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SCICOM STEERING GROUP ON REGIONAL SEA PROGRAMMES

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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)

1–5 March 2010

Gdynia, Poland



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## Executive summary

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ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) met at the Sea Fisheries Institute (SFI) in Gdynia, Poland on 1–5 March 2010. The present SGEH was established in 2008 to follow the main lines of the "old" SGEH, established in 2003 in support of the Baltic Sea Regional Programme (BSRP). The BSRP SGEH covered all major themes related to the general concept of ecosystem health (EH), while the current SGEH is 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 by SGEH but still highly relevant for the outcome of this study group. 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 (SGIMC) and in close collaboration with HELCOM.

Since SGEH is focusing on the same targets as the Baltic Sea BONUS+ Programme project BEAST (Biological Effects of Anthropogenic Chemical Stress: Tools for the Assessment of Ecosystem Health) with the same life span (2009–2011) the group is largely relying on the practical work and results achieved within this project. Therefore, a marked part of meeting time was allocated to examining the progress of the BEAST project during its first year 2009, including collection of new field data in the different sub-regions of the Baltic Sea, laboratory experiments, development of the project database (BonusHAZ; joint with BONUS+ project BALCOFISH that also deals with biological effects), the development of guidelines and Standard Operating Procedures for the Baltic Sea as well as training workshops and intercalibration activities carried out partly in collaboration with BALCOFISH. An important goal of the BEAST project is the testing and development of integrated assessment indices for pollution and ecosystem health but this work is awaiting the submission of data from the BEAST project as well as the input of data collected during the earlier "biological effects project", the EU BEEP.

Examination of the literature review on biological effects research in the Baltic Sea showed that especially during the past more than a decade the amount of studies and available data has increased significantly in amount and geographical coverage. This is important not only for the development of integrated chemical-biological monitoring of hazardous substances but also to new strategies in assessing ecosystem health in the Baltic Sea. Biological effects data (lysosomal membrane stability [general health indicator] and micronuclei [genotoxicity indicator] were already included in the HELCOM integrated thematic assessment of hazardous substances in the Baltic Sea (2010).

The establishment of methodological standards Assessment Criteria (AC) for biological effects methods is a critical issue in the development of environmental monitoring and assessment. The significant work carried out in the OSPAR area during the recent years (WKIMON, now SGIMC) will be taken advantage of when developing a revision of the Baltic Sea monitoring strategy. The methodological background

documents and ACs available concerning biological effects methods and parameters was agreed by the SGEH to be carefully examined and modified as needed to be applied in the Baltic region.

With regard to the organisation and future work of Expert Groups under the SSGRSP, SGEH sees that organised collaboration especially between groups dealing with integrated ecosystem assessments in different regional sea areas (mainly WGIAB, WGHAME, WGNARS, WGWEASS) is a key aspect to be developed, e.g. by forming a cluster of expert groups of the RSP; this would ensure that the basic approaches would be more-or-less consistent between the regions to achieve comparability of the assessments.

In the next meeting in spring 2011 SGEH will evaluate and report on Baltic Sea issues related to i) progress in the BEAST project, ii) development of background documents for biological effects methods, iii) development of assessment criteria for biological effects parameters, iv) developments in MSFD related to the implementation of biological effects methods, v) list of biological effect techniques proposed to integrated monitoring and assessments, vi) planning of a project for the BONUS-169 call in 2011, vii) biological effects methods applied in ERAs, EIAs and "post-accident" studies, viii) biological effects of perfluorinated compounds, ix) examinations of effects of hazardous substances on biodiversity in the Baltic Sea, and x) fish diseases as an indicator of ecosystem health.

## 1 Opening of the meeting

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ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH) held its meeting at the Sea Fisheries Institutes (SFI) in Gdynia, Poland, on 1–5 March 2010.

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 warm gratitude of the group to the local hosting organization and SGEH local member Henryka Dabrowska who introduced the practical arrangements for the meeting. A welcome address was kindly presented by the Director of SFI, Prof. Tomasz Linkowski.

The Chair presented the Terms of Reference for the meeting (as adopted by the SSGRSP, 2009): The ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea [SGEH] (Chair: K.K. Lehtonen, Finland) will meet in Gdynia, Poland, 1–5 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.

## 2 Adoption of the agenda

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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. Since a significant number of key members of the group could not attend the meeting and some last-minute postponements, adjustments had to be made to the meeting agenda accordingly. However, some of the absentees contributed by correspondence. The agenda was adopted by the meeting and a tentative timetable and share of work was agreed upon.

### 3 Appointment of rapporteurs

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Principle contributors and rapporteurs for the agenda were identified and are mentioned in connection to the different contributions in this report. PowerPoint presentations, background documents and reporting documents were viewed and circulated using the ICES SharePoint.

### 4 ToR a) Review the outcome of the BEAST project Data Treatment and Index Testing & Development Workshop

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This ToR was contributed to by Doris Schiedek by correspondence and widely discussed within the SGEH. As part of BEAST project (see more details of the project in Section 5) WP3 activities, a "Data Treatment and Index Testing & Development Workshop" was foreseen to be arranged in February 2010. The main idea of the workshop was to apply and compare different integrated biomarker indices in order to assess their usefulness for application as part of an integrated assessment of contaminant effects in different regions of the Baltic Sea. A couple of examples for such indices and relevant studies in other European coasts are given below. One of the indices which should be tested is the in computing integrated biomarker response (IBR) as defined by Beliaeff and Burgeot (2002). These authors have established a simple method summarizing biomarker responses that simplifies the interpretation in bio-monitoring programs. IBR has also been previously tested in the Baltic Sea using data from the EU BEEP project (Broeg & Lehtonen 2006). In a study performed by Zorita *et al.* (2008) in using the IBR index it was possible to discriminate mussels from locations suffering from different degrees of anthropogenic stress. IBR also indicated that lysosomal membrane stability was the most discriminating biomarker. Overall, the IBR index provides an integrated view on biological effects of pollution and may be useful for ranking the health status of mussels in coastal areas. Another index which has been used in several studies is the Biomarker Response Index (BRI) which also provides a holistic understanding of the health status of marine and estuarine systems as shown by Hagger *et al.* 2009).

However, the planned workshop was postponed since it turned out that it took much longer than expected to come up with data from the first BEAST field studies, carried out in 2009, that could be used for the purpose. As an alternative data source the possibility to use existing data from the BEEP project was discussed but these data were not as easily available and need to be fed into the new BEAST database. It is expected that sufficient data will be available in autumn 2010 allowing holding the workshop with BEAST participants and invited experts. The planning of the workshop was agreed in the next BEAST meeting in St. Petersburg in April 2010. Connections to and collaboration with HELCOM in the further development of the CHASE assessment tool used in the integrated thematic assessment of hazardous substances in the Baltic Sea (HELCOM 2010b) as well as the HELCOM HOLAS Baltic Sea Pressure/Impact Indices (BSPI/BSII)(HELCOM 2010b) will be examined. Development of an index where existing ecotoxicological data (e.g. from REACH) on EC<sub>50</sub> and/or LC<sub>50</sub> values of hazardous substances determined on model aquatic species would be incorporated in chemical concentration values to increase the meaning of the measured concentration values in different matrices was also discussed within the group.



**Suggestions by SGEH concerning the Data Treatment and Index Testing & Development Workshop**

- Time: December 2010
- Place: National Environmental Research Institute (NERI), Roskilde, Denmark
- Participants: All interested BEAST partners; invited experts
- Topic: testing of integrated approaches on existing data sets
- Extensive homework prior to the workshop needed; responsible persons for each suggested approach (in teams of two): data sets ready, tested approaches selected
- Comparison of different methods; Suggestions on modification of an index to fit the Baltic sub-regions, agreement of the index to be applied for the BEAST/BEEP data
- Scientific publication as an outcome?
- "Ecosystem Health Index Workshop" in connection with the next BEAST meeting (2011); development of "BEAST Baltic Sea Sub-regional Ecosystem Health index"
- Funding for the visiting experts: open question; BEAST co-ordination?

**Recommendations of SGEH concerning the new assessment tools of HELCOM**

- CHASE
  - collaboration with the BEAST project in the further development of the tool, especially concerning biological effects and the linking of ecotoxicological data with concentrations of hazardous substances in the environment
- BSPI/BSII
  - strongly related to the targets of BEAST WP3
  - BEAST collaboration with HOLAS Core Group and HOLAS Task Force
  - reconsideration of the number of assessment units for Baltic Sea Ecosystem Health assessment, taking into account e.g.
    - salinity-dependency (gradients and their seasonal changes)
    - water currents
    - river deltas
    - selection of stations: more randomized approach needed to obtain a more realistic picture of the overall status of a sub-region

**Literature**

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- HELCOM (2010) Hazardous substances in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. *Balt. Sea Environ. Proc. No. 120B*
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- Zorita I, Ortiz-Zarragoitia M, Orbea A, Soto M, Marigómez I, Cajaraville MP (2008) Application of an integrated biomarker response index (IBR) to assess the health status of mussels in the Basque coast (NE Iberian Peninsula). *Comparative Biochemistry and Physiology, Part A* 151 (2008)19–30

## **5 ToR b) Review of the progress in the BONUS+ BEAST project**

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### **5.1 Introduction to the BEAST project**

