ICES WGGIB Report 2006

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Report of the ICES-IOC-SCOR Working Group on GEOHAB Implementation in the Baltic (WGGIB)

6–7 April 2006

Gdynia, Poland

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES-IOC-SCOR Working Group on GEOHAB Implementation in the Baltic (WGGIB) met in 5–7 April 2006 in Gdynia, Poland, in order to:

a) Report and discuss new findings on HABs and HAB modelling in the Baltic;

b) Update the checklist of the harmful species of the Baltic Sea;

c) Estimate the health hazard of cyanobacteria and dinoflagellate toxins to humans and review the concentrations of HAB toxins in the upper trophic levels of the Baltic foodweb;

d) Finalize the proposal for a Cooperative HAB study in the Baltic Sea and agree upon its implementation;

e) Take into account the recommendations of the Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB).

New findings

Nodularin is the main toxin existing in the Baltic HAB species. New nodularin analogues have been identified with Liquid Chromatography Mass Spectrometry methods.

Recent laboratory experiments have revealed differences between phosphorus sources for the two main bloom-forming species, *Aphanizomenon flos-aquae* and *Nodularia spumigena*. *A. flos-aquae* relies mainly on dissolved inorganic phosphorus supplies, while *N. spumigena* grows equally well on intracellular phosphorus stores and an organic phosphorus compound. Phosphorus limitation of nitrogen fixation was found to have high placticity and no effects were found even at cellular N:P ratios exeeding 60:1.

The operative HAB monitoring on ships-of-opportunity is probably more developed in the Baltic Sea than anywhere else in the world. New routes are being planned between Gdansk and Karlskrona, and between Riga and Stockholm. This will provide important latitudinal data for the southern and central Baltic Sea. Satellites are also used for bloom detection in most Baltic countries. Increased cooperation between institutes could lead into a more rapid development of remote sensing of the algal blooms in the Baltic.

Fishermen on the Finnish and Polish coastlines were sent a questionnaire on cyanobacteria bloom effects. The results reveal area-, species- and gear-specific effects. Fishermen generally felt that cyanobacteria blooms are causing financial losses for them.

Checklist of the potentially harmful algal species of the Baltic Sea

The HAB species checklist was updated by WGGIB taxonomical experts.

Review of concentrations and hazards of HAB toxins in the Baltic Sea

A review summarised the effects of *Nodularia spumigena* on zooplankton and planktivores. Zooplankton was shown to take up dissolved nodularin directly from the water. In the field, herbivorous surface dwelling species were accumulating more nodularin than species migrating species capable of selective feeding. Larger, mainly carnivorous zooplankton species contained nodularin as well, suggesting that nodularin is transported between trophic levels in pelagic food webs. The egg production of copepods decreased with increasing *N. spumigena* concentrations. In food chain experiments, only trace amounts of nodularin were transferred to planktivorous fish and mysids. However, the sublethal effects of chronic exposure of cyanobacteria toxins to Baltic organisms, as well as health hazards to humans, remain unclear.

GEOHAB Implementation in the Baltic

Since the GEOHAB SSC has already provisionally endorsed Baltic Sea as a GEOHAB focus area, it was decided that the Group will meet in 2007 with the focus on initiating an international HAB research project. Prior to that it will be necessary to review the HAB research activities currently under way, and to contact the partners willing to participate. It was noted that the existing activities need to be better coordinated to form an integrated project, and that financing probably needs to be applied for to fill in the existing gaps in activities. The Group reviewed the preliminary *Proposal for the Cooperative HAB study in the Baltic*, and discussed its implementation. The following issues were discussed: Comparative approach, taxonomy, model parametrisation and validation, physical oceanographical processes, data mining, integration and enhancement of existing monitoring programmes.

Take into account the recommendations of the Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB)

The WKIAB meeting had taken place two weeks earlier and no specific recommendations had been provided that could be taken into account. It was however held important that harmful algae are taken into account in compiling an Integrated Assessment for the Baltic Sea.

1 Opening of the meeting

The ICES-IOC-SCOR Working Group on GEOHAB Implementation in the Baltic (WGGIB) met in 5–7 April 2006 in Gdynia, Poland. The meeting was excellently hosted by the Institute of Oceanography, Gdansk University. The meeting was arranged back to back with the meeting of the Working Group of Harmful Algae Bloom Dynamics [WGHABD], with one joint day.

Altogether 13 scientists from Finland, Latvia, Poland, Germany and Sweden participated. In addition, 10 particpants of the WGHABD attended during the joint day of WGGIB and WGHABD. The list of participants is presented in Annex 1 and the meeting agenda in Annex 2.

The meeting was opened by the Chair, and the participants introduced themselves.

2 Adoption of the agenda

The agenda was approved, and group members kindly agreed to act as rapporteurs.

3 Terms of reference for 2006

At the 92nd Statutory Meeting (2005), Aberdeen, Scotland, UK, the council approved the proposed terms of reference and decided to change the group from a Study Group to a Working Group (C. Res. 2005/2BCC06).

The ICES-IOC-SCOR Working Group on GEOHAB Implementation in the Baltic [WGGIB] (Chair: M. Viitasalo, Finnish Institute of Marine Research, Finland) will meet in Gdynia, Poland, from 5–7 April 2006 to:

a) Report and discuss new findings on HABs and HAB modelling in the Baltic;
b) Update the checklist of the harmful species of the Baltic Sea;
c) Estimate the health hazard of cyanobacteria and dinoflagellate toxins to humans and review the concentrations of HAB toxins in the upper trophic levels of the Baltic foodweb;
d) Finalize the proposal for a Cooperative HAB study in the Baltic Sea and agree upon its implementation;
e) Take into account the recommendations of the Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB).

4 New findings

New nodularin analogues in the Baltic (Hanna Mazur-Marzek, Poland)

So far, in the Baltic Sea only two nodularin (NOD) variants have been identified: NOD-R and [Asp^1]NOD. New analyses of the structure of the Baltic *Nodularia spumigena* with Liquid Chromatography Mass Spectrometry done by a Polish-Finnish research group showed the presence of unmodified nodularin (NOD-R) and three demethylated variants. The linear NOD and the geometrical isomer of NOD-R, reported earlier in *N. spumigena* from New Zealand, have also been detected. Out of the eight nodularin variants characterised in the current study, two - [dhb^5]NOD and [MeAdda]NOD - have not been described earlier.

HAB nutrient dynamics in the northern Baltic Sea (Emil Vahtera, Finland)

The main HAB events in the Baltic Sea are caused by diazotrophic filamentous cyanobacteria. During the blooms the cyanobacteria are mainly phosphorus limited. Recent laboratory experiments have showed differences between principal phosphorus sources for the two main bloom-forming species, *Aphanizomenon flos-aquae* and *Nodularia spumigena*. The biomass peak of *A. flos-aquae* is frequently found at 10-15 m depth, overlying the seasonal thermocline, which is also usually in the vicinity of the phosphacline. *N. spumigena* biomass maxima often lie closer to the surface where most part of the phosphorus is either in particulate or organic form. Correspondingly, we observed that *A. flos-aquae* grew best on dissolved inorganic phosphorus, whereas *N. spumigena* grew equally well on intracellular phosphorus stores and on an organic phosphorus compound. *N. spumigena* could be able to form blooms relying on intracellular stores and organic phosphorus coumpounds, which also are its main phosphorus sources during late summer. *N. spumigena* growth is strongly temperature limited restricting its use of abundant available phosphate during spring and early summer. *A. flos-aquae* growth is more eurythermal but growth on intracellular stores and organic phosphorus is slower than for *N. spumigena*. Therefore, the large bloom inocula formed by spring and early summer populations of *A. flos-aquae* are important for it's bloom formation.

