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Report of the Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH)

2–5 March 2009

Warnemünde, Germany

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H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) met at the Leibniz Institute for Baltic Sea Research (IOW) in Warnemünde, Germany on 2–5 March 2009.

The "new" SGEH was established to follow the main lines of the "old" SGEH, established in 2003 in support of the Baltic Sea Regional Programme (BSRP). The original focus of SGEH covered all major themes related to the general concept of ecosystem health (EH). The outcomes of the SGEH contain a substantial amount of relevant information and proposals that are valuable for the formulation of practical integrated strategies to the assessment of EH in the Baltic Sea.

As the second phase of the BSRP did not come to reality the SGEH was on the brink of being dissolved. Among the wide scope of SGEH internal subgroups dealing with eutrophication, biodiversity, fisheries impacts and socio-economic issues, the subgroup on hazardous substances in the Baltic Sea, and particularly on their biological effects and development of monitoring and assessment methods, is focusing on work that is currently not being carried out by any other ICES expert group in the Baltic Sea area. To ensure that this type of activity embracing a lesser focused but important and internationally emerging field it was considered important that the SGEH group would continue its activities.

Since the focus of the SG became changed, its name was changed from 'Study Group on Baltic Ecosystem Health Issues in support of the BSRP' to the present 'Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea', which better portrays the new focus of the group. Instead of tackling the whole large field of themes comprising the general concept of EH the SGEH is now targeted on (1) hazardous substances and especially their biological effects, and (2) biodiversity. The group focuses especially on linkages between hazardous substances and their effects at different level of biological levels, from the molecular "early warning" level via effects on individuals and population up to ecosystem level. To successfully proceed with the development of integrated methods for the monitoring and assessment of EH in different Baltic Sea subregions, the SGEH relies on linking and collaboration with other expert groups targeted on issues not focused on by SGEH but which still are highly relevant for the outcome. The other main task of the present SGEH is to contribute to the development of integrated chemical-biological monitoring of hazardous substances in the Baltic Sea following the requests of the Baltic Sea Action Plan. This will be done in harmony with the work done in the OSPAR area (WKIMON, SGIMC) and involves close collaboration with HELCOM.

When planning the first meeting of the "new" SGEH it was seen of great importance to carefully define and agree upon the new role of the group. The "legacy" of the "old" SGEH was inspected by the group's members and is summarised in the report as an overview of the work done already. Further discussions and presentations resulted in the formulation of a general task agenda for the coming meetings:

- future meetings should focus on aspects related to all four main issues of the HELCOM Baltic Sea Action Plan (eutrophication, hazardous substances, biodiversity, maritime activities) in order to be able to make recommendations concerning monitoring and assessment in an integrated way, needed to assess ecosystem health;

- strengthening of interactions and collaboration among groups dealing with integrated assessments (e.g. WGIAB and OSPAR/SGIMC) aiming at harmonisation of targets and methodology;
- inclusion of a wider scope of national experts to attend the SGEH meetings in regard to the integrated approach for monitoring and assessment;
- establishing and maintaining close links between SGEH and HELCOM, the main end-user of the SGEH deliverables and recommendations;
- serving as a key expert group in issues related to the implementation of the BSAP as well as the Marine Strategy Framework Directive where the Baltic Sea has been identified as a pilot area;
- targeting at the implementation of biological effects methods in the HELCOM monitoring and assessment toolbox.

1 Opening of the meeting

ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) met at the Leibniz Institute for Baltic Sea Research (IOW) in Warnemünde, Germany on 2–5 March 2009.

The SGEH Chair Kari Lehtonen welcomed the participants of the meeting. He invited the participants to introduce themselves and their affiliations and describe their area of interest and field of expertise. The list of attendees is given in Annex 1.

The Chair then introduced the goals of SGEH and the purpose of this meeting (see Introduction). Further, he expressed the gratitude of the group to the local hosting organization and SGEH local member Rolf Schneider who introduced practical arrangements for the meeting. A welcome address was kindly presented by the Vice Director of IOW, Prof. Wolfgang Fennel.

The Chair presented the Terms of Reference for the meeting:

2008/2/BCC01: The Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH) will be renamed the Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) [Chair: Kari Lehtonen*, Finland] and will meet from 2–5 March 2009 in Warnemünde, Germany, to:

a) report on new developments regarding ecosystem-based approaches to management of the marine environment with particular reference to progress in EU, ICES, HELCOM and OSPAR;

b) develop the Ecosystem Health concept in the Baltic Sea specifically in relation to biological effects of hazardous substances and loss of biodiversity;

c) evaluate the progress made regarding the planning of Sea-going Demonstration Project on the Ecosystem Health of the Gulf of Finland;

d) review progress within the BEAST project (Baltic Sea BONUS+ Programme);

e) follow the developments of the newly established SGIMC (the successor of the closed ICES/OSPAR WKIMON) in providing guidance and technical annex for integrated monitoring of chemicals and their biological effects in the Baltic Sea and addressing specific questions in regard to specific biomarker methods to be employed in the Baltic Sea;

f) review and update progress with national and international biological effect monitoring activities e.g. OSPAR, MEDPOL, WFD, Marine Strategy, harmonisation initiatives, integrated assessment and application of biological effect techniques, and the ICON/NSHEALTH programme;

g) review and report the progress on the development of assessment criteria and integrated chemical-biological effect assessment tools in the Baltic Sea region;

h) contribute to the implementation of the HELCOM Baltic Sea Action Plan (BSAP) in relation to sustaining Baltic Sea Ecosystem Health, and in particular regarding preservation of its biodiversity, and prevention against effects of hazardous substances.

2 Adoption of the agenda

The Chair invited participants to examine the Terms of Reference (ToR) and went through the agenda explaining the priority and background to the agenda items. A draft agenda had been circulated prior to the meeting (Annex 2) and it was agreed that the ToRs were reflected in the agenda. The agenda was adopted and a tentative timetable and share of work was agreed upon.

3 Appointment of rapporteurs

Due to the reorganization of the SGEH (see below) a considerable proportion of time was dedicated to summarizing the past work and achievements of the previous SGEH, adjusting and refining the focus and aims of the work of the new SGEH, and planning of the next meeting. Therefore, only few of the agenda items were actually "reported" by a specific group member and rapporteurs in that sense were not named.

4 Review and discussion on the past activities of the predecessor of the SGEH (ICES SGEH, 2003–2007) (ToR a, ToR b)

4.1 Introduction

The group felt it very important to review and discuss the work accomplished during the previous edition of the SGEH (The Study Group on Baltic Ecosystem Health Issues in support of the BSRP). A summary of the previous activities (the "legacy" of the past SGEH) was considered to be valuable as a theoretical and practical starting point for (1) revisiting the definition of the meaning of the term "ecosystem health" in the Baltic Sea, (2) updating the goals and outputs of the new SGEH, and (3) establishing the working methods of the new SGEH.

The group split into subgroups and reviewed the reports of the previous SGEH that met 5 times during the period 2003–2007. In addition, the report of the 2005 Workshop on Report of the ICES/BSRP/HELCOM/UNEP Regional Sea Workshop on Baltic Sea Ecosystem Health Indicators was reviewed. The aim of the reviews was to extract the most valuable information relevant for the work of the new SGEH.

It is pointed out that most parts of the text in this section are selected direct extracts of the previous reports. However, some editing has been made for clarification and readability.

4.2 SGEH 2003 meeting (ICES 2004)

4.2.1 Agreement on definitions

Definitions as agreed by Bergen Declaration, 2002/ EC European Marine Strategy / HELCOM / OSPAR:

- The ecosystem approach is commonly defined as "...the comprehensive integrated management of human activities based upon the best available scientific knowledge about the ecosystem and its dynamics in order to identify and take action on influences which are critical to the health of the marine ecosystem, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity"

Definitions, as agreed by 5th North Sea Conference, Bergen Declaration 2002 and HELCOM MONAS 6/2003 for the Baltic Sea:

- Ecological quality is an "...overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographical, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities."
- Ecological Quality Elements are the individual aspects of overall ecological quality.
- Ecological Quality Objectives are the desired level of ecological quality (EcoQ). This level can be set in relation to a reference level.

One goal is to maintain ecosystem health and integrity which means:

- maintain viable populations of species;
- protect representative examples of all native ecosystem types across their natural range of variation;
- maintain evolutionary and ecological processes;
- manage landscape and species in response to both short- and long-term environmental change;
- accommodate human activities within these constraints.

Ecosystem health: "To be healthy and sustainable, an ecosystem must maintain its metabolic activity level and its internal structure and organisation, and must resist external stress over time and space scales relevant to the ecosystem." (Costanza et al. 1992).

Two main distinctions can be applied to concepts of ecosystem health, and the SGEH chose to adopt both approaches:

- Forward Looking - A healthy or sustainable state is defined a priori, and it is the aim of the Baltic Sea Regional Projects to work toward attaining this goal of a healthy state. Progress reports and lessons learned will be provided periodically.
- Backward Looking - A particular healthy state is not defined explicitly. Rather, by re-examining past changes in environmental conditions relative to currently monitored conditions, early warning signs of ill health (unexpected conditions) are detected and work is focused on defining thresholds of change in chronic conditions. BSRP pollution and ecosystem health objectives are met in this approach by observing the occurrence or non-occurrence of changes. These will be supported by real-time reporting. Over time, thresholds of change in baseline condition will be established and will define structural and functional ecosystem health. Summary reports will be provided on the changing state of the Baltic Sea ecosystem when mechanisms and/or predictions of changes have been validated.

Both approaches are required to integrate findings and, in turn, support the productivity indicator, fish/fisheries indicator and the governance and socio-economic indicators of the BSRP modules.

The structure, functioning and dynamics of the Baltic Sea ecosystem should be understood in relation to environmental driving forces, i.e., climate and meteorological conditions and human impact. The SGEH will concentrate on the effects of human impact, which can be influenced by ecosystem-based policy:

- eutrophication;
- overexploitation of marine living resources (mainly fishing);
- chemical contamination;
- oil pollution;
- introduction of alien species;
- physical disturbance of habitats.

4.2.2 Brief history of the ecosystem health concept, some cautions, and recommendations in evaluating the extension of the concept

The International Society for Ecosystem Health began to formalize the ecosystem health concept between 1992 and 2002. The general consensus after ten years of debate is to drop definitions that dwell on extended metaphors and substantiate changes in condition using time series and indicators. Many governments have embraced the goal of large area multijurisdictional management and called that ecosystem management. Management questions and measures of success rely upon identifying sufficiently large disturbance forcing factors impacting the system. In the case of the U.S. Greater Yellowstone Ecosystem fire was identified. The International Joint Commission concerned with air-sheds (US and Canada) includes humans as part of the system. Recently groups like those in conservation medicine have developed cross training programs to get veterinarians and public health specialists to share epidemiological techniques and apply them jointly to marine ecosystem problems. Marine epidemiology as a consequence offers a forum for the exploration of both chemical contamination and natural ecological impacts upon species. Importantly, public health and economic motivations are the primary drivers for environmental or ecological decisions so it is expedient to include these variables in any study. To effectively address the concept of Baltic marine ecosystem health, human epidemiology should be included as humans are the best and if not the best always the most compelling indicators of lapses in environmental quality.

4.2.3 Initial ecosystem roadmap for the Baltic Sea

Ecological quality can be used at different levels when defining environmental strategies and objectives:

- strategic vision;
- strategic goals;
- ecological quality objectives;
- indicators;
- variables to be monitored.

From the beginning it is important to formulate a commonly accepted vision. For this purpose there are already several Baltic and European agreements which could be used for common visions, inter alia:

- the Helsinki Convention: to restore and preserve the ecological balance of the Baltic Sea (Article 3 of the 1992 Convention);
- the EU Water Framework Directive: good status for all waters;
- the EU Habitats Directive: restore and maintain favourable conservation status, natural habitats and wild species;

- the European Marine Strategy: healthy seas and oceans and their ecosystems as well as a sustainable exploitation of their resources;
- the Swedish national quality objectives: a balanced marine environment, sustainable coastal areas and archipelagos, a non-toxic environment and zero eutrophication;
- the Finnish national Baltic Sea Programme: good ecological state of the Baltic Sea;
- the Johannesburg declaration requests to halt biodiversity decline by 2010.

Based on the above few examples the vision for the Baltic Sea could be formulated as

"A healthy and balanced Baltic marine ecosystem, where resources are exploited sustainably":

1) to develop the Baltic ecosystem health concept in relation to the main ecological problems of eutrophication, hazardous substances, overfishing, invasive species, biodiversity, and habitat destruction;

2) to initiate reference level/baseline work on a set of ecological quality (EcoQ) elements that reflect associated ecological quality objectives (EcoQOs), as follows:

   - Secchi depth or other proxy measure for light attenuation;
   - oxygen depletion in shallow waters;
   - phytobenthos (e.g., bladder wrack [Fucus vesiculosus]);
   - organic contaminant concentration (e.g., PCBs, DDts, TBT, dioxins, pesticides, algal toxins) in selected fish, shellfish and seabird eggs (bioaccumulation);
   - endocrine disruption (imposex, intersex, vitellogenin, embryo sex ratio, reproductive success, chromosomal aberrations in gonads);
   - biomarkers (AChE, MT, EROD, lysosomal stability, PAH metabolites, oxidative stress biomarkers);
   - changes in the size distribution of fish;
   - CPUE (catch-per-unit-effort) of non-assessed fish;
   - changes in fish community structure;
   - changes in abundance, biomass and distribution of native and alien species;
   - physical disturbance of the shoreline and coastal water zone (e.g., habitat destruction, nesting sites disturbed or disappearing, obstruction of migratory corridors, habitat fragmentation, shoreline disturbance, stagnation, turbidity);

3) develop a Baltic Multiple Marine Ecological Disturbances (MMED) indicator system with the support of NOAA;

4) review the COMBINE Programme, including methodology, especially coastal fish monitoring in cooperation with HELCOM MON-PRO including workshops already set by HELCOM MONAS 6/2003;

5) evaluate the value of large projects being conducted in the Baltic Sea area, e.g., CHARM, BEEP, which deal with ecosystem health issues.

