Report of the first meeting of SCOR/LOICZ Work Group 132

Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems

28-31 July 2008, GKSS-Forschungszentrum, Geesthacht GmbH, Geesthacht, Germany

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1. BACKGROUND

To date, attempts to relate the occurrence of particular HAB species with nutrient loading have largely been based on a limited amount of data from the literature on HAB occurrences where nutrient loading and other parameters could also be found. Most available studies lack specific information on nutrient loading rates and often details of the coastal typology. Initial efforts combining literature data on HAB species occurrences with the outputs of global nitrogen loading models suggested a high degree of correspondence for one group of HABs, as represented by the dinoflagellate *Prorocentrum minimum*, but a lesser correspondence for the species that tend to form paralytic shellfish poisoning (Glibert and Burkholder 2006). Comparable relationships for other nutrients or nutrient forms are not yet available, and these initial efforts represent only a small portion of HAB species groups and the data were not geo-referenced.

Major efforts have been underway that will enable to study the relationships between HAB occurrences and nutrient loading. The IOC-HAB program is developing a global database on the occurrence of species, along with many site characteristics. Maps based on frequency of occurrence are also available for ICES nations for the past ten years. There are also a number of excellent databases for particular regions that have not yet been submitted to the IOC-HAB program and thus are not yet included in the database.

The Unesco-IOC Global NEWS work group has developed models of nutrient export for dissolved inorganic, organic and particulate nitrogen, phosphorus and carbon, as well as for dissolved silica (Seitzinger et al., 2005; and more recent work). These models account for nutrient sources (natural as well as anthropogenic, including fertilizer, atmospheric depositon, crops, manure and sewage), hydrology and physical factors watershed characteristics such as river discharge, land use, precipitation intensity, human population and in –river processing and removal. The Global NEWS workgroup is currently developing input databases for their nutrient export models that are consistent with the four scenarios for the year 2030 and 2050 outlined in the Millennium Assessment.

Several classification schemes of estuarine and coastal typology are now available that have been related to algal composition, but not necessarily HABs (e.g., the global LOICZ typology, the typology used in the US assessment of coastal ecosystems and an extension of the LOICZ work in the GNUX project at

Utrecht University).

This SCOR working group on "Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems" was formed to use the Global NEWS data, coastal typologies and available information on HAB occurrences to investigate and establish possible relationships between nutrient loading, nutrient forms and sources and HAB occurrence. In this working group the Global NEWS future scenarios will also be used in concert with the relationships to be established between nutrient loading and HAB occurrence to explore future scenarios of HAB occurrence. Hence, this effort also will begin to link human dimensions with coastal ecosystem effects.

This is the report of the first working group meeting hosted by LOICZ at GKSS-Forschungszentrum, Geesthacht GmbH, Geesthacht, Germany, 28-31 July 2008. The list of participants and the meeting programme of the first meeting is added as annex 1 and 2 to this report. The Working Group wishes to underscore its approeciation to LOICZ for co-sponsoning this working group and for its logistical support of the first meeting.

2. REPORT OF THE MEETING
The terms of reference in the original project proposal to SCOR have been discussed by the working group. The result was the following, slightly modified list of terms (no change in intent; wording clarified) which was agreed upon by the working group

Terms of reference for the working group
1. Integrate existing databases and nutrient loading databases into a comparable GIS format;
2. Advance the development of a GIS coastal typology and its relationship to HABs;
3. Interrogate the above databases for relationships between HAB species, nutrient loadings/forms/ratios and coastal typology and develop broad relationships with specific HAB species;
4. Explore possible changes in HAB occurrences in the future (for example, year 2030) using the relationships developed above and global nutrient export patterns under the Millennium Scenarios;
5. Publish the results in peer-reviewed scientific journals, and develop articles for GEOHAB and LOICZ newsletters as well as other outlets. Papers may cover the global perspective, regional time series and individual case studies.

A large part of the discussions concentrated on the key questions that need to be answered by the working group that cover the issues formulated in the terms of reference and that can be translated in a workable approach. Four key questions evolved from these discussions:

Key Questions
Do relationships exist between HABs and nutrient loading and can we quantify those with respect to:

1. Typology of coastal marine ecosystems (based on physical and biological parameters)?
2. Spatial variation of nutrient loading, forms and ratios?
3. Temporal variation of nutrient loading, forms and ratios?
4. Relative contribution of different nutrient sources including aquaculture to nutrient loading?

Approach and work plan

Together with the key questions, the group also discussed the approaches to be followed in the three years of the project. First of all the available information on the occurrence of HAB species will need to be brought together by this working group. For this purpose the work will be organized by world region, i.e. Europe, North and Central America, South America, Asia. Possibilities to incorporate African data and data from Oceania will be investigated during the first months of the first year of the working group. The idea is to bring together information from ICES/PICES, HAEDAT, CERAC (UNEP) for Korea, Japan, Russia and China, Gulf of Oman and Arabian Sea, data for North America, the Gulf of Mexico and the Pacific coast from California to Peru, Chile, including information available through the members of the working group and their contacts. Where available, the data will also include time series. The identification of databases, querying the availability to this group, and assessing the quality and completeness, and collection of the data will be performed within the first year.

