Baltic Committee

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REPORT OF THE

STUDY GROUP ON GEOHAB IMPLEMENTATION IN THE BALTIC

Dublin, Ireland
12–13 March 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 WELCOME AND OPENING OF THE MEETING

The ICES/IOC/SCOR Study Group on GEOHAB Implementation in the Baltic (SGGIB) was convened by Marine Institute, Abbotstown, Dublin, Ireland 11–12 March, 2001. The meeting was organized by Terry McMahon and it was chaired by Kaisa Kononen (Finland). 13 scientists from 11 countries participated, including representatives of the IOC. The list of participants is in Annex 1. The meeting agenda is presented in Annex 2.

The meeting was opened by heartily welcome presented by the local organizer, Terry McMahon as well as by introduction of the meeting participants.

2 TERMS OF REFERENCE

At the 88th Statutory Meeting, Stockholm, Sweden the Council resolved that (C. Res. 2000/2H02)

The ICES Study Group on GEOHAB Implementation in the Baltic [SGGIB] (Chair: Dr K Kononen, Finland) will meet in Dublin, Ireland, from 12 – 13 March 2001 to:

a) create a plan for the implementation of GEOHAB in the Baltic Sea

b) plan co-ordinated multi-ship field experiments in support of GEOHAB in the Baltic

The IOC and SCOR will be invited to cosponsor the Study Group.

3 THE POTENTIAL ROLE OF ICES ON GEOHAB IMPLEMENTATION IN THE BALTIC

On behalf of the GEOHAB Scientific Steering Committee (SSC), Adriana Zingone introduced GEOHAB, presenting the motivation, overall goals and specific objectives of this SCOR-IOC science initiative. Adriana Zingone gave an overview of the structure and content of the recently completed GEOHAB Science Plan. A discussion followed on the implementation of GEOHAB in relation to the Baltic Sea, and on the benefit and obligations related to the participation to this international programme.

The group felt that ICES, as binding together institutes that manage majority of the oceanographic research facilities in the Baltic Sea area, has a great potential in promoting research along the lines depicted in the GEOHAB Science Plan. ICES has e.g., in the past been behind the development and implementation of several regional field programmes such as for example PEX and SKAGEX, GLOBEC Cod and Climate, etc.

ICES is not a funding agency, but proposals for regional studies developed by study or working groups are presented to the relevant ICES Science Committee for endorsement. Through subsequent endorsement by ICES Delegates at the ICES Statutory Meeting, the Delegates can either directly commit national resources or commit themselves to work for the identification of resources for implementing the project. Additionally, ICES endorsement of a regional project may be an advantage when applying to the respective national research councils for funding to participate.

Thus it is important for this mechanism to work, and to achieve strong endorsement by the ICES Delegates, that Study Group/Working Group members actively brief their respective ICES Delegates in advance of the ICES Statutory Meeting.

In summary, the added value of organising a co-operative regional study through ICES is:

- ICES provides a recognised organisational platform for regional co-operative research
- ICES provides a mechanism for facilitating access to national funding
- ICES provides a mechanism for involving scientists from outside the study region in a project with the view to exchange experience and share data.
- ICES is a tool for co-ordinated data management
- ICES is tool for development of standard methodology protocols
- ICES can assist with publication
- ICES can organise and sponsor targeted workshops
- ICES can organise and sponsor targeted conferences

The role ICES can fulfil in the implementation of GEOHAB corresponds to the goals in the ICES Strategic Plan:

- understand the physical, chemical, and biological functioning of marine ecosystems;
- enhance collaboration with organisations and scientific programmes that can contribute to fulfilling ICES' vision.

Based on this framework provided by the ICES, IOC and SCOR, and the support from national institutions committed via the ICES delegates as described above, it will be up to the individuals and research teams in the SG to submit the fully developed activities for funding to relevant funding sources.

4 PLAN FOR THE GEOHAB IMPLEMENTATION IN THE BALTIC SEA

The group discussed about possible activities that could be organized through ICES. The following activities were identified:

1) High resolution monitoring of HABs
2) Understanding the short term and seasonal dynamics of the HAB species
3) Testing the hypotheses of nutrient regulation of HAB development
4) Studying biology of HAB species
5) Update of the phytoplankton check-list
6) Modelling

The proposal for the GEOHAB implementation in the Baltic Sea with the description goals, objectives and justifications is presented in Annex 3.

The opportunity to present the results of this study group to the next SSC meeting (Shanghai, China, 3–7 April 2001) was highlighted.

