effects largely stem from similar concerns in other regional marine areas that have been expressed continuously since the inception of marine regional monitoring programmes. Unfortunately, metals have assumed a degree of global public importance that belies their actual scales of damage and threats. Most of the adverse effects of metals released from anthropogenic sources occur on relatively small distance scales. In this context, concerns about the consequences of excessive releases are wholly justified. Against this backdrop, there are legitimate residual concerns about the large-scale effects of certain metals, principally lead, cadmium and mercury, released by human activities. In this respect, the emphasis given to these three metals in the Arctic assessment process is wholly justified. However, as a consequence of the assessment carried out by Macdonald and Bowers (1996), it would appear that, in terms of adverse effects caused by human activities, the only metal among these of outstanding concern in the Arctic is mercury because of its atmospheric transport, accumulation in the high lipid tissues of Arctic animals and the peculiarities of the diets of animal and human inhabitants of the Arctic. This is not to imply that other metals do not show the mark of man's activities in terms of their levels and distributions, merely that in terms of contemporary damage and the threats posed to animal and human health, mercury is the metal of primary concern.

One other metal, however, deserves mention. This is tin in the form of tributyl tin and its derivatives that appears, from recent Icelandic and Norwegian surveys, to justify some attention because of the diversity of imposex in molluscs and its apparent persistence in both temperate and Arctic marine environments. If molluscan imposex, evident in areas like the coastal inlets of Iceland, is primarily due to the presence of dibutyl and tributyl tin released from anti-fouling preparations, there is clear reason to examine the presence of organotin compounds and their effects in Arctic areas.

**Radioactivity:** Concerns about radionuclides in the Arctic are widespread but, in the main, largely unwarranted. Contemporary levels of radionuclides in the region give little cause for legitimate concern except in relation to the exposures to humans from both natural and artificial nuclides resulting from the peculiarities of the diets of Arctic inhabitants. However, this situation does not pertain to the threats of excessive exposures to radionuclides that might result from accidents in nuclear power installations, releases from dumped and stored radioactive wastes or accidents in the process of removing, transporting, storing or disposing of spent fuel from nuclear vessels. Such threats are significant in terms of their probabilities and their radiological consequences.

## Deficiencies and Uncertainties in Scientific Understanding

In a general context, it is probably the inability to adequately predict the effects of climate change in the Arctic that is of greatest concern. However, measurements to provide an improved predictive capacity are probably best developed within the Climate Module of GOOS. An exception would be the limited understanding of the relationships between nutrient inputs and biological productivity which deserves specific attention within HOTO.

There exists a conception that, in common with other regional areas, knowledge of the processes of contaminant transport, partitioning, fate and effects are inadequate for comprehensive assessments of the nature and severity of existing damage and impending threats in the Arctic environment. In fact, this view is probably more justified in the case of the Arctic than it is for most other regional areas because of the comparative difficulty of conducting scientific studies under harsh climatic conditions and more remotely from the centres of scientific research in northern temperate areas. Nevertheless, of greater relevance in respect to the design of a programme of measurements tailored to management demand, scientific deficiencies of a more specific nature deserve particular attention in the Arctic.

Dealing specifically with the damage and threats posed by anthropogenic activities, including the release of contaminants to the environment, which is of direct relevance to the HOTO Module, the most important deficiency in the Arctic relates to the transport of contaminants by ice. In addition, the nature of the introduction of freshwater and freshwater ice into the system, and the chemical compositions of these flows both in space and time is a continuing knowledge gap that requires focussed attention within a HOTO measurement system. Related to these deficiencies, increased attention to the removal of contaminants in riverine and estuarine systems and the rates and composition of sediment accumulation in the Arctic marine environment, especially on the shelves, is warranted.

While there exists much information on the levels of contaminants in the Arctic environment, there is less knowledge of temporal and spatial trends. Geographical coverage of the levels of a range of contaminants is relatively poor. This would justify some attention to areas susceptible to contaminant influxes from freshwater and ice-melt. Of greater relevance in an environmental protection context are temporal trends, especially for contaminants, such as mercury and persistent organics, that are suspected of being at levels close to thresholds for adverse effects on animal or human health. Indeed, current uncertainties about the any temporal trend in mercury inputs to the Arctic as a consequence of human activities in the northern hemisphere should be specifically addressed within a HOTO component of GOOS in the Arctic.