4.3 SGEH meeting 2004 (ICES 2005a)

During their 2nd meeting in 2004 the SGEH reviewed progress in marine ecosystem health developments and further continued activities related to the development of Ecosystem Health Indicators, EcoQOs and Reference Conditions. Preliminary proposals for the general and specific EcoQOs, pressure and State Indicators (and in some cases Reference Conditions) were elaborated. Proposals for development of monitoring activities were also presented.

4.3.1 Overview of developments of ecosystem health assessment and ecosystem-based approaches to management (HELCOM EcoQO Project)

EcoQOs and indicators showing how the objectives are met should be the main tools in assessing the health of the Baltic Sea ecosystem. In order to fulfil this assessment purpose the indicators used should have agreed reference and target values based on ideal conditions and an agreed acceptable deviation level from these conditions, respectively. The final definition of these targets should be based on sound scientific understanding on the functioning of the ecosystem but might also become an issue for political debate. The Baltic Sea EcoQOs and associated indicators need a set of target values and limits in order to become a part of an operational assessment and management system.

At all scales, effective indicators should be SMART:

- **S**pecific indicators should clearly characterise the state to be achieved and be interpreted unambiguously by all Stakeholders.
- **M**easurable. Good indicators should relate to measurable properties of ecosystems and human societies, so that Indicators and Reference Points can be developed to measure progress towards the Objective.
- **A**chievable. Good indicators should not conflict. Within an effective management framework, it should be possible to achieve all targets. Good targets should describe a state of the ecosystem, including the position and activities of humans within it, which accurately reflects the values and desires of a majority of stakeholders.
- **R**ealistic. Good targets will be implementable using the resources (research, monitoring, and assessment and enforcement tools) available to managers and stakeholders. Good targets should reflect the aspirations of stakeholders, such that the majority of stakeholders will strive to achieve them and ensure sustainable development.
- **T**ime bound. There should be a clearly defined time scale for meeting targets. The idea is to compile and condense existing information on inter alia present national and regional research relating to WFD implementation, historical data sets and relevant regional literature for Baltic Sea subregions.

4.3.2 Developments at US EPA

Research projects carried out in the USA from 1990–2000, involving many water quality, sediment, habitat, and biological scientists determined that approximately 125 specific data indicators could be combined in five indices that can be used to the assess the ecological condition of coastal resources in the US. These five indices include Water Quality, Sediment Quality, Habitat Quality, Benthic Biodiversity, and Fish Contaminant Index. The US EPA is at the point of application of indices to conduct assessments (one in 2000 and another in 2004 and documented in its National Coastal

Condition Reports). The US EPA has spent 15 years developing index approaches and is ready and willing to transfer this technology to the SGEH working group members of the BSRP:

1) There is sufficient similarity among the specific indicators used in the US and those proposed for BSRP that index approaches developed in the US would be useful for BSRP adoption, modification, and use.
2) Depending upon the flexibility of the sampling typology directed for use by the European Water Framework Directive and the European Marine Strategy, alternative sampling approaches could be developed that would be more parsimonious, more efficient, and less expensive.
3) US EPA is willing to work with BSRP to transfer the technologies (skills, knowhow, software, etc.) necessary to permit BSRP development of broad scale indices "without completely reinventing the wheel".

Discussion: With all its long-term experience, the US EPA is still at a point of application of indices, while in the Baltic Sea we are still at a stage of discussion the indicators. So, are we a right audience to discuss indices, if indicators are not set up yet? Indeed, we are a right group to decide, if we need indices, or not. US EPA spent 15 years on making a hierarchical pyramid of indicators and indices, and this experience is ready to be transferred over to the other large marine ecosystems, as it has proved to be operational and cost-effective. The US EPA experience shows that the average cost of sampling and data analysis per one site makes ~4,000 USD. However, many questions on a 'political' level remain unclear at the moment, as the European Water Framework Directive and Marine Strategy imply certain rules and requirements on the BSRP plans, activities and outputs. It has to be decided, which part of US EPA experience could be applied most effectively way during the BSRP. However, it was noted that HELCOM is expecting to produce a 'holistic' report on the Baltic Sea environment in the coming years, where environmental indices system, similar to US EPA indices will (hopefully) be implemented.

4.3.3 Developments related to phytobenthos monitoring

Phytobenthos is considered to be one of the best biological elements reacting to coastal eutrophication. Aquatic vegetation is proposed to be monitored in WFD as one of the most important ecological quality elements.

4.3.3.1 Definition of reference conditions

High ecological status

The WFD states that 'For each surface water body type [..], type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydromorphological and physico-chemical quality elements [..] at high ecological status [..]. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements [..] at high ecological status [..] (WFD, Annex II, 1.3 (i)). Reference conditions thus are equal to a high ecological status. This status is achieved when water bodies show 'no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body types from those normally associated with that type under undisturbed conditions' and 'the values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion' (WFD, Annex V, Table 1.2).

The WFD also gives more detailed definitions of high ecological quality for benthic vegetation in coastal waters (WFD, Annex V, Table 1.2.4):

- all disturbance-sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present;
- the levels of macroalgal cover and angiosperm abundance are consistent with undisturbed conditions.'

A present state or in the past

- Reference conditions or high status is a state at present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only minor modification of physicochemistry, hydromorphology and biology (REFCOND Guidance, p. 52). It is an open question what exactly is meant by "very low pressure", and therefore also open questions remain when exactly reference conditions may have existed in the past or where reference conditions may still exist.

Not necessarily totally undisturbed conditions

- Reference conditions do not demand totally undisturbed, pristine conditions, they include minor disturbance which means that human pressure is allowed as long as there are no or only minor ecological effects.

The desired direction of change

- Reference conditions or high ecological status thus represent the desired direction of change in water quality of European coastal waters, but the WFD does not require that water bodies necessarily achieve high status. The goal of the WFD is a good status of surface waters.

A state which is possible to re-establish

- The WFD assumes that biological quality elements return to reference levels if human pressure is reduced to reference levels. This requires that:
  1) The relation between human pressure and quality elements is reversible; and
  2) That the level of quality elements depends mainly on human pressure;
  3) Reference conditions are relatively static. There are many examples, however, that key organisms or community composition may change over time without being clearly related to human pressure.

4.3.3.2 Assessing reference conditions

There are several ways of assessing reference conditions for water body types*:*

1) Spatially based reference conditions

2) Temporally based reference conditions using either historical data or paleoreconstruction or a combination of both.

3) Reference conditions based on predictive modelling.

4) Expert judgement.

5) A combination of the above approaches.

The Water Framework Directive requires "a sufficient level of confidence about the values for the reference conditions" regardless of which method is used for establishing reference conditions. This demand is not specified in statistical terms so it is up to the Member States to decide about this definition. The error of the estimate of the biological reference conditions must incorporate the natural (e.g., real) variability of the quality element in time and space and the errors in the method of estimation (REFCOND Guidance, p. 44).

Discussion: One issue of discussion was possibility of mapping the reference conditions at a finer scale and with wider regional coverage. It was admitted, that only a few areas around the Baltic Sea are rather well studied in this aspect, but certain methodologies could help to produce "best expert judgment" estimates for the areas where detailed studies are missing at the moment, so that a complete spatial coverage of reference conditions for the key species could be obtained.

4.3.4 Impact on fish and ecosystem effects of fishing in the Baltic Sea

The four internationally managed fish species in the Baltic Sea – cod, herring, sprat, and salmon – are relatively well-studied with regard to distribution, population structure, migrations, feeding and environmental influences upon important stock parameters and processes such as reproduction, recruitment and growth. Despite international scope, management of the above-mentioned resources has not been always sustainable. Research and management of other (commercial) fish is of national responsibility and only a few international joint efforts have been undertaken. The literature survey indicates that different natural factors impacting fish directly or indirectly are (1) abiotic environment, (2) food-web mediated effects, (3) marine mammals and (4) seabirds. Antrophogenic influence can be categorized as (1) eutrophication, (2) pollution and (3) thermal discharges. A variety of different impacts can be observed both at community, population and individual level. Amongst others: species composition, distribution and abundance; growth rate and mortality; fecundity, maturation, reproduction and recruitment; parasite infestations and deformation of bony structures are getting impacted. Fishing activities have documented impacts to biota and abiotic components of the ecosystem like: (1) fish resources, (2) marine mammals, (3) seabirds, (4) benthic communities and (5) food-webs (6) nutrient dynamics and (7) sediments. While towed gear (bottom trawl) pose the major threat to benthic communities, bottom sediments and associated processes, coastal fisheries (fixed gear) is the major source for mortality of marine mammals and seabirds.

The internationally non-assessed commercial fish species need more systematic and internationally coordinated research efforts, both on basic and applied aspects at various levels, with substantially higher research budgets. As there is a rather limited amount of knowledge on the non-commercial fish and their food-web interactions (both as predators and prey) in the Baltic Sea, these investigations should receive much higher attention.

4.3.5 Developments related to marine biodiversity

Among the indicators of biodiversity, some serve well as the ecosystem health indicators, the examples are: the log normal distribution, Caswell's neutral model, the ratio between pollution sensitive and insensitive taxa, the phylum-level meta-analysis, and abundance/biomass plots.

The keystone species concept (species meaning for the ecosystem more than their abundance would suggest) is of special value for the ecosystem health assessment. Some categories of keystone-like species have been used in this respect:

- habitat builders, structural species;
- "wasp waist species";
- charismatic species (usually not good as highly mobile and generalists);
- the diversity of fish parasites (monoxenous versus heteroxenous);
- single taxon as indicator of EH (fishes, epifauna, peracarida).

The habitat concept is of the utmost importance for the biodiversity/ecosystem health issue, and the possible approaches are considering:

- presence/absence or simple count of habitats per unit area;
- habitat assessed by its function (e.g., depth of bioturbation, filtration);
- the same habitat of different quality (not just coverage but quality);
- concept of "distinctive habitats" versus representative habitats;
- concept of fragmentation and natural variation of habitats;
- statistical models testing interdependencies between ecosystem components

The functional diversity is also used in EH assessment, and the examples are:

- mineralisation rates and level of microbial biochemical traits;
- sustainable and diverse yield production;
- ability to restore itself;
- number of functional groups.

Discussion: it was pointed out that normally it is not a case that total extinctions (regional and even local) do not take place frequently, but it is rather the case that reduction of range and distribution of species occur in certain marine areas. Functional role of habitats diversity and species diversity was discussed, and it was pointed out that diversity of species not necessarily reflect the overall quality of the marine ecosystem. As an example, a case of polluted and otherwise severely impacted harbour areas may be characterized on certain occasions by impressive diversity of species, whereas marine environment generally is in a poor shape. In this aspect, richness of natural habitats may be the best indicator of ecosystem health in general. In support to this statement, examples of unwise strategies of some biodiversity restoration projects were mentioned, where major investments were assigned for the restoration of certain non-key (in terms of biodiversity and habitat formation), but rather 'charismatic' species, whereas restoration of natural marine habitats, which would host the whole variety of traditional species has not been taken into account at all. Despite the fact that natural fragmentation of marine habitats plays an important role in general improvement of biodiversity situation, the anthropogenic stress, often causing massive habitat fragmentation effects, is still one of the most severe biodiversity loss triggers.

4.3.6 Proposals for development of monitoring in the Baltic Sea

4.3.6.1 Biological effects

Detecting biological effects of pollutants in marine organisms is an increasingly important issue in monitoring programmes. The significance of observing biological responses is that they tell us – contrary to chemical measurements – that an organism has been exposed to such levels of pollutants bioavailable in the environment that have elicited a defence response. Whether or not parallel or further effects can be observed or the response soon returns back to the baseline level in any case we have detected an early warning signal of hazardous concentrations of toxic substances in the environment. If utilizing only environmental chemistry by selecting certain contaminants or contaminant groups for analysis we usually do not have any connection to toxic effects, regardless the concentrations measured in the environment or in the organism. Bioavailability is affected by numerous factors while metabolism of xenobiotics rapidly modifies/degrades the original compounds and toxic effect may not be proportional to the residual concentrations of the compounds in tissues. On the other hand, many organisms store harmful substances in inert or metabolically inactive tissue (lipid) or cellular compartments (e.g., metal-accumulating microgranules) where they exert no harm to the organism unless being redistributed due to physiologically stressful condition (e.g., starvation, reproduction, metabolic changes).

In fact, the only meaningful context where pollutant concentrations are valuable as such is when their transfer along the food chain is being examined, looking at the step-wise biomagnified concentrations of pollutants in top predators, including human, and their food. Therefore, since the original motivation for measuring pollutant concentrations in marine biota (as a result of contamination in water, sediments or primary food sources) seems to be based rather on the quality control of human food than protecting the marine ecosystem from anthropogenic damage, the current monitoring strategy followed in the Baltic Sea is adequate. However, if we aim at the latter, a change is evidently needed.

While we are still largely missing direct links between molecular levels and ecologically relevant levels it should be understood that even the onset and maintenance of "reversible" biomarker responses related, e.g., to the detoxification enzyme machinery and biosynthesis of chaperone proteins requires considerable energy which is bound to take its toll on other biochemical and physical functions within the organism, e.g., on those related to locomotion, feeding, behaviour and reproduction. A "stress syndrome" observed at a molecular or cellular level may therefore have marked implications at higher levels through complex interactions at the physiological level. An operative and effective integrated chemical and biological monitoring programme is a relevant and achievable goal, with biomarkers as screening tools that provide information guiding targeted chemical analyses of the likely agents that lie behind the observed physiological perturbations in organisms. Linking early-warning exposure signals to higher organisation levels, the truly meaningful effects, is difficult and probably achievable only in cases where the main pollutant compound (e.g., TBT) or group of compounds (e.g., PAHs) are identified and the impairments observed are more or less specific to higher level injuries (e.g., imposex, liver tumours). However, pollution commonly occurs as a mixture of a variety of compounds present at different levels and the complex interactions with physicochemical and biotic factors makes a direct linking – with present knowledge – practically impossible. This holds especially for the highly eutrophicated Baltic Sea.