5 RESOLUTION

The ICES-IOC-SCOR Study Group on GEOHAB in the Baltic [SGGIB] (Chair K. Kononen, Finland) will meet in Stockholm on November 24, 2001 to:

a) continue the planning of GEOHAB implementation in the Baltic;
b) plan a SG meeting combined with an open workshop for the spring 2002 to discuss and finally develop the Baltic project, including the co-ordination of field experiments to be implemented 2002–06;
c) prepare application to the GEOHAB SSC for endorsement of the Baltic project and the planned workshop.

Supporting Information

Priority:	GEOHAB is a global programme of very close relevance to ICES.
Scientific justification:	a) The mission of GEOHAB is to foster international co-operative research of HABs in ecosystem types sharing common features, comparing key species involved and the oceanographic processes that influence their population dynamics. This mission implies the necessity for multidisciplinary work in the field and by modelling. The research infrastructure in the Baltic sea region consists of governmental institutes and universities and these can be deployed to mutual benefit in a GEOHAB programme. b) The overall goal of the workshop is to broaden the participation of the international HAB community in designing and implementing a GEOHAB project involving HAB's c) The Baltic project and the associated workshop developed by the SGBIB will be a contribution to GEOHAB implementation.
Relation to strategic plan	Relevant to quantifying human impacts on the marine ecosystem, and the understanding the relative roles of natural and anthropogenic impacts.
Resource requirements:	Travel money from national source is required for participants.
Participants:	The 2001 SGGIB meeting attracted 13 participants, demonstrating the interest for the group.
Secretariat facilities:	none
Financial:	none
Linkages to Advisory Committees	ACME
Linkages to other Committees or Groups	SGPBI, WGHABD
Linkage to other organizations:	The work of this group is undertaken in close co-operation with the IOC-SCOR Scientific Steering Committee for GEOHAB. ICES is recommended to invite the GEOHAB SSC to meet in conjunction with the SGGIB (autumn 2001) and WGHABD (spring 2002).

ANNEX 1 – LIST OF PARTICIPANTS

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ANNEX 2 – AGENDA OF THE MEETING

STUDY GROUP OF GEOHAB IMPLEMENTATION IN THE BALTIC SEA
The Marine Institute, 80 Harcourt Street Dublin 2, 3rd floor

Agenda

SUNDAY, 11 MARCH

13:00	Opening of the meeting. Introduction of the meeting participants.
13:15	Presentation of the GEOHAB Science Plan. Members of the Scientific Steering Committee.
13:45	Presentation of preliminary structure of the GEOHAB Implementation Plan.
14:00	General discussion.
14:30	Coffee Break
15:00	Setting priorities for GEOHAB in the Baltic Sea. Meeting participants are asked to prepare presentations about their views.
17:00	Coffee break
17:30	Discussion continues.
18:30	Decision about the procedure to prepare a draft document.

MONDAY, 12 MARCH

9:00	Preparing a draft document.
11:00	Discussion about the draft document.
12:00	Closing the meeting.

If needed, SGGIB will meet again later during the week.

ANNEX 3 – PROPOSAL FOR A COOPERATIVE HAB STUDY IN THE BALTIC SEA

ICES-IOC-SCOR Study Group of GEOHAB Implementation in the Baltic Sea
PROPOSAL FOR A COOPERATIVE HAB STUDY IN THE BALTIC SEA

Dynamics of Harmful Algal Blooms in the Baltic Sea

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1 BACKGROUND

1.1 The Baltic Sea

The Baltic Sea is a semi-enclosed, non-tidal, brackish sea characterized by a pronounced density stratification due to large river inflow from the surrounding drainage are occasional inflowing salt water from the North Sea. Ca. 85 million people inhabit the drainage area. During the last decades, eutrophication with massive algal and cyanobacterial blooms has become the most serious environmental issue in the area.

The plankton dynamics of the Baltic Sea is dominated by seasonality. Two seasonal blooms occur. The diatom-dinoflagellate spring bloom develops in March-May as soon as solar irradiation in relation to density stratification create suitable light environment for algae to grow. This bloom contributes about half of the annual primary production. As soon as nutrients become exhausted from the surface layer and begin to limit algal growth, most of the bloom biomass settles down to the bottom. The other seasonal bloom is caused by cyanobacteria that accumulate at the surface. The growth of cyanobacteria is based on surplus phosphorus in the surface layer and on nitrogen fixation from the atmosphere. This bloom is decomposed in the surface layer.