This section was led by Kari Lehtonen, the co-ordinator of the BEAST project. BEAST (Biological Effects of Anthropogenic Chemical Stress: Tools for the Assessment of Ecosystem Health, 2009–2011, [www.environment.fi/syke/beast](http://www.environment.fi/syke/beast)) is, by number of participating institutions (16), the biggest of the projects in the Baltic Sea BONUS+ Programme, and involves, including PhD students, approx. 40 researchers. BEAST is targeted at the development of integrated measures of pollution and tools contributing to ecosystem health assessments. Progress in this field is important for the understanding of human-induced pressure on the ecosystem of the Baltic Sea and prudent management aimed at safeguarding the sustainable use of the ecosystem's goods and services. Science-based recommendations and formulation of sub-regional monitoring and assessment practices for the whole Baltic Sea area allows better understanding and thus managing of environmental problems and their potential socio-economic impacts. BEAST provides scientifically based recommendations for the implementation of an integrated chemical-biological effects monitoring for the assessment of biological effects of hazardous substances. Demonstrations of sub-regional assessments in regard to pollution status contribute to future integrated assessments of Baltic Sea ecosystem health. The project generates an integrated multi-level toolbox consisting of biomarkers as sensitive diagnostic tools to identify impacts of hazardous substances affecting the Baltic Sea ecosystem, allowing to establish links between responses within individuals and effects at population levels, e.g. feeding, growth and reproduction. Capacity building, strengthening of networking, workshops aiming at exchange and intercalibration of methodologies, and training forms an integral part of the project. Partner institutions from all Baltic Sea countries are involved in BEAST; the work consists of fieldwork and experimental studies using both established and novel methods and will focus on 5 major sub-regions with so far limited information on biological effects of hazardous substances.

#### **Partner institutions of BEAST:**

Finnish Environment Institute, Finland (SYKE, co-ordinator); Latvian Institute of Aquatic Ecology, Latvia (LHEI); Nature Research Centre, Vilnius University, Lithuania (NRC IE); Institute of Biology, University of Latvia, Latvia (IB UL); Alfred Wegener Institute for Polar and Marine Research, Germany (AWI); Sea Fisheries Institute in Gdynia, Poland (SFI); Institute for Applied Ecology Ltd., Germany (IAE); Zoological Institute of Russian Academy of Sciences, Russia (ZIN RAS); Scientific Research Center for Ecological Safety RAS, Russia (SRCES RAS); Johann Heinrich von Thünen-Institut/Institute of Fishery Ecology, Germany (vTI / FOE); Atlantic Research Institute of Fisheries & Oceanography, Russia (AtlantNIRO); National Envi-

ronmental Research Institute, University of Aarhus, Denmark (NERI); Leibniz Institute for Baltic Sea Research, Germany (IOW); Department of Applied Environmental Research, Stockholm University, Sweden (ITM); Estonian University of Life Sciences, Estonia (EULS); Finnish Game and Fisheries Research Institute, Finland (FGFRI).

## 5.2 Overview of progress in BEAST in 2009

Kari Lehtonen continued with an overview of the BEAST project. In general, BEAST reached all its milestones and accomplished all the deliverables planned for each of the three WPs and Task (sub-regions) for the year 2009. Similar to the other BONUS+ projects, a significant cut (19–22%) to the original research budget of BEAST was made prior to the start of the project. Some modifications to the sampling and analysis programme had to be made along the way; mainly, the intended number of analyses, target species and parameters had to be reduced. These changes caused some problems in co-ordination, management and execution of the project during the first year. Associated uncertainties concerning the sampling campaigns and number of samples also occurred. To find solutions to these problems, a reinforced BEAST Steering Group (6 persons) held an extra meeting in October 2009 in Hamburg to carefully go through the practical problems and uncertainties encountered during the project so far. Also, a useful document clarifying the role and duties of project partners was produced as an annex to the minutes of the meeting.

In 2009, four major BEAST sampling campaigns were carried out on board Finnish and German research vessels, including a major multidisciplinary two-week sampling campaign in the Gulf of Finland in Aug/Sept 2009 aiming at an integrated assessment of the ecosystem health of the Gulf of Finland. In addition, coastal samplings were organised by the sub-regional BEAST Task Leaders. As a result, samples were obtained in all five BEAST sub-regions (Gulf of Bothnia, Gulf of Finland, Gulf of Riga, Gulf of Gdansk, Belt Sea) and the first results are available that will be entered into the first version of the common database (BonusHAZ), which is ready for data submission. The methodologies applied have been standardised to a great extent and the development of guidelines and Standard Operating Procedures for the Baltic Sea is progressing. A number of training workshops and intercalibration activities have been carried out in this context, partly in collaboration with the BONUS+ project BALCOFISH (Integration of pollutant gene responses and fish ecology in Baltic coastal fisheries and management, <http://www.balcofish.science.gu.se/english>).

BEAST achieved close collaboration with the BALCOFISH project, and common samplings, experimental and workshop activities are planned to be continued during 2010 and 2011. BEAST also attracted collaboration with a number of various non-BONUS projects related to biological effects of contaminants and ecosystem health, and collaboration (participation in cruises, sample sharing, testing of new analytical methods and approaches) with these projects will be continued and new interested parties are actively sought for.

### 5.2.1 BEAST WP 1: Field studies and experiments in selected sub-regions of the Baltic Sea

Brita Sundelin reported on the BEAST WP1 by correspondence. WP1 is focused on studies regarding biological effects of hazardous substances in a variety of target organisms (bioindicators), reflecting different taxa and habitats in different sub-regions of the Baltic Sea, i.e. Belt Sea, Gulf of Gdansk, Gulf of Riga, Gulf of Bothnia and Gulf of Finland. By using field studies (sub-regional sampling and caging) combined with

laboratory exposure experiments WP1 addresses specific basic research topics related to geographical locations, methods, species and chemical compound groups. The biological-effects measurements are carried out at various levels of biological organisation, i.e. sub-cellular, cell, tissue, organ, whole organism, and represent lower-order and higher-order responses, reflecting different degrees of ecological relevance. The biological effects and chemical analysis studies are divided into two categories: core programme: carried out at each 5 sub-region with a minimum of 2 sampling campaigns in each region and research and development (R&D) programme: carried out in 1–4 sub-regions according to resources and feasibility.

Five field campaigns have successfully been performed during 2009:

- 1) Gulf of Riga: r/v *Aranda* visited the gulf in April 2009, *Macoma balthica* for analyses of oxidative stress and sediment for contaminant analyses were collected on 4 sites.
- 2) Belt Sea: A field campaign was performed in November 2009, sediment, mussels, eelpout were collected for contaminant analyses, bioassays and biomarker analyses.
- 3) Gulf of Finland: The largest research activity in 2009 was the GOF-IA (Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland) joint 2-week research cruise of r/v *Aranda* and r/v *Walther Herwig III* in August-September. Unfortunately, no permission to sample in Russian waters could be obtained and the original sampling plan had to be adjusted. Sampling was carried out at 20 point stations (*Aranda*) and 9 fishing areas (*WHIII*) in different parts of the Gulf of Finland within the Finnish and Estonian EEZ. The research performed consists of measurements of several biological and chemical parameters with emphasis on selected biomarkers. The main aim is to use the data (plus additional existing data sets) for an integrated assessment of ecosystem health in the different sub-regions of the Gulf of Finland by using methods tested and developed under WP3.
- 4) Gulf of Gdansk and Gulf of Riga: Field campaigns were performed in November 2009 with national vessel for sampling of flounder. R/V *Walter Herwig III* visited Gulf of Gdansk (4 stations) and Gulf of Riga (3 stations) in December 2009. Herring, flounder and eelpout were collected for analyses of fish disease, histopathology and biochemical endpoints.
- 5) Gulf of Bothnia: Research vessel *KVB 005* visited Gulf of Bothnia one week in the middle of December 2009. The amphipod *Monoporeia affinis* and sediment for contaminant analyses were collected on 8 stations in Bothnian Bay and 5 stations in the Bothnian Sea. Analyses of reproduction disorders have been performed.

Planned field work for 2010:

- Amphipod sampling in the Gulf of Bothnia in January
- Caging study (mussels, *Fucus*) in the Gulf of Bothnia (mid-June – early September)
- Caging study (mussels) in the Gulf of Gdansk
- *Macoma balthica* sampling in the Gulf of Gdansk
- Eelpout (*Zoarces viviparus*) sampling in the Gulf of Bothnia

- r/v *Walther Herwig III* sampling cruise in the Gulf of Bothnia (flounder [*Platichthys flesus*], herring [*Clupea harengus membras*])
- Belt Sea sampling in May and November (amphipods, mussels, *Macoma balthica*, flounder, eelpout)
- r/v *Aranda* sampling cruise in the Gulf of Bothnia and Gulf of Riga (30.08.–10.09.2010)

Various laboratory exposure studies are also included in the BEAST research programme.

### **5.2.2 BEAST WP 2: Application and validation of methods in monitoring and assessment in the Baltic Sea**

BEAST WP2 Leader Thomas Lang reported on section 5.2.2. by correspondence. The identification and validation of suitable methods for integrated monitoring and assessment is underway and will be finalised at the end of the project, based on the practical experiences made and the results of the integrated data assessment. In collaboration with BEAST WP 1 and the regional Task Leaders for the five Baltic Sea sub-regions under study, the field sampling programme was designed accordingly (location of sampling sites, timing of sampling, number of sampling campaigns, target species (algae, bivalves, gastropods, crustaceans, fish), sample sizes (number of specimens & replicates), parameters to be measured (biomarkers, chemistry in biota and sediments, bioassays, supporting parameters), sample storage and distribution etc.). Use was made of existing concepts and guidelines (OSPAR, HELCOM, ICES, BSRP, ICES/OSPAR WKIMON, SGIMC etc.) and experiences made in previous integrated studies (EU-funded BEEP project, ICON North Sea project etc.).