One of the products evolving from the collection of the HAB occurrences information is a series of maps of HAB occurrences and, if data allow for that, their extent and magnitude. Production of a map for the occurrence of Noctiluca was already planned to be completed within the first year. Plans for the production of maps for other HAB species will evolve from the data collection.

Satellite data on chlorophyll, ocean colour, sea surface temperature will be collected, transformed to a common format and resolution, and used to investigate and establish possible relationships between algal biomass and nutrient loading, using a global coastal ocean model as a framework. In the first year this will be performed, and on the basis of these results further work will be planned.

A task force of the working group will work on a common structure of the HAB database, so that eventually a global database will be compiled from the regional data. Parallel to this, and depending on the database structure and the completeness of the data, specific statistical techniques will be proposed in the first year to be used for the analysis of the data to investigate relationships between species-specific HAB occurrences and nutrient loading, nutrient ratios and increasing nutrient loading and changing ratios (questions 2-4).

The working group will use the GNUX coastal typology, which is an extension of the LOICZ typology, based on more detailed information such as bathymetry, and including models and approaches for describing flushing time and nutrient retentions, aspects that are highly relevant to the work of this group. The GNUX typology will be completed in spring 2009.

The Global NEWS data are being prepared for 1970-2000 by that working group, and data will be made available in spring 2009, together with the projections of nutrient loading following the four Millennium Assessment scenarios.

Global NEWS data include river nutrient export to coastal marine ecosystems. In the working group it was agreed upon that there is a need to develop spatially explict maps for the nutrient loading caused by aquacultural production of fish, and nutrient uptake and transformations caused by production of seaweeds and shellfish. Since the information to produce such maps is readily available from FAO's FISHSTAT, together with information from FAO reports and literature of feeding regimes, management and nutrient use efficiencies in fish farming enterprises, the working group will produce these maps within the first 15 months of this project. This is of particular interest because of aquacultural activities are strongly concentrated spatially, and are thus "point" sources of nutrients.

The actual analysis of the HAB occurrences data and maps, and Global NEWS nutrient loading data is foreseen for the period after the second workshop in October 2009. Hence, the first 15 months will be used for data collection and database structure. However, some products that will be completed in the first 12-15 months are already specified below.

Key question 1. The first key question relates to the possibility that certain types of coastal ecosystems (estuaries, lagoons, fjords, deltas, etc.) show a propensity to the development of HABs or specific HAB species. For this purpose overlays will be made of the spatially explicit maps of HAB occurrences and coastal typology to investigate possible relationships. For those maps of species-specific HAB occurrences this exercise is planned to be completed in the second year of the project.

Key question 2. A similar exercise is needed to answer the second question on the impact of nutrient loading. Overlays will be made of the HAB occurrences maps and the Global NEWS nutrient loading data including data on nutrient loading and nutrient transformations caused by aquaculture for the year 2000, using the coastal typology map as a framework. Hence, the river nutrient export and loading within a specific type and location will be related to the HAB occurrences map.

Key question 3. For answering the third question the working group will use the data covering the period 1970-2000 for nutrient loading which will be made available by Global NEWS, including the aquacultural nutrient loading and transformations and available time series data on HAB occurrences in manner similar to that used under key question 2.

Key question 4. For investigating possible relationships between the sources of nutrients and the occurrence of HABs, the working group will use the Global NEWS data on the relative contribution of point sources (households, industries),
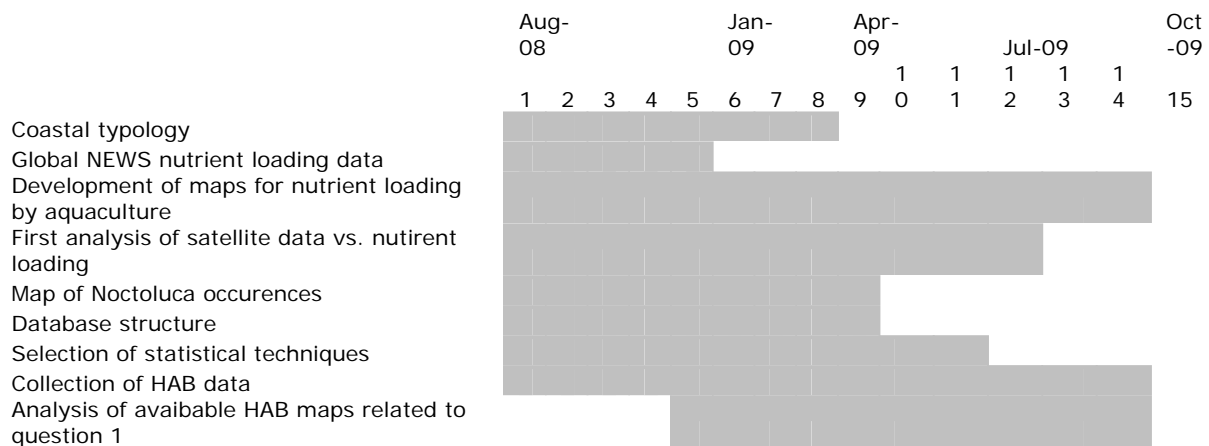
fertilizer, animals manure, natural vegetation, atmospheric deposition, and aquaculture. Where relevant, these relationships will be established.