Owing to the shallow and complicated bottom topography and the profound salinity gradients, the Baltic Sea is a hydrodynamically complex system, where different hydrodynamical events (wind-induced mixing, currents, eddies, fronts, upwelling) show considerable spatial and temporal variation. Small spatial and temporal scales characterize the Baltic Sea hydrodynamics. The most important hydrodynamical processes that induce external, auxiliary energy to the system are those occurring over a time scale of hours or at most a few days. The ***spatial and temporal scales*** characteristic to the Baltic Sea hydrodynamics are presented in Table 1.

Table 1: Characteristic physical scales in the Baltic Sea

SPATIAL SCALES	CHARACTERISTIC RANGE
Microscales	
• the Kolmogorov scale	0.1 cm
• the Ozmidov scale	0.1–3.0 m
Scale of light penetration	1–10 m
Mixed layer depth	
• summer (thermocline)	10–20 m
• winter (halocline)	60–70 m
Topographical scales	
• sill depths	20 – 60 m
Mesoscales	
• the internal Rossby radius	5–10 km
• the external Rossby radius	150–300 km
TEMPORAL SCALES	
Internal/inertial wave band	10 min – 14 hours
Inertial oscillations	14 hours
Time scale of weather patterns (wind forcing)	≈ 3 – 5 days

The phytoplankton ***species diversity*** in the Baltic Sea**,** like in other brackish waters, is low in comparison to fresh or marine waters. The current species checklist lists altogether over 2000 phytoplankton taxa in the Baltic Sea, of which more than 20 are known to be potentially toxic (Table 2).

1.2 HABs in the Baltic Sea

Two types of HABs are common in the Baltic Sea: cyanobacterial and dinoflagellate blooms, the dynamics of which is quite different. The two HABs occur at the same time of the year, the highest cell numbers being found at the end of July- first half of August. The dinoflagellates (*Dinophysis norvegica* and *D. acuminata*) are usually found in high concentrations in a one-meter thick layer close to the halocline. The cyanobacteria (*Nodularia spumigena* and *Aphanizomenom* spp.) are either found distributed throughout the upper water layer or if the temperature is above 18^{o}C and if no strong turbulence occurs, accumulates in half meter thick layers at the surface waters. When the cyanobacterial cells accumulate in surface waters, they are dying, forming large aggregates where bacteria and other heterotrophic organisms thrive.

In addition to the above mentioned cyanobacteria and dinoflagellates, several other toxic planktonic species are regular components of the plankton flora of the Baltic Sea (Table 2) and may form highly unpredictable harmful blooms.

Table 2: Harmful species of the Baltic Sea

Species	**Division**	**Class**	**Toxicity and/or other harmful effect**	**Toxins in or harmful effect through….**	**Open / coastal**	**Distribution in the Baltic**	**Marine/ brackish/ fresh water**
Regular blooms							
Nodularia spumigena	CYA	Nost	HT	water	O, C	whole Baltic Sea except the Bothnian Bay (occasional blooms in the Gulf of Riga)	B
Aphanizomenon sp.	CYA	Nost	NT (not proved in the Baltic)	water	O, C	whole Baltic Sea except the Bothnian Bay (occasional blooms in the Gulf of Riga)	B, F
Occasional blooms							
Microcystis spp.	CYA	Nost	HT	water	C	in estuaries and low saline coastal areas	F, B
Anabaena lemmermannii	CYA	Nost	HT	water	O, C	northern Baltic (in low numbers in the Gulf of Riga)	B
Planktothrix agardhii	CYA	Nost	HT	water	C	in estuaries, in highly eutrofied coastal areas with low salinity and in the Bothnian Bay	B
Heterocapsa triquetra	DINO	Dino	could be harmful in small inlets causing oxygen depletion	?	O, C	Whole Baltic Sea Except the Bothnian Bay, (in low numbers in the Gulf of Riga)	M, B
Prymnesium parvum	HAPT	Prim	not harmful IC	water	C	Coastal inlets with very low salinity	B, F
Prorocentrum minimum	DINO	Dino	?	mussels ?	O, C	Central Baltic, western Gulf of Finland (in low numbers in the Gulf of Riga)	B, M
Dictyocha speculum, (flagellate form)	CHRY	Dic	IC	fish	C	Western and southern Baltic	M, B
Chrysochromulina spp.	HAPT	Prim	IC	fish	O, C	Western Baltic (sometimes in high numbers also in northern Baltic proper)	M, B, (F)
Chaetoceros spp. (C. wighamii, C. danicus)	CHRY	Diat	mechanical	fish	O, C	South-eastern Baltic	M, B
Regularly in plankton but not in bloom amounts							
Anabaena lemmermannii	CYA	Nost	HT	water	O, C	Whole Baltic Sea, Except western proper, Kattegat and the Belt Sea	B
Anabaena spp.	CYA	Nost	HT, NT	water	O, C	Whole Baltic Sea	F, B
Dinophysis spp.	DINO	Dino	DSP	mussels	O, C	Whole Baltic Sea	M, B
Prorocentrum spp.	DINO	Dino	DSP?	mussels ?	O, C	whole Baltic Sea except the Bothnian Bay	M, B
Chrysochromulina spp.	HAPT	Prim	IC	fish	O, C	whole Baltic Sea	M, B, (F)
Chaetoceros spp.	CHRY	Diat	Mechanical	fish	O, C	whole Baltic Sea	M, B
Occasionally in plankton in low numbers							
Alexandrium spp.	DINO	Dino	PSP?	mussels	C	southern and western Baltic Sea	M, B
Gyrodinium aureolum	DINO	Dino	IC	water	O	southern Baltic Sea	M