It seems reasonable to assume that deficiencies in the understanding of dose-effect and dose-response relationships are best developed in areas more amenable to scientific study, augmented as necessary by laboratory experiments. Emphasis in the Arctic should be on measurements of biological effects on species indigenous to the region, especially those believed, because of existing burdens of contaminants, to be at levels close to thresholds for adverse effects. In view of the habitat conditions in the Arctic (cold, large seasonal variations in temperature) and the peculiarities of the life-cycles of indigenous species, care will need to be exercised that any environmental stress not related to human influences is taken into

consideration. In many cases, the same species will be of concern in relation to the risks to the health of indigenous peoples reliant on native (i.e., country) foods, such as marine mammals.

### **Required Measurements for a GOOS/HOTO Component for the Arctic**

Based on the foregoing, the following categorizes the measurements that would be appropriate for a HOTO programme in the Arctic marine environment. Measurements more appropriate to a climate component of GOOS, specifically addressing hydrological and radiation balance, have in the most part been excluded from this discussion. Nevertheless, such measurements should be selected in coordination with the design and implementation of a HOTO component of an Arctic GOOS. The following HOTO measurements are selected both to address contemporary management concerns and to rectify deficiencies in understanding that are most critical to evaluating the health of the region from the perspective of human influences and impacts.

### **Contaminant (and Carrier) Fluxes**

More accurate assessments of the rates of introduction of contaminants would be a high priority within an Arctic HOTO. Measurements of the fluxes of contaminants in runoff from rivers draining into the margins of the Arctic Ocean, especially into the Eurasian Basin, and, to the extent possible, temporal trends in these fluxes should be included. Existing programmes of measurement of atmospheric deposition of a range of substances, including contaminants, would also be essential. These latter measurements would need to be made in representative land areas within the Arctic such as in coastal areas and on islands. Although the general nature of Atlantic water flows into the Arctic is known, the need to improve the geographical resolution of conditions in the region will probably require more detailed definition of Atlantic water influxes. Some attention should also be given to the effluxes of Arctic water, nutrients and contaminants through the Canadian Archipelago and Fram Strait to improve the detail in understanding and to facilitate mass-balance construction. It is worth noting that some of the hydrological and oceanographic measurements advocated here will also correspond to the likely requirements of an Arctic climate component of GOOS.

### **Contaminant Levels and Trends**

Trends in the presence of critical contaminants in marine organisms, especially those likely to reflect such trends in the form of increasing body burdens, should be determined through a sequence of time-series measurements. The term "critical" is used here to define contaminants that are believed to be at levels close to thresholds for the induction of adverse effects or for which there are suspicions that the fluxes to the Arctic are increasing as a result of human activities. The only exception to this requirement are measurement series that could reveal trends, or changes in source functions, such as those of radionuclides because this will provide information on environmental removal rates (sometimes referred to as "environmental half-lives"). Prevailing concerns about radionuclide releases in the Arctic would demand that some attention to surveillance monitoring for radionuclides likely to show evidence of local releases be included in a measurement programme. In view of the burgeoning concern about the persistence of tributyl tin, the widespread nature of imposex in molluscs in areas like the Icelandic and Norwegian

coasts and the introduction of new marine antifouling preparations, a close eye would need to be kept on the use of such compounds, changes in shipping traffic volume and routes to institute appropriate surveillance measurements to detect adverse effects.

### **Coastal Development**

The programme should include attention to disturbances resulting from development in coastal areas. This requirement is heightened by the strong likelihood of early exploitation of offshore hydrocarbon deposits on the northern Russian shelf. Remote surveillance of activities in coastal areas should, accordingly, be included in the HOTO programme and, where appropriate, augmented by ground surveys of sediment transport and benthic community conditions in coastal areas. Coupled surveillance of any increased shipping traffic and oil spills could also be achieved should offshore hydrocarbon development occur although the extent to which such surveillance could achieve temporal frequencies and resolutions suitable for real-time information is not known. Coastal erosion and inundation by sea-level rise is a factor in the suitability of areas for coastal development and some attention should be given to obtaining data to assess existing and future threats to coastal areas of interest to indigenous peoples and to commercial development of the Arctic.