A first draft of a Handbook with Guidelines and Standard Operating Procedures (SOPs) for integrated monitoring and assessment of contaminant and biological effects in sub-regions of the Baltic Sea, ultimately supposed to cover all aspects relevant for sampling, laboratory analyses, data collection, analysis and assessment has been prepared and solicited to BEAST partners for review. The SOPs will be updated with new information as required. The goal is to publish the handbook and make it available for future national and HELCOM Baltic Sea monitoring and assessments.

Plans were made to organise a number of BEAST training workshops (open to BEAST partners and other interested participants) and intercalibration exercises (largely BEAST internal) over the entire project period, out of which four were held in 2009: (1) Training and intercalibration of methods for field sampling of biomarkers and fish disease studies (Lead: vTI/FOE), (2) Workshop on reproduction and developmental disorders in crustaceans/amphipods (Lead: ITM), (3) Practical workshop on eelpout sampling and examinations (in collaboration with BONUS+ BALCOFISH)(Lead: NERI), (4) Workshop on measurement of enzymatic biomarker in bivalves (Lead: SYKE). An intercalibration exercise on measurement of PAH metabolites in fish bile has been initiated end of 2009 (Lead: vTI/FOE).

#### **5.2.2.1 Identifying suitable methods for integrated monitoring in different sub-regions of the Baltic Sea**

Identifying suitable methods for integrated monitoring in different sub-regions is an ongoing task over the entire project period since it will only be accomplished based on the overall outcome of the BEAST project and according to the experiences made and data generated mainly as part of WP 1 and WP 3. The selection of methods for integrated monitoring applied within the practical part of the BEAST project (under WP 1) and, according to the results obtained, to be assessed in the light of their use-

fulness for integrated monitoring in the Baltic Sea (under WP 2 and WP 3) is largely based on experiences made in the EU-funded BEEP project (2001–2004) and on existing programmes and activities outside the Baltic Sea, particularly under ICES and OSPAR Co-ordinated Environmental Monitoring Programme (CEMP).

Within the BEAST project, measurements on hazardous substances and their biological effects are being carried out in five geographical sub-regions of the Baltic Sea in a variety of target organisms (bioindicators), reflecting different taxa and habitats of the marine ecosystem. The wide range of biological effects measurements are carried out at different levels of biological organisation, i.e. sub-cellular, cell, tissue, organ, whole organism, and represent lower-order and higher-order responses, reflecting different degrees of ecological relevance. Table 5.1. summarises the species and the measurements carried out in BEAST as well as the other data to be utilised for the integrated assessment. In addition to the biological effects techniques applied in field studies, experiments (e.g., in situ cage exposure of bivalves, laboratory experiments with bivalves, amphipods and fish) and bioassays (sediment toxicity) are carried out to provide more information on specific mechanistic links between contaminants and biological responses.

Out of the biological effects techniques, the contaminant chemistry and the other supporting parameters applied and measured, the most suitable ones will be selected and recommended for integrated chemical and biological-effect monitoring in sub-regions of the Baltic Sea at a later stage within the project.

The fundamental concept followed in the BEAST project is that of integrated monitoring which basically means that contaminants, a suite of biological effects and supporting parameters are preferably measured at the same time, at the same sampling station, in the same species and in the same individual. Figure 5.1. provides an example for measurements carried out in flounder (*Platichthys flesus*) illustrating the integrated approach. In addition, other species from the same location are studied using the same integrated approach in order to provide a more holistic characterisation of the region under study. However, it is clear that such a comprehensive integrated approach cannot be achieved in all cases and that there, thus, is a need to compromise to a certain extent. Guidance on how this can be done will be provided at a later stage in the finalised deliverable, based on the experiences made in the practical part of BEAST and the integrated assessment of the data generated.

Table 5.1. Parameters measured in the framework of the BEAST project

Response Category	Parameter	Species/Matrix					
		Algae	Bivalves	Gastropods	Crustaceans	Fish	Sediment
Sub-cellular Response	Molecular biology/Gene expression	-	-	-	Mo	Pl, Zo	-
	Comet assay	-	My	-	Mo	Pl	-
	EROD	-	-	-	-	Pl, Cl, Zo	-
	AchE	-	Ma, My	-	Mo, Po	Pl, Cl, Zo	-
	Oxidative stress enzymes	Fu	Ma, My	-	Mo	Pl, Cl, Zo	-
	Vitellogenin	-	-	-	-	Pl	-
	PAH metabolites	-	-	-	-	Pl, Cl, Zo	-
	Micronuclei and other genotoxic effects	-	Ma, My	-	Co	Pl, Cl, Zo	-
	Lysosomal stability/other histochemical biomarkers	-	Ma, My	-	Mo, Co, Po	Pl, Cl, Zo	-
Cell/Tissue/Organ Response	Haematology	-	-	-	-	Pl, Cl, Zo	-
	Cardiac activity	-	Ma, My	-	-	-	-
	Immunocompetence	-	My	-	-	Pl, Cl, Zo	-
	Liver histopathology	-	-	-	-	Pl, Cl, Zo	-
	Macroscopic liver neoplasms	-	-	-	-	Pl, Cl, Zo	-
Whole Organism Response	Externally visible diseases/parasites	-	-	-	Mo	Pl, Cl, Zo	-
	Reproductive disorders (incl. embryo/larvae development)	-	-	Hy, Bu	Mo, Co, Po	Pl, Cl, Zo	-
Sediment Bioassays	Various endpoints	-			Mo, Co, Gm	-	
Contaminant Analysis	Trace metals	Fu	My	-	-	-	+
	Organic compounds (incl. PAH, TBT)	-	Ma, My	-	-	Pl, Cl, Zo	+
Supporting Parameters	Size, weight, age, sex, condition, LSI, GSI etc.	+					
	Hydrography	+					
	Historic Data	+					

Bu: *Buccinum undatum*, Cl: *Clupea harengus*, Co: *Corophium volutator*, Gm: *Gmelinoides fasciatus*, Fu: *Fucus vesiculosus*, Hy: *Hydrobia ulvae*, Ma: *Macoma balthica*, Mo: *Monoporeia affinis*, My: *Mytilus* sp., Pl: *Platichthys flesus*, Po: *Pontoporeia femorata*, Zo: *Zoarcas viviparus*

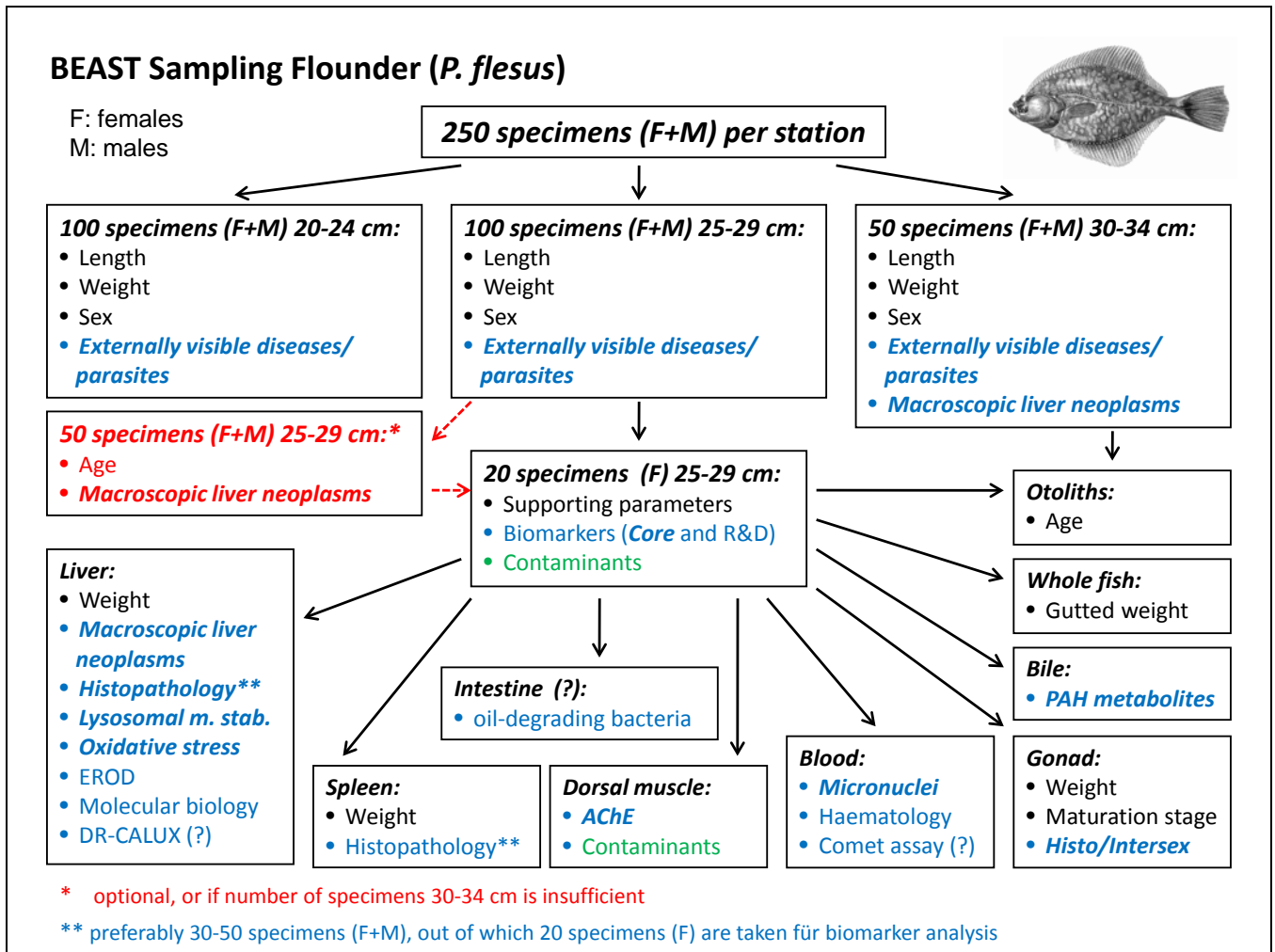


Figure 5.1. BEAST sampling scheme for integrated monitoring of contaminants and biological effects in Baltic flounder (*Platichthys flesus*)