Species	Division	Class	Toxicity and/or other harmful effect	Toxins in or harmful effect through….	Open / coastal	Distribution in the Baltic	Marine/ brackish/ fresh water
Dictyocha speculum	CHRY	Dic	IC?	water	O, C	southern and western Baltic, Arkona, Kattegatt, Skagerrak	M
Only cyst form observed *Alexandrium excavata*	DINO	Dino	PSP	mussels	C	Skagerrak, Kiel bight	M

From Kononen K., Elbrachter M., Balode M., Hallfors S., Hallfors G., Goebel J., Hajdu S., Olenina I., Konoshina I., Jaanus A., Ledaine I., Dahl E.

DIVISIONS:

CYANOPHYTA (CYANOBACTERIA) **– CYA**
DINOPHYTA (PYRROPHYTA) **–DINO**
HAPTOPHYTA- HAPT
CHRYSOPHYTA (HETEROKONTOPHYTA) **– CHRY**

CLASSES

Nostocophyceae (Cyanophyceae) - **Nost**
DINOPHYCEAE - Dino
PRYMNESIOPHYCEAE (Haptophyceae) - Prym
DICTYOCHOPHYCEAE – Dic
DIATOMOPHYCEAE **(Bacillariophyceae)** - Diat

1.3 Baltic-GEOHAB

The Baltic Sea offers good opportunities for research of HAB dynamics to be carried out in several spatial and temporal scales simultaneously. There exist already systems to obtain high-resolution oceanographic and remote sensing data from the surface layer over the whole sea. Because of the relatively small spatio-temporal scales of the hydrodynamics, studies of physical-biological couplings and their influence on HABs are possible with reasonable allocation of ship-time. Processes on small scales are best carried out in mesocosms and laboratory conditions. Baltic-GEOHAB Implementation Plan will focus on integrated experiments carried out with several research approaches, i.e., real-time, high-resolution observation systems, laboratory and mesocosm experiments combined with parallel field experimentation. Relative simplicity of the system, already existing observational capabilities, experience in multiscale research strategies and decades long experience in multinational co-operation within ICES and HELCOM create a good basis for Baltic Sea to be as a test laboratory for the GEOHAB approach.

2 GOAL

The goal of the Baltic-GEOHAB is to improve observation and prediction of HABs by determining the ecological and oceanographic mechanisms underlying the population dynamics of harmful algae. This is achieved by integrating biological, chemical and physical studies supported by enhanced observation and modelling systems.

3 OBJECTIVES WITH REFERENCE TO GEOHAB SP/IP OBJECTIVES

4 OUTPUTS

- Better understanding of the role of human impact in relation to natural variability of HABs in the Baltic Sea.
- Improved monitoring and surveillance capability of HABs.
- Better prediction capabilities of HABs in the Baltic Sea.
- Sound scientific basis for advice concerning environmental management strategies in the Baltic Sea.

5 ACTIVITIES/TASKS

5.1 High resolution monitoring of HABs

Objective

The objective is to further develop effective early warning systems of HABs covering the spatial and temporal scales of blooms in the Baltic Sea. This is achieved by implementing the state of the art technologies for real-time *in situ* observations. The resulting high quality data will also be used to develop and verify models for forecasting of blooms.

Justification

Development of HABs is the result of interactions between physiological and ecological characteristics of the species as well as the physical and chemical processes in its environment. Therefore, dynamics of the development of blooms cannot be studied without the integration of a variety of observation approaches.