The practical differences between early-warning indicators (i.e., biomarkers) and "ecologically relevant" effects (population and community effects) should be acknowledged. Understanding the purpose of monitoring and the benefits and limitations of monitoring methods should be discussed rationally; evaluating critically the cost-benefit ratio of the information attained using different methods. Currently, due to the high costs of today's sophisticated environmental analytical chemistry the vast majority of potentially dangerous substances may remain undetected in routine chemical monitoring programmes or are found only occasionally because usually there has to be an anticipation of possible and specific contamination prior to analysis. Ideally, a suitable set of screening biomarkers enables one to actually detect when and which further measures should be taken.

Although highly desirable, no practical way of applying a common species for the whole Baltic Sea seems possible, mainly due to distribution but also due to the physiological adaptation of species into the highly extreme variability in the physical environment. This hampers the direct comparison of biomarker responses measured between the different regions and call for a regional approach. However, the selection of species representing the same functional level should provide comparable data on the health status of the different sub-regions if health indices are the main goal.

Finally, our future monitoring programmes should therefore not be technique-driven but approach-driven. In the Baltic Sea, the combination of eutrophication–pollution related effects calls for (1) general stress biomarkers as a first tier approach. With regard to monitoring of specific effects of specific pollutant a set of (2) specific biomarkers should also be made available. When serious disturbances are being detected (3) TIE procedures should be considered to be used to identify the pollutant group responsible for the damage.

A proposed reorganisation of the monitoring strategy of hazardous substances

First tier procedures

- Proxy contaminants in sediments and tissues: metals (Cd, Cu, Zn, Pb, Hg), organochlorine POPs (PCBs, DDTs) and TBT. Motivation: levels of common pollutants in the marine environment have to be established; temporal and spatial trends have to be monitored;
- General "stress biomarkers" (related to exposure to diverse pollution): neurotoxicity (acetylcholinesterase inhibition), immunotoxicity (lysosomal stability), genotoxicity (e.g. micronuclei), oxidative stress (e.g. catalase). Motivation: early warning indication of exposure to pollutants;
- Histopathology (fish liver).

If the first tier procedure indicates elevated pollutant levels and/or biomarker responses the second tier procedures should be initiated.

Second tier procedures

- Bioassays. Motivation: acute toxicity evaluation of sediments exhibiting markedly elevated pollutant levels;
- Specific biomarkers (e.g., EROD/PAH metabolites/DNA adducts, ED biomarkers, Ala-D, MT, GST). Motivation: specification of the biological response; directing of more detailed chemical analytics.

Biological effects can now be assessed. If needed, specific pollutants can be identified through third tier procedures.

Third tier procedures

- More detailed chemical analyses (e.g., pesticides, dioxins, brominated flame retardants). Motivation: identification of the hazardous compound/congeners/group not detected by regular monitoring;
- (TIE protocols (fractionation and bioassays). Motivation: identification of the hazardous compounds/congeners/group not detected by regular monitoring).

Discussion: The EEA has initially supported the general idea of biomarker studies as part of the monitoring system, but later the Agency rejected this initiative. Now EEA and BSRP have established a bilateral cooperation, and new perspectives for biomarkers monitoring become promising and reliable approach. This activity should also take benefit from BONUS program.

4.3.6.2 Fish diseases

It is proposed that Baltic Sea countries should implement monitoring programmes on the occurrence of externally visible diseases and parasites and on the occurrence of histopathological liver changes as part of national programmes for the assessment of the state of the marine environment (coherent to what has been implemented as part of the OSPAR JAMP/CEMP for the North Atlantic).

Fish disease monitoring should be part of an integrated monitoring programme, encompassing, e.g., studies on biological effects of contaminants (biomarker approach), on biodiversity, physical and chemical measurements, and methods applied in fish stock assessment. Fish disease monitoring programme should be coordinated by ICES (through its expert Working Group on Pathology and Diseases of Marine Organisms, WGPDMO) and should ultimately be incorporated into the HELCOM monitoring. The ICES Marine Data Centre should act as central database (as for other ICES and HELCOM programmes).

4.3.6.3 Marine birds

The Baltic Waterbird Monitoring Program under HELCOM will be composed of three key elements, which are (1) monitoring of wintering waterbirds, (2) monitoring of breeding waterbirds and (3) monitoring of oil pollution by Beached Bird Surveys.

It is expected that integrated waterbird data collected in the whole Baltic area would constitute a new and important source of information on the state of marine environment in relation to eutrophication, hazardous substances, shipping lanes, overfishing and habitats.

4.3.7 Developing the Baltic ecosystem health concept and ecosystem-based management tools

4.3.7.1 Effects of eutrophication

Results of deliberations of the SGEH Subgroup on Effects of Eutrophication are given in Table 4.1.1.

Table 4.1.1. Preliminary proposal for EcoQO, Indicators and Reference conditions for effects of eutrophication.

GENERAL ECOQO/ VISION: REDUCE EUTROPHICATION IN ORDER TO RESTORE ECOLOGICAL BALANCE AROUND HISTORICAL REFERENCE VALUES WITHIN THE BALTIC SEA AND TO ENSURE FUNCTIONING OF MARINE ECOSYSTEM		
Specific EcoQOs	EcoQElement/Indicator	Ref point/Ref conditions
Restore Water clarity levels to those of 50s of the 20th Century	**Depth distribution of macroalgae –** definition of depth conture parameters according to typology (sometimes irrelevant) **Secchi depth** – the only measure widely used, useful measure despite great variabilty (possible variants max, mean, seasonal mean etc.). **PAR measurements** (not subjective, automated, well correlated with macrophyte production). **Direct measuremets of turbidity** **Chlorophyll *a***	Available in historical data and in literature (e.g., CHARM) Available in historical data To be found out To be found out To be found out
No oxygen depletion where it should not occur naturally	**Frequency of hypoxia and annoxia** **Loss of sessile benthos** **Kills of invertebrates and fish** (poor indicator) **Presence/absence of laminated sediments**	Historical data To be determined Historical data
Depth range of perennial vegetation returned to regionally defined historical levels	**Type and species specific EQR** (for reference conditions see CHARM report)	Literature (CHARM)
No massive algal blooms	**Chlorophyll *a*** **Frequency of harmful algal blooms** (annual, decadal?) **DOC** **Size structure of plankton community**	To be developed To be developed Historical data Historical data and moddelling
No massive HAB (Harmful algal bloom) and presence of algal toxins in benthic organisms	**Abundance of HAB species** **Annual frequency of HAB** **Presence oh hepatotoxins and DSP in shellfish and benthic fish liver**	
To maintain the abundance of opportunistic species at regionally defined level	**Proportion (biomass/cover) of opportunistic to perennial species** **Changes in size structure of zooplancton community** **Incresaed abundance of species sensitive to TOC additions** **Changes in dominance of taxonomic species of fish.** **Frequency of occurrence of macroalgal mats**	Literature (CHARM) NIA, Hist, Modelling Modelling, NIA Historical data available Uncertain info available
Restoring of historic nutrient levels and ratios	**Winter nutrient concentrations** **Winter N:P:Si ratios**	Could be delivered from modelling Could be delivered from modeling
Loadings at historical levels	**Land based inputs** **Atmospheric inputs** **Internal loading**	Could be delivered from modeling Could be delivered from modelling Could be delivered from modeling

4.3.7.2 Effects of Hazardous Substances

Results of deliberations of the SGEH Subgroup on Effects of Hazardous Substances are given in Table 4.2.1. The group identified several gaps regarding Assessment Criteria, which are marked with *.

Table 4.2.1. EcoQos and EcoQ elements for hazardous substances.

General EcoQO/Vision: Concentrations of hazardous substances in the Baltic Sea near background values for naturally occurring substances and close to zero for man-made substances.	
Specific EcoQOs	**EcoQo element/indicator**
.	**The "Inputs" of specified contaminants should not be included in this programme. The purpose of the planned marine monitoring programme includes the measurement of hazardous compounds in the environment and their biological effects.** Concentrations of: PCBs, DDTs, Cd, Pb, Hg, PCDD/PCDF(dioxins), Brominated flame retardants, TBT compounds, Radionuclides) in water and/or sediments. Regional target levels need to be agreed upon **Addition of Cu to the list of measured contaminants. Motivation: Cu is widely used in new generation anti-fouling paints; elevated environmental concentrations are already seen in the North Sea.** *Addition of PAHs to the list of measured contaminants. Motivation: increasing chronic exposure due to oil shipping and drilling; background data in case of major accidents **Distinction between the commonly assessed persistent organic pollutants and specifically endocrine disrupting (ED) compounds: addition of alkylphenols and phthalates monitoring in sediments.**
No illegal oil discharges No oiled birds	No oil slicks in aerial surveys No oiled birds
All fish caught in the Baltic Sea shall be suitable for human consumption.	Concentrations of: PCBs, DDTs, Cd, Pb, Hg, PCDD/PCDF(dioxins), Brominated flame retardants, TBT compounds, Radionuclides in herring and cod ***Inclusion of benthic/demersal fish in the monitoring programme. Motivation: 1) directly in contact with sediment-bound contaminants, 2) commercial importance and quality of food.**
Toxic substances shall not cause sub-lethal nor intergenerational or transgenic effects to the health of marine organisms (e.g., reproductive disturbances).	Endocrine disruption (vitellogenin, Gonado-Somatic index) ***Gonadosomatic index may not be regarded as a biomarker: gonad histology should be included as an indicator of endocrine disruption.** Biomarkers (AChE, EROD, lysosomal, PAH metabolites) from cod, herring and/or blue mussel *** A proposed reorganisation of the monitoring strategy of hazardous substances is given below.**
Attain pre-Chernobyl concentrations of man-made radioactivity in the Baltic Sea ecosystem causing risk neither to humans nor the Natural systems sustaining human, plant and wildlife populations	Annual radiation doses in selected fish (concentrations of radioactive isotopes)
Other	Cod and herring stock ***condition of the individuals might be affected by the contaminants**
	Parasites and disease in fish ***the frequency of parasites is not necessarily related to the level of contamination**

4.3.7.3 Effects of Fishing Activities

- Management of all fish resources (i.e., assessed commercial fish stocks, non-assessed commercial and non-commercial fish stocks) should be based on natural (stock) units and guarantee healthy and viable fish communities to ensure the optimum justifiable long-term socioeconomic benefit. The major precondition for success, regarding both target and non-target species, is the management of excessive fishing effort;
- The associated ecosystem impacts of fishing activities should be minimized, thereby facilitating recovery of vulnerable and declining species and habitats.

Table 4.3.1. Linkages between some basic data requirements, indicators (suggested examples) and operational objectives for a hypothetical fishery to be considered for development of the sustainable fisheries indicators in the Baltic Sea.

Source: http//www.fao.org/DOCREP/005/Y4470E/y4470e0f.htm
General EcoQO/Vision: To achieve sustainable fisheries in sustainable ecosystems

OBJECTIVE	EXAMPLE INDICATOR	DATA REQUIREMENTS
Fishery resources (target species)		
Reduce fishing effort	Fishing effort of different fleets	Vessels, time fished and gear type per fleet
Reduce fleet capacity	Fleet capacity	Vessels registered and gear type per fleet
Increase/maintain fish landings of commercially valuable species by area	Fish landings by major species by area	Total landings by major species per fleet per year
Increase/maintain spawning stock biomass of key retained species above a pre-defined limit	Spawning stock biomass of key retained species (or suitable proxy such as standardized cpue)	Length and/or age composition of major retained species
Decrease/maintain the level of fishing mortality for key retained species below a predefined limit	Level of fishing mortality for key retained species	Length and/or age of the discarded component of the target species catch
Other ecological concerns		
Reduce discards to the extent practical	Total amount of discards	Total catches of by-catch species (or species groups/indicator species),per fleet per year
Reduce discards of high- risk species (or species groups) to predefined level	Amount of discards of high-risk species (or species groups)	Length and/or age of high-risk by-catch species
Reduce number of deaths of vulnerable and/or protected species to predefined level	Number of deaths of vulnerable and/or protected species	Catch of vulnerable and/or protected species Catch of non-fishery material (critical habitat)
Decrease/maintain same area of the fishery impacted by gear	Area of the fishery impacted by gear	Area fished by each fleet

OBJECTIVE	EXAMPLE INDICATOR	DATA REQUIREMENTS
Increase amount of habitat protected by MPAs to predefined level	Amount of habitat protected by MPAs	Area under MPAs by habitats
Increase ratio of large fish in the community	Size spectrum of fish community	Length of fish in a representative sample of community
Minimize the impact of other activities on fish resources and habitats	Area of fish nursery habitat degraded	Area of habitat, e.g., seagrass beds, mangroves and coral reefs
Maintain ecological balance	Mean trophic level of catch	Species composition from sample catches
Economic		
Increase the contribution of fishing to the national economy	Net economic return for fishery	Revenue from fishing per fleet per year. Costs per fishing unit per
Increase/maintain profit of the harvesting sector to that of similar industries	Profit to harvesting sector	
Increase exports	Export value	Destination of landings from each fleet
Maintain or increase economic contribution to community	To be developed	
Social		
Health benefits/Increase fish consumption per capita	Fish consumption per capita	Fish consumption from representative sample
Ensure seafood quality meets food safety requirements	Number of food compliance reports	Food safety compliance reports
Increase/maintain employment in the harvesting and processing sector by fleet	Employment in the harvesting sector by fleet	Total number of fishermen employed in each fleet Total number of people employed in fishery-associated activities (e.g., processing)
Maintain or improve lifestyle value	Life-style value	Social surveys
Maintain or improve cultural values	Cultural value	Cultural sites and values
Maintain/increase level of activity of indigenous community	Number of indigenous fishers	Dependence of local community on fishing as a source of income and/or food.
Reduce the dependence of community on fishing	Dependence of community on fishing	Other income or livelihoods of the fishermen
Management activity: have well-developed management plans, including indicators and reference points and evaluation procedure in place for all fisheries	Number of fisheries with well-developed management plans, including indicators and reference points	Number of fisheries with a well developed management plan, including operational objectives, indicators and reference points

4.3.7.4 Loss of Biodiversity (including xenodiversity and habitat destruction)

The assessment of the health of the Baltic ecosystem from the biodiversity point of view shall be focused on the habitats, and reflect the level of naturalness. The naturalness is assessed after the best available scientific judgment, on the basis of habitats that have existed before man-induced disturbance, taking into consideration the importance of physical control. As the indicators of the level of naturalness we propose:

- percent of the area with the specific biotopes filled with their respective biocenoses;
- observed shift of the proportion of characteristic functional groups in the ecosystem (trend in time).