### 5.2.3 BEAST WP 3: Developing tools for Ecosystem Health assessment in the Baltic Sea

Doris Schiedek, the BEAST WP Leader, reported on this item by correspondence. One of the main tasks for 2009 has been the set-up of a database to host all relevant data produced within the BEAST project but also other data already available concerning biological effects (e.g. data from the EU Project BEEP Baltic Sea component). When setting up the database, a further aim has been to provide the same database structure for two BONUS projects, i.e. BEAST and BALCOFISH. To ensure this, a joint BALCOFISH/BEAST workshop in October 2009 (Holbæk, DK) was used to present and discuss the structure and status of the database.

Since the end of 2009 the BEAST database (BonusHAZ) is in operation. The report format is based on Excel with a coupled Access database including a brief "user manual". BEAST partners have started to test BonusHAZ and to fill in data. From the beginning, the ICES code lists have been used as a foundation for data exchange and consistency between institutes. As of 2010 BEAST has a formal arrangement with ICES to use their code lists from their RECO database <http://www.ices.dk/datacentre/reco/reco.asp>. At present these code lists are being implemented in the BonusHAZ structure. During the development of the BEAST da-



tabase a close collaboration with ICES data managers was established, among others to give technical advice. The collaboration with ICES also allows that data from BonusHAZ can be submitted to ICES at a later stage. Submission of data to ICES has to be decided by the BEAST partners and an output format has to be coded.

Another task in 2009 has been to reassemble the BEEP database. This has been done in collaboration with the former BEEP data manager at Polish Institute of Oceanography, (IO-PAN). Presently the BEEP data are in the process to be imported into BonusHAZ.

The BonusHAZ database forms the bases for the planned multivariate analyses and integrated assessment later in the project. First ideas concerning integrated analyses have been developed during 2009 and presented as poster during the BONUS annual conference in Vilnius in January 2010.

## **6 ToR c) Examination of the review of (a) literature on basic & applied research on biological effects of contaminants, and (b) chemical contamination in the Baltic Sea**

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This item was contributed to by Doris Schiedek by correspondence. SGEH concluded that the part (b) of the ToR c) could not be covered during the meeting. Thus, only the review on biological effects (a) was considered and a first outline is presented below.

### **6.1 Biological effects**

In order to understand and assess the impact of contaminants on the Baltic ecosystem and its biota, both concentrations and biological effects of hazardous substances have to be taken into consideration. A large number of hazardous substances are released to the Baltic Sea, often in low concentrations. In other cases the only way to detect the impact of previously unknown substances is through applying biological effects monitoring methods, similar to observations in seal and predatory bird reproductive health indicating pollution by PCBs and DDTs during the 1970s. Specific methods to detect biological effects (such as molecular biomarkers) caused by unknown and known substances are presently under development (HELCOM, 2006; HELCOM HOLAS HAZAS 2010). Substances or substance groups of specific concern to the Baltic Sea have also been included in the HELCOM BSAP (HELCOM, 2007).

In the past years, monitoring of hazardous substances in the Baltic Sea in the framework of HELCOM activities has mainly been based on the measurement and assessment of contaminant concentrations in water, biota and sediments (HELCOM, 2002, 2003) despite the fact that techniques to detect biological effects of contaminants in indicator species are available (see e.g. review by van der Oost *et al.*, 2003, Hagger *et al.* 2006, Viarengo *et al.* 2007). The “bioeffect approach” has so far been applied in national monitoring programmes of very few Baltic Sea countries, and mainly to a small extent only (ICES, 2004). To date, national-based biological monitoring programmes have been employed in coastal waters in Sweden (and in inland waters in Finland) most notably to assess the environmental impact of pulp and paper mill effluents. In addition, the Swedish Environmental Protection Agency has supported an integrated coastal fish monitoring programme since 1988, including four sites along the Swedish coast. Denmark is also running a National contaminant monitoring and biological effects programme as part of NOVANA (Nationwide Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment). A result of these activities, effects on the reproduction success of eelpout has been documented (Strand *et al.* 2009). Furthermore, the German fish disease monitoring programme in the western

Baltic Sea which started in the 1980s (Lang *et al.* 2006). Since the mid-1990s it has increasingly been supplemented by biomarker studies [liver histopathology, 7-ethoxyresorufin-O-deethylase (EROD) activity, PAH metabolites in bile] (Kamman 2007). Basic research concerning biological effects in various species has also been performed and an overview is given in Lehtonen & Schiedek 2006. More focused research activities regarding biological effects has been performed during the BEEP project and major achievement have been made (Lehtonen *et al.*, 2006, and other publications in Special Issue of Marine Pollution Bulletin 53, 2006). They are described in the following.

## 6.2 The BEEP project (2001–2004): evaluation of the biological effects techniques applied

For most of the biological effects techniques employed in the BEEP project a large volume of literature exists (see e.g. recent review by van der Oost *et al.*, 2003), but many of them have not been applied in brackish systems such as the Baltic Sea. A brief evaluation of each of the main endpoints applied is found in Lehtonen *et al.* (2006; Table 1) based on the results obtained in the different Baltic subregions studied in the BEEP project.

The field-testing of a battery of biological effects measurements carried out in six study areas in the Baltic Sea, implied that the selected endpoints are suitable to detect chemical pollution and contaminant gradients, both in fish and bivalves. The analysis of the various biomarkers indicating biological effects at different biological levels, e.g. lysosomal membrane stability (LMS), acetylcholinesterase inhibition (AChE), EROD activity, micronuclei frequency (MN), metallothionein induction (MT), neutral lipid accumulation (NL), macrophage activity (MA), PAH metabolites in bile (fluorescent aromatic compounds, FAC) and liver histopathology showed responses to contaminant gradients (Baršienė *et al.*, 2004, 2006b; Hansson *et al.*, 2006, b; Kopecka *et al.*, 2006; Lang *et al.*, 2006, b; Schiedek *et al.*, 2006; Vuorinen *et al.*, 2006). The results clearly indicate that the present contaminant concentrations in the different parts of the Baltic Sea are eliciting biological responses in various species, and in some areas leading to chronic stress.

In some cases the responses detected could be attributed to contaminant impacts associated with sediment dredging, dumping or an oil spill (Baršienė *et al.* 2006) and effects in offshore areas (Rybakovas *et al.*, 2009). However, in some areas the biological responses (e.g. EROD) to specific organic pollutants were very low, possible due to prevailing chronically high exposure levels (Hansson *et al.*, 2006), potentially altering liver functions, e.g. those related to detoxification.

Data on reproductive disturbances (endocrine disruption) in the eelpout (*Zoarces viviparus*), a viviparous fish species, are of considerable value with a direct link to population effects (Gercken *et al.*, 2006). Studies carried out on liver histopathology in the Baltic flounder indicated a relationship between the health status and contaminant levels (Lang *et al.*, 2006).

## 6.3 Studies outside the BEEP project

Besides the BEEP project other studies have been performed to better understand how contaminants affect the Baltic ecosystem. A range of studies have been carried out on two important bivalve species, which markedly differ in their feeding modes and living habitats, inhabiting most parts of the Baltic Sea: the infaunal deposit/suspension-feeder *Macoma balthica* and the hard-bottom filter-feeder *Mytilus edulis*. The effects of exposure to copper and malathion on metallothionein (MT) lev-

els and acetylcholinesterase activity (AChE) were evaluated in specimens from the northern Baltic Sea (Lehtonen & Leinio, 2003). In another study, selected biomarkers (AChE, GST, CAT, MT) were measured in both bivalve species, collected at the coast of southern Finland (Lehtonen *et al.* 2006). Biomarker gradients were observed for MT, GST and CAT, in *M. balthica* from the Turku Archipelago region, mostly coinciding with the tissue concentrations of total PCBs, DDTs and selected metals. In *M. edulis*, the biomarker responses were less consistent with regard to tissue pollutant concentrations. The integrated biomarker response (IBR) index showed good accordance with the observed high tissue levels of organo-chlorines at one of the sampling location. The results clearly demonstrated the usefulness of the multi-biomarker approach. However, food availability, reproductive status and water temperature are factors that could affect enzyme activities, e.g. GST, CAT or AChE in mussels (Leiniö & Lehtonen 2005, Pfeifer *et al.* 2005). Salinity is another factor which has to be taken into account. The salinity gradient, typically for the Baltic, is another factor which as to be taken into consideration when comparing different sites within the Baltic Sea as shown by Pfeifer *et al.* (2005) and Prevodnik *et al.* (2007).