Most planktonic algae have ways of influencing their vertical position in the sea, e.g., by swimming or control of buoyancy. Populations often develop at depth. Algal blooms often last days to weeks while monitoring from research vessels in the open Baltic is made monthly at best. Only at very few stations the sampling is carried out more frequently. Thus the development of blooms is seldom reliably recorded. To solve this problem, several complementary observation systems are required. Ferries are being used for automatic recording of e.g., chlorophyll *a* concentrations and also for sampling at predefined positions. The plankton composition and abundance is analysed weekly in these samples as well as nutrient and chlorophyll *a* concentrations. This system gives a good spatial and temporal coverage of blooms but does not reveal true vertical variation. Another approach is remote sensing using satellites or aeroplanes as instrument platforms. Satellite images can be very valuable in clear weather but are often useless because of clouds. Results from air-borne sensors are mostly non-quantitative. Both methods record information from the upper part of the sea only.

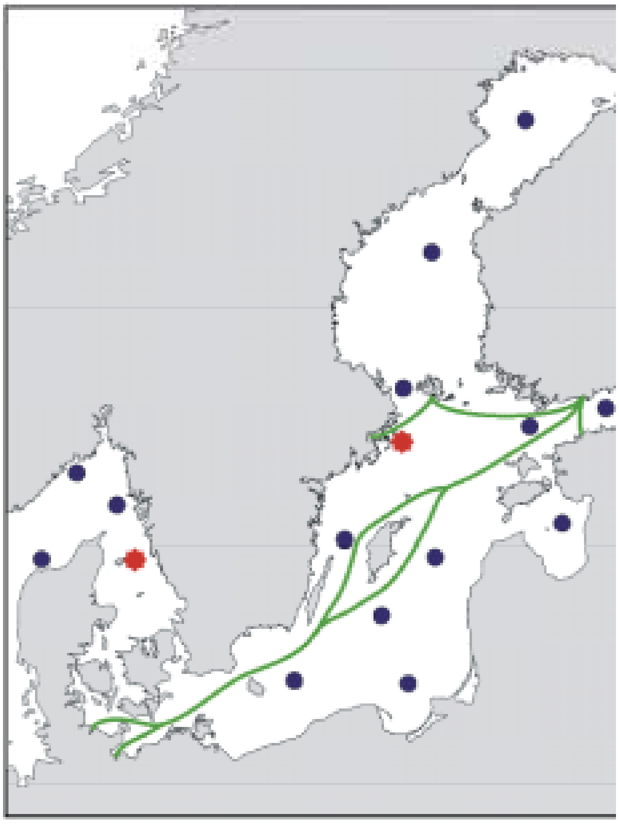

Figure 1: Map of the Baltic and adjacent seas showing approximate positions of proposed buoys for real-time *in situ* data acquisition. Red dots indicate buoys to be deployed in 2001. These are initially equipped with sensors for chlorophyll *a* fluorescence at one depth only. The red lines indicate the present SOOP lines. Preferred extensions are marked with dotted lines.

Techniques for real-time monitoring of HABs using automatic detection have developed rapidly during the last few years. Equipment has become smaller and less expensive and instruments measuring new parameters relevant for the formation of HABs have been developed. Also automatic-profiling devices has become available meaning that single set of sensors can cover the whole photic zone. Transmission of data using mobile phones and satellites makes it possible to publish data from offshore localities on the Internet in near real-time. These systems are still under development but their reliable operational use can be estimated to start in few years.

Specific activities:

A. Further development of ship of opportunity (SOOP) recordings and sampling:

- The present ferry route network should be extended especially in the southern –and southwestern Baltic Sea.
- New types of sensors should be added to existing ones, e.g., phycoerythrin fluorescence.
- Sampling techniques should be developed for better sampling of cyanobacterial assemblages.
- Undulating towed instrumentation should be taken in operation when available for unattended use.
- To establish routines for near real-time presentation of data on the Internet and for archiving and quality control of data.

B. Real-time monitoring using buoys as instrument platforms:

- To organise a workshop on the state of the art of the sensor and buoy technology and to select suitable systems and choosing positions for buoys in the Baltic taking into account present knowledge of HABs and physical oceanography, the SOOP routes as well as other practical circumstances.
- The instrumentation should cover not only the sensors necessary for HAB studies but also basic oceanographic and meteorological sensors for multi-user purposes.
- To deploy 10–15 buoys (two to start with) using satellite data transmission and e.g., the following sensors:

    1) Chlorophyll *a* fluorescence (profiling)
    2) Phycoerythrin fluorescence (profiling)
    3) Turbulence (profiling)
    4) Temperature (profiling)
    5) Salinity (profiling)
    6) Nutrients (profiling NH_4, NO_3, PO_4, Si)
    7) Current speed and direction (profiling ADCP)
    8) In air – light (PAR)
    9) Wind speed and direction
    10) Wave height and direction

- To establish routines for near real-time presentation of data on the Internet and for archiving and quality control of data.