For the Baltic, the relict species are a special case for consideration, since they represent the uniqueness and the evolution of the sea. Their presence in the ecosystem should be especially taken care of.

We consider the existence of natural, not manageable processes that are influencing biodiversity and habitats in the Baltic:

- global warming;
- oceanisation;
- storminess and coastal evolution.

Proposal of indicators related to xenodiversity:

- percent of ships implementing ballast water management;
- percent of harbours treating ballast water and sediments;
- percent of invasive species in local communities;
- percent of invasive species in local communities biomass;
- ratio between alien and native key stone species.

Table 4.4.1. EcoQOs and Indicators for biodiversity

General EcoQO/Vision: A Baltic Sea marine environment with maintained natural biodiversity at all levels, strengthening its natural integrity	
Ecological Quality Objectives (EcoQOs - vision)	**Ecological Quality Element (Indicator of Environmental status)**
Detailed EcoQOs: 1) A sufficient number, size and network of coastal and marine BSPA, to ensure the preservation of: - natural coastal landscapes within the Baltic Sea; - natural ecosystems and processes ensuring long-term interconnectedness between areas; - protect declining/endangered species. 2) Restore species supporting climax communities in areas where they have disappeared, especially: - Eel grass meadows (*Zostera*); - Bladder wrack beds (*Fucus*); - Mussel beds (*Mytilus edulis*); - Baltic Sea relict species. 3) Maintain the integrity of habitats and their key functions that allow existence of healthy and viable populations of top-predators: mammals, seabirds, fish (salmon, trout, cod). 4) Minimize the man-induced introduction of non-native species, especially from ballast water and aquaculture activity, through the full treatment of ballast water and sediment.	Indicators and indices of EcoQOs achievement 1) Implemented adaptive management plan and networking of all BSPA: - percent of BSPA that have met this criterion; - percent of shorelines habitats damaged; - percent of coastal habitats restored; - percent of bird nesting and resting areas disturbed; - percent of man induced key habitats loss. 2) Restoration and protection of key habitats - percent of biotopes that host proper communities/biocenoses based on the best scientific expertise; - percent of the specific habitat area that received restoration treatment; - percent of the area of specific habitat that is protected. 3) Food web diversity and integrity - trend in change of trophic group share; - reduction of functional groups diversity. 4) Xenodiversity control - percent of alien species, in local communities (and their share in biomass); - ratio between native and alien key stone species; - percent of ships and harbors with facilities for ballast load treatment.

4.4 SGEH meeting 2005 / Workshop (ICES 2005b, 2006)

4.4.1 Exercise on indicators

The number of indicators was reduced and prioritized. Indicators which received scores "very good" or "sufficient" can be regarded as operational indicators. They can be used in the ecosystem-based assessment and management. Tables of indicators are prepared in relation to:

1) effects of eutrophication;
2) effects of hazardous substances;
3) effects of fishing activities;
4) biodiversity loss and habitat destruction.

New developments on:

1) further integration of indicators into indices (US EPA Benthic Community Index),
2) identification of development of socio-economic driving forces of pollution of the Baltic Sea, and
3) public health aspects.

Working procedure of the exercise:

- use the ICES/BSRP/HELCOM /UNEP Sopot Workshop Report and the HELCOM EcoQO indicator outline (computer files and/or hard copies with these documents were available for each subgroup);
- select/prioritize the list of indicators to absolute minimum for each topic. Include only those parameters for which you think that present data and scientific consensus is strong enough to create reference values/target levels (omit variables which are good but not yet ripe for implementation and try to raise above your own professional specialty and select only the best indicators for each general topic (Quality element etc.) even if you have personal interest in something else);
- consider socio-economic (D [Driver] type indicators) relevant to your subgroup and give illustrative examples of D-type indicators;
- description (general description of the indicator and why this is good) (copy/paste relevant parts from HELCOM document);
- measurement units (to make it clear);
- data availability (indicate if you have some knowledge of existing data sources, particularly if they are not commonly known);
- suggest reference levels (indicate the prospects for deciding on target levels).

4.4.2 Overview of developments of ecosystem-based approaches

- Discussions leading to the formation of WKIAB (then leading to WGIAB).

4.4.3 HELCOM activities including Baltic Sea Action Plan

The decisions concerning management measures should aim to attain good ecological status of the marine environment. In practice this means that we must reach a scientific consensus on a) what is the pristine, or background state, and b) what is the acceptable deviation from this state.

The main fields of concern in the Baltic Sea Action Plan have been formulated as: eutrophication, contamination by hazardous substances, marine traffic and biodiversity and nature conservation, i.e. very similar to BSRP SGEH interests. Set of indicators equipped with background levels as well as acceptable deviations should be developed for each of these concerns should be agreed upon. It was pointed out that we should concentrate efforts on finalizing discussion on the suggested indicators and begin considering threshold values and target quality levels. Ecosystem health, even though being a very complex issue, can be roughly covered with a relatively small set of environmental indicators for pragmatic assessment purposes.

4.4.4 Indicator selection and development of Marine Environmental Quality Indices

4.4.4.1 Indicator selection

The National Coastal Assessment by the US EPA applies a set of indicator selection criteria that has been used to reduce the set of potential scientific environmental/ecological indicators to a limited set of operational indicators that are applied by all members participating in the surveys. These criteria imply that all operational indicators should be:

1) regionally responsive – the indicator must reflect changes in ecosystem conditions and respond to stressors (pressures) of concern across most resource classes and habitats within the monitored region;

2) unambiguously interpretable – the indicator must be related unambiguously to an assessment endpoint (relevant exposure/stressor/habitat variable) that forms part of the ecosystem's overall conceptual model of ecological structure and function;

3) simply quantifiable – the indicator can be quantified by synoptic monitoring or by cost-effective automated monitoring that can be adopted by all participants in the monitoring survey;

4) stable over the sampling period – the indicator exhibits low measurement error and stability of regional cumulative frequency distribution during the sampling period (low temporal variation during the sampling period in regional statistics);

5) low year-to-year variability – the indicator must have sufficiently low natural year-to-year variation to detect ecologically significant changes within a reasonable time frame;

6) low environmental impact – sampling for the indicator should have minimal environmental impact.

Using these criteria, the National Coastal Assessment (US EPA) selected the following indicators to be used operationally in the monitoring surveys:

1) Exposure (Stressor) Indicators: nutrients (DIN, DIP), sediment contaminants, sediment toxicity, dissolved oxygen, and contaminants in fish and shellfish

2) Response Indicators: benthic community structure (species and abundance), fish community structure (species and abundance), and fish pathology (diseases and injury);

3) Habitat Indicators: percent light transmittance (water clarity), salinity, temperature, pH and substrate type (percent silt-clay).

4.4.4.2 Marine Environmental Quality Indices

For the decision-making, even the simplest ranking (like "good", "fair" and "poor") is often sufficient as background information. Regional distribution of those values can serve as implication for the general level of management efforts: large area in poor quality would require massive international intervention, while local concentrations of bad quality sites may require national- or even municipal-level management activities. The five major marine environment quality indicators in the USA EPA National Coastal Assessment are the following:

- Water Quality Index;
- Sediment Quality Index;
- Coastal Habitat Index;
- Benthic Community Index;
- Fish Tissue Contaminants Index.

These are used to produce a set of the Overall Poor Condition Estimate values, which are also mapped for more clear perception by the general public.

4.4.4.3 Eutrophication

Reference conditions

According to the Water Framework Directive guidance documents, reference conditions should describe environmental status of NO or only MINOR disturbance from human activities, being synonymous to high ecological status. Hence, they may be either spatially based i.e. determined at reference sites or based on historical data and modelling or may be derived by a combination of these methods. Where it is not possible to use these methods, expert judgement may be used to establish such conditions.

The results of HELCOM EUTRO Project showed that reference sites are not found in the Baltic Sea area; hence the reference conditions were determined basing on historical data, modelling and expert judgement. Historical data were used mainly for winter DIP, DIN and Secchi depth as well as for depth range of macrophytes.

Background values

Historical data used in HELCOM EUTRO came from different time periods, e.g. submerged vegetation depth distribution data from Denmark, Estonia and Finland come even from 1880s, as do the Secchi depth data in Finland. Winter DIP data in Latvia and Poland come from the period after the World War II and early 1950, like the data on winter DIN and DIP in Germany. Different uncertainty is associated with these data than with the data from biogeochemical or ecological models. It is quite frequent that experts use the term background values in relation to historical values considering reference values as a different entity.

Target values

Ecological objective set by WFD is the good ecological status defined as slight change in ecological quality elements in comparison to high status. This can be regarded also as the target regarding combating eutrophication effects:

ecological objective = good ecological status = target.

Within HELCOM EUTRO the quality objective was set as the level of reference conditions increased by acceptable deviation:

eutrophication quality objective = REFCOND ± acceptable deviation.

("+" applied in the case of indicators having positive response to nutrient enrichment, e.g. chlorophyll-*a*, winter nutrient concentrations; "–" – for indicators having negative response to nutrient enrichment, e.g. Secchi depth, oxygen concentrations).

The indicators used in HELCOM EUTRO were grouped in three categories:

- Category I: causative factors, e.g. N-riverine inputs, P-riverine inputs, atmospheric deposition of nitrogen, winter DIN and DIP concentrations;
- Category II: direct effects, e.g. primary production, chlorophyll-*a* concentrations, Secchi depth;
- Category III: indirect effects, e.g. zooplankton biomass, number of benthic species, zoobenthos biomass, number of species of phytobenthos, depth range of submerged vegetation, near-bottom oxygen concentrations.

It was concluded that reference sites were not found in the Baltic Sea area, i.e. there is no sites with high ecological status. It was concluded that the information on reference conditions is both an anchor and a bottleneck in the process of eutrophication assessment; the tested procedure does not work without information on reference conditions.

Only indicators describing macrophytobenthos, macrozoobenthos, and Secchi disk depth fulfilled the criterion of low year-to-year variation. For Secchi depth, the low interannual variability is most likely due to the high background signal from water components other than phytoplankton, which make the method robust, whereas benthic fauna and flora contain long-living species that “integrate” the eutrophication signal over a time-period of several years. Turnover times in the pelagic system, on the other hand, span from several days (phytoplankton) to several weeks (zooplankton). These components therefore respond fast to changes in the nutrient supply. However, high interannual variation in nutrient supply is an inherent characteristic of the Baltic Sea, especially in coastal areas and semi-enclosed sub-basins, because of the high contribution of freshwater to the water budget.

An indicator system restricted to the interannually stable elements of the Baltic Sea ecosystem was not felt useful for eutrophication assessment, as it omits important causative factors (e.g. nutrient loads, winter nutrient concentrations), direct effects (e.g. changes in phytoplankton) and indirect effects of eutrophication (e.g. frequency of harmful algal blooms). Inclusion of the relatively variable pelagic indicators into the indicator framework is also necessary to fulfil the legal requirements to monitoring and assessment in the Baltic provided by the EU Water Framework Directive and the draft EU Marine Strategy. Both require a broad ecosystem status assessment, including also hydrographic variables, a description of the nutrient status, as well as phytoplankton and zooplankton (only Marine Strategy). To mitigate the effects of interannual variability we recommend that assessments should be based on averaging periods of several years.

Reference conditions

Reference conditions for indicators characterizing quality elements in the Baltic Sea were taken either to represent the situation in the early 1900s, the situation right after World War II, or the lowest percentiles of data from the 1970s and 1980s. Within the HELCOM EUTRO project an acceptable deviation from the reference conditions (50% or less) was used to define good ecological status. The EU Marine Strategy suggests conducting initial assessments and defining good environmental status as a target for management. The developments coming out from the work of the Baltic GIG (Baltic GIG, 2005) recommend to focus on response curves which quantify relations between pressures and ecological indicators and are needed for several reasons: 1) they are easily understood, 2) they illustrate the range in pressures and environmental responses, 3) they are useful in justifying and explaining what an acceptable deviation between good and moderate ecological status is, 4) they should be the basis for setting up the measures.

The costs of nutrient load reductions (direct costs of new constructions of e.g. sewage treatment plants, manure storage tanks and indirect costs of e.g. reduced harvest, set-aside land) can be regarded as socio-economic indicators or as requisite information to rank management options. Also the impact of nutrient load reduction, leading to decreased marine productivity and fish stocks has to be addressed to for ecosystem management of the Baltic.

Land-based nutrient inputs

Land-based nutrient inputs (N, P) provide information on the driving forces of marine eutrophication. Concentrations in the freshwater (N-tot, P-tot, DIN, DIP) describe changes in nutrient loss from land, whereas marine eutrophication is driven by the combined effect of riverine nutrient concentration and the freshwater runoff. Riverine nutrient loads are sensitive to the measurement frequency of riverine nutrient concentrations.