In a study performed on blue mussels (*Mytilus* sp.) from two regions within the Baltic proper were exposed to copper (35 ppb) or petrol (0.3 mL/L) for 10 days and mRNA expression in the gill tissue was analyzed (Liljaab *et al.* 2008). Expression of mRNAs for the heat shock proteins HSP70 and HSP90 was significantly induced by copper, but not by petrol. For the metallothioneins MT10 and MT20, regional differences in mRNA expressions could be seen. Expression of cytoskeletal proteins and other responses on the protein level were found in blue mussels after exposure to organic contaminants and also in field samples (Jonsson *et al.* 2004, 2006a,b).

Biomarkers of genotoxicity (DNA damage, measured as tail moment in the Comet assay), neurotoxicity (AChE inhibition) and general stress (lysosomal membrane stability, LMS) were studied in native and transplanted blue mussels (*Mytilus edulis*) in coastal areas of western Denmark potentially affected by anthropogenic pollution originating from chemical dumping sites. The results indicate responses to pollution in all the biomarkers applied at the suspected areas, but seasonal differences were obvious. These investigations further stress the importance of understanding the effects of natural factors (salinity, temperature, water levels, precipitation or storm events) for the assessment of biological responses. Moreover, the use of two sessile bivalve species with markedly differing feeding modes and living habitats is considered a rational strategy for assessing the pollution status of coastal sea areas.

To understand how contaminants may affect higher trophic levels such as fish, studies on key species have been performed. The pattern of enzymatic activities, environmental genotoxicity and cytotoxicity was studied in the flounder, *Platichthys flesus*, from the Polish coastal area of the Baltic Sea. The activities of different enzymes, e.g. AChE, GST or CAT were measured, as well as the frequency of micronuclei, nuclear buds and fragmented apoptotic cells. The study documented that compared to fish from a reference area, flounder from the Gulf of Gdansk clearly showed different enzyme activity, genotoxicity and cytotoxicity biomarker response pattern (Napierska *et al.* 2009).

Atlantic cod (*Gadus morhua*) is another important species in the Baltic ecosystem. In order to evaluate any pollution impacts, different biomarkers of contaminant exposure were analysed and contaminant levels were measured in cod from the western and southern Baltic Sea. In most specimens, hepatic ethoxyresorufin-O-deethylase activity (EROD) and bile 1-OH pyrene, a common polycyclic aromatic hydrocarbon

metabolite, were detectable. Both features indicate an induction of the CYP1A biotransformation system in response to toxic substances. The increased occurrence of DNA adducts in some of the specimens also indicates the presence of genotoxic substances. AChE was inhibited, an indication of exposure to organophosphates, carbamates, or certain heavy metals. In general, spatial differences in the biomarker responses as well as in contaminant loads were found, suggesting differences in physiologically active concentrations and mixtures of organic contaminants in the Baltic (Schnell *et al.* 2008).

Another important research topic has been TBT related effects. Imposex and intersex in certain species of marine snails (Prosobranch gastropods) are signs of endocrine disruption and widely used as specific biomarkers for TBT contamination (OSPAR 2008, Strand 2009, HELCOM 2010). Ship traffic is regarded as the main source to TBT in the Baltic environment Strand & Jacobsen, 2002). Imposex has been observed in nine different species in Danish waters, together with intersex in periwinkles (Strand *et al.*, 2003, 2005).

Five different snail species have been used as TBT indicators in the national monitoring programme in Denmark, as these species differ in geographical distribution, as well as in sensitivity towards TBT. Owing to the ban of TBT as an antifouling agent on ship hulls TBT levels have been reduced and also the imposex levels have declined in the recent years, particularly in coastal water species such as the netted whelk (*Hinia reticulata*), whereas this trend is not that obvious in the more sensitive and long-living red whelk in the open waters of the Belt Sea (Strand *et al.* 2009). In more low-saline regions of the Baltic Sea, imposex has also been found in the mudsnails like *Hydrobia ulvae* (Magnusson, 2008).

Increased levels of micronucleus (MN) are a well-known indicator for environmental genotoxicity, and has been used as an index for cytogenetic damage. The formation of MN often clearly correlates with pollution load, as it has been shown in a number of studies carried out in the Baltic (Baršienė & Bučinskienė, 2002; Baršienė *et al.*, 2004; 2005; 2006a, b, c; 2008). Micronuclei, as a sensitive endpoint, were used in Bioeffect Assessment Index (BAI) and Integrated Biomarker Index (IBI) development to describe the toxin-induced stress levels in different sites of the Baltic Sea (Broeg & Lehtonen, 2006).

Lysosomal Membrane Stability (LMS) is an integrative parameter which reflects the combined impact of a mix of contaminants due to its responsiveness to most contaminant classes. Thresholds for LMS have been defined for mussels and fish, characterizing the different stages of toxic cell damage (Broeg *et al.* 2005, Broeg & Lehtonen 2006, ICES 2008a). The “non-disturbed status” is defined as low LMS index values, which are rarely found in the Baltic Sea (HELCOM, 2010). Results of LMS measured in flounder (*Platichthys flesus*) collected from different sites in the southern Baltic in 2001 and 2002 document marked effects in coastal and harbour areas (HELCOM, 2010).

An integrated study on female eelpout from the southern Baltic was performed in Polish coastal waters during November 2001, 2002 and 2003. Selected biomarkers were analysed as well as the reproductive capacity and fry malformation frequencies in relation to environmental conditions in the examined areas. Relative fecundity (RF) and embryo somatic (ESI) indexes were highest at the reference site. The frequency of females carrying dead and malformed fry was the highest at selected sites from the outer and inner part of the Gulf of Gdansk. The highest mean activity levels of muscular AChE were noted in fish sampled at the reference site and one site from the

outer part of the gulf, whereas liver GST activity was the highest in samples from other site from the outer part of the gulf and the reference site. The results of trace metals analyses in fish muscle and liver did not indicate any substantial differences in the mean tissue concentrations between samples from contaminated sites and the reference site. The concentrations of PCBs, HCHs and DDTs in liver were markedly higher at three of the contaminated sites in comparison with the other sites. (Napier-ska & Podolska 2006).

Effects on the reproduction of the viviparous fish eelpout (*Zoarces viviparus*) have also been measured in coastal areas of Sweden, Denmark and Germany (Strand *et al.* 2004, Gercken *et al.* 2006). These measurements are now included in national monitoring programmes. The presence of abnormal development of embryos and larvae in eelpout broods is used as an indicator of impaired reproduction because chronic exposure to various contaminants has the potential to induce adverse developmental effects in fish. Other studies on endocrine disturbances in eelpout carried out in German and Danish coastal waters have also recorded a widespread occurrence of intersex, i.e., primary oocyte development, in the testes of more than 25% of the males studied (HELCOM, 2010).

Reproductive success has also been studied in the benthic deposit-feeding amphipod *Monoporeia affinis* using soft-bottom microcosms, and studies of field populations from contaminated and pristine locations. Determination of malformed embryos has proven to be a sensitive method for detecting contaminant effects, and by discriminating between different types of embryo aberrations, it is also possible to detect effects of environmental stressors e.g. oxygen deficiency and temperature stress (Eriksson-Wiklund & Sundelin 2001, Sundelin *et al.* 2008). The reproductive variables include: sexual maturation, fecundity (embryos/female), embryo developmental stage, malformed embryos, undifferentiated embryos and dead embryos/broods.

An endocrine disruptor, the fungicide fenarimol, was investigated regarding its effects on reproduction and hormone (ecdysteroid) levels in *M. affinis*. In addition, the influence of food shortage alone and in combination with fenarimol on reproduction was examined. Field-collected amphipods were exposed in flow-through microcosms during the period of sexual maturation and mating in four treatment series: Control with low food, fenarimol with low food, control with high food, and fenarimol with high food. Fenarimol was added at a concentration of 0.3 mg/L in two pulses/week. Fenarimol had a negative effect on fertilization rate and male mating ability and a tendency towards delayed male sexual development was found. Food shortage decreased weight in both sexes and retarded female oocyte development. Higher ecdysteroid levels were recorded in males than in females, and food shortage increased male ecdysteroid levels. No effect of fenarimol exposure on ecdysteroid levels was observed. No synergistic effects of fenarimol and food shortage could be distinguished in any variable examined. Thus, *M. affinis* was vulnerable to reproductive impairment by fenarimol, with effects on the next generation (i.e., a disturbed sexual development and fertilization ability). Food shortage had a negative effects on *M. affinis*, but it does not enhance the effects of fenarimol (Jacobson & Sundelin, 2006)

The response of a set of reproduction biomarkers to natural climate variables has been studied in the amphipod *Monoporeia affinis*. Data from field studies carried out between 1994 to 2000 were analysed to evaluate the sensitivity of the biomarker 'malformed embryos' to oxygen deficiency, temperature increase and OC in sediments and to perform a field validation of some reproduction biomarkers targeted at these factors. The biomarker 'malformed embryos' was related neither to oxygen concen-

tration nor to temperature, while a relationship was found with OC content of the sediment. A negative correlation was found between females carrying a dead brood and the oxygen concentration of the bottom water. Fecundity was positively correlated with the carbon content of the sediment but negatively correlated with the temperature of the bottom water. These results confirm the findings of previous laboratory experiments (Eriksson-Wiklund & Sundelin, 2001; Wiklund & Sundelin, 2004). The combined effects of temperature and exposure to a pesticide (Jacobson *et al.*, 2008) also revealed the importance to included environmental factors into the assessment of pollution effects on the Baltic amphipod *Monoporeia affinis*.