Recent observations from the Gulf of Finland and the northern Baltic Proper have shown that vertical movement of cyanobacteria might function as a biological nutrient pump, moving phosphate up from the thermocline to the upper water layers. Vertical measurements of phosphorus accumulation into size fractions showed abiotic adsorbtion of phosphate to be the most important form of phosphorus scavenging at deeper depths (>12 m). The abiotic adsorbtion was most important in the >10 μm fraction, which is usually dominated by filamentous cyanobacterial aggregates during blooms. The scavenging of phosphate in this size fraction could amount up to 40-60% of total phosphorus accumulation at depths >12m.

Further it was found that upwelling along the Gulf of Finland northern coast alleviates phytoplankton community phosphorus stress to some degree. Measured phosphorus turnover times were found to be slower, indicating better phosphorus nutrition, in cooler upwelled waters. Also, at a salinity front, probably related to a large scale gyre system in the northen Baltic Proper, the phytoplankton community was less phosphorus stressed. The phosphorus nutritional status of the two main bloom forming cyanobacteria was different, as shown by species specific enzyme labelled fluorescence. *A. flos-aquae* showed a low alkaline phosphatase activity, indicating little phosphorus deprivation. In contrast, *N. spumigena* showed a spatially even but temporally increasing labelling, indicating increasing phosphorus stress of the populations. These observations support the earlier laboratory and field observations of different phosphorus acquisition strategies for the two main bloom forming species in the Baltic Sea.

Development of continuous monitoring and satellite methods in Baltic HAB detection

Presently the operative monitoring on ships-of-opportunity of HABs is probably more developed in the Baltic Sea than anywhere else in the world. Phytoplankton and HAB data are collected on several routes criss-crossing the Baltic Sea by the international Alg@line program lead by the Finnish Institute of Marine Research. Data are collected weekly/daily throughout the growing season. The program provides useful information for validating the algorithms needed for satellite images of the phytoplankton and cyanobacteria blooms in the Baltic Sea. Also, parametrisizing and validating the ecosystem models for various purposes (e.g. cyanobacteria bloom forecasts) can be done by these data.

New routes are being planned between Gdansk and Karlskrona, and between Riga and Stockholm. If realized, these routes will provide additional latitudinal data for the southern and central Baltic Sea. This automated monitoring will provide a very useful backbone for GEOHAB implementation in the Baltic.

Satellites are being used for detection of algal blooms in most Baltic countries independently. It appears that a better coordination and increased cooperation between institutes could lead into a more rapid development of methods of remote sensing of the algal blooms in the Baltic Sea.

HAB effects on fishermen (Jari Pääkkönen, Finland & Anna Tyminska, Poland)

While fish kills due to dinoflagellate toxins have been rare in the Baltic Sea, cyanobacteria and their massive blooms have impoortant consequences to the summertime ecosystem. There is increasing evidence for cyanobacteria having harmful effects on fish feeding and growth due to either cyanobacteria filaments interfering with the visual feeding of fish, or toxin containing food causing a metabolic cost for the fish. However, the effects of cyanobacteria for fisheries, or the livelihood of fishermen has not been systematically investigated.

As a part of a larger research project investigating ecological and socioeconomic effects of the Baltic cyanobacteria, fishermen on the Finnish and Polish coastlines were approached with a questionnaire on cyanobacteria bloom effects on their professioin. The results reveal area-, species- and gear-specific effects of cyanobacteria blooms. According to fishermen replies, blooms affected their income in both countries. In the fishermen opinion, the reasons were (1) decreased total catch due to the fish disappearing, (2) decreased catch value, (3) higher costs of fishing due to more fuel spent (checking of nets needs to be done more often), (4) more time consumed for cleaning the nets, and (5) need to stop fishing during the bloom. Finnish fishermen obtained information about blooms mainly from the TV and newspapers but Polish fishermen rely on their own observations. Although the most updated and accvurate information on the occurrence of the blooms exists on the Internet, it was only scarcely used by the Finnish fishermen, and not at all in Poland.

5 Checklist of the potentially harmful algal species of the Baltic Sea

Updating of the checklist had been done by the WGGIB experts before the meeting. In Gdynia the checklist and its developments were introduced by M. Viitasalo, Finland, and M. Elbraechter, Germany.

Three new species (*Dinophysis sacculus*, *Lingulodinium polyedrum* and *Gonyaulax spinifera*) were added. *Gymnodinium aureolum* was removed from the checklist. The harmful effect of *Akashiwo sanguinea* was changed from PSP to anoxia. The name of *Karlodinium micrum* was changed to *K. veneficum. Chattonella* aff. *verruculosa* was moved from class Raphidiophycea to the class Dictyochophyceae. Northern Baltic Sea was added to the distribution information of *Prorocentrum minimum*.

The full checklist is in Annex 6.

6 Review of concentrations and hazards of HAB toxins in the Baltic Sea (Miina Karjalainen, Finland)

Cyanobacterial blooms occur every year in the Baltic Sea, and their frequency and intensity have increased during recent decades. Since one of the dominant species in these blooms, *Nodularia spumigena*, is toxic, the effect of these blooms in food webs has been recently actively investigated in several countries around the Baltic. This review summarises the results of a research group of Finnish Institute of Marine Research, also more throughly described in the Ph.D. tehsis of Miina Karjalaine (2005). The aim of these studies was to increase the level of understanding of the effects of *N. spumigena* on zooplankton and planktivores feeding on zooplankton. In addition, the fate of nodularin in planktonic food webs was studied both experimentally and by collecting samples from the field.

In nodularin uptake experiments it was observed that zooplankton can take up dissolved nodularin directly from the water. In both ciliates and copepods the concentrations of nodularin attained higher values than in the surrounding water, indicating that bioconcentration of nodularin occurred in the zooplankton. Therefore, no direct contact with cyanobacterial filaments and zooplankton was needed for dissolved nodularin to accumulate in zooplankton. When obtained via grazing, the nodularin accumulation was about 20 times larger than when obtained directly from the water. There was a positive relationship between the nodularin level found in the copepods and the ingestion rates for *N. spumigena*.

Only a minor fraction of nodularin was detected in copepods, compared with the levels found in ingested cyanobacteria. This indicates that copepods can effectively metabolize or detoxify nodularin after ingestion, or that filamentous cyanobacteria are broken down before ingestion and part of the toxin is released to the surrounding water. The concentrations of nodularin were 6–12 times higher in copepods than in their faecal pellets, suggesting that faecal pellets are unlikely to act as vectors for nodularin recycling in the pelagic zone.

The degradation of nodularin occurred rapidly in copepods. In depuration experiments the degradation rate, i.e. the half-life, of nodularin varied from 7.4 to 13.9 h, depending on the method used in the toxin analysis. Rapid decrease in the toxin concentrations indicates effective detoxication capacity in copepods. However, after 24 h the exposed copepods still contained 51–58% of the initial concentrations of nodularin.