### **Human Health**

A major concern, both socially and politically, is the health of indigenous residents of the Arctic. Ensuring adequate health protection relies on a great deal more than purely measurements in marine dietary components of native peoples. Nevertheless, there is strong justification for the inclusion of significant marine-derived components of the diets of northern peoples as matrices for contaminant measurements. It is assumed that the ongoing work within the AMAP Programme will include attention to detailed specification of diet and to epidemiology that will provide respective a medium for using the results of such measurements and a mechanism for indicating what chemicals and radionuclides deserve inclusion in long-term measurement series.

### **Biological Productivity and Eutrophication**

Interpretation of oceanographic and some contaminant data will require the inclusion of nutrient measurements. Attention to seasonal patterns in nutrient supply and biological productivity, especially in the margins of the Arctic Ocean, deserves inclusion in any HOTO measurement programme. Such measurements might also be required in the design of a Living Resources Component of a GOOS Programme for the Arctic. Accordingly, although we advocate the inclusion of nutrient measurements in concert with physical oceanographic and contaminant measurements in rivers and marine waters, we would prefer to await the development of the Living Resources Module of GOOS before addressing additional biological measurements.

### **An Arctic HOTO Pilot Project**

It now merely remains to summarize the above selection of measurements in a form suitable to depict the nature and scale of an Arctic HOTO Pilot Programme. This is done in the form of Table 1.

The exclusion of measurement frequencies from Table 1 is deliberate. The greater difficulties in collecting samples and making measurements in the Arctic compared to other areas, measurement types and frequencies will have to be selected with greater care to avoid making the programme prohibitively expensive. Accordingly, there will be a need to undertake preliminary reconnaissance surveys to determine what areas are suitable, mainly from a logistical perspective but also considering the degree to which they can provide representative trend information. The existing programmes of measurement that are providing data to the Arctic Monitoring and Assessment Programme (AMAP) and any new measurement sequences introduced as a result of the current Arctic Assessment process should be used as a base wherever appropriate.

The AMAP assessment of the Arctic is planned for completion by the end of 1996. The proposed list of measurements for a Pilot HOTO component of GOOS for the Arctic marine environment should be re-examined at that time to ensure that all essential marine measurements for satisfying management demand are included. As previously noted, major management concerns relate to climate change and living resource issues that should be addressed by the Climate and Living Resource Modules of GOOS respectively. Ideally, any Pilot Programme for the Arctic should include a comprehensive set of measurements and represent an integration of the needs of all GOOS Modules.

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**TABLE 1**  
**PROPOSED HOTO MEASUREMENTS IN THE ARCTIC**

| Measurement Type       | Contaminant(s)                                                                  | Matrix/Phase                                                      | Location(s)                         |
|------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------|
| Atmospheric Deposition | Hg, <sup>7</sup> Be, OCs, PAHs, NO <sub>x</sub> , SO <sub>4</sub> <sup>-2</sup> | Total and Drey Deposition                                         | Coastal/Inland Sites                |
| Riverine Fluxes        | H <sub>2</sub> O, Nutrients, DOC, Tms, PAHs                                     | Water                                                             | Ob, Yenisei, Lena, Mackenzie        |
| Riverine Fluxes        | POC, TMs, PAHs, OCs, RNs                                                        | SPM                                                               | Ob, Yenisei, Lena, Mackenzie        |
| Estuaries              | TMs, PAH's, OCs                                                                 | Water, SPM                                                        | Ob, Yenisei, Lena, Mackenzie        |
| Estuaries              | Downcore RNs, OCs, TMs, PAHs                                                    | Sediments                                                         | Ob, Yenisei, Lena, Mackenzie        |
| Physical Transport     | Atlantic Inflow STNO                                                            | Water                                                             | Norwegian Current                   |
| Physical Transport     | Outflow STNO                                                                    | Water                                                             | Canadian Archipelago<br>Fram Strait |
| Physical Transport     | Sea-Ice                                                                         | SPM, RNs, TMs                                                     | Kara, Barents, Laptev Seas          |
| Human Health           | [Diet Characterization]                                                         | [Indigenous and Average Residents]                                | All Areas                           |
| Human Health           | RNs, TMs, PAHs, OCs                                                             | Dietary Constituents<br>(Traditional/Country Marine Food Species) | All Areas                           |
| Coastal Development    |                                                                                 | Remote Sensing                                                    | All Areas                           |
| Offshore Development   |                                                                                 | Remote Sensing                                                    | All Areas                           |
| Shipping Traffic       |                                                                                 | Remote Sensing                                                    | All Areas                           |