The combination of a set of biomarkers showing differences in their sensitivity to various stressors, provides a powerful tool to monitor the effects of both contaminants and other environmental stressors, and allows to discriminate between the effects of different environmental disturbances (Sundelin *et al.* 2008).

Impact on contaminants on marine mammals (e.g. seals) and seabirds inhabiting the Baltic Sea have also intensively studied and main results are summarised in ( HELCOM, 2010). The reproduction and health status of the white-tailed sea eagle (*Haliaeetus albicilla*) has recovered since the late 1960s, and since the mid-1990s eagle productivity has largely returned to pre-1950 levels. Based on productivity and egg residue concentrations measured in 82 individual females between 1965 and 1997, a lowest observable effect level (LOEL) for DDE of approximately 100–120 mg kg<sup>-1</sup> has been estimated. The further positive development of productivity from 1998–2005 continues to support the estimated LOEL (HELCOM,2010).

In another case, exceedingly high chick mortalities have led to the population decline of the nominate lesser black-backed gull (*Larus fuscus fuscus*) in the Gulf of Finland, which has been associated with the very high concentrations of organochlorines observed in the liver of the chicks (Hario *et al.* 2004). The prevalence of intestinal ulcers in immature Baltic grey seals (*Halichoerus grypus*), which is suspected to be related with presence of PCBs, has decreased in recent years. This group of contaminant have also been associated with interrupted pregnancies and uterine obstructions in both ringed and grey seals as well as with uterine leiomyomas in the latter, and thus probably contributed to the small number of Baltic seals in the 1960s and 1970s. No uterine obstructions have been observed since 1997 and the occurrence of uterine leiomyomas has also decreased (HELCOM, 2010).

Diseases in wild Baltic Sea fish have been monitored on a regular basis since the beginning of the 1980s as a component of national environmental monitoring and assessment programmes (Lang *et al.* 2006). Within these programmes, significant alterations in the disease prevalence are used as a general ecosystem health indicator, reflecting the effects of environmental change, including anthropogenic impacts, on the disease resistance of wild fish. The fish diseases cannot be directly linked to any specific compound, but they are probably caused by multiple stressors in the environment (HELCOM, 2010). A fish disease index has been developed (for details see 12.2.3 in this report).

Application of biosensors to reveal water toxicity by using whole-organism or cellular response approaches has also been further developed and tested in the Baltic Sea, as described and discussed under 12.2.4 in this report.

#### 6.4 Climate change and contaminants

In the past years, more and more awareness has been raised concerning the need to improve our understanding how multiple stressors such as salinity, temperature,

hypoxia or UV radiation and chemical pollution act together to affect biota in brackish water ecosystems. According to a recent comparative assessment, the BACC report, the mean sea surface temperature of the Baltic Sea is projected to increase by about 2–4°C by the end of the 21<sup>st</sup> century, depending on the model and scenario used (Dippner *et al.* 2007). The projected changes in abiotic factors will have an effect on the spatial distribution of Baltic Sea biota and their acclimation capacity. Moreover it is likely that climate change will influence those processes involved in the metabolism of toxic substances: higher temperatures result in increased turnover rates or generally higher metabolic rates. Higher temperatures and/or lower salinity will affect the species' ability to cope with toxic substances and the various physiological regulation processes involved in the detoxification of hazardous substances (Schiedek *et al.* 2007).

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## **7 ToR d) Evaluation of the relevance of the literature review above (Item 6) for the development of integrated biological chemical monitoring and assessment criteria**

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### **7.1 General discussion**

The SGEH group discussed the literature review presented in Item 6. Based on studies in other sea areas as well as those documented in the literature review above including the extensive studies carried out within the BEEP project, the following molecular and sub-cellular biomarkers have been identified and recommended as being suitable to monitoring and assessment of chemical contamination in the Baltic Sea:

- Lysosomal membrane stability (histochemical/in vitro Neutral Red Retention test)
- Acetylcholinesterase inhibition
- Micronuclei frequency
- PAH metabolites
- EROD activity
- Glutathione S-transferase
- Oxidative stress complex (CAT, SOD, GPx & GR measured as a battery) (in bivalves)

Similarly, the following affecting individual/population levels have been recommended:

- Embryonic malformations (fish, amphipods)
- Imposex (gastropods) & intersex (fish)
- Liver histopathology
- Fish diseases

Results from the BEEP project Baltic Sea field studies have demonstrated that:

- i) a multi-biomarker methodology together with a multi-species approach can be applied to detect exposure to and effects of contaminants in different areas of the Baltic Sea, and
- ii) local research laboratories, facilities and human resources for the implementation of biological effects monitoring and assessment exist in different countries around the Baltic.

## 7.2 Progress of SGIMC 2010

ICES SGIMC met in January this year in Copenhagen. Ulrike Kammann presented the topics discussed and agreed upon during the SGIMC meeting. The main outputs were (1) updated background documents, (2) more assessment criteria for biological effects and (3) a progress in the discussion of integrated monitoring strategies.

SGIMC recommends the calculation of background assessment criteria (BAC) using data from reference areas. The 90<sup>th</sup> percentile of the data is used as BAC. This strategy requires suitable reference sites which have been already identified for a set of biological effect techniques including EROD and PAH metabolites. Together with the outcome of former WGBEC and SGIMC meetings now BAC for most recommended techniques exists. In addition environmental effect criteria (EAC) for PAH metabolites were developed during the meeting combining experimental results from Steinar Sanni (IRIS Stavanger) with German (vTI) monitoring data.

The challenges of integrated monitoring have been discussed extensively. With the BAC/EAC in hand monitoring data can be categorized following the traffic light system and condensed to one overall assessment. During this process every parameter and every parameter group has to be equipped with a specific weighting factor. SGIMC discussed different strategies to develop such weighting factors and mentioned the ecological relevance of the biological effect method as one possibility of ranking. Also a higher ranking of results exceeding EAC was mentioned. SGIMC identified some crucial components and open questions concerning integrated monitoring: parameter grouping, weighting factors, handling of data gaps, possibly integration of the one-out-of-all-approach and the definition of assessment regions.

The SGEH discussed the results of the work done in the SGIMC and concluded that the BAC for the three species can be used also for Baltic specimens. However, since seasonality may affect the normal concentrations it is recommended that the values are used under the same seasonal periods for which the ACs have been determined. Concerning PAH metabolites as a specific example, the amount of metabolites from different natural sources was also discussed and was assessed to mainly be a problem when measuring OH-pyrene alone.

## 7.3 Assessment criteria for PAH metabolites in fish calculated from reference sites

Ulrike Kammann reported on recent progress in the development of Assessment Criteria (AC) for PAH metabolites. PAH metabolites are sub-cellular biomarkers which are contaminant specific markers of PAH exposure. However, PAH metabolites do not indicate directly a population relevant effect. Assessment Criteria (AC) for PAH metabolites such as BAC (Background Assessment Criteria) which are usually derived from reference sites describe the threshold which indicates a significant difference to background values (green → yellow). EAC (Environmental Assessment Criteria) are usually derived from toxicological data and indicate a significant risk for the organism. In the “traffic light system” data exceeding EAC are displayed in red.

A set of monitoring data produced by vTI (Germany) comprising PAH metabolites analysed in bile samples of dab, flounder, cod and haddock caught mainly in the North Sea and the Baltic was presented. In total more than 2000 individual fish have been analysed between 1998 and 2007. The analytical method used was HPLC fluorescence. All fish were caught in August or September, so no seasonal variation is reflected in the data. No time trends were visible in any of the regions during the time period covered (Kammann 2007). Comparing the areas North Sea, German Bight

and Baltic regional differences in PAH metabolites obviously are larger than species differences.

BACs were calculated using the 90th percentile of reference site data. This strategy is recommended by SGIMC. Two areas as reference sites: Iceland and Barents Sea and BACs were obtained close to values presented by SGIMC 2009 (except flounder). Data from additional reference sites may improve the quality of the BAC in future. BAC were applied for dab, cod and flounder using either species specific BAC (dab value for flounder) or an overarching BAC for all species under investigation. An example of the results is given in Figure 7.1. The PAH metabolite data categorized according to BAC showed a plausible regional distribution with higher values for PAH metabolites in the western Baltic compared to the North Sea.