Nodularin was detected in the field-collected zooplankton samples. Herbivorous species as well as species with a limited capacity to vertically migrate from the dense surface accumulations of toxic cyanobacteria were more vulnerable to nodularin uptake, whereas species capable of selective feeding had lower concentrations in their tissues. Larger, mainly carnivorous zooplankton species contained nodularin as well, suggesting that nodularin may be transported between trophic levels in pelagic food webs.

During feeding experiments, copepods fed actively on toxic *N. spumigena*, as well as on the associated ciliate community. The egg production rates decreased with increasing *N. spumigena* concentrations in the food solution. These findings support the view that copepods can utilize cyanobacteria as a food source, but the poor food quality of cyanobacteria, as well as their toxins, can negatively affect their reproduction.

In food chain experiments, trace amounts of nodularin were transferred to planktivorous fish and mysid shrimps via zooplankton. These trace amounts of nodularin did not affect the growth of mysid shrimps, but decreased the ingestion rates of pike larvae. Since detoxication is an energy-demanding process, it may affect the reproduction and gross growth efficiency of zooplankton and, along the food chain, also the condition of zooplanktivorous fish.

In conclusion, even though relatively small concentrations of nodularin are transported to higher trophic levels, the sublethal effects of chronic exposure to organisms of the Baltic Sea remain unclear and call for further investigation. Also, the long term health hazards possibly posed for humans remain unexplored.

For a full list of observations of nodularin concentrations in Baltic Sea biota, from field-collected samples and after experimental exposures in the laboratory (Karjalainen 2005, with updates), see Annex 7.

7 GEOHAB Implementation in the Baltic

GEOHAB implementation in the Baltic and the future of the Working Group was discussed. The GEOHAB SSC representative stressed that it is essential to start implementing GEOHAB objectives in the Baltic. This opinion was supported, but it was also held useful that the small but active Baltic HAB researcher community meets to discuss also other HAB related issues than those that are in the GEOHAB interest, i.e., bloom dynamics.

Since the GEOHAB SSC has already provisionally endorsed Baltic Sea as a GEOHAB focus area, it was decided that the Group will meet in 2007 with the focus on initiating an international HAB research project. Prior to that it will be necessary to review the HAB research activities currently under way, and to contact the partners willing to participate. A potential place for a first meeting of the possible participants will be the Harmful Algae meeting in Copenhagen in autumn 2006. It was noted that the existing activities need to be better coordinated to form an integrated project, and that financing probably needs to be applied for to fill in the existing gaps in activities.

The Group reviewed the preliminary *Proposal for the Cooperative HAB study in the Baltic*, and discussed its implementation. The following issues were discussed:

Comparative approach

GEOHAB recommends that regional comparisons of HAB dynamics should made to fully understand the ecosystem-level regulation of bloom formation and decay. The Baltic Sea however forms a special case where comparisons can be made between basins and, e.g., between the open sea and the archipelago areas.

Comparisons can be also made between bloom dynamics between taxonomic groups. In the case of Baltic HABs this essentially means comparisons between Cyanobacteria and dinoflagellates, which both can form blooms. A special study issue in this respect is allelopathy, i.e., the effects that e.g. cyanobacteria have on other phytoplankton taxa.

Causative organisms

As in phytoplankton taxonomy in general, reliable species identification of HAB species is of primary importance. This need is stressed by the rapidly developing genetical methods, possible diminishing in traditional taxonomical skills, changes in nomenclature, as well as the threat of getting non-indigenous HAB species into the Baltic with ships' ballast waters.

Model parametrisation and validation

It was held important that the existence and uses of (ecosystem) models currently available will be reviewed. Existing projects (past-present-future) that might have produced relevant information should be identified.

Second, it is necessary to identify the most important needs in models regarding e.g. existing biological compartments and the physical-biological interactions, and which new compartments should/could be added.

It was noted that, since models are run (at the present stage) to predict HA events caused by cyanobacteria, the first priority should be to improve this aspect. Compartments for dinoflagellates could be added later. Before that, to be able to predict species dominance patterns in Cyanobacteria blooms, it will be necessary to divide the functional compartment of Cyanobacteria into species specific compartments that respond individually to external forcing. Thus the models should include at least the Cyanobacteria *Nodularia spumigena*, *Aphanizomenon flos-aquae* and *Anabaena* spp. As for the dinoflagellates the modelling should first concentrate on *Dinophysis* spp., and possibly also *Prorocentrum minimum*.

To improve model performance the biological compartments could be amended with more accurate information on nutrient availability and nutrient competition (DIP, DOP-sources). Specific experiments need to be designed for assessing tne degree of nutrient competition.

Physical oceanographical processes

In addition to nutrient dynamics, purely physical processes, such as advection, dispersion and small-scale turbulence, need to be better understtod to be able to describe HAB dynamics in the Baltic Sea. For this, specific workpackages need to addressed in the eventual plan.

Data mining, integration, enhancements

To improve the understanding of HAB dynamics, the existing monitoring programmees need to be better integrated. Ships of opportunity, satellite imagery and modelling needs to be integrated to provide a more areally and temporally comprehensive view of the bloom dynamics.

Existing unanalysed data sets in different countries should be identified and checked for usability in HAB dynamical analyses. After this, the need and character of possible new field data and new experiments (lab or mesocosm experiments) needed for model parametrisation and validation can be identified.

8 Taking into account the recommendations of the ICES-HELCOM Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB)

The WKIAB meeting had taken place two weeks earlier and no specific recommendations had been provided that could be taken into account.

Generally it was held important that harmful algae are taken into account in compiling an Integrated Assessment for the Baltic Sea. During mass occurrences the harmful algae cause various effects in the whole ecoystem. Some effects may be positive (such as enhancement of the production of the organisms of the microbial loop), but mostly the changes induced by HABs are held negative. Recently it has been shown that HABs influence negatively the zooplankton production. Further, the fish larvae and juveniles that have been eating cyanobacteria fed zooplankton show a recreased condition and growth. Thus especially if HABs increase in intensity and duration, they may have sublethal but negative consequences for the higher trophic levels of the Baltic Sea.

9 Other Business

It was decided that the Group will meet in 2007 with the focus on initiating an international HAB research project. Also, presentations on new findings on HABs, and HAB dynamics and modelling specifically, will be welcome.

Maija Balode invited the next WGGIB meeting to be held in the Institute of Aquatic Ecology, University of Latvia, Riga. This proposal was accepted with gratitude and the meeting was decided to be arranged in 6–7 April 2007, back to back with the WGHABD meeting.

Annex 1: List of participants

* = present only during the joint day with the WGHABD.

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Annex 2: WGGIB Agenda

ICES-IOC-SCOR Working Group on GEOHAB Implementation in the Baltic [WGGIB]
5-7 April 2006, Inst. Oceanography, Univ. Gdansk, Gdynia, Poland

Wednesday, 5 April 2006

ToR a: **Report and discuss new findings on HABs and HAB modelling in the Baltic**

ToR c: **Estimate the health hazard of cyanobacteria and dinoflagellate toxins to humans and review the concentrations of HAB toxins in the upper trophic levels of the Baltic foodweb**

09:30 **Welcome & Introduction**; adoption of the WGGIB agenda (on the behalf of WGGIB, M. Viitasalo, FIMR, Finland)

09:40 New nodularin analogues in the Baltic *Nodularia spumigena* and other environmental samples (Hanna Mazur-Marzek, UG, Poland)

10:00 Nodularin analogues, ctd... (Berndt Lukas, Germany)

10:10 Phytoplankton-community phosphorus dynamics in the northern Baltic Sea during a cyanobacteria bloom (Emil Vahtera, FIMR, Finland)

10:30 **Morning break**

11:00 Development of satellite methods in Baltic ecosystem monitoring (Adam Krezel, Department of Physical Oceanography of University of Gdansk)

11:30 Cyanobacteria blooms in the Baltic in 1997-05: a satellite view (Bengt Karlson, SMHI)

11:50 Ecosystem effects and health hazards of cyanobacteria toxins in the Baltic – a review (Miina Karjalainen, FIMR, Finland)

12:10 Latest results on nodularin concentrations in Southern Baltic sediments, mussels and flounder; with comments on health hazard of cyanobacterial blooms (Hanna Mazur-Marzec, University of Gdansk)

12:30 **Lunch**

13:50 Latest news on the neurotoxin BMAA in the Baltic Sea (Kankaanpää H. and Viitasalo, M.)