A first paper for LOICZ, SCOR and GEOHAB (Global Ecology and Oceanography of Hamrful Algal Blooms Programme) newsletters will be prepared in autumn 2008. Possibilities for making a website for this working group for advertising the work and for data exchange will be investigated.

Timing of activities
A detailed planning of the activities for the first 15 months was made during the meeting. The time schedule is summarized below.

	Aug-08				Jan-09			Apr-09			Jul-09			Oct-09
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Coastal typology
Global NEWS nutrient loading data
Development of maps for nutrient loading by aquaculture
First analysis of satellite data vs. nutirent loading
Map of Noctoluca occurences
Database structure
Selection of statistical techniques
Collection of HAB data
Analysis of avaibable HAB maps related to question 1

A detailed planning by task for the period after October 2009 will be developed at the Beijing meeting of the working group.

3. DATES OF MEETINGS
1. 13-16 October 2009 in Beijing, in conjunction with the 2nd Open GEOHAB Meeting on HABs and Eutrophication— The second meeting will be to critique and interpret the maps and data collection, and to outline the data analysis and the projections of future scenarios required; and
2. Fall 2010, in conjunction with the 14th International HAB meeting in Greece— The third and final workshop will be to assess the scenarios developed from applying the Millenium Assessment projections; to critique, interpret and discuss all the findings of the working group; and to prepare the final manuscripts and report.

References

Glibert, P.M. and J.M. Burkholder. 2006. The complex relationships between increasing fertilization of the earth, coastal eutrophication and proliferation of harmful algal blooms. pp 341-354 in: E. Graneli and J. Turner (eds), *Ecology of Harmful Algae*. Springer.

Seitzinger, S.P., J.A. Harrison, E. Dumont, A.H.W. Beusen, and A.F. Bouwman. 2005. Sources and delivery of carbon, nitrogen and phosphorous to the coastal zone: An overview of global nutrient export from watersheds (NEWS) models and their application. *Global Biogeochemical Cycles* 19:GB4S09.

Annex 1.

List of Attendees for Working Group 1
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Annex 2. Draft Program of the first meeting of the working group in LOICZ, GKSS Geesthacht, Germany, 28-31 July 2008.

AGENDA

Day 1: Introductions
8:45 - 9:00 Introduction and welcome: Hartwig Kremer, Franciscus Colijn
               Pat Glibert and Lex Bouwman
9:00 - 10:30 Introductory overview talks and introduction of the task of the group (30 min each)
               Sybil Seitzinger
               Pat Glibert
               Lex Bouwman
10:30 - 11:00 Break
11:00 - 12:40 Introductory talks by working group members (20 min each)
12:40 - 2:00 Lunch
2:00 - 3:00 Continue introductory talks
3:00 - 3:30 Break
3:30 - 5:00 General discussion

Day 2: Small group discussions
8:45 - 9:00 Overview of goals for the day: Pat Glibert, Lex Bouwman
9:00 - 10:30 Groups 1 and 2 (1.5 hours)
               HAB's: good candidate, and data availablity
               Land-based nutrient export: status and data sources
10:30 - 11:00 Break
11:00 - 11:30 Reconvene and report
11:30 - 1:00 Groups 3, 4 – by region (1.5 hours) : data availability
1:00 - 2:00 Lunch
2:00 - 2:30 Reconvene and report
2:30 - 4:00 Groups 5,6 – data bases and time/space scales (1.5 hours)
               Export models
               Time series
4:00 - 5:00 Reconvene, report and group discussion

Day 3: Moving forward
8:45 - 9:00 Overview of goals for the day: Pat Glibert, Lex Bouwman
9:00 - 10:30 Case study
10:30 - 11:00 Break
11:00 - 12:30 Case study continued
12:30 - 2:00 Lunch
2:00 - 4:00 Beyond the case study- how to realistically bring data together; other data sources

Day 4: Moving forward and next steps
8:45- 9:00 Overview of goals for the day: Pat Glibert, Lex Bouwman
9:00 - 10:30 Group discussion on additional expertise required
10:30 - 11:00 Break

11:00 - 12:30   Review of working group terms of reference; tasks and time line
12:30 - 2:00   Lunch
 2:00 -   4:00   Content for the web site; SCOR report drafted