Atmospheric nutrient inputs

Atmospheric nutrient inputs are most important for the open areas of the Baltic Sea. Atmospheric N deposition in off-shore regions is determined by model calculations.

Nutrient concentrations

Winter nutrient concentrations provide a suitable eutrophication indicator. However, the use of winter nutrient concentrations can be hampered by ice conditions, especially in coastal areas. Also, some shallow coastal systems might not have a winter nutrient maximum because of high nutrient take-up by filamentous algae.

The draft of the EU Marine Strategy also demands information on nutrient cycling, specifically on currents and sediment-water exchange. With respect to the Baltic Sea, water/nutrient exchange between sub-basins and the exchange with the North Sea is important for several sub-regions/sub-basins. The water and nutrient exchange is not an eutrophication indicator per se, but acts as a driver and is therefore important in assessing eutrophication. However, nutrient and water exchange between Baltic Sea sub-basins and Baltic Sea/North Sea is difficult to estimate.

Sediment-water exchange of nutrients, as suggested in the EU Marine Strategy, is mainly assessed through proxy data, e.g. near bottom nutrient concentrations, which in turn are affected by hydrological conditions. Direct measurements are restricted to research projects and have high spatial and temporal limitations. Therefore no indicators describing the sediment-water exchange of nutrients have been included in the current indicator system.

Phytoplankton

Chlorophyll-*a* is the most practical indicator to describe eutrophication effects of the Baltic Sea phytoplankton. Chlorophyll-*a* is used most frequently as a proxy for phytoplankton biomass, because it is easy to measure, and has long time series of comparable data in the Baltic Sea. Both with respect to chlorophyll-*a* as well as with respect to phytoplankton indicators, different seasons provide useful indicators. However, care has to be taken, that each season is covered by various monitoring surveys to provide stable indicators.

Chlorophyll *a*

Summer chlorophyll *a*. The summer period should include the time after the spring bloom subsided up to the beginning of autumn mixing. Measurements should cover a time period of several months, e.g. June to September as proposed in HELCOM EUTRO or May to September as proposed by the Baltic GIG.

Annual average chlorophyll *a*. Annual average of chlorophyll *a* should be determined for the period of ice-free water. Annual average stabilizes the variability of the chlorophyll indicator; however, calculation of annual averages is only feasible if the temporal sampling frequency is high.

Spring chlorophyll *a*. In many areas of the Baltic Sea the spring bloom is more pronounced than the summer bloom. The intensity of the spring bloom also determines the input of organic matter to the bottom sediments and therefore is important with respect to ecosystem functioning. Determination of a spring chlorophyll average requires high temporal sampling frequency for the spring months and is not feasible in many monitoring programmes.

Phytoplankton species composition provides important information on foodweb functioning and biogeochemical processes, but analysis is time consuming and reference conditions for phytoplankton species composition are difficult to establish. In addition, phytoplankton species composition is sensitive to changes in salinity and therefore reflects also changes in hydrological conditions. Phytoplankton species composition, especially the proportion of functional groups, is considered sensitive to eutrophication in several seasons. The proportion of functional groups also provides important information on organic matter fluxes in the marine ecosystem.

Several HAB indicators have been included in the indicator system. Assessment of the frequency and duration of HAB blooms relies on measurements with high temporal coverage, e.g. SOOP data. It also has to be taken into account that the occurrence of HAB species is region specific, as for example cyanobacteria blooms are restricted to salinities below 11 PSU.

Primary production, though providing important information on the organic carbon available to the ecosystem, is currently measured only in some subareas of the Baltic Sea. The amount of data is insufficient to use primary production as eutrophication indicator for the entire Baltic Sea area.

Macrophytes

In areas with substrate suitable for macrophyte growth, the depth ranges of several species provide suitable eutrophication indicators. In some cases, historical data exists that allow establishing well-defined reference conditions. However, eelgrass (*Zostera marina*) distribution has also been affected by diseases not only by eutrophication.

Four of the indicators concern the depth distribution of the vegetation and include various parameters describing depth distribution (see Figure 4.1.1):

1) The depth limit of eelgrass shoots/algal individuals;
2) The depth limit of eelgrass meadows/algal belts;
3) The depth of maximum abundance of eelgrass/macroalgae;
4) The downward slope of eelgrass/macroalgal abundance.

Depth distribution of macrophytes is largely determined by light and therefore also by parameters affecting the light climate. Increased nutrient concentrations stimulate the production of phytoplankton and epiphytes, which reduce water clarity and thereby reduce the depth penetration of macrophytes. Depth distribution of macrophytes should therefore respond predictably to eutrophication.

The ratio of annual to perennial macroalgae and of filamentous algae to Zostera marina form potentially sensitive indicators because high nutrient concentrations generally favour the growth of ephemeral flora.

The presence and abundance of sensitive species such as Charophytes is suggested a potential indicator because Charophytes are believed to be very sensitive to eutrophication, especially to increased turbidity. The presence of at least some Charophyte-species therefore seems to be a reliable quality indicator in limnetic ecosystems.

The area covered and the bed structure of eelgrass is suggested as potential macrophyte indicator because a reduction in depth limit due to low water quality should also reduce the potential area covered by this species and possibly also change the bed structure towards more sparse and scattered patches.

Eventually, the eelgrass-associated fauna is suggested a potential indicator because recent studies have shown that the fauna composition responds to changes in water quality.

Water clarity

Secchi depth is the most simple and robust indicator of water clarity. Similarly to chlorophyll-*a*, several metrics can be used to define water clarity indicators, e.g. summer average, annual average or spring average. Most historical data are available for the summer season.

Oxygen conditions

Oxygen conditions provide a suitable indicator in some areas of the Baltic Sea, but cannot be used as an eutrophication indicator in the deep Baltic basins, because the hydrological regime controls the extent of anoxia there. Depending on the shape of the coastline, oxygen conditions in coastal areas can also be affected by upwelling.

Zooplankton

Zooplankton is an important link between primary producers and secondary consumers (planktivorous, young and larval fish) in the Baltic foodwebs. Zooplankton abundance and biomass dynamics is affected by changes in productivity, but reacts also to forcing from its predators. In addition, some zooplankton species are sensitive to changes in temperature, salinity and eutrophication/pollution.

Macrozoobenthos

Macrozoobenthos should be used as eutrophication indicator only in shallow areas of the Baltic. In deep areas, hydrological conditions regulate oxygen regime and thus macrozoobenthos occurrence. Several indicators have been proposed during last years to be used to assess eutrophication but for most of them defining good reference conditions were proven to be a difficult task. The use of different indices characterizing the community structure, species richness, and functionality have been tested in several recent investigations and the results show some promising conclusions in certain areas and complete failure in others. More investigations should be concentrated on this topic in nearest future.

Fish

Selected fish species or their various life stages (adults, juveniles, larvae or eggs) can be good indicators for eutrophication. Based on the available research results it may be concluded that percids and cyprinids are good indicators of eutrophication. However, it must be stressed that there can be other processes in parallel at work which may impact fish species dynamics in a similar direction. For instance, warm summers facilitate an increase in the abundance of cyprinids and percids and very often, separation of these effects from eutrophication is very difficult. In a similar manner, a decrease of abundance of several marine commercial species might mainly be due to fishery, not just because of decreased eutrophication.

4.4.4.4 Biological effects of hazardous substances

Biomarkers

In order to develop the concept of detecting contamination-related effects, the approach of utilising "reference values" for biological effects was initiated by using data obtained during the EU Project BEEP. The data represented selected parameters measured for flounder and blue mussels from different study areas.

The lowest seasonal mean response levels recorded at each study area were rounded downwards by ca. 20 %. The recommended reference value was obtained by the approximate mean of values from all areas using expert judgement. Exceptions are indicated in footnotes.

As a working hypothesis, an elevation/decrease (depending on the effect) of two-fold represents an effect (signal) in most of the selected biomarkers. However, more reliable criteria have to be created. It is emphasized that this is the first exercise to estimate the reference levels for a set of biomarkers in the Baltic Sea covering a larger geographical area. More relevant data, existing and new, are needed for more precise evaluation of reference levels. Furthermore, the use of other approaches, e.g. including "grey areas" of response levels or calculating the mean only for a fixed percentage of the most affected individuals (most sensitive part of the population) at each site, have to be tested.

Table 1. Approximate reference levels of biological endpoints in flounder (*Platichthys flesus*).

	Lithuanian coast		Gulf of Gdansk		Offshore areas	Recommended reference value
	Spring	Autumn	Spring	Autumn	December	
LMS	8	13	12	12	15	12
AChE	300[1]	250[1]	100[1]	200[1]	550	500
MN	0.15	0.15	0.40[2]	0.30[2]	0.10	0.15
MT	350	500	300	400	500	300/450[3]
FAC	4	3	2	5	2	3
Liver histopathology	2.0	1.0	1.0	0.0	0.0	1.0
Lymphocystis					10	10
Skin ulcer					0	0

[1]Inadeaquate data

[2]High values likely associated with biological effects of contaminants

[3]Spring and autumn values separated because of seasonal variability

Table 2. Approximate reference levels of biological endpoints in the blue mussel *Mytilus* spp.

	Lithuanian coast		Gulf of Gdansk		Wismar Bay		Recommended reference value
	Spring	Autumn	Spring	Autumn	Spring	Autumn	
LMS	12	15	10	8	10	12	12
AChE	40	30	30	30	70	50	40[1]
MN	1.00	2.00	2.00	2.00	2.00	1.00	1.50
MT	250	200	150	200	120	200	150/200[2]

1Levels possibly related to higher salinity

2Spring and autumn values separated because of seasonal variability

Programme of the ICES/BSRP Sea-going Workshop on Fish Diseases Monitoring in the Baltic Sea (WKFDM): background

Based on long-term experience there is no doubt that fish diseases are an appropriate indicator of ecosystem health and that the prevalence's of diseases respond to environmental change, including contaminant effects. Furthermore, many fish diseases are of ecological and economical relevance since they may affect growth, reproduction and survival in affected fish populations. Therefore, many ICES member countries monitor fish diseases as part of their national marine monitoring programmes.

In the Baltic Sea, only Poland, Germany and partly Russia are presently conducting regular fish disease monitoring programmes. However, from data assessments carried out by the ICES Working Group on Pathology and Diseases (WGPDMO) there is an indication of methodological problems, particularly regarding the comparability of disease prevalence data, and a clear need for more intercalibration has, thus, repeatedly been emphasised.

Besides these countries, there is also interest in other Baltic Sea countries to implement fish disease monitoring as part of the coastal or offshore monitoring, but there has been an apparent lack of either capacity or experience. Within the BSRP, this has been realised and funding was provided for capacity building related to fish disease monitoring in the BSRP beneficiary countries. The AtlantNIRO was appointed as BSRP Lead Laboratory for Fish Diseases, Parasites and Histopathology in order to coordinate activities.

4.4.4.5 Public health aspects of pollution and eutrophication

There exists similarities between the human health – the state of complete physical, social and mental well being – not merely the absence of disease or infirmity – and the good ecological status of marine environment.

Marine environment is valuable to humans in various aspects: for recreation, it supplies food and nutrition and enhances the quality of human life in terms of aesthetic enjoyment. Simultaneously, adverse public health effects can be direct – due to ingestion of polluted water, by skin contact with water or inhalation of polluted aerosols; or indirect – due to fish consuming, consumption of toxic seafood after toxic algal blooms. Among indirect effects are the loss of recreational value due to massive growth of algal mats or toxic algal blooms.

The interactions between humans and the sea are significant and necessitate more comprehensive study and assessment. The seas provide great health benefits to humans, ranging from food and nutritional resources to recreational opportunities, and a novel resource for new bioactive compounds and food additives. Marine plants, animals and microbes have served as a source for pharmaceuticals to treat diseases.

The marine ecosystem acts as a conduit for many human diseases. The distribution of viral, bacterial, and protozoal agents and chemical contaminants in marine habitats depends on the interplay of currents, tides, and human activities. The presence of algal toxins in marine environment is receiving increasing attention around the world as a public health concern. The basic route of human exposure to hazardous agents is through ingestion of contaminated seafood, but illness can also result from direct contact with seawater during recreational or occupational activities and from contact through aerosols (sea spray) containing toxins.

Pathogens from human or animal waste and different chemical compounds contaminate coastal and estuarine areas through freshwater runoff from sewers, rivers and streams. Marine pathogen bacteria and harmful algal species can invade new areas through the transport of organisms in the ballast water of ships. Viruses and bacteria of faecal origin become concentrated in filter-feeding shellfish such as oysters and clams. No specific test exists for detecting contaminated fish. At the same time fisheries products are transported and sold worldwide.

Many types of chemical contaminants threaten the marine ecosystem as well as human health. Substances of particular concern are synthetic organic chemicals, specific heavy metals, marine (algal) toxins, and possibly genetically modified organisms. A major concern for public health is the ingestion of contaminated seafood, putting those humans who eat contaminated seafood over time at the greatest risk. The long-term exposure has a variety of effects on human reproduction, neurobehavioral development, liver and kidney function, immune response, and tumorigenesis. More recently, these compounds have been found to possess endocrine properties and have been associated in animals and humans with male fertility problems.

Algal toxins are produced by marine organisms on a scale large enough to induce adverse effects on communities of higher organisms. Humans may be exposed through the consumption of seafood or through dermal contact from occupational or recreational exposure to a toxin. Different toxins have different effects. Symptoms include nausea or respiratory problems up to severe memory loss, with fatality rates exceeding 10% in some cases.

Linking the health of the marine ecosystem with that of human population is a long-term endeavour that will require considerable efforts and resources. Reduction and prevention of human health threats caused by marine ecosystem changes requires determination of cause-effect relationship. It is possible only by correlating data on ecosystem health changes with reliable reports from the public health sector.