14:10 WGHABD: HAE-DAT reporting (Monica Lion, Spain)

15:30 **Afternoon break**

16:00 WGHABD: Meeting location and Terms of Reference for 2007.

17:00 **Adjourn for the day**

~17:30 Tour of Gdansk and Dinner in Sopot (WGHABD & WGGIB)

Thursday, 6 April 2006

09:30 ToR b: **Update the checklist of the harmful species of the Baltic Sea**
Updating has been done by the WGGIB experts before the meeting. In Gdynia brief presentation of the checklist (M. Viitasalo), discussion, possible editions.

ToR e: Take into account the recommendations of the Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB)

Brief presentation of WKIAB (M. Viitasalo). Discussion.

ToR a: **Report and discuss new findings on HABs and HAB modelling in the Baltic**

10:00 Physiological effects in juvenile three-spined sticklebacks feeding on zooplankton exposed to cyanobacteria. (Sanna Rönkkönen, FIMR, Finland)

10:30 Morning break

11:00 Cyanobacteria-zooplankton-fish interactions in the Gulf of Finland: Results from cruises 2004-2005 (Jari-Pekka Pääkkönen, FIMR, Finland)

~11:30 Questionnaire on HAB effects on fishermen in Finland (J.-P. Pääkkönen, FIMR, Finland)
Questionnaire on HAB effects on fishermen in Poland (Anna Tyminska, UG, Poland)
Questionnaire on HAB effects on fishermen in Latvia (Maija Balode, Latvia)
Discussion on socioeconomic effects of HABs in the Baltic.
Discussion on health hazards of the toxins

12:30 Lunch

13:30 Discussions continued if necessary.

ToR d: Finalize the proposal for a Cooperative HAB study in the Baltic Sea and agree upon its implementation

Review of the GEOHAB Science/Implementation plan and the Proposal for the Baltic Co-operative study (M. Viitasalo).

Reports on other HAB projects/activities in the Baltic region. Gaps in knowledge identified:

Discussions on implementing of the GEOHAB goals in the Baltic.

15:00 Afternoon break

15:30 Proposal/implementation work continues. Discussions on the structure, contents and editing of the Proposal. Items to discuss / Deciding on actions that can and need to be done in order to implement the GEOHAB plan.

Comparative approach (regional comparisons)
Causative organisms: Taxonomical matters, new techniques, biogeography, introduced species
Parametrisation: Nutrient dynamics, life cycles, mesocosm and large-scale experiments
Validation and observation: existing data; new field data: cruises, ships of opportunity, buoys, satellites
Physical oceanographical processes: advection, dispersion, turbulence
Data mining, integration, enhancements: combining and coordinating monitoring programmes
Co-operative workshops
Funding possibilities

~17:00 Adjourn for the day.

Friday, 7 April 2006

09:30

Recent developments in ship-of opportunity monitoring of the Baltic Sea (S. Kaitala & M. Viitasalo)

Other business

WGGIB in 2007–2008: Terms of reference for 2007; meeting place for 2007. Deciding on chairing in 2007–2008.

10:30 Proposal/implementation work continues.

Review of the original cooperative plan.
Writing of parts of the report (in sub-groups).
Final organising of the report writing.

12:30 Lunch

13:30 Report writing

15:00 Meeting adjournment

Annex 3: WGGIB proposed Terms of Reference 2006

The ICES-IOC-SCOR **Working Group on GEOHAB Implementation in the Baltic** [WGGIB] (Chair: M. Viitasalo, Finland) will meet in Riga, Latvia, from 5–6 April 2007 to:

a) Report and discuss new findings on HABs and HAB modelling in the Baltic

b) Update the checklist of the harmful species of the Baltic Sea

c) Agree on actions needed for implementing the Proposal for a Cooperative HAB study in the Baltic Sea

WGGIB will report by 15 May 2007 for the attention of the Baltic Committee.

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into issues related to the dynamics and prognosis of harmful algae blooms (HABs) in the ICES area. Additionally, information on effects of HABs on Baltic ecosystem, as well as fisheries, is being disseminated tio the ICES researchers. Consequently these activities are considered to have a high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 1. *Term of Reference a)* There is currently an intense research activity on HABs in the Baltic. It is in the interest of ICES, IOC, SCOR and GEOHAB to foster international cooperative HAB research in the Baltic Sea. *Term of Reference b)* A list of potentially toxic and bloom forming species was prepared during the SGGIB meeting in 2004. Due to the rapidly developing taxonomy and new observations on blooms, it is necessary to keep updating this list annually. *Term of Reference c)* Development of HAB studies in the Baltic Sea provide a unique opportunity in studying HABs at the scale of one ecosystem. Initiation of a cooperative study is necessary for GEOHAB implementation in the Baltic Sea.
RESOURCE REQUIREMENTS:	Part of the research that provides input to this group are already underway in the participating countries, and resources are already committed. Additional resources are required to build an international cooperative HAB study in the near future.
PARTICIPANTS:	The Group is normally attended by some 10–20 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with several working groups in the Oceanography Committee (Harmful Algae Bloom dynamics, Phytoplankton Ecology and Phytoplankton and Protist Taxonomy) and Baltic Committee (Working Groups in support for the BSRP).
LINKAGES TO OTHER ORGANIZATIONS:	The Group is fulfilling the requirements of GEOHAB and IOC to foster international cooperative HAB research in the Baltic Sea.
SECRETARIAT MARGINAL COST SHARE:	

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. The WGGIB recommends that harmful algae are taken into account in compiling an Integrated Assessment for the Baltic Sea. During mass occurrences the harmful algae cause various effects in the whole ecoystem. Recently it has been shown that HABs influence negatively the zooplankton production, and that fish larvae that have been eating cyanobacteria fed zooplankton show a recreased condition. Therefore, especially if HABs increase in intensity and duration, they may have sublethal but negative consequences for the higher trophic levels of the Baltic Sea.	To the attention of WKIAB

Annex 5: Abstracts of the presentations

New nodularin analogues in the Baltic *Nodularia spumigena* and other environmental samples

Hanna Mazur, Jussi Meriluoto*, Marcin Plinski, Janusz Szafranek, Gdansk University, Poland
*** Åbo Akademi University, Turku, Finland**

So far, in the Baltic Sea only two nodularin (NOD) variants have been identified: NOD-R and [Asp^1]NOD. Results of structural analyses of the Baltic *Nodularia spumigena* with Hybrid Quadrupole-TOF LC-MS/MS instrument showed the presence of unmodified nodularin (NOD-R) and three demethylated variants. The sites of demethylation were located on aspartic acid [Asp^1]NOD, Adda residue [$DMAdda^3$]NOD, and dehydrobutyric acid [dhb^5]NOD. In two other NOD variants an additional methyl group was located in Adda [MeAdda]NOD and Glu [Glu^4(OMe)]NOD residues. The linear NOD and the geometrical isomer of NOD-R, reported earlier in *N. spumigena* from New Zealand, have also been detected. Out of the eight nodularin variants characterised in the current study the following two: [dhb^5]NOD and [MeAdda]NOD have not been described earlier.