Key: STNO = Salinity, temperature, nutrients and dissolved oxygen.  
RNs = Radionuclides;  
TMs = Trace metals;  
PAHs = Polycyclic aromatic hydrocarbons;

## ANNEX XVI

### REGIONAL BLUEPRINT AND PILOT PROJECT FOR THE BLACK SEA

#### INTRODUCTION

This document describes a pilot study design for the implementation of the Health of the Oceans (HOTO) Module of the Global Ocean Observing System (GOOS) for the Black Sea. The pilot study defines the key variables and parameters to be measured on a permanent basis with regard to the sustainable development of marine resources and prevention of adverse effects of anthropogenic activities on the environment, including marine environmental and human health issues.

The Black Sea, an almost enclosed marginal sea faced with severe environmental problems, may be considered as one of the best application areas for a HOTO Pilot Project in the world oceans. In a recent study by the Intergovernmental Oceanographic Commission (IOC) that examined the health of 12 marine areas (Caribbean, North Sea, West African coast, Baltic Sea, northern former Soviet Union (FSU), Mediterranean, Red Sea, the Gulf, Asian Seas, Black Sea, Oligotrophic Gyre, and the Great Lakes) with respect to various contaminants, it received the poorest marks. In terms of marine pollution, the Black Sea thus deserves increased vigilance and effective environmental management.

The environmental crisis in the Black Sea results from severe eutrophication due to excessive anthropogenic forcing. When accompanied by natural variability and climatic changes, as well as excessive and selective fishing, it is manifested by dramatic changes in its ecosystem and resources. Heavy metals, pesticides, and hydrocarbons originating mostly from land-based activities (notably from the Danube in alarmingly high amounts per annum: Total Inorganic Nitrogen 23,000 tons, Total Phosphorus 35,000 tons, Oil 53,300 tons) have led to chemical and microbial pollution, affecting public health and the tourism industry. Harmful algal blooms are frequently observed in coastal areas. Considerable changes in the species composition and phytoplankton biomass and bloom structures have taken place. The fishery yields have declined dramatically, with an 80% reduction in total catch in the last few years. Moreover, only 6 out of the 26 commercially valuable fish species remain in exploitable quantities. Frequent hypoxia and occasional anoxia have resulted from eutrophication and have led to a nearly complete decline of benthos over broad regions of the northwestern shelf. On the Romanian coast alone, a single event of anoxia in 1991 eliminated an estimated 50% of the remaining benthic fish. Decreased light penetration has led to a 95% loss in the harvest area of the commercially valuable shallow water algae *Phyllophora*. Irretrievable losses of some significant deltaic wetlands and their habitats have taken place. In addition to dramatic effects of anthropogenic forcing, the basin's food web has also been affected significantly by the population growth and spread of predators, especially the ctenophore "*Mnemiopsis leidyi*", as well as excessive and selective fishing throughout the basin during the late 1980's.

As stated in the "Strategic Plan for the Assessment and Prediction of the Health of the Ocean", the ultimate benefit which might be expected from a Black Sea HOTO Pilot Project is to develop strategies for maximizing the economic benefits derived from the efficient use of marine resources, and to assist national decision makers in efforts to ensure the sustained protection of marine health and its exposure to human health. In the following, a brief description of the major

research and management programmes carried out to date, which might provide a basis for HOTO-related future studies, is provided initially. A programme of priority measurements and observations planned to be performed within the framework of Black Sea HOTO Pilot Project is then provided.

## **EXISTING ENVIRONMENTAL/OCEANOGRAPHIC PROGRAMMES**

Various research and management programmes have been developed during the 1990s by the riparian states and by international organizations to address the environmental and socioeconomic issues facing the Black Sea. Because they might form the basis for the Black Sea HOTO Pilot Project design, the objectives and accomplishments of the major programmes and projects are outlined briefly.