4.4.4.6 Socio-economic aspects

Socio-economic indicators are useful to describe the driving forces leading to nutrient enrichment, especially indicators that describe the intensity of agriculture (e.g. fertilizer use, livestock density, farm size, number of manure tanks per specific number of farms), forestry, traffic emissions (e.g. number of cars) or industry (point source loads).

Preliminary proposal for socio-economical indicators in regard to hazardous substances:

- loss in fisheries (change in fisheries value, reduction of commercial fish stocks, and species diversity);
- lowered quality of fish and other marine organisms as food;
- increased costs of fish surveillance in the case of toxin incidence [monitoring];
- loss of marine organisms (micro-, macroalgae and others) used for producing food additives, cosmetics, fertilisers, pharmaceutics;
- reduced options for aquaculture development;
- increased risk to human health (infection diseases, poisonings, allergy, cancer, etc);
- increased costs of human health protection and medical treatment;
- loss of tourism, recreation and aesthetic values (closing of beaches, etc.);
- costs of monitoring (monitoring of pollution, biota, human health);
- costs for remediation of aquatic ecosystem (removal of polluted sediments, beach cleaning, etc);
- costs of reduction and liquidation of pollution (liquidation of oil spots and cleaning, etc.).

4.4.4.7 Fish

As the fisheries ecosystems of the 'true seas' (e.g. North Sea) are very different from the brackish young seas (the Baltic Sea), the indicators which have been developed and are working there cannot be directly applied in the conditions of the Baltic Sea. Even more, most of them were ranked as 'requires further evaluation' or even dropped out of the list. It should be mentioned here that both the scope and efforts of the fisheries science in the Baltic Sea region (i.e., by countries) differs from that in other major fisheries regions, which is partly due to substantial regional natural heterogeneity within the Baltic Sea. In addition, for instance, our knowledge on population characteristics is very limited for most of the non-commercial fish.

4.5 SGEH meeting 2006 (ICES 2007)

The 2006 SGEH meeting reviewed progress on ecosystem based approaches for Baltic Sea health assessment. Indicators of biodiversity, biological effects of hazardous substances, eutrophication, and fishery, developed during previous meeting, were discussed and further developed. Also, a preliminary compilation of genetic diversity was prepared. After plenary presentations and discussion the SGEH group had split into two sub-groups that concentrated on biodiversity and hazardous substances selecting and developing best possible indicators.

The meeting outcomes were:

- revised and updated tables with a list of indicators for each group of indicators shown above. A sort of an indicator diagnosis i.e., an assessment of practical applicability and specificity of a given indicator was developed;
- referenced conditions and target levels were established for some specific indicators;
- plans on future demonstration project on an integrated multidisciplinary assessment of the Gulf of Finland contamination status;

- recommendation that the outcome of the meeting would be used when developing programmes for monitoring and/or assessment of the Baltic Sea ecosystem.

4.5.1 Hazardous substances

A proposal of indicators on hazardous substances and biological effects including fish diseases and parasites was updated (see Annex 5).

4.6 SGEH meeting 2007 (ICES 2008)

SGEH reviewed the progress regarding ecosystem-based approaches to management of the marine environment and discussed ecosystem health (EH) issues of the Baltic Sea with respect to two of the four HELCOM BSAP activities (ICES 2008):

- biological effects of contaminants, and
- loss of biodiversity.

The scientific background for the implementation of the HELCOM Baltic Sea Action Plan (BSAP) and the EU Water Framework Directive (WFD) was the focus of the meeting. The SGEH referred to its report from the 2003 meeting, where the following 4 environmental concerns were identified as ecosystem health priority issues:

- effects of eutrophication,
- biological effects of hazardous substances (and fish diseases),
- effects of fishing, and
- loss of biological diversity (including xenodiversity and habitat destruction).

These issues are not completely in line with issue covered by the four HELCOM BSAP goals:

- Baltic Sea unaffected by eutrophication,
- Baltic Sea unaffected by hazardous substances,
- favorable status of Baltic Sea biodiversity, and
- maritime activities carried in an environmentally friendly way.

4.6.1 Identification of SGEH links

SGEH links to HELCOM:

- provide scientific background for the implementation of the HELCOM Baltic Sea Action Plan (BSAP)
- contribute to HELCOM Thematic Assessment on Biodiversity
- contribute to HELCOM Thematic Assessment on Hazardous Substances
- provide background to future monitoring of biological effects of contaminants

SGEH links to EU:

- Development of indicators (biodiversity) for the EU Water Framework Directive (WFD)

NB: Marine Strategy Framework Directive was NOT mentioned in the 2007 Report.

SGEH links to OSPAR:

- Corresponding work with ICES/OSPAR WKIMON regarding the development of indicators of biological effects of contaminants and related assessment criteria as well as guidelines for integrated monitoring and assessment of contaminants and their biological effects

SGEH links to other ICES Expert Groups:

- ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB),
- Working Group on Regional Ecosystem Description (WGRED),
- Benthos Ecology Working Group (BEWG),
- Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice co-sponsored by ICES, EUROCEANS, and GLOBEC (WKEFA).

4.6.2 Presentation of projects

- Classification of biodiversity and assessment methodologies
- Gulf of Finland biodiversity case study (comprehensive annex)
- The trophic status index for brackish water quality assessment in the Baltic coastal waters
- Sea-going Demonstration Project on the Ecosystem Health of the Gulf of Finland (as part of the BONUS+ BEAST project)
- Other BONUS+ projects

4.6.3 Recommendations from the 2007 SGEH meeting

Concerning the Ecosystem Health Concept, SGEH proposed to concentrate in the future on the following aspects:

- development of tools for the assessment of ecosystem health,
- demonstration Project on the Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland,
- work towards implementation of EU WFD and BSAP,
- development of reference values, assessment criteria and ecosystem health indices,
- development of socio-economic (D-type) indicators.

The SGEH agreed to continue its activities concerning:

- biological effects of hazardous substances (including fish diseases),
- biodiversity (including fish diversity),
- issues regarding the implementation of WFD and HELCOM BSAP (reference values, indices),
- contributing to the development and use of socio-economic indicators (D-indicators),
- extending its activities on ecosystem effects of biotoxins produced by harmful algal blooms.

It has also been agreed that:

- the reference values (assessment criteria for biological effects) suggested by WKIMON (2007) shall be discussed and evaluated in a Baltic perspective at the 2008 SGEH meeting, and
- SGEH should take an active part in selection of relevant indicators and indices for HELCOM Thematic Assessments and EU WFD.

Literature cited

ICES (2004) Report of the Study Group on Baltic Ecosystem Health Issues (SGEH). ICES CM 2004/H:02, 58 pp.

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ICES (2008) Report of the Study Group on Baltic Ecosystem Health Issues (SGEH). ICES CM 2008/BCC:01, 40 pp.

5 Review and discussion on new developments regarding ecosystem-based approaches to management of the marine environment with particular reference to progress in EU, ICES, HELCOM and OSPAR (ToR a)

5.1 EU

5.1.1 WFD and MSFD

There are a few differences in approach between WFD and MSFD that can be noted. WFD focus more on marine-chemical parameters than the MSFD, where aspects like e.g. biological diversity and fishing is of higher concern. MSFD does not regulate at the same level of detail as the WFD and regional differences is taken into account. An important difference between the directives is that in WFD measures is related to the benefit. In the MSFD the measures should be related to the risk for the environment. Measures should be devised on the basis of the precautionary principle and the principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay.

5.1.2 MSFD

Within the MSFD good environmental status shall be determined on the basis of eleven qualitative descriptors (Annex 6). Eleven expert groups have been formed within EU, one for each descriptor. In September 2009 the expert group will present the suggested criteria and methodological standards for the descriptors to the commission. Thereafter the commission will consult all interested parties, including Regional Sea Conventions. In July 2010 the commission will decide on standards and criteria and methodological standards. Regional differences will be regarded. Thereafter an initial assessment of the current environmental status should start. By 15 July 2012 the initial assessment should be completed and "good environmental status" and targets and associated indicators should be determined. The initial plan for the organisation of the work within EU with the MSFD is presented Annex 7.

The suggested criteria and methodological standards for the descriptors should be discussed in this group in the meeting next year.

In the MSFD is it stated that where the status of the sea is critical to the extent that urgent action is needed, Member States should endeavour to agree on a plan of action and making the region a pilot area. HELCOM have recently agreed to suggest to the commission that, based on BSAP, the Baltic Sea should become a pilot area.

5.1.3 EU Strategy for the Baltic Sea Region

The European Commission is preparing an EU Strategy for the Baltic Sea Region on the request of the European Council. The aim of the Strategy will be to coordinate the efforts of various actors in the Region (Member States, regions, financing institutions, the EU, pan-Baltic organisations, non-governmental bodies etc.) so that by working together they would promote a more balanced development of the Region.

The Strategy will aim at four main objectives:

1) to improve the environmental state of the Baltic Sea Region and especially of the Sea;
2) to make the Baltic Sea Region a more prosperous place by supporting balanced economic development across the Region;
3) to make the Baltic Sea Region a more accessible and attractive place for both its inhabitants, for competent labour force and for tourists; and
4) to make the Baltic Sea Region a safer and more secure place.

The Commission services, with Directorate General Regional Policy leading the work, will present the first draft of the Strategy in the last trimester of 2008 and consult the stakeholders during several events to be organised in the Baltic Sea Region. The Strategy will be presented to the European Council in June 2009 and be one of the main priorities of the Swedish EU Presidency during the second half of 2009.

Reference: http://ec.europa.eu/regional_policy/cooperation/baltic/index_en.htm

5.2 ICES

Ecosystem approach within the ICES is mainly related to fisheries.

5.3 HELCOM

A number of monitoring programmes are coordinated by HELCOM. A holistic assessments of the state of the Baltic marine environment over the period 1999–2002 was published in 2003. Results from the monitoring programmes are used in annually updated indicator fact sheets and thematic reports on various topical issues. A thematic assessment on eutrophication was published in March 2009. Thematic assessments on biological diversity, maritime activities and hazardous substances are planned. The time plan for the report on hazardous substances is that the next planning meeting will be the 27–28 of April 2009. The first draft should be ready in July 2009 and the second draft in October 2009. The report should be finished at the end of 2009. Based on these thematic report an holistic assessment will be done. The report on the holistic assessment is expected to be of use within the work to fulfil the BSAP.

WGIAB have developed a so-called ”traffic-light plot” that can describe changes within ecosystems. In the future it can be interesting to establish links with this group (see further: WGIAB report 2008).

5.4 OSPAR

OSPAR is working on the Quality status report for 2010. This working group should follow the outcome of this report and it will be discussed in the meeting next year.

6 Review and update progress with national and international biological effect monitoring activities e.g. OSPAR, HELCOM, MED-POL, WFD, MSFD, harmonization initiatives, integrated assessment and application of biological effect techniques, and the ICON programme (ToRs e, f)

SGEH is providing a summary and update of the implementation and application of biological effects monitoring activities in the frame of international programmes, conventions, as well as EU-directives. In addition, information on intercalibration, harmonization, and other quality-assurance procedures are given with respect to biological effects of contaminants including fish diseases.

6.1 OSPAR

The core marine environmental monitoring activity under the JAMP is the OSPAR CEMP (The Co-ordinated Environmental Monitoring Programme). CEMP is focussed on monitoring of the concentrations and effects of selected contaminants and nutrients in the marine environment. The only mandatory effect biomarker is TBT effects in gastropods.

With regard to biological effects monitoring, OSPAR provides JAMP guidelines for:

- General biological effects monitoring (agreement 1997–7).
- Contaminant specific effects monitoring (agreement 2008–9).
- Integrated Monitoring and Assessment of Contaminants and their effects (in preparation)

The ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their effects in coastal and Open-sea Areas (former WKIMON, now SGIMC) came up with a list of biomarkers useful for different integrated monitoring purposes including their assessment criteria (WKIMON 2007, SGIMC 2009). In addition, they provided background documents on the status of biological effects monitoring techniques and draft guidelines for the integrated assessment of contaminants and their effects.

In that frame, the project ICON (start in 2008) acts as a demonstration project and a pilot study for the application of biomarker techniques in integrative contaminant and effect studies of European coasts and offshore regions.

The following biomarkers are analyzed in the frame of regional/ national monitoring activities in the OSPAR-area and data sent to the ICES database: Denmark: imposex, France: imposex, Germany: 2-hydroxy naphthalene, fish diseases, Norway: EROD, ALA-D, 3-hydroxy benzo(a)pyrene, imposex, MT, 2-hydroxy naphthalene, 1-hydroxy phenanthrene, 1-hydroxy pyrene, Spain: imposex, sterility of females, Sweden: imposex, The Netherlands: oyster embryo assay, intersex, fish diseases, United Kingdom: EROD, imposex, intersex, sterility of females,1-hydroxy pyrene, fish diseases.

6.2 HELCOM

Even though there are no mandatory biological effects monitoring activities in the HELCOM area, part D of the HELCOM COMBINE monitoring programme defines the monitoring of contaminants and their effects with the following objectives:

- study the relationships between concentrations and effects;
- provide knowledge on health parameters;
- integration of measurements from the level of effects of contaminant concentrations at the tissue level up to effects at the population level;
- coverage of different levels in the food web;
- assessment of acute as well as chronic responses;
- simultaneous measurements of the levels of relevant contaminants in the study organism and relevant environmental matrix.

ICES has been invited by HELCOM to advice on methods for determining effects primarily on reproduction, immunology and metabolism of marine organisms. In addition, the recommendations of OSPAR on the parameters used should be taken into considerations to harmonize the programmes and to make use of the expertise relevant for Baltic species and the Baltic environment.

HELCOM stresses the need for studies providing knowledge about the applicability of several of the contamination-related biomarkers in current use (e.g. EROD induction, histopathology) in Baltic Sea organisms that are potentially useful as monitoring species.