Phytoplankton-community phosphorus dynamics in the northern Baltic Sea during a cyanobacteria bloom

Emil Vahtera, Finnish Institute of Marine Research

The community phosphorus turnover time (P_T) and the accumulation of phosphorus into three size fractions were measured using ^{33}P as a tracer during a 10 day cruise in the northern Baltic Sea. Samples for analysis were collected from the surface layer (5 m) along a longitudional transect from the mouth of the Gulf of Finland to the northern part of the Baltic Proper. Vertical sampling of P_T and accumulation into size fractions was conducted at five stations along the transect, at 5 to 25 m depth. To resolve hydrographic features, 12 h nighttime surveys and CTD casts along the sampling transect were carried out. The nighttime surveys were carried out with the ships flow-through system, measuring temperature, salinity and chlorophyll *a* fluorescence.

Temperature and salinity was consistently lower in the northeastern part of the study area, probably due to a coastal upwelling along the Finnish coastline. Chlorophyll *a* values were in general higher in the cooler water. A salinity front was observed between longitudes 21.7° and 21.8°E. A chlorophyll *a* peak was also observed at this location. The front was likely to be a part of a larger cyclonic gyre system in the northern Baltic Proper.

DIN concentrations were consistently below 0.15 $\mu mol\ l^{-1}$ and DIP was below the detection limit (0.05 $\mu mol\ l^{-1}$). Phosphate concentrations rose to measurable quantities at the base of the thermocline (>20m). Phosphorus turnover times were fast (< 0.3 h), indicating phosphorus depletion. The results showed a more phosphorus replete situation at the eastern end of the transect. Fluctuations of P_T at the east end of the transect were also, at least partly, accounted for by upwelling events. P_T increased with depth, reflecting the increasing availability of phosphate in the water column. The P_T was also relatively long at the observed salinity front already at 9 m depth (3.38h), while all other stations showed persistently faster P_T at this depth (<1h). Even though the phosphacline rose from the west to the east from 30m to 20m no effect in UML (<12m) phosphorus dynamics was seen at the east end of the transect. There was apparent nutrient supply to the topmost part of the UML (>10m) at the salinity front even though no apparent increase in phosphate concentrations were observed.

At the relatively more phophorus depleted western end of the transect, uptake was dominated by the 0.2–1 μm size fraction. Uptake of phosphate was dominated by the 1–10 μm size fraction at the middle portion of the transect, slightly east of the sharp salinity front. At the east end of the transect, uptake was more evenly distributed between the two smaller size fractions. The proportion of uptake by the >10 μm size fraction had an even horizontal distribution, and it was always smallest. With increasing depth, more phosphorus accumulated into the fraction >10 μm. Most of this accumulation was accounted for by abiotic adsorbtion. This might be a novel mechanism for phosphorus scavenging by organisms associated with the cyanoabcterial aggregates. Cyanobacterial aggregates are large (>10μm), occur frequently during the summer months in the pelagic Baltic Sea and they possess buoyancy regulation mechanisms allowing them to move in and out of the phosphacline. Aggregates adsorb phosphate at deeper depths, which subsequently could be utilised by the associated organisms in nutrient deplete surface waters.

Development of satellite methods in Baltic ecosystem monitoring

Adam Kr□□el & Katarzyna Bradtke, Department of Physical Oceanography, Gdansk University

The idea of the project: *Development of satellite method of the Baltic ecosystem monitoring* (DESAMBEM; http://www.iopan.gda.pl/projects/PBZ-KBN-056-P04-2001) for creating mathematical models and a complex algorithm for the remote sensing of the Baltic ecosystem and its primary production was presented. The final aim of the project was the development of a routine remote sensing methodology for determining characteristics of the Baltic ecosystem such as distribution maps of sea surface temperature, upwelling currents, phytoplankton blooms, photosynthetically active radiation, pigment concentrations and primary production.

Taking into account results of DESAMBEM and other investigations, several aspects of the satellite monitoring of the Baltic Sea ecosystem were presented. Among others: i) influence of coastal upwelling on chlorophyll concentration at the sea surface, ii) nodularine vs. turbidity index, iii) relationships between algal bloom and such dynamic phenomena as eddies and thermal or saline fronts, iv) differences in spatial distribution of algal blooms between spring and summer.

Ecosystem effects and health hazards of cyanobacteria toxins in the Baltic – a review

Miina Karjalainen, Finnish Institute of Marine Research, Finland

The effect of cyanobacteria blooms in food webs has been recently investigated in several countries around the Baltic. This review summarises the results of a research group of Finnish Institute of Marine Research, also more throughly described in the Ph.D. thesis of Miina Karjalainen (2005). The aim of these studies was to increase the level of understanding of the effects of *N. spumigena* on zooplankton and planktivores feeding on zooplankton. In addition, the fate of nodularin in planktonic food webs was studied both experimentally and by collecting samples from the field. It was observed that zooplankton can act as a short-term vector for toxin transfer to higher trophic levels. This can affect the growth rates of especially sensitive life stages, like juvenile fish, due to the extra energy demand for detoxification. Therefore also organisms that do not consume cyanobacterial filaments directly, may be affected via their food. However, nodularin is effectively metabolised by aquatic organisms, therefore no biomagnification of nodularin takes place in the food web.

Latest results on nodularin concentrations in Southern Baltic sediments, mussels and flounder; with comments on health hazard of cyanobacterial blooms

Hanna Mazur, Anna Tyminska & Marcin Plinski, Gdansk University, Poland

In the Gulf of Gdańsk, as in other parts of the Baltic Sea, toxic blooms of *Nodularia spumigena* are an annual phenomenon. Nodularin (NOD) accumulation in sediments, blue mussels and flounders from the Gulf of Gdańsk were analysed. In the surface layers of the sediments NOD concentration ranged from 2.3 µg/kg d.w. several months after cyanobacterial bloom to 75.4 µg/kg d.w. during the bloom. The highest toxin content in mussels (139 µg/kg d.w.) was measured in July, during *N. spumigena* bloom. NOD was also detected in June and August, at low abundance of *N. spumigena* cells. In flounder, NOD accumulated in the liver (489 µg/kg d.w.), guts (20 µg/kg d.w.) and gonads (21 µg/kg d.w.) (July). In flounder muscles NOD was detected in samples collected in September. Hybride Quadrupole-TOF LC-MS/MS confirmed the presence of NOD in analysed samples. Additionally, other NOD analogues ([DMAdda^3]NOD and [dhb^5]NOD) were detected in sediments and mussel tissue. No NOD conjugates with reduced glutathione of cysteine (Cys) were found in fish and mussels. At two sampling stations situated in the coastal waters of the Gulf of Gdańsk the concentrations of NOD in sediments and mussels were significantly lower than those measured in the Gulf of Finland. In summer 2006 three incidents of cyanobacterial dermatitis were recorded.