A major government-level initiative undertaken by the Black Sea countries was the creation of the Black Sea Environmental Programme (BSEP) in 1993. This was mainly funded by the Global Environmental Facility (GEF), with additional funds from the European Union's (EU's) PHARE and Technical Assistance to the Commonwealth of Independent States (TACIS) Programmes. The primary objective of the BSEP has been to develop and implement policy and a legal framework for the assessment, control, and prevention of pollution and to maintain and enhance biodiversity, as well as to create and strengthen regional capabilities for managing the Black Sea ecosystem.

The major achievement of the BSEP was the preparation of the Transboundary Diagnostic Analysis, which formed the basis of the Black Sea Strategic Action Plan (BS-SAP), developed during 1996. The BS-SAP identified the major causes of environmental degradation in the Black Sea: (1) eutrophication and over-exploitation of marine natural resources, (2) poor coastal management, (3) inadequate sewage collection systems and sewage treatment facilities, (4) industrial hot spots, and (5) lack of port reception facilities. By signing the BS-SAP on 31 October 1996, the six Black Sea coastal countries, with the help of the international community, committed themselves to a pragmatic programme of actions based upon common objectives and milestones for restoring the Black Sea from environment degradation.

The Environmental Programme for the Danube River Basin is another effort, established in 1991 by 11 major Danube countries. It is supported by the EU and GEF as well as some international donors. The programme covers water quality monitoring, marine accident warning systems, data collection and assessment, strengthening the environmental management of the catchment area, and preparation of a "Danube River Basin Strategic Action Plan" for 1995-2005 to provide a comprehensive, forward-looking strategy for regional and transboundary actions to address the main environmental problems and priorities in the basin.

The Danube Delta Project complements other GEF-supported programmes that address the Danube River Basin and the Black Sea Environmental Programme; all have the common objective of demonstrating the value of a coordinated approach to resolving water pollution and biodiversity problems with transborder linkages. This project has two parallel tracks: one for the Romanian and one for the Ukrainian Delta ecosystems.

The Cooperative Marine Science Programme for the Black Sea (CoMSBlack) launched in 1991 was the first, truly multi-institutional scientific effort to establish a scientific basis for the effective and integrated management of the Black Sea, including environmental preservation,

protection and optimum utilization. The main funding for this programme came from each participating nation's programme, together with some financial contribution from the Intergovernmental Oceanographic Commission (IOC). Within the framework of CoMSBlack, a series of basin, sub-basin and regional-scale multiship oceanographic surveys were carried out between 1991 and 1993. The data collected during these surveys were instrumental in developing a new understanding and perception of the physical and biogeochemical characteristics of the Black Sea.

The NATO TU-Black Sea Project is the first highly significant NATO endeavor to establish scientific collaboration with the central and eastern European countries. This multi-institutional project is a 5-year activity that will continue until the end of 1997. The purpose is to improve the health of the Black Sea through using ecosystem models as a management tool, capacity building, and fostering an interactive scientific community for the Black Sea. Under this programme, various interdisciplinary ecosystem models have been developed for different regions of the Black Sea to analyze the effects of physical processes, changes in anthropogenic forcing, and natural variability on the dynamics of the lower trophic levels of the biological community. The capacity-building component focuses on providing cross-training; making scientific equipment interoperable; carrying out intensive and extensive joint observations; monitoring through satellite imagery, collaborative analysis, and synthesis of past and recent data; producing joint publications; and developing a communication network. A data base management system (DBMS) has been established by including the last 30 years of environmental and oceanographic data pertinent to the goals of the programme. It is expected to serve as a continuously updated baseline for future activities concerned with the sustainable use and protection of the Black Sea environment and management purposes.

The EROS 2000 (European River-Ocean System) Programme of the European Union focuses on the interaction between the Danube River and the northwestern Black Sea. As a 3-year project started in 1994, its major objective is the development of an integrated approach (on the basis of existing data, field work and numerical modeling) to address the coastal ecosystems' response to natural and man-made changes in land use and hydraulic management, and the problems of eutrophication, contaminants and particle transfer, sedimentation, and biogas production.