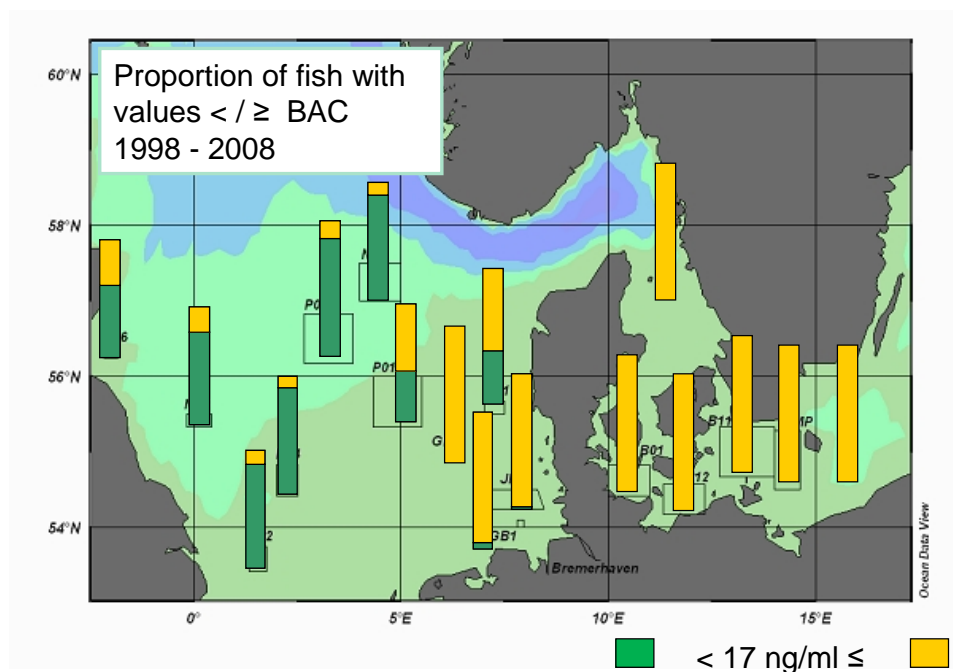


Figure 7.1. 1-Hydroxypyrene in bile fluids of dab, flounder and cod caught between 1998 and 2007 categorized by the species overarching BAC of 17 ng/ml. Proportion of single fish per station are categorized in relation to BAC. By Werner Wosniok & Ulrike Kammann (ICES 2010).

The species overarching BAC are justified by the observation that different species from the same areas exhibit similar values of PAH metabolites. The second argument is the fact that the BAC calculated for single species are not distinguishable in the light of analytical variance of the method which has a CV of 15% for HPLC fluorescence (calculated from a reference material analysed in vTI over a 3-year period). The overarching BAC might be of advantage when no species specific BAC is available because of the lack of reference areas.

BAC can be calculated from reference site data using the 90% percentile of all data considered as reference. If no reference site is available, BAC can be calculated using the 10% percentile of a data set which is believed to contain low values close to reference values as well as non-reference data. Comparing both ways of BAC calculation for the present cod data shows that the 10% approach underestimates the BAC value (Figure 7.2.) In general also an overestimation might occur, if a dataset contains very few or no near-reference values.

We conclude that a BAC can only be calculated reliably using data from reference areas. However, by identifying more or new reference areas the quality of a BAC can be improved continuously.

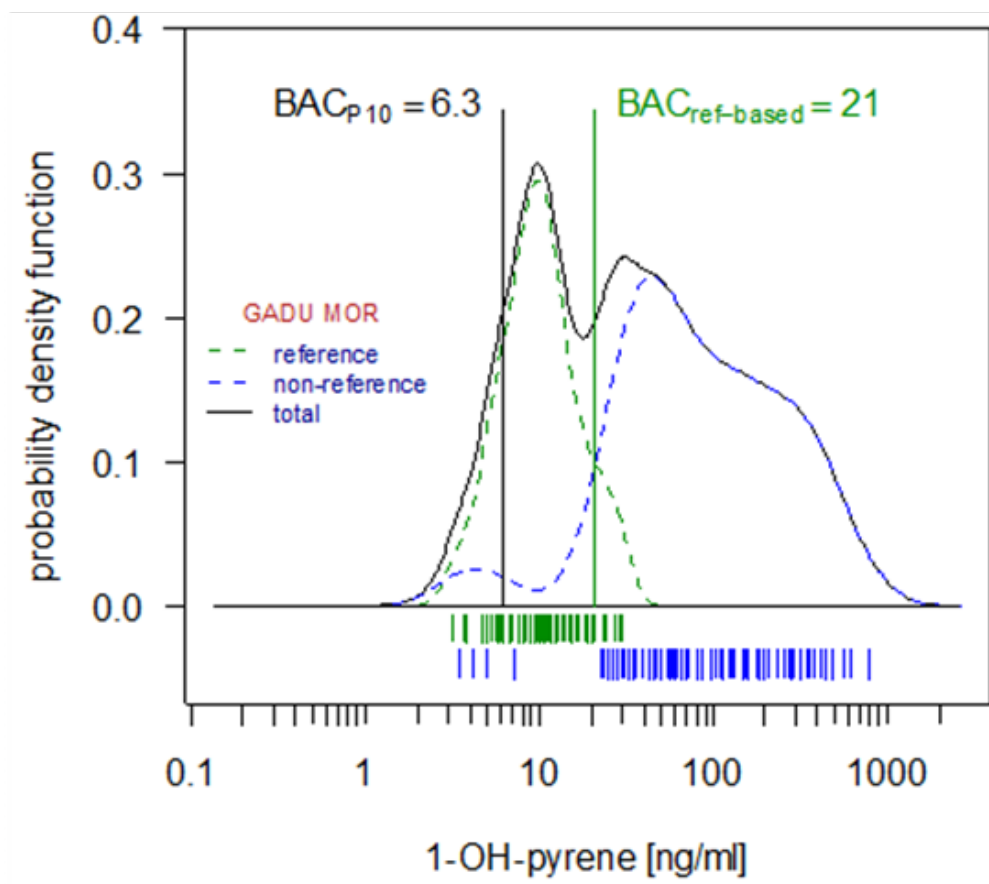


Figure 7.2. Distribution of 1-hydroxypyrene data in bile fluids of cod from reference (green) and non-reference regions (blue). BACs based on 10% of all and 90% of reference data are indicated. By Werner Wosniok & Ulrike Kammann (ICES 2010).

Even if PAH metabolites are a marker of exposure, high levels of metabolites can be linked to deleterious effects in fish so that EACs can be identified. During SGIMC 2010, Steinar Sanni (Norway) made data available from toxicological experiments linking oil exposure and PAH metabolites in fish with DNA adducts and fitness data (Morton *et al.* submitted; Skadsheim *et al.* 2004; Skadsheim *et al.* 2009) where the latter serves as the effect quantity for the calculation of the EAC.

#### Literature

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#### 7.4 Comments and suggestions by SGEH

The most recent ICES WGBEC List of Recommended BEC parameters was checked and it was noted that most of them were being examined under the BEAST project and are, as in the OSPAR region, potentially applicable in the integrated assessment in the Baltic Sea region.

The role of "early-warning" biomarkers was re-checked. Despite their position in the "lower" biological level (molecular, biochemical, sub-cellular, etc.) their value should probably be increased since they serve as the first biological response indicators to exposure to/effects of hazardous substances before any damage is occurring at higher biological levels. "Early warning" covers two different dimensions:

- "early" in the way of the development of a disease, pathological state or severe physiological disturbance or damage;
- "early" in a way of the temporal rapidness of response.

Two examples: change in cardiac activity is an integrated, "high", systemic level biomarker that responds very rapidly; many behavioural changes ("high" in a sense of effects reflected at population or community levels) occur rapidly, being controlled by neurological and hormonal factors.

Regarding integration of chemical and biological data the SGEH discussed the use of available ecotoxicological data (EC<sub>50</sub>, LC<sub>50</sub>, PNEC, etc.) from "standard aquatic test species" used for toxicity testing of chemical compounds (*Daphnia*, zebra fish, algae, cell cultures, etc.) for weighting and connecting the measured concentrations of chemical compounds with their toxicity in the study areas. Standardisation (values between 0–1) of data obtained this way would enable the assessment of the relative contribution of specific compounds to overall toxicity. This differs from e.g. the approach used in the current version of e.g. the HELCOM CHASE tool by selection of one specific ecotoxicological test to and using standardisation to better enable comparisons of different sites in regard to most toxicologically important compounds present. This approach naturally does not take into account the complex characteristics of mixture toxicity but would in any way increase the realism of the assessments.

The SGEH concluded that, especially in the Baltic Sea area, one of the major questions hindering the implementation of biological effects methods in monitoring programmes and assessments is the scarcity of well-established assessment criteria (AC) in regard to a number of parameters. This obviously requires some more basic research, specifically in regard to the effects of natural fluctuations both in the physical environment and the biology of the target organisms. However, suitable data that could be used to establish AC is already available in regard to some species and biological effect parameters from the Baltic Sea. As an example, AC on lysosomal membrane stability (histochemical method) and micronuclei frequency were recently applied in the HELCOM integrated thematic assessment of hazardous substances in the Baltic Sea (HELCOM 2010). It is important that the process should be continued in a coordinated way. The continuation of the work was considered to be central part of the work agenda of both SGEH and the BONUS+ BEAST project.

The SGEH acknowledges that in the OSPAR area the work on AC accomplished by the WKIMON (I-V) group (2005–2008) and its successor SGIMC have already come up with significant progress on the development of AC (e.g. ICES 2010) in biological effects parameters for monitoring in the CEMP of Northeast Atlantic area. This work has also produced background documents on the parameters used. In regard to the harmonisation of monitoring activities in the different sea areas of Europe SGEH considers it very useful to take maximum benefit from the extensive work done in WKIMON/SGIMC to transfer the knowledge and approaches to the HELCOM area. However, since the sea areas are in many ways quite different, feasibility of the transfer must be carefully checked in all parts and adjustments made accordingly.

The SGEH agreed that OSPAR background documents for biomarkers will be examined for their applicability in Baltic Sea monitoring activities and revised where necessary. Missing documents (not available/ the method not included in the OSPAR list) will be created. The tasks will be distributed to SGEH members (? = acceptance of task to be confirmed) as suggested in the Table 7.1. below.