In addition, the development of chronic sediment and water bioassays are considered by HELCOM useful for studies in heavily contaminated areas.

6.3 MEDPOL

MEDPOL Phase III (1996–2005)

Biological effects monitoring has been included in the monitoring programmes as a pilot activity to test the methodology and its use as early-warning tools to detect any destructive effects of pollutants on marine organisms. Biomarkers are considered as "impact" indicators used for the evaluation of toxic effects of pollutants on coastal marine life. They are considered as the most direct method to assess exposure to, and effects of, chemical contaminants at very early stages (at cellular or organism level) (UNEP/RAMOGE, 1999, UNEP, 2007).

The principal programmatic components of MED POL Phase IV (2006-2013) were discussed at the Third Review Meeting on MED POL – Phase III Monitoring Activities in December 2005.

The biological effects monitoring activity will continue to be a component of MED POL monitoring and assessment. The programme will be further developed using caged organisms and the 2-tier approach (UNEP, 2007).

6.4 WFD

In the EU Water Framework Directive there is no implementation of biological effects monitoring.

6.5 MSFD

Indications for a potential future application of biological effects monitoring in the frame of the Marine Strategy Framework Directive are given in the "Directive 2008/56/EC of the European Parliament and of the Council" of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). In the Annex "Qualitative descriptors for determining good environmental status (referred to in Articles 3(5), 9(1), 9(3) and 24)" it is mentioned that:

- All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
- Concentrations of contaminants are at levels not giving rise to pollution effects.

In the Directive it is mentioned that member states shall identify those descriptors which are to be used to determine the good environmental status for their marine region or subregion. When a Member State considers that it is not appropriate to use one or more of those descriptors, it shall provide the Commission with a justification in the framework of the notification made pursuant to Article 9(2).

6.6 Harmonisation, intercalibration, and training of biological effects parameters

The following recent international activities for the harmonisation, intercalibration, and training of biological effects parameters were identified and discussed during the meeting:

- BEQUALM Biological Effects Quality Assurance in Monitoring programmes. Intercalibration workshops and ring-tests for the following parameters:
    - EROD
    - External fish diseases
    - Liver histopathology
    - Acute 10 day *Corophium volutator* (amphipod) sediment test
    - Luminescent Bacteria Programme
- QUASIMEME
    - Imposex and intersex in marine snails (shell height, penis length, vas deferens stage, female prostrate length and intersex change)
- ICON project
- Harmonisation of the techniques to measure PAH metabolites in bile
- SGIMC Workshop in Aberdeen 2009
- Workshop Bremerhaven (Training): Lysosomal membrane stability, histochemical approach has been performed in October 2008 at AWI/IMARE
- SGIMC Workshop Spain in 2009: Neutral red retention tests, lysosomal membrane stability
- The MED POL programme has established a regional data quality assurance (DQA) programme. The DQA programme, intended for all MED POL participating laboratories, comprises several components.

- The University of Alessandria, Italy, act as a reference centre for biological effects studies and conducts LPS for the biological affects monitoring in cooperation with ICES and BEQUALM. It will implement training and intercalibration as required.

7 Review and report the progress on the development of assessment criteria and integrated chemical-biological effect assessment tools in the Baltic Sea region (ToR g)

7.1 Review of indicators and assessment criteria in previous SGEH reports

The SGEH reviewed the information on indicators and related assessment criteria for environmental impacts relevant for the Baltic Sea provided in the previous SGEH reports. It was noted that especially the report from the 2006 meeting in Tallinn (ICES 2007) contains a number of comprehensive annexes detailing:

1) indicators of habitat destruction and loss of biodiversity (Annex 13)

2) indicators on hazardous substances and biological effects (incl. disease and parasites) (Annex 14)

3) indicators of eutrophication (Annex 15)

4) indicators of fishery (Annex 16)

In the annexes information is provided on the immediate applicability of the indicators listed for Baltic Sea monitoring and assessment as well as on the extent to which the indicators meet the requirements defined (as regards data availability, regional responsiveness to stressors, unambiguous interpretation, simple quantification, index period stability, low year-to year variation and environmental impact).

Another annex (Annex 3) in the report from the 2006 SGEH meeting described an exercise on Gulf of Finland bivalve data, aimed at the determination of sub-regional reference/target and effect levels for biomarkers.

For many of the indicators, information on reference/target values needed for the establishment of assessment criteria is given in the SGEH 2006 report. However, notes of caution were made regarding the status and applicability of the values for the entire Baltic Sea and it was clearly stated that more work is needed to generate values with a higher degree of confidence.

Because of the expertise of the 2009 participants of SGEH, the SG did not feel sufficiently competent to draw conclusions regarding progress achieved on assessment criteria for the indicators of habitat destruction and loss of biodiversity, eutrophication and fishery. However, for the indicators on hazardous substances and biological effects it was noted that the information contained in the 2006 SGEH report still represents the current situation. It is anticipated that significant progress will be achieved through the BONUS+ project BEAST (see SGEH report section 9) since the project focuses explicitly on the development of assessment approaches for biological effects of contaminants in the Baltic Sea.

7.2 Review of indicators and assessment criteria in the OSPAR area

The SGEH further reviewed progress made in the development of assessment criteria for biological effects of contaminants in the ICES/OSPAR context. The newly formed ICES/OSPAR Study Group on Integrated Monitoring of Contaminants and Biological Effects (ICES/OSPAR SGIMC) and its predecessors (the ICES/OSPAR Workshops on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-sea areas; WKIMON I-IV) focused on the development of assessment criteria and provided relevant information in their reports (ICES 2008, 2009). Particularly the SGIMC report provides detailed tables on the current status of assessment criteria developed for the OSPAR CEMP/JAMP and further work on the topic is included in the SGIMC work plan for the coming years. For instance, a workshop on assessment criteria is scheduled for autumn 2009 (Aberdeen, UK).

Another current activity that is aimed at developing assessment criteria and strategies is the ICON project (Integrated Assessment of Contaminant Impacts of the North Sea) that constitutes a demonstration programme for the applicability of the ICES/OSPAR integrated approach to monitoring and assessment of contaminants and their biological effects in the North Sea. Results obtained in ICON are expected to be available in late 2009.

In the discussion, it was emphasized that the results of the ICES/OSPAR efforts as well as of the ICON project should be reviewed by the SGEH at its 2010 meeting in detail in order to evaluate their applicability to the Baltic Sea conditions. It was stressed that the review should focus on both, the design of the assessment criteria as well as the values recommended as reference/target values. The SGEH further noted that assessment criteria for hazardous substances and for biological effects have been generated and applied also in other geographical areas and programmes, such as in the Mediterranean Sea through the MED POL programme. These should also be considered in the review.

7.3 Conclusions

1) The SGEH concluded that the information on assessment criteria for hazardous substances and their biological effects contained in the SGEH report from its 2006 meeting still represents the current status. However, progress is expected to be made through the BONUS+ project BEAST and through other activities for areas outside the Baltic Sea. These should be reviewed at the 2010 SGEH meeting and an update report should be prepared.

2) It was pointed out that for many of the parameters for which assessment criteria are needed there is still a lack of baseline data from sub-regions of the Baltic Sea. However, such data are required and will be obtained within the BONUS+ BEAST project.

Literature cited

ICES (2007) Report of the ICES Study Group on Baltic Ecosystem Health (SGEH). ICES CM 2007/BCC:01, 112 pp.

ICES (2008) Report of the ICES/OSPAR Workshop on on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-sea areas (WKIMON IV). ICES CM 2009/ACOM:49, 69 pp.

ICES (2009) Report of the ICES/OSPAR Study Group on Integrated Monitoring of Contaminants and Biological Effects (ICES/OSPAR SGIMC) ICES CM 2009/ACOM:30, 64 pp.

8 Review progress within the BONUS+ Programme BEAST project with discussions on development of especially the parts of the project related to development of integrated monitoring (Workpackage 2) and assessment of ecosystem health (Workpackage 3) to serve the goals of the SGEH and BSAP (ToR d)

8.1 Review progress within Bonus BEAST WP 3

The main objectives of work package 3 are a) to perform integrated analyses of biological effect data generated within BEAST and available from previous studies (e.g. BEEP) or national and regional monitoring in the Baltic Sea; b) to test existing integrated approaches and (based on those) to develop new approaches suitable for the Baltic Sea sub-regions and the area as a whole; c) to perform regional assessments in selected Baltic Sea subregions.

Another task of WP 3 concerns the set-up of the database needed to host all relevant data produced within the BEAST project but also other data/metadata already available concerning biological effects (e.g. BEEP data), data on chemical measurements and environmental variables measured (e.g. temperature, salinity, oxygen). The work on this database has started and a first structure should be available to all BEAST partners in June 2009.

Another WP3 activity during 2009 will be to compile and review information on existing approaches concerning integrated biomarker indices, expert systems and other assessment strategies which have been developed for other marine regions. In relation to this activity an expert workshop will be organised to be held in Jan/Feb 2010. During this workshop, BEAST partners and external experts will discuss and evaluate the compiled information, and will perform first practical exercises using Baltic Sea data. Another goal will be to give recommendations concerning the further integrated analyses of the BEAST data and other data available from other sources (e.g. BEEP).

9 Evaluation of progress made regarding the planning of Sea-going Demonstration Project on the Ecosystem Health of the Gulf of Finland (a specific subregional part of the BONUS+ BEAST project) (ToR c)

9.1 BEAST GOF-IA (Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland)

GOF-IA (Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland) is a part of the BEAST project (Biological Effects of Anthropogenic Chemical Stress: Tools for Ecosystem Health Assessment) that belongs to the BONUS+ Programme. The aim of the GOF-IA is to foster and execute the ecosystem health approach in the assessment of the state of the different sub-regions of the Baltic Sea. Measurements and sampling are planned to be carried out at 24 stations and 10 fishing areas in Finnish, Russian and Estonian waters of the Gulf of Finland in August-September 2009. The researches will be executed as a joint cruise of the Finnish ocenographic r/v Aranda and the German fishery r/v Walther Herwig III. The parameters studied include (1) hydrography (nutrients, salinity, temperature, pH, oxygen content), (2) biomarkers of hazardous substances in biota, (3) hazardous substances and algal toxins in biota and sediment, (4) fish diseases and histopathology and (5) abundance, biomass and structure of benthos, phytoplankton, zooplankton and fish communities. Samples will also be collected for specific research needs and experimental approaches, e.g. mussels deployed in cages in the Kotka region during the previous cruise will be collected for analyses. The collected new data will be combined, in feasible parts, with previous material. The GOF-IA will provide decisively new information especially of the biological effects of hazardous substances in this Baltic Sea subregion.

10 Planning of intersessional work, contributions to the implementation of HELCOM BSAP, and key topics of next year's SGEH meeting (ToR h)

The SGEH meeting discussed, identified and agreed upon the following intersessional work and topics for the meeting in 2010:

1) review the outcome of the BEAST project Data Treatment and Index Testing & Development Workshop (early 2010);
2) review the progress in the BONUS+ BEAST project;
3) examine the review of (a) literature on basic & applied research on biological effects of contaminants and (b) chemical contamination in the Baltic Sea;
4) evaluate of relevance of the literature review above for the development of integrated biological chemical monitoring and assessment criteria;
5) follow-up of the SGEH input to the HELCOM HOLAS Thematic Assessment concerning hazardous substances (HAZAS);
6) discuss the methodological standards and criteria suggested to the EU Commission within the Marine Strategy Framework Directive concerning qualitative descriptors for determining good environmental status;
7) review the concept of ecosystem health concerning the Baltic Sea in particular and its implementation in HELCOM BSAP.

11 Any other business

The SGEH will investigate the possibility to arrange the next meeting in March/April 2009 at the Sea Fisheries Institute, Gdynia (Poland), kindly offered by Henryka Dabrowska.