The IOC Assembly established a Black Sea Regional Programme in 1995 to promote, develop, and coordinate the programmes on regional joint marine sciences and services at an intergovernmental level, taking into account the existing programmes carried out by international institutions and organizations. One of the IOC's two pilot projects, a Step Towards Observation and Prediction Systems (STOPS), is designed to develop and improve regional capabilities on operational oceanography, including observational, predictive, and management-oriented multidisciplinary applications. The other pilot project assesses the sediment flux in the Black Sea, gauges its space-time variability and identifies key processes of transformation and sedimentation in order to analyze their influence on the Black Sea ecosystem.

The littoral states of the Black Sea have identified radioactive pollution as a priority, based on public concern related to the Chernobyl accident and risks associated with local nuclear facilities and possible waste storage problems. The International Atomic Energy Agency (IAEA) conducted a coordinated research programme between 1994 and 1996 on "The Application of

Tracer Techniques in the Study of Processes and Pollution in the Black Sea." The major objectives of this programme were to assess the inventory of radionuclides in the Black Sea; to evaluate future trends in radioactive pollution; and to apply Tracer methods in studies of oceanographic process and pollutant transport.

## **PILOT PROJECT DESIGN**

### **Continuous Monitoring Programme**

The sustainable development of coastal and marine resources in the Black Sea requires implementation of a systematic monitoring programme, which provides the information to ensure the maintenance of biodiversity and integrity of marine communities, minimize the loss of species, limit human influences on living marine resources, protect critical habitats, and safeguard human health. The HOTO Pilot Project would consider two broad categories of monitoring for these purposes: (i) biogeochemical-ecological measurements for understanding of the present status and future trends in the health of the Black Sea, and (ii) measurements concerned with human health hazards.

#### **(I) Biogeochemical-Ecosystem measurements:**

The changes in the biogeochemical structure and ecosystem characteristics of the Black Sea due to anthropogenic nutrient input and contamination can be assessed and controlled by monitoring the parameters for: (i) ecosystem processes (i.e. productivity, nutrient fluxes, plankton biomass and species composition, etc.); (ii) biodiversity and habitat loss and degradation; (iii) endangered and threatened species; and (iv) changes in community structure.

#### **(II) Human Health Measurements:**

Public health can be threatened by contaminants either through seafood consumption and/or direct contact with the contaminants. The contaminant groups which might be hazardous for human health are classified as: (i) industrial organics, trace metals, agricultural chemicals and pharmaceuticals; (ii) naturally occurring toxins in marine organisms; (iii) alien pathogens entering into the marine environment through sewage, industry, etc.; and (iv) native pathogens present in the marine environment. The threshold levels of these variables must be monitored continuously in order to avoid increasing risk from their adverse effects.

The Strategic Action Plan for HOTO identifies a general framework of measurements which consists of Synthetic Organic Compounds, Polycyclic Aromatic Hydrocarbons (PAHs), Trace Metals, Petroleum Hydrocarbons (Oil), Herbicides/Pesticides, Dissolved Oxygen, Artificial Radionuclides, Pharmaceuticals, Phytoplankton Pigments and Community Structure, Human Pathogens, Nutrients, Algal Toxins, Litter and Plastic Materials, Suspended Particulate Matter, Temperature, Salinity and Currents. Clearly, continuous monitoring of all of these variables may not always be possible due to technical limitations and difficulties of measurements. Furthermore, regional environmental characteristics might dictate different preferences and priorities. Nevertheless, the following general guideline may be given for priorities of the measurements in the Black Sea coastal waters.

| HIGH                                         | MEDIUM                   | LOW             |
|----------------------------------------------|--------------------------|-----------------|
| Algal Toxins                                 | Artificial Radionuclides | Pharmaceuticals |
| Herbicides/Pesticides                        | Litter/Plastics          | Pathogens       |
| Phytoplankton Pigments & Community Structure | Human Synthetic Organics |                 |
| Nutrients                                    | PAHs                     |                 |
| Dissolved Oxygen                             | Trace Metals             |                 |
| Petroleum                                    | Suspended Particulates   |                 |

Sampling and monitoring in hot spots at coastal and near-shore waters around the periphery of the basin should be made as frequent as possible; preferably at weekly time scales. These hot spots are the locations where there are riverine inputs, harbors and marinas, industrial sewage, fish farms and other aquaculture facilities. Further offshore, at open sea waters, these kinds of sampling and monitoring may be performed at monthly-seasonal time scales.