Latest news on the neurotoxin BMAA in the Baltic Sea

Harri Kankaanpää & Markku Viitasalo, Finnish Institute of Marine Research

The neurotoxin BMAA was detected dy an international research group ca. one year ago in cyanobacteria species growing in the Baltic Sea. The analyses were however made from cultures, and filed analyses were lacking. The FIMR collected cyanobacteria for BMAA analyses from various parts of the Baltic Sea in 2005 and found out that BMAA does exist in the Baltic field populations of cyanobacteria, but that the concentrations are lower than those detected in labortory cultures. This far it is not known if BMAA poses any hazard for Baltic organisms, or for humans consuming Baltic Sea fish.

Physiological effects in juvenile three-spined sticklebacks feeding on zooplankton exposed to cyanobacteria

Jari-Pekka Pääkkönen, Sanna Rönkkönen, Miina Karjalainen, Markku Viitasalo, Finnish Institute of Marine Research, Finland

Feeding, growth and nutritional condition of juvenile three-spined sticklebacks (*Gasterosteus aculeatus*) were studied during and after an exposure to the nodularin-producing cyanobacterium *Nodularia spumigena*. Wild caught juvenile three-spined sticklebacks were fed for 15 days to *N. spumigena* exposed zooplankton, either in water containing cyanobacteria filments "bloom conditions"), or in water with no filaments. Food consumption was shown to be highest in *N. spumigena* bloom conditions, which may be due to zooplankton getting easier to catch after grazing on toxin containing cyanobacteria. However, fish that were feeding in bloom conditions had a lower RNA/DNA ratio and protein content than the control fish, which suggests a negative effect of cyanobacteria on fish larval growth.

Cyanobacteria-zooplankton-fish interactions in the Gulf of Finland: Results from cruises 2004-2005

Jari-Pekka Pääkkönen, Finnish Institute of Marine Research & the CYBER Consortium

We conducted two open sea cruises in 2004 and 2005, studying the distribution, abundance and behaviour of plankton and fish in the Gulf of Finland, with some sampling also conducted on the easternmost Baltic Proper. Application of two vessels, R/V Aranda and R/V Muikku, ensured intensive sampling on several biological, chemical and physical variables. The fish abundance and distribution were determined with echosounding and trawling, and environmental factors and zooplankton species and abundances were sampled with traditional methods as well as continuously measuring devices.

Variance partitioning methods were used to analyze the interactions between fish abundance, plankton communities and environmental variables. Distribution of cyanobacteria blooms was taken into account in the analysis of fish and zooplankton distribution. Preliminary results suggest that the abundance of fish was linked with marine copepods, which involves taxa (especially *Temora longicornis*). The fish abundance was also linked with the glacial freshwater relict *Limnocalanus macrurus*. The large size of this species may compensate for its relatively low abundance. The links between fish distribution and the other freshwater copepod *Eurytemora affinis* may be off less importance, although this species can be abundant in diets of clupeid fish.

Questionnaire on HAB effects on fishermen in Finland

Jari-Pekka Pääkkönen, Finnish Institute of Marine Research & Anna Tyminska, University of Gdansk, Poland

As a part of a larger research project investigating ecological and socioeconomic effects of the Baltic cyanobacteria, a questionnaire was sent to professional fishermen on the Finnish coastline while Polish fishermen were interviewed personally. The fishermen were asked: (1) if and how algal blooms have affected their fishing methods, catch and revenue, (2) which areas and fish species they consider to be affected, (3) how do they modify their fishing practises during blooms and (4) where do they get the information about the blooms. The results to be presented reveal area-, species- and gear-specific effects of blue-greens. According to fishermen replies, blooms affected their income in both countries. In the fishermen opinion, the reasons were: decreased total catch due to the fish disappear, the catch value, higher costs of fishing like: more fuel spent for checking nets more often, spent more time for cleaning the nets, stop fishing during the bloom. During the most intensive bloom season in July-August, general information about the cyanobacterial blooms is given in television, radio and newspapers. The most detailed and updated information is available in the internet, where cyanobacterial bloom prognosis and present occurrences are given. Finnish fishermen obtain information about blooms mainly from the TV and newspapers but Polish fishermen rely on their own observations. The cyanobacterial blooms are a problem for fishermen only during a relatively short period (4–5 weeks) in the northern Baltic, while in the southern Baltic the bloom period seems to be longer, and thus a more continuous nuisance.

Recent developments in ship-of opportunity monitoring of the Baltic Sea

Seppo Kaitala & Markku Viitasalo, Finnish Institute of Marine Research

Presently the Alg@line algal monitoring program of the Finnish Institute of Marine Research collects data from a route between Helsinki, Finland and Travemunde, Germany. Other regular routes operated by the Alg@line partners include those between Helsinki and Tallinn, Helsinki and Stockholm, and Kotka and Mariehamn (coastal Gulf of Finland and the Archipelago Sea). On all routes, salinity, temperature and chlorophyll a are continuoulsy monitored. Also, water samples are taken at regular intervals for quantitative or semi-quantitative phytoplankton analysis. New developments on the Helsinki-Travemunde route include online determination of phycocyanin and phycoerythrin, pigments specific to cyanobacteri and picocyanobacteria. Also, turbidity is measured and automated nutrient analysis will soon be started. The data is currently manually loaded from the instrument computers after the ship has arrived to port, and loaded to the web pages of FIMR (www.itameriportaali.fi). In summer 2006 a new communication system will start to operate where the data is transferred automatically via satellite from the ship to the institute, thus making the www-broadcasted data better up-to-date.

Annex 6: Potentially harmful phytoplankton species of the Baltic Sea

Regular blooms							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Nodularia spumigena	CYAN	Nost	HT	water	O, C	whole Baltic Sea except Bothnian Bay (occasional blooms in Gulf of Riga)	B
Aphanizomenon flos-aquae	CYAN	Nost	NT,PSP	water	O, C	whole Baltic Sea except Bothnian Bay (occasional blooms in Gulf of Riga)	B, F

Occasional blooms							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Microcystis aeruginosa	CYAN	Nost	HT	water	C	in estuaries and low saline coastal areas	F, B
Microcystis flos-aquae	CYAN	Nost	HT	water	C	in estuaries and low saline coastal areas	F
Anabaena circinalis	CYAN	Nost	HT, NT; PSP	water	C	in estuaries and low saline coastal areas	F
Anabaena cylindrica	CYAN	Nost	HT, NT; PSP?	water	O, C	whole Baltic Sea except Archipelago Sea and Both-nian Bay	F, B
Anabaena flos-aquae	CYAN	Nost	HT, NT; PSP	water	C	whole Baltic Sea	F
Anabaena lemmermannii	CYAN	Nost	HT, NT; PSP?	water	O, C	northern Baltic Proper and Gulf of Finland	B, F