12 Closing of the meeting

The meeting closed on 5 March 2009 at 16:00.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Katja Broeg	Alfred Wegener Institute for Polar and Marine Research Haus E, Am Handelshafen 12 D-27570 Bremerhaven Germany	+49 471 48311618 +49 471 48311425 (fax)	katja.broeg@awi.de
Henryka Dabrowska	Sea Fisheries Institute in Gdynia ul. Kollataja 1, 31-332 Gdynia Poland	+48 58 735 6205 +48 662 595 601 +48 58 735 6110 (fax)	dabrowska@mir.gdynia.pl
Sergey Kholodkevich	Scientific Research Center for Ecological Safety RAS Korpusnaya str. 18 RU-197110 St. Petersburg Russia	+7 9112273948 +7 8122307875 +7 8122354361(fax)	kholodkevich@mail.ru
Tatiana Kuznetsova	Scientific Research Center for Ecological Safety RAS Korpusnaya str. 18 RU-197110 St. Petersburg Russia	+7 9500443864 +7 8122307875 +7 8122354361(fax)	kuznetsova_tv@bk.ru
Thomas Lang	Johann Heinrich von Thünen-Institut Institute of Fishery Ecology Deichstrasse 12 D-27472 Cuxhaven Germany	+49 4721 38034 +49 4721 53583 (fax)	thomas.lang@vti.bund.de
Kari Lehtonen	Finnish Environment Institute Marine Research Centre POB 140 FI-00251 Helsinki Finland	+358 40 7030305 +358 9 323 3970 (fax)	kari.lehtonen@ymparisto.fi

Doris Schiedek	National Environmental Research Institute (NERI), Aarhus University P.O. 358, Frederiksborgvej 399 DK-4000 Roskilde Denmark	+45 46301962 +45 46301914 (fax)	dosc@dmu.dk
Rolf Schneider	Leibniz Institute for Baltic Sea Research Seestrasse 15 D-18119 Rostock Germany	+49 381 5197 213 +49 381 5197-302	rolf.schneider@io-warnemuende.de
Brita Sundelin	Department of Applied Environmental Research Stockholm University Frescativägen 54 A SE-10691 Stockholm Sweden	+46 86747235 +703136059 +46 86747338 (fax)	brita.sundelin@itm.su.se
Petra Wallberg	Swedish Environmental Protection Agency Valhallavägen 195 SE-106 48 Stockholm Sweden	+ 46 8 698 11 18 + 46 8 20 29 25 (fax)	petra.wallberg@naturvardsverket.se
Pekka Vuorinen	Finnish Game and Fisheries Research Institute P.O.Box 2 (Viikinkaari 4) FI-00791 Helsinki Finland	+358 40 732 7357 +358 205 751202 (fax)	pekka.vuorinen@rktl.fi

Annex 2: Meeting agenda

1. Opening of the meeting; including a welcome address from the Vice Director of IOW, Prof. Wolfgang Fennel;
2. adoption of the agenda;
3. appointment of rapporteurs;
4. review and discussion on the past activities of the predecessor of the SGEH (BSRP/HELCOM SGEH, 2005-2008) (ToR a, ToR b):
    a. the legacy of the past SGEH;
    b. redefining Ecosystem Health in the Baltic Sea (?);
    c. updated goals and outputs of SGEH;
    d. working methods of SGEH;
5. review and discuss on new developments regarding ecosystem-based approaches to management of the marine environment with particular reference to progress in (ToR a)
    a. EU (e.g. WFD, MSFD);
    b. ICES;
    c. HELCOM (e.g. WGIAB);
    d. OSPAR;
6. review and update progress with national and international biological effect monitoring activities e.g. OSPAR, MEDPOL, WFD, MSFD, harmonisation initiatives, integrated assessment and application of biological effect techniques, and the ICON programme (ToRs e, f);
7. review and report the progress on the development of assessment criteria and integrated chemical-biological effect assessment tools in the Baltic Sea region specifically in regard to (ToR g)
    a. work done under the previous SGEH;
    b. work done in the OSPAR area applicable in the Baltic Sea area;
8. review progress within the BONUS+ Programme BEAST project with discussions on development of especially the parts of the project related to development of integrated monitoring (Workpackage 2) and assessment of ecosystem health (Workpackage 3) to serve the goals of the SGEH and BSAP (ToR d);
9. evaluate the progress made regarding the planning of Sea-going Demonstration Project on the Ecosystem Health of the Gulf of Finland (a specific subregional part of the BONUS+ BEAST project) (ToR c);
10. planning of intersessional work, contributions to the implementation of HELCOM BSAP, and key topics of next year’s SGEH meeting (ToR h);
11. any other business;
12. recommendations and action list;
13. adoption of the report and closure of the meeting.

Annex 3: SGEH terms of reference for the next meeting

The **Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea** [SGEH] (Chair: K. Lehtonen, Finland) will meet in Gdynia, Poland from 1 to 5 March 2010 to:

a) review the outcome of the BEAST project Data Treatment and Index Testing & Development Workshop (early 2010);
b) review the progress in the BONUS+ BEAST project;
c) examine the review of (a) literature on basic & applied research on biological effects of contaminants and (b) chemical contamination in the Baltic Sea;
d) evaluate of relevance of the literature review above for the development of integrated biological chemical monitoring and assessment criteria;
e) follow-up of the BEAST/SGEH input to the HELCOM HOLAS Thematic Assessment concerning hazardous substances in the Baltic Sea;
f) discuss the methodological standards and criteria suggested to the EU Commission within the Marine Strategy Framework Directive concerning qualitative descriptors for determining good environmental status;
g) review the concept of ecosystem health concerning the Baltic Sea in particular and its implementation in HELCOM BSAP.

SGEH will report by 30 April 2010 to the attention of the Science Committee.

Supporting Information

Priority:	The activities of SGECOH will lead ICES to progress related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently these activities are considered to have a very high priority.
Scientific justification and relation to action plan:	Action Plan Nos: 1.2, 2.3, 2.6 SGEH will continue its activities, but focusing more on the effects of anthropogenic contaminants at different biological levels. Several countries are conducting or have recently completed significant studies in aspects being potentially of relevance for the integrated assessment. The integrated assessment of WGIAB would benefit from a review of progress and an evaluation of the results obtained. This shall be done to support WGIAB with all availbale information in a structured manner and to help WGIAB in selecting appropriate areas for the integrated assessment. SGEH will directly link with the Baltic Sea BONUS+ Programme project BEAST whose partners form the backbone of the group. SGEH will also link closely with the Baltic Sea BONUS+ Programme project BALCOFISH. SGEH will link with the ICES WGIAB on matters concerning methods of integrated assessments in the Baltic Sea. Key members of the now closed SGEH are also members of WGBEC, and during the annual WG meetings they reported regularly about ongoing activities in the Baltic Sea in regard to research and development on biological effects and other issues in relation to Ecosystem Health. SGEH will form an even stronger link between these two ICES groups. SGEH will act as a consultant of HELCOM concerning advice on re-structuring/re-organisation/establishment of integrated biological-chemical monitoring of hazardous substances in the Baltic Sea.
Resource requirements:	The research programmes which provide the main input to this group are underway and resources already committed. The additional resources required to undertake additional activities in the framework

	of this group are negligible.
Participants:	The Group, apart from appointed national members, will be attended by experts involved in implementation of BONUS +/BEAST project.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	
Linkages to other committees or groups:	There is a close working relationship with (WGIAB, WGBEC & SGIMC.
Linkages to other organizations:	The work of this group is closely aligned with similar work in FAO.

Annex 4: Recommendations

Recommendation	For follow up by:
1. Future meetings of the ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) should focus on aspects related to all four main issues of the HELCOM Baltic Sea Action Plan (eutrophication, hazardous substances, biodiversity, maritime activities) in order to be able to make recommendations concerning monitoring and assessment in an integrated way, needed to assess ecosystem health.	WGIAB, SSGRSP, HELCOM MONAS
2. Interactions and collaboration among groups dealing with integrated asessments (such as SGEH, WGIAB and OSPAR/SGIMC) should be strengthened with the aim of harmonisation of targets and methodology.	WGIAB, SSGRSP, OSPAR/SGIMC, HELCOM MONAS
3. The integrated approach for monitoring and assessment should be reflected in the SGEH participation, and ICES Member Countries are encouraged to nominate appropriate national experts to attend the future SGEH meetings.	WGIAB, SSGRSP, OSPAR/SGIMC, HELCOM MONAS
4. Close links between the SGEH and HELCOM should be established since HELCOM is expected to be the main end-user of the SGEH deliverables and recommendations; regular participation of HELCOM representatives would serve this purpose.	WGIAB, SSGRSP, HELCOM MONAS
5. SGEH should serve as a key expert group concerning biological effects in issues related to the implementation of the BSAP as well as the Marine Strategy Framework Directive where the Baltic Sea has been identified as a pilot area.	WGIAB, SSGRSP, OSPAR/SGIMC, HELCOM MONAS
6. Biological effects methods have to be included in the monitoring and assessment toolbox to support (a) the Marine Strategy Framework Directive and (b) the HELCOM Holistic Assessment of the Baltic Marine Environment, thus to comply with BSAP.	WGIAB, SSGRSP, OSPAR/SGIMC, HELCOM MONAS, WGBEC, WGDPMO

Annex 5: A proposal of indicators on hazardous substances and biological effects (including fish diseases and parasites).

Annex 14: Revised table of indicators on Hazardous Substances and Biological Effects (incl. disease and parasites)

Revised by the SGEH Sub-group on Hazardoes Substances (K. Lehtonen, T. Lang (co-chairs), J. Baršienė, B. Hedlund, G. Rodjuk, D. Schiedek andJ. Strand)

Applicability of the indicators: For an evaluation of the applicability of the indicators for monitoring and assessment purposes, the following scoring system was applied in the tables:

Indicator diagnosis:	1: directly applicable 2: more validation needed
Indicator Assessment Criteria:	scores 1-5, the higher the number the better does the indicator meet the criteria optimum

Table A. Hazardous Substances

Indicator	Indicator Diagnosis	Indicator Assessment Criteria							Remarks
		Data availability/ source	Regionally responsive	Unambiguoully interpretable	Simple quantification	Index period stability	Low year-to-year variation	Environmental impact	
Hg, Cu, Cd, Pb, Zn, DDT and metabolites, CBs, HCB, a-HCH, g-HCH, PAH***, organotin compounds, dioxins and furans, brominated flame retardants, PFAS, in biota Data source: national, ICES, HELCOM	1	4	5	5	*3	5	5	**4	*depends on substance **depends on substance and concentration (incl. human consumption) *** only in bivalves
Radioactive substances (g-emitters K-40 and Cs-137; Sr-90, Tc-99, Pu-239/240, Am-241 natural radionuclides) in biota Data source: national, HELCOM	1	3	5	5	4	5	5	*5	*depends on concentration
Hg, Cu, Cd, Pb, Zn, DDT and metabolites, PCBs (IUPAC),	1	4	5	5	4	5	5	*4	*depends on concentration

Indicator	Indicator Diagnosis	Indicator Assessment Criteria							Remarks
		Data availability/ source	Regionally responsive	Unambiguoully interpretable	Simple quantification	Index period stability	Low year-to-year variation	Environmental impact	
HCB, a-HCH, g-HCH, PAH, organotin compounds in sediments Data source: national, ICES, HELCOM									
Radioactive substances (Sr-90, Pu-239/240, Am-241, natural radionuclides) in sediments Data source: national, HELCOM	1	3	5	5	4	5	5	*5	*depends on concentration

Table B. Bioassays

Indicator	Indicator Diagnosis	Indicator Assessment Criteria							Remarks
		Data availability/ source	Regionally responsive	Unambiguoully interpretable	Simple quantification	Index period stability	Low year-to-year variation	Environmental impact	
Acute Sediment Toxicity Data source: national	1	2	5	5	4	5	5	5	A variety of techniques is available that has been validated and can be applied depending on the objectives

Table C. Biological Effects

Description of the structure of Table C on Biological Effects: **In this table, the "Parameters" (measurements) used are categorized under three biological response levels (column "Effects Level") that have further been divided into five "Indicators", representing different levels of ecological relevance. In the assessment, each indicator has to be represented by at least one parameter (preferably more) from the respective indicator group.**

Since all the parameters in each indicator group have been selected to be good representatives of an effect observed at the response level in question, it is suggested that the choice of the parameter is free. This facilitates the required inclusion of parameter(s) from each indicator group in the assessment by diminishing problems related to matters such as lack of technical capacity and local species availability. However, the choice of parameters should be based on the objectives of the monitoring and assessment and on the environmental problems encountered. For instance, the different parameters of the indicator 'Contaminant-specific biomarkers' are able to detect only effects of certain groups of contaminants. To give examples: if there are environmental problems related to metals, the parameters selected under this indicator should e.g. be metallothioneins (MT) or delta-aminolevulinic acid dehydratase (ALA-D) and if there are problems related to organic contaminants affecting the enzymatic detoxification system the measurement of e.g. ethoxyresorufin-O-deethylase (EROD) or glutathione-S-transferase (GST) is recommended.

It is also possible to include "new" parameters to each indicator group provided that their relevance and suitability has been adequately demonstrated. Furthermore, the approach enables the possibility to focus on problems at regional level and the continuation of long-term data series if considered feasible.

For the large-scale assessment of the Baltic Sea, synthetic indices enabling comparisons between each indicator have to be developed if different parameters are used to describe each indicator.

Effects level	Indicator	Parameter	Parameter Diagnosis	Indicator Assessment Criteria							Remarks
				Data availability/ source	Regionally responsive	Unambiguously interpretable	Simple quantifycation	Index period stability	Low year-to-year variation	Environmental impact	
Molecular, biochemical, physiological level ("early-warning" biomarkers)	"General/non-specific stress" biomarkers Data source: national	Lysosomal stability Micronuclei frequency AChE Macrophage activity Oxydative stress enzymes	1 1 1 2 2	2	5	3	*4	*3	3	*3	*Depends on parameter
	"Contaminant-specific" biomarkers Data source: national	EROD PAH metabolites in bile DNA adducts ALA-D VTG GST MT	1 1 1 1 1 2 2	*3	5	4	*4	*3	*3	*3	*Depends on parameter

Effects level	Indicator	Parameter	Parameter Diagnosis	Indicator Assessment Criteria							Remarks
				Data availability/ source	Regionally responsive	Unambiguously interpretable	Simple quantifycation	Index period stability	Low year-to-year variation	Environmental impact	
Individual and population level	Health effect Data source: national, ICES	Externally visible diseases/parasites in fish; Pathology (histopathology: fish liver, bivalve soft body; pathology: seal intestinal tract**)	1 1 for fish/bivalves, 2 for seals	*4	*3	4	*3	5	4	4	*Depends on parameter ** Details to be elaborated by the HELCOM seal expert group
	Reproductive disorders Data source: national, HELCOM (?)	Imposex/intersex in gastropods Reproductive success in *Monoporeia affinis* Reproductive success in eelpout Gonad histopathology (fish and shellfish) Shell thickness of guillemot eggs Breeding success/brood size of white-tailed eagle Histopathology in seal reproductive organs** Reproductive success in seals**	1 1 1 1 1 1 2 2	*3	*4	5	*3	5	4	5	*Depends on parameter ** Details to be elaborated by the HELCOM seal expert group
Population and community level	Quantitative population/community change Data source: national, ICES, HELCOM (?)	Biodiversity indices (phyto- and zooplankton, benthos, fish, mammals and birds) Abundance and biomass	1 2	*4	*4	3	*3	*3	*3	*3	*Depends on parameter

Annex 6: Qualitative descriptors for determining good environmental status (MSFD Annex 1).

1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.

3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

8) Concentrations of contaminants are at levels not giving rise to pollution effects.

9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Annex 7: Initial structure (2009/2010) of the work for the MSFD.