5.2 Understanding the short-term and seasonal dynamics of the HAB species

Objective

The goal is to understand the dynamics of HAB initiation, development, maintenance and termination. The high quality real-time monitoring data obtained from Section 5.1 makes it possible to use ship and other resources efficiently by the implementation of adaptive sampling strategies.

Justification

Physical factors influencing formation of HABs in the Baltic basically operate on the time scales of seasons and the passage of low and high-pressure meteorological systems, i.e., days to weeks. In general, cyanobacterial blooms occur in late summer in the Baltic Sea, but blooms have also been observed late in autumn or in spring. There is a large interannual variation in the intensity of the blooms. It is unknown if this variability is due to the intensity of the blooms of the previous year, winter conditions, or to pre-bloom conditions. It is not known how and where the blooms start, what determines its termination, and where and how the cells overwinter.

Monitoring programs, aimed at long-term changes, investigate the phytoplankton at a low temporal resolution and depth distribution is not investigated at all since only mixed samples from 0–10 m are analysed. Description of the plankton community has been restricted to the larger phytoplankton in most monitoring programmes. Using high temporal and depth resolution with the addition of molecular biology techniques coupled with flow cytometry and fluorescence microscopy makes it possible to describe and understand the dynamics of the plankton community in much more detail. Analyses of HAB-toxins are possible to do onboard research vessels today. The information obtained would be very useful for the implementation of adaptive sampling strategies.

Specific activities:

- This part should be implemented as a four-year project.
- Near a few of the buoys described in Section 5.1, sampling of phytoplankton and other relevant parameters including toxicity, should be performed with high frequency (lower during winter), using modern techniques and high depth resolution. It is probably necessary to use resources from different nations to perform the sampling and analyses.
- Effective use of SOOP sampling should be implemented.
- For some of the parameters an adaptive sampling strategy should be used. This means e.g., that toxins should be analysed with higher frequency of samples during blooms and their development.
- Towed undulating vehicles with multisensor and sampling systems should be effectively used on research vessels.
- On ship experiments should be encouraged in addition to the sampling.
- Data on the basic, but advanced, parameters should be presented on the Internet within 3 days after sampling.
- Acquired data should be used to calibrate *in situ* sensors on buoys.
- Acquired high quality data should be used for the development and verification of models for bloom forecasting.
- Standardisation of techniques and intercalibration should be co-ordinated by the ICES.
- ICES should organise meetings of ship managing institutes.

5.3 Hydrodynamical control of HAB development

Objective

To understand the mechanisms how hydrodynamical processes regulate nutrient limitation, species selection and HAB development

Justification

The question which nutrient is limiting algal growth and how ratios of nutrients affect species selection is critical in evaluating the linkage between HABs and eutrophication. It is also one of the key issues of GEOHAB. Physical processes play a major role in nutrient entrainment and transport as well as plankton species selection, dispersal and accumulation. In addition, atmospheric deposition of nutrients, operating in large scales, creates an additional source of nutrients in the open sea. Plankton ecosystems are not horizontally bounded, and therefore laboratory or mesocosms experiments with no horizontal dispersal of the patch have only a limited capability to simulate the effects nutrient pulsing caused by meso- and small-scale physical processes. Synoptic studies *in situ*, carried out simultaneously in different scales are required for revealing the mechanisms of physical-biological couplings. This cannot be done with one research vessel only, but coordinated multi-ship field campaigns are required.

A novel approach to solve the problem of nutrient regulation was applied in the equatorial Pacific and Southern ocean iron fertilization experiments, where bloom patch dynamics was followed in *situ* after addition of a limiting nutrient. In 1986, ICES organized Baltic Sea Patchiness Experiment, which studied the patch dynamics without addition of nutrients. A coordinated multiship experiment where nutrients are added directly to the system, the development of the bloom patch is followed, the species selection, development of toxicity and various other aspects of HABs are studied, complemented with measuring transects by 'ships-of-opportunity', a set of moored oceanographic instrumentation and remote sensing, could serve as a platform for biological studies, will allow a real integration of biology and physics.