Most of the HOTO-related sampling and measurements must be coordinated with other potential national-international programmes as well as those planned within the framework of other GOOS Modules. Accordingly, various additional measurements might be carried out using (a) small vessels for weekly-to-monthly measurements across selected transects from coastal areas to shelf and continental slopes, (b) shore-based continuous monitoring stations, (c) ships of opportunity measurements, (d) moorings and drifters, and (e) satellite color imagers.

The ultimate sampling system should be designed as cost-effective and affordable by all the riparian countries of the Black Sea. It should further ensure a realization of a comprehensive set of measurements which satisfy the management demand issues and sustainable use of the Black Sea resources. The proposed list of measurements and sampling strategy might be subject to future revisions from a logistical perspective and degree of information provided.

The monitoring programme must be complemented by a data management system to provide a complete, efficient and internationally accessible data base. The oceanographic institutions around the Black Sea have long-standing experience with data handling procedures. Presently, two data bases exist for the Black Sea. The first one is the "Black Sea Geographic Information System" developed under the BSEP, consisting of 550 basin-wide maps arranged in seven thematic blocks, representing different aspects of the Black Sea ecosystem. It has been created from a wide range of national and international data sources. The other is the "NATO TU-Black Sea Data Base". It includes nearly 150 MB physical and biogeochemical data obtained from 26,537 oceanographic stations during the last 25 to 30 years. This data base might form a basis for the future Black Sea HOTO Pilot Project.

## MODELING PROGRAMME

The efforts on the monitoring programme is complemented by some modeling efforts which might provide either understanding the details of the processes and interactions taking place in the ecosystem or some forecasting capability for predicting future evolution of some particular events. Some important modeling issues relevant to HOTO objectives, which might be realized with present modeling capabilities, are: (a) development of a simple early warning system for intensive eutrophication conditions in the coastal waters, such as prediction of harmful algal

blooms, (b) water quality modeling, (c) prediction of dispersions of passive tracers such as spreading of oil spills and other accidental releases of hazardous material, (d) transport of radioactive tracers and sediment load, and (e) modeling possible impacts of environmental changes on pelagic fish recruitment.

## ANNEX XVII

### A CASE IN THE CARIBBEAN: THE CIENAGA GRANDE DE SANTA MARTA (CGSM)

Located on the Caribbean coast of Colombia, the CGSM is the largest coastal lagoon of the country having an area of 450km<sup>2</sup>. This lagoon is a part of the Magdalena River Delta and was naturally connected with this river. In addition, the CGSM is the recipient of the waters from four minor rivers from the Sierra Nevada massif to the east.

The lagoon once provided 25 percent of the country's fish catch and was surrounded by healthy mangroves. In 1958, construction of a road stretching along the coast from Barranquilla to Cienaga City closed off the mangrove/lagoon ecosystem to the necessary exchange of salt and fresh waters. As a consequence, mangroves have been dying in considerable quantities for three decades. Extensive coffee, rice and banana cultivation in the Sierra with accompanying deforestation in the watershed has cut water, but increased silt, nutrient and chemical runoff into the shallow lagoon below. As a result, biodiversity and fish yield has diminished drastically and in the past years large fish kills have been reported for the warmest months of the year; in 1995 about 350 tons of fish died overnight following a green tide of toxic cyanobacteria and anoxic conditions in the waters. The resulting social and economic impact on hundreds of fishermen inhabiting six villages, three of them palafitte settlements, has been severe.

Concerned with this scenario, local authorities with aid from the German Society for Technical Cooperation (GTZ) have been carrying on efforts in a project (1992 - 1998) directed to the rehabilitation of the condition within the CGSM. With funds from a loan of about US\$16 million provided by the Interamerican Development Bank, channels are being reopened to bring freshwater from the Rio Magdalena into the lagoon and reduce the high salinities. Results on the long term are yet to be seen.

On the other hand, in order to obtain additional resources, heighten international awareness and provide the lagoon ecosystem with appropriate management, action is currently being taken to declare the CGSM and adjacent areas a Reserve of the Biosphere. Since the lagoons connected to the sea, the deterioration of the environmental health in the CGSM will eventually affect the health of the ecosystems in a wider coastal area, including the coral reefs of the bays in the Tayrona Natural Park located to the northeast.