Occasional blooms							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Anabaena spiroides	CYAN	Nost	HT, NT; PSP?	water	O, C	whole Baltic Sea, except northern Baltic Sea, Archipelago Sea and Bothnian Sea	F
Planktothrix agardhii	CYAN	Nost	HT	water	C	in estuaries, in highly eutrophied coastal areas with low salinity and in Bothnian Bay	B
Prorocentrum minimum (different strains)	DINO	Dino	depends on the strain	Oyster larvae	O, C	Kattegat, southern, central and northern Baltic Sea, Gulf of Finland	M, B
Dinophysis acuminata	DINO	Dino	DSP	mussels	O, C	whole Baltic Sea	M, B
Dinophysis norvegica	DINO	Dino	DSP	mussels	O, C	whole Baltic Sea	M, B
Heterocapsa triquetra	DINO	Dino	could be harmful in small inlets causing oxygen depletion	?	O, C	whole Baltic Sea except Bothnian Bay, (in low numbers in Gulf of Riga)	M, B
Alexandrium ostenfeldii	DINO	Dino	PSP, NSP	mussels	O, C	southern, central and northern Baltic Sea, Gulf of Gdansk, Archipelago Sea (in low numbers in Kattegat and Belt Sea,)	M
Ceratium fusus	DINO	Dino	anoxia, and harmful to invertebrate larvae	?	O	Kattegat, southern Baltic Sea	M
Dictyocha speculum, (flagellate form)	CHRY	Dict	IC	fish	C	western and southern Baltic Sea	M, B
Chrysochromulina spp. (at least about 40 species, e.g. C. polylepis, C. leadbeateri, C. brevifilum, C. kappa, C. strobilus)	HAPT	Prym	IC	fish	O, C	western Baltic Sea (sometimes in high numbers also in the northern Baltic proper)	M, B, (F)
Prymnesium parvum	HAPT	Prym	IC	water	C	coastal inlets with very low salinity	B, F

Occasional blooms							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Chaetoceros borealis	CHRY	Diat	mechanical	fish	O	Kattegat and Belt Sea	M
Chaetoceros danicus	CHRY	Diat	mechanical	fish	O, C	whole Baltic Sea	M, B
Chaetoceros decipiens	CHRY	Diat	mechanical	fish	O	western and southern Baltic Sea	M
Chaetoceros impressus	CHRY	Diat	mechanical	fish	O, C	south-eastern Baltic Sea	M, B
Pseudo-nitzschia spp. (P. calliantha, P. delicatissima, P. multiseries, P. pseudodelicatissima, P. pungens, P. seriata)	CHRY	Diat	ASP	mussels	O, C	Kattegat and Belt Sea, southern Baltic Sea	M
cf. Chattonella sp.	CHRY	Dict	clogging of fish gills by mucus excretion, gill damage by haemolytic substances; NT?	fish	O, C	Kattegat and Belt Sea	M

Regularly in plankton but not in bloom amounts							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Anabaena cylindrica	CYAN	Nost	HT, NT; PSP?	water	O, C	whole Baltic Sea except Archipelago Sea and Bothnian Bay	F, B
Anabaena lemmermannii	CYAN	Nost	HT, NT; PSP?	water	O, C	Gulf of Bothnia, Gulf of Riga, Central Baltic Sea, Southern Baltic proper	B, F
Dinophysis acuta	DINO	Dino	DSP	mussels?	O, C	whole Baltic Sea except Gulf of Bothnia	M, B
Dinophysis rotundata	DINO	Dino	DSP	mussels	O, C	whole Baltic Sea	M, B
Protoceratium reticulatum	DINO	Dino	DSP	mussels?	O	whole Baltic Sea	M
Chrysochromulina spp.	HAPT	Prym	IC	fish	O, C	whole Baltic Sea	M, B, (F)
Chaetoceros spp.	CHRY	Diat	mechanical	fish	O, C	whole Baltic Sea	M, B

Regularly in plankton but not in bloom amounts							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Coelosphaerium kuetzingianum	CYAN	Nost	NT, HT	water	C	whole Baltic Sea, except Archipelago Sea and Bothnian Sea	F
Microcystis ichtyoblabe	CYAN	Nost	HT?	water	C	in estuaries, in highly eutrophied coastal areas with low salinity in Kattegat and Belt Sea, Arkona Basin, southern Baltic Sea	F
Microcystis viridis	CYAN	Nost	HT	water	C	in estuaries, in highly eutrophied coastal areas with low salinity in Arkona Basin, southern Baltic Sea	F
Microcystis wesenbergii	CYAN	Nost	HT	water	C	in estuaries, in highly eutrophied coastal areas with low salinity in Arkona Basin, southern Baltic Sea, Gulf of Riga, Gulf of Finland	F
Snowella lacustris	CYAN	Nost	HT	water	C	whole Baltic Sea in estuaries, in highly eutrophied coastal areas with low salinity	F
Woronichinia naegeliana	CYAN	Nost	NT, HT	water	C	whole Baltic Sea, in estuaries, in highly eutrophied coastal areas with low salinity	F
Anabaena spp. (A. macrospora, A. planctonica)	CYAN	Nost	NT	water	O, C	southern Baltic Sea, Bothnian Bay	F, B
Aphanizomenon gracile	CYAN	Nost	PSP	water	O	whole Baltic Sea except Kattegat and Belt Sea	F, B
Trichormus variabilis	CYAN	Nost	NT	water	O	southern Baltic Sea, Gulf of Finland	F

Regularly in plankton but not in bloom amounts							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Prorocentrum lima	DINO	Dino	DSP	?	C	benthic, occasionally in littoral plankton, Kattegat and Belt Sea	M
Dinophysis sacculus	DINO	Dino	DSP	mussels	C	Kattegat and Belt Sea	M
Amphidinium carterae	DINO	Dino	Haemolytic compounds	?	O	Kattegat and Belt Sea	M
Amphidinium operculatum	DINO	Dino	Haemolytic compounds	?	O	Kattegat and Belt Sea	M
Akashiwo sanguinea	DINO	Dino	Anoxia	fish	O	whole Baltic Sea	M
Karenia mikimotoi	DINO	Dino	IC	fish	O	Kattegat and Belt Sea	M
Karlodinium veneficum	DINO	Dino	IC	fish	O	Kattegat and Belt Sea	M
Noctiluca scintillans	DINO	Dino	NH_3-producer	fish	O	Kattegat, Belt Sea and Arkona Basin	M
Peridiniopsis polonicum	DINO	Dino	?	fish	C	southern Baltic Sea, Gulf of Riga, Gulf of Finland	F
Protoperidinium crassipes	DINO	Dino	DSP		O	Kattegat and Belt Sea	M
Protoperidinium curtipes	DINO	Dino	DSP	?	O	Kattegat and Belt Sea	M
Scrippsiella trochoidea	DINO	Dino	IC?	?	O	whole Baltic Sea	M
Alexandrium tamarense	DINO	Dino	PSP	fish	O	Kattegat and Belt Sea	M
Alexandrium spp.	DINO	Dino	PSP, NT	mussels	C	southern and western Baltic Sea	M, B
Ceratium tripos	DINO	Dino	Anoxia, hypoxia	?	O	Kattegat and the Belt Sea, southern Baltic Sea	M
Gonyaulax spinifera	DINO	Dino	DSP	mussels	O, C	whole Baltic Sea except Gulf of Bothnia , Archipelago Sea and Gulf of Riga	M
Lingulodinium polyedrum	DINO	Dino	DSP	mussels	O, C	Arkona Basin, Kattegat, Skagerrak,	M
Phaeocystis globosa	HAPT	Prym	Anoxia, hypoxia	?	C	Kattegat and Belt Sea, southern Baltic Sea	M

Regularly in plankton but not in bloom amounts							
Species	***Division***	***Class***	***Toxicity and/or other harmful effect***	***Toxins in or harmful effect through…***	***Open sea/ coastal***	***Distribution in the Baltic Sea***	***Marine/ brackish/ fresh water***
Dictyocha speculum	CHRY	Dict	IC?	water	O, C	southern and western Baltic Sea, Arkona Basin, Kattegat, Skagerrak	M