Questions to be solved:

- how do the hydrodynamical processes modify nutrient limitation of the bloom species
- how do physical processes affect the patch formation and species selection
- what is the species' physiological response to nutrient pulsing
- how rapidly does a bloom patch develop and disperse
- how does the species selection operate, which species becomes dominating
- is the patch development *in situ* comparable to the development observed in a mesocosm

Specific activities:

- planning and organization of coordinated multiship *in situ* nutrient addition experiments during 2002–2006
- integration of information obtained from 5.1. and 5.4. for the interpretation of bloom development *in situ*
- using the information obtained from *in situ* nutrient addition experiments for the development and verification of species-of-interest models to be developed under Section 5.6.
- studying the effect of small scale turbulence on HAB species

5.4 Studying biology of HAB species

Objectives

To obtain information about key biological characteristics of the HAB species, which are necessary for the interpretation of the findings obtained during oceanographic expeditions in the Baltic Sea, using parallel land-based experiments (micro and mesocosms) with natural phytoplankton communities and unialgal cultures of relevant HAB-species.

Justification

Field surveys are powerful tools that can be used to understand the physical processes involved in HABs initiation and accumulation at different depths of the water column, fronts, eddies, etc. However, there are not, at the moment, methods and techniques that enable us to understand how HAB species interact with their chemical and biological environments in the field. These interactions depend on intrinsic characteristics of HAB species such as their life cycle, morphology, toxicity, mixotrophic behaviour, production of infochemicals, growth rates, etc. Some of these characteristics will enable HABs to out compete other species and/or eliminate their grazers. On the other hand, HAB intrinsic characteristics might change if the cells are growing under nutrient sufficient or deficient conditions; low or high light and/or temperature conditions. The combination of both factors (chemical and physical factors affecting HAB-cell-intrinsic characteristics) will be of importance for the success of the HAB species, and this is best studied by examining the influence these factors will have on their growth and their losses (grazing, sensitivity to infection by virus, bacteria, parasites) and apoptotic behaviour.

Thus, in order to get a complete picture on the *how* and *why* the targeted HAB populations are found at specific layers/fronts, etc. during the oceanographic surveys, complementary laboratory and mesocosms studies will be carried out using natural plankton communities and unialgal cultures of the regional HAB species.

Questions to be solved:

What are the most important factors contributing to the accumulation of the cyanobacteria in surface layers during warm periods in late summer? Is temperature affecting the expansion of gas vacuoles or are physical processes the only reason for such accumulations? What is the role of nutrient deficiency (and in particular P-starvation) in this buoyancy process?

How are life cycle strategies involved in the initiation of blooms and survival of species during adverse conditions?

How do nutrients, algal morphology, and other biological or behavioural factors interact to diminish losses from grazing? What factors control nitrogen fixation in Baltic waters, and what determines the species succession among species with this N-acquisition strategy.

Specific activities:

the following experiments need to be performed:

1. How nutrient concentrations and ratios affect:
    a) Production of toxins
    b) Production of infochemicals
    c) Sensitivity to parasites
    d) Apoptosis
    e) Accumulation or flotation
    f) Growth rates
    g) Life cycle
    h) Mixotrophic behaviour
    i) Species succession

5.5 Update of the phytoplankton HAB species checklist

Objective

To improve the knowledge of the taxonomy, toxicity and distribution of the HAB species in the Baltic Sea area.

Justification

The phytoplankton species diversity in the Baltic Sea area is low in comparison to fresh or marine waters. From the current species checklist more than 20 are known to be potentially toxic or can cause other harmful effects. In addition to several cyanobacterial species, many species of Chromophytes division (representatives of following classes: Dinophyceae, Bacillariophyceae, Prymnesiophyceae, Dictiophyceae), are known to form harmful blooms in the Baltic Sea area.

Specific activities:

Right now the update of the overall phytoplankton checklist of the Baltic Sea is under the work co-ordinated by the HELCOM. It should be completed in the near future. The checklist should be available and further developed in a specific database with Internet access. ICES should complete the leaflets of HAB species in the Baltic Sea area and they should be included in the above-mentioned database.

5.6 Modelling

Objective

To develop species-of-interest models that allows reliable prediction of HAB development in their natural physico-chemical environment.

Justification

Models are important and often necessary tools to increase the understanding of processes, to improve interpretation of measurements and design of experiments, and to develop capabilities to make predictions. In a plan for GEOHAB implementation in the Baltic Sea modelling is a natural component.