In this Series, entitled

**Reports of Meetings of Experts and Equivalent Bodies**, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' (*Also printed in Spanish*)
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping (*Also printed in French and Spanish*)
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica (*Spanish only*)
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources (*Also printed in French and Spanish*)
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (*Also printed in French*)
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOC-IAEA-UNEP Group of Experts on Recruitment in Tropical Coastal Demersal Communities (*Also printed in Spanish*)
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' (*Also printed in Spanish*)
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic (*Also printed in French*)
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (*Also printed in Spanish*)
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans (*Also printed in French*)
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' (*Spanish only*)
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (*Also printed in Spanish*)
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
80. Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
81. Fifth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes

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82. Second Meeting of the UNEP-IOC-ASPEI Global Task Team on the Implications of climate Change on Coral Reefs
83. Seventh Session of the JSC Ocean Observing System Development Panel
84. Fourth Session of the IODE Group of Experts on Marine Information Management
85. Sixth Session of the IOC Editorial Board for the International Bathymetric chart of the Mediterranean and its Geological/Geophysical Series
86. Fourth Session of the Joint IOC-JGOFS Panel on Carbon Dioxide
87. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific
88. Eighth Session of the JSC Ocean Observing System Development Panel
89. Ninth Session of the JSC Ocean Observing System Development Panel
90. Sixth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
91. First Session of the IOC-FAO Group of Experts on OSLR for the IOCINCWIO Region
92. Fifth Session of the Joint IOC-JGOFS CO<sub>2</sub> Advisory Panel Meeting
93. Tenth Session of the JSC Ocean Observing System Development Panel
94. First Session of the Joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing
95. Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean
96. Fourth Session of the IOC Group of Experts on the Global Sea Level Observing System
97. Joint Meeting of GEMSI and GEEP Core Groups
98. First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
99. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
100. First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific
101. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
102. Second Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
103. Fifteenth Session of the Joint IOC-IHO Committee for the General Bathymetric Chart of the Oceans
104. Fifth Session of the IOC Consultative Group on Ocean Mapping
105. Fifth Session of the IODE Group of Experts on Marine Information Management
106. IOC-NOAA *Ad hoc* Consultation on Marine Biodiversity
107. Sixth Joint IOC-WMO Meeting for Implementation of IGOSX XBT Ship-of-Opportunity Programmes
108. Third Session of the Health of the Oceans (HOTO) Panel of the Joint Scientific and Technical Committee for GLOSS
109. Second Session of the Strategy Subcommittee (SSC) of the IOC-WMO-UNEP Intergovernmental Committee for the Global Ocean Observing System
110. Third Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
111. First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate
112. Sixth Session of the Joint IOC-JGOFS CO<sub>2</sub> Advisory Panel Meeting
113. First Meeting of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GLOSS)
114. Eighth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of "El Niño" (*Spanish only*)
115. Second Session of the IOC Editorial Board of the International Bathymetric Chart of the Central Eastern Atlantic (*Also printed in French*)
116. Tenth Session of the Joint IOC-IHO General Bathymetric Chart of the Oceans (GEBCO)
117. IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Fifth Session, USA, 1997
118. Joint Scientific Technical Committee for Global Ocean Observing System (J-GOOS), Fourth Session, USA, 1997
119. First Session of the Joint IOC-WMO IGOSX Ship-of-Opportunity Programme Implementation Panel, South Africa, 1997
120. Report of Ocean Climate Time-Series Workshop, Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate, USA, 1997
121. IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS), Second Session, Thailand, 1997
122. First Session of the IOC-IUCN-NOAA *Ad hoc* Consultative Meeting on Large Marine Ecosystems (LME), France, 1997
123. Second Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), South Africa, 1997
124. Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (*also printed in Spanish*)
125. Seventh Session of the IODE Group of Experts on Technical Aspects of Data Exchange
126. IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), First Session
127. Second Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME)
128. Sixth Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1997
129. Sixth Session of the Tropical Atmosphere - Ocean Array (TAO) Implementation Panel
130. First Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS)
131. Fourth Session of the Health of the Oceans (HOTO) Panel of the Global Ocean Observing System (GOOS)