Divisions

Cyanophyta (Cyanobacteria) - CYAN

Dinophyta (Pyrrhophyta) - DINO

Haptophyta - HAPT

Chrysophyta (Heterokontophyta) - CHRY

Classes

Nostocophyceae (Cyanophyceae) - Nost

Dinophyceae - Dino

Prymnesiophyceae (Haptophyceae) - Prym

Dictyochophyceae - Dict

Diatomophyceae (Bacillariophyceae) - Diat

Raphidiophyceae (Chloromonadophyceae) – Raph

Abbreviations of toxin syndromes

ASP = Amnesic Shellfish Poisoning

DSP = Diarrhetic Shellfish Poisoning

HT = Hepatotoxic

IC = Ichtyotoxic

NT = Neurotoxic

NSP=Neurotoxic Shellfish Poisoning

PSP = Paralytic Shellfish Poisoning

Acknowledgements and references

This checklist of potentially harmful species of the Baltic Sea is an update of Table 2 (compiled by K. Kononen, M. Elbrächter, M. Balode, S. Hällfors, G. Hällfors, J. Göbel, S. Hajdu, I. Olenina, I. Konoshina, A. Jaanus, I. Ledaine and E. Dahl) in Report of ICES-IOC-SCOR Study Group on GEOHAB Implementation in the Baltic ICES CM 2002/H:02 Ref. ACME, Annex 3: Proposal for Cooperative HAB Study in the Baltic Sea.

Updates

Updated in April 2004 by Seija Hällfors and Guy Hällfors, according to:

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Annex 7: Observed concentrations of nodularin in the Baltic Sea water and biota

Table A7.1: Observed concentrations of nodularin in Baltic Sea biota, from field-collected samples and after experimental exposures in the laboratory. Source: Karjalainen (2005), with updates.

SOURCE		NODULARIN CONCENTRATION	UNIT	SAMPLING TIME	REFERENCE
Water	Field	<0.5–2.6	µg l^{-1}	August 1999	Kankaanpää *et al.*, 2001a
Water	Field	14	µg l^{-1}	August 1999	Vuori *et al.*, 2001
Water	Field	0.02–0.05	µg l^{-1}	June–July 1998, 1999	Repka *et al.*, 2004
Seston	Field	90–18135	µg l^{-1}	June–September 2001	Mazur and Plinski, 2003
Phytoplankton	Field	100–2400	µg g^{-1} DW	August 1986	Sivonen *et al.* 1989
Phytoplankton	Field	0–18100	µg g^{-1} DW	July–August 1990	Kononen *et al.* 1993
Phytoplankton	Field	500–2300	µg g^{-1} DW	August 1999	Kankaanpää *et al.* 2001a
Phytoplankton	Field	200–6000	µg g^{-1} DW	August 2000	Laamanen *et al.* 2001
Phytoplankton	Field	3000–3520	µg g^{-1} DW	June–Sep 2001	Mazur and Plinski, 2003
Phytoplankton	Field	0.004–565	µg l^{-1}	June–Sep 2002	Henriksen 2005
Phytoplankton	Field	9800±7000	µg g^{-1} DW	June–Sep 2002	Henriksen 2005
Phytoplankton	Field	149–804	µg l^{-1}	July 2003	Luckas *et al.* 2005
Phytoplankton	Field	100–1000	µg g^{-1} DW	July 2003	Karlsson *et al.* 2005
Zooplankton	Field	0–0.62	µg g^{-1} DW	August 2001, 2002	Karjalainen *et al.*, 2006
Zooplankton	Exp.	0.8–1.3	µg g^{-1} DW	exp., fed with natural phytoplankton community	Kozlowsky-Suzuki *et al.*, 2003
Zooplankton	Exp.	4.94	µg g^{-1} DW	exp., fed with *Nodularia*	Lehtiniemi *et al.*, 2002
Zooplankton	Exp.	1.3–4.5	µg g^{-1} DW	exp., fed with *Nodularia*	Kozlowsky-Suzuki *et al.*, 2003
Zooplankton	Exp.	0.1–0.2	µg g^{-1} WW	exp., via water	Karjalainen *et al.*, 2003
Blue mussels	Field	2.15±0.06	µg g^{-1} DW	June–September 1999	Sipiä *et al.*, 2001a
Blue mussels	Field	0.04–1.49	µg g^{-1} DW	August 1999–September 2000	Sipiä *et al.*, 2002a
Blue mussels	Field	0.5–0.64	µg g^{-1} DW	July–August 2001	Karlsson *et al.*, 2003a
Blue mussels	Exp.	0.1	µg g^{-1} DW	exp., seawater	Svensen *et al.*, 2005
Blue mussels	Exp.	80.4	µg g^{-1} DW	exp., fed with *Nodularia*	Svensen *et al.*, 2005
Clams	Field	0.1±0.13	µg g^{-1} DW	August 2000	Sipiä *et al.*, 2002a
Clams	Exp.	0.32	µg g^{-1} DW	exp., via water	Kankaanpää *et al.*, 2001b
Clams	Exp.	1.6–16.6	µg g^{-1} DW	exp., fed with *Nodularia*	Lehtonen *et al.*, 2003

Source		Nodularin concentration	Unit	Sampling time	Reference
Mysid shrimps	Field	0.21–0.56	µg g^{-1} DW	July–August 2004	Karjalainen *et al.*,unpubl.
Mysid shrimps	Exp.	0.7	µg g^{-1} DW	exp., via zooplankton	Engström-Öst *et al.*, 2002
Mysid shrimps	Exp.	0.59	µg g^{-1} DW	exp., via zooplankton	Karjalainen *et al.*, 2005
Herring muscle	Field	0.0025–0.0065	µg g^{-1} DW	August 1997	Sipiä *et al.*, 2002b
Pike larvae	Exp.	0.41	µg g^{-1} DW	exp., via zooplankton	Karjalainen *et al.*, 2005
Stickleback, viscera	Field	0.035–0.17	µg g^{-1} DW	August 1999	Kankaanpää *et al.*, 2001a
Stickleback	Exp.	0.14	µg g^{-1} DW	exp., via zooplankton	Engström-Öst *et al.*, 2002
Flounder liver	Field	0.082–0.637	µg g^{-1} WW	August 1995	Karlsson *et al.*, 2003b
Flounder liver	Field	0.137–0.399	µg g^{-1} DW	August 1999	Sipiä *et al.*, 2001b
Flounder liver	Field	max 0.41±0.012	µg g^{-1} DW	August 1999 – Sep 2000	Sipiä *et al.*, 2002a
Flounder liver	Field	0.24–0.35	µg g^{-1} DW	July–August 2001	Karlsson *et al.*, 2003a
Flounder liver	Field	20–2230	µg g^{-1} DW	July–September 2002	Kankaanpää *et al.*, 2005
Cod liver	Field	0.053–0.056	µg g^{-1} DW	August 1998	Sipiä *et al.*, 2001b
Salmon liver	Field	0.0049	µg g^{-1} DW	August 1997	Sipiä *et al.*, 2002b
Sea trout liver	Exp.	Max 1.6	µg g^{-1} DW	exp., oral exposure	Kankaanpää *et al.*, 2002
Eider liver	Field	0.003–0.018	µg g^{-1} DW	August–September 2002	Sipiä *et al.*, 2003