Ecological modelling has a long tradition in the Baltic area and a set of models ranging from box, 1-d water column to fully coupled 3-d circulation and biological models. Using the state-of-the-art modelling is an integral part of the planning of a co-operative HAB study in the Baltic Sea.

The combination of high resolution, coastal, physical modelling with biological and biogeochemical models has made progress during the last years. But many improvements are required. For example, for some species the importance of physical-biological processes at scales ranging from millimetres to meters – behaviour, thin layers, predator-prey interaction, and turbulence has been demonstrated.

Details of interactions of individual organisms with the environment may also use modelling based on the organisms' physiology, behaviour, life cycles etc.

Specific activities

Similarly as any modelling, the ecosystem modelling involves simplifications and approximations. For models designed to be useful in practical applications the introduction of errors have to be accurately analysed and ranked for each source of error. The modelling community needs to develop methodologies for estimating errors associated with forcing and initialisation data as well as due to approximations in physical/biological models.

Validation, both in the laboratory and in the field, is an essential part of establishing model skill assessment. Comparative studies are also an important component of validation. A co-operative HAB study in the Baltic can serve as an excellent experimental basis for the validation of model components.

Many components of modelling physical/biological interaction still remain to be developed. Examples of required components or needs for improvements are:

- methodologies for dealing with multiscale problems, such as interactions in thin layers
- systematic methods for aggregating species into functional groups. Functional groups are here defined to include those species that share a common biological primitive equation but have different values for the parameters in the equations.
- modelling of turbulence at scales appropriate to the physical/biological interaction of interest
- determination of rates required for biological primitive equations.

A cooperative HAB study in the Baltic is recommended to include projects where several of the model requirements for physical/biological interaction can be approached.

6 DATA ISSUES

6.1 Methodology

6.2 Quality assurance

6.3 Validation

6.4 Data banking

7 THE GEOHAB APPROACH TO A COOPERATIVE BALTIC STUDY:

7.1 Description of the comparative approach applied

7.2 Identification of the expertise expected to be contributed to project by being affiliated with GEOHAB

7.3 Identification of the type of projects/research teams which the project wish to interact within the GEOHAB Programme

7.4 Outline of the mechanisms to be established in the Project to allow international participation (re. obligations for endorsement as a GEOHAB Project)

7.5 Role of ICES and national partners

ICES have in the past been behind the development and implementation of several regional field programmes such as f.ex. PEX and SKAGEX, GLOBEC Cod and Climate, etc.

ICES is not designed to function as a funding agency, but proposals for regional studies developed by study or working groups are presented to the ICES Oceanography Committee for endorsement. Through subsequent endorsement by ICES Delegates at the ICES Annual Science Conference, the Delegates can either directly commit national resources or commit themselves to work for the identification of resources for implementing the project. Additionally, ICES endorsement of a regional project may be an advantage when applying to the respective national research councils for funding to participate.

Thus it is important for this mechanism to work, and to achieve strong endorsement by the ICES delegates, that SG/WG members actively brief their respective ICES delegates in advance of the ICES Annual Science Conference.

In summary, the added value of organising a co-operative regional study through ICES is:

- ICES provides a recognised organisational platform for regional co-operative research
- ICES provides a mechanism for facilitating access to national funding
- ICES provides a mechanism for involving scientists from outside the study region in a project with the view to exchange experience and share data.
- ICES is a tool for co-ordinated data management
- ICES is tool for development of standard methodology protocols
- ICES can assist with publication
- ICES can organise and sponsor targeted workshops
- ICES can organise and sponsor targeted conferences

The role ICES can fulfil in the implementation of GEOHAB corresponds to the goals in the ICES Strategic Plan:

- understand the physical, chemical, and biological functioning of marine ecosystems;
- enhance collaboration with organisations and scientific programmes that can contribute to fulfilling ICES' vision.

Based on this framework provided by the ICES, IOC and SCOR, and the support from national institutions committed via the ICES delegates as described above, it will be up to the individuals and research teams in the SG to submit the fully developed activities for funding to relevant funding sources.

8 WORK PLAN AND TIME SCHEDULE

8.1 Endorsement of proposal by ICES i) Baltic and Oceanography Committees; ii) Statutory Meeting Resolution

8.2 Submission to GEOHAB SSC for acceptance as GEOHAB project

8.3 SG meeting 2002 to refine programme document (plan activities)

8.4 Submission to ICES ASC and GEOHAB SSC for final approval

8.5 Implementation

science workshop I

cruise I
lab package I

.. etc

9 FORM FOR SUBMISSION TO GEOHAB SSC FOR ACCEPTANCE AS A GEOHAB PROJECT