**Table 7.1. Examination and revision of OSPAR background documents for biomarkers in regard to their applicability in Baltic Sea monitoring activities: share of work within the SGEH.**

**A. Fish**

Method	Responsible person
Lysosomal membrane stability	Katja Broeg (?)
Micronuclei frequency	Janina Barsiene (?)
Acetylcholinesterase activity	Kari Lehtonen and Magdalena Podolska
Ethoxyresorufin-O-deethylase activity	Henryka Dabrowska
PAH metabolites	Ulrike Kammann and Pekka Vuorinen
DNA adducts	Halldora Skarphethingsdottir (?) (non-member)
Liver nodules	Thomas Lang (?) and Magdalena Podolska
External diseases	Thomas Lang (?)
Reproductive success (eelpout)	Jakob Strand (?)
Vitellogenin induction	Pekka Vuorinen and Thomas Lang (?)
Glutathione S-transferase activity	Magdalena Podolska
Comet Assay	Henryka Dabrowska

**B. Invertebrates**

Method	Responsible person
Metallothionein induction	Kari Lehtonen
Acetylcholinesterase activity	Kari Lehtonen
Micronuclei frequency	Janina Barsiene (?)
Lysosomal membrane stability	Katja Broeg (?)
DNA adducts	Halldora Skarphethingsdottir (?) (non-member)
Oxidative stress (several parameters)	Kari Lehtonen
Glutathione S-transferase activity	Kari Lehtonen
Comet Assay	<i>no candidate yet</i>
Reproduction disorders in crustaceans	Brita Sundelin (?)

The documents produced should follow the following structure (adopted from OSPAR background documents):

- 1 ) Background
- 2 ) Confounding factors
- 3 ) Ecological relevance
- 4 ) Quality assurance
- 5 ) Baseline and assessment criteria
- 6 ) Future work
- 7 ) Acknowledgements
- 8 ) Literature

The documents produced by SGEH members will be reviewed during the SGEH meeting in 2011.

#### **Literature**

HELCOM (2010) Hazardous substances in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. Balt. Sea Environ. Proc. No. 120B

ICES (2010) Report of the Joint ICES/OSPAR Study Group on Integrated Monitoring of Contaminants and Biological Effects (SGIMC), 25–29 January, Copenhagen, Denmark. ICES CM 2010/ACOM:30. 56 pp

## **8 ToR e) Follow-up of the BEAST/SGEH input to the HELCOM HOLAS Thematic Assessment concerning hazardous substances in the Baltic Sea**

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During 2009–2010, HELCOM elaborated a Thematic Assessment of hazardous substances in the Baltic Sea (HELCOM 2010). Several of the SGEH members participated the work as experts concerning biological effects of hazardous substances. Biological effects data (lysosomal membrane stability [general health indicator] and micronuclei [genotoxicity indicator] from the EU BEEP project (2001–2004) were included in the assessment. The integration of data was used using the CHASE assessment tool developed by HELCOM for this purpose.

### **8.1 HELCOM Thematic Assessment of hazardous substances in the Baltic Sea 2010: The HELCOM CHASE assessment tool**

Jakob Strand reported (by correspondence) on this item. The CHASE assessment tool was used to prepare a HELCOM integrated thematic assessment of hazardous substances in the Baltic Sea. A draft report is available and the final version is to be published later this year (HELCOM 2010). The report is connected to the HELCOM Baltic Sea Action Plan, which identifies pollution by hazardous substances as one of the four main issues to improve the health of the Baltic Sea.

The CHASE assessment tool is used to create an integrated traffic light system. CHASE is used to integrate the status of contamination by individual chemicals and biological effects at specific sites or areas into a single status value called contamination ratio. Ultimately, the use of this integrative tool provides an overview of the status of contamination and biological effects by hazardous substances over the Baltic Sea.

The threshold levels used in CHASE were obtained from national legislation or international agreements or EU directives (e.g. EC Environmental Quality Standards,



OSPAR Environmental Assessment Criteria). The use of national or international threshold levels ensures that this assessment is fully compatible with national legislation and the implementation of the European Union directives.

Altogether, 144 assessment units were analysed using CHASE, 40 of the assessment units were open sea areas and 114 were coastal assessment units.

CHASE includes four themes:

- a ) Contaminants close to natural levels (water, sediment, biota)
- b ) Fish safe to eat
- c ) Healthy wildlife
- d ) Radionuclides

CHASE calculates a "Contamination Ratio (CR)" for all variables within each theme:  $CR = \text{measured value} / \text{threshold level}$ .

CR are integrated within each theme to a "Contamination sum", which is calculated as "sum of all Contaminant ratios / (sqrt n)".

The contamination sum is assessed according to five assessment classes: High (0–0.5), Good (0.5–1), Moderate (1–5), Poor (5–10), and Bad (>10). The overall integrated assessment is based on the worst condition of the four themes. Assessments for at least two themes have to be included in the calculation before the overall assessment is performed.

Each of the CHASE classifications with moderate, poor or bad status were examined to determine whether there were common causes for the poor status. The three most common substances causing the degraded status of the marine environment (i.e. having highest CRs) were collated.

All common groups of hazardous substances: PCBs, dioxins, heavy metals, organometals, alkylphenols, phthalates, brominated substances, polycyclic aromatic hydrocarbons (PAH), DDTs and chlorinated pesticides were found among the decisive substances.

- PCBs were among the top three substances in 39% of the cases,
- Mercury in 22%,
- Cadmium in 19%,
- Tributyltin in 18% and
- Lead in 18%

Dioxins/dioxin-like PCBs, DDT and DDE had a high influence on the chemical status in circa 10% of the cases.

The above-mentioned 'decisive substances' were mainly found in samples from biota (60%, fish, mussels and birds) and only secondarily in sediment samples (35%). Only five per cent of those samples were from water.

Biological effects measurements, such as imposex in marine snails and lysosomal membrane stability, micronuclei and PAH-metabolites in fish have also impact on the assessment in some areas, mainly in the southern part of the Baltic Sea, where data were available.

Various comments on the CHASE Tool were provided earlier by SGIMC (ICES 2010) and SGEH largely agrees with those. The development of the CHASE assessment tool

is seen as an interesting and important prospect where also SGEH expects to contribute, e.g. by working on AC of biological effects.

### Literature

HELCOM (2010) Hazardous substances in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. Balt. Sea Environ. Proc. No. 120B

ICES (2010) Report of the Joint ICES/OSPAR Study Group on Integrated Monitoring of Contaminants and Biological Effects (SGIMC), 25–29 January, Copenhagen, Denmark. ICES CM 2010/ACOM:30. 56 pp

## 9 ToR f) Discussion on the methodological standards and criteria suggested to the EU Commission within the Marine Strategy Framework Directive concerning qualitative descriptors for determining good environmental status

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The SGEH went through the presentation of Petra Wallberg (by correspondence) and relevant parts of the accompanying background documents and discussed the information. The following notes were made:

- Radioactivity: in all countries there are national monitoring programmes. New nuclear power plant stations are being planned and built globally. This increases the risk of effects of radionuclides both for humans and wildlife. Biomarkers of genotoxic damage (chromosomal aberrations, Comet assay, etc.) can also give early warning on biological effects of increased radiation while histopathological examinations e.g. on the frequency of liver tumours reveal effects at an advanced level of pathology.
- In the background document "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions concerning the European Union Strategy for the Baltic Sea Region" "Main issues concerning the marine environment", pollution by nutrients and fishing have been described as the main issues for the Baltic Sea. However, hazardous substances were not even mentioned in the document. This is not in line with the priority goals of the BSAP.
- MSFD: SGEH examined and discussed the new draft document "MSFD GES Task Group 8 Report on the recommendations for the Good Environmental Status of European Seas regarding contaminants and pollution effects under the Marine Strategy Framework Directive" (later available as European Commission 2010). The group considered the review and presentation of especially the effects of hazardous substances as well-covering and it presented the current understanding and views of numerous experts. Concerning the Baltic Sea, it was noted that the BONUS+ BEAST project was mentioned in the document as an example of relevant EU projects to MSFD TG8.

Relevant extracts from "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions concerning the European Union Strategy for the Baltic Sea Region":

"Many challenges require action at the level of the Baltic Sea Region: responses at national or local level may be inadequate. Four key challenges have been identified as requiring our urgent attention. They are:

- To enable a sustainable environment
- To enhance the region's prosperity
- To increase accessibility and attractiveness
- To ensure safety and security in the region."

"The unique features of the Baltic Sea, and its environmental pressures, demand a macro-regional approach to combat its long-term deterioration. This has been long-recognised, including through joint action in HELCOM, although there is a need for increased coordination among sectoral policies."

"Main issues concerning the marine environment"

"Available data suggest that pressures such as pollution by nutrients, predominantly nitrates and phosphates, cannot easily be absorbed but have rapid and visible impacts. The increasing algae blooms, covering more of the sea each summer, are the result. These algae consume oxygen at the expense of fish and other forms of life. This problem has been recognised for many years but so far the initiatives taken have not been effective enough due to increased population pressure, insufficient targeting of the agricultural measures to intensive agricultural areas and a time-lag before the measures show significant results.

Fishing activities pose another significant impact on the eco-system. Stocks of some species have significantly declined and certain fishing practices cause incidental catches of non-target species or destroy habitats. Establishing an ecosystem-based management approach, as proposed under the reform of the CFP, and using CFP provisions to minimise the effect of fishing on marine environment will support the conservation of the Baltic ecosystem, taking into account the HELCOM Baltic Sea Action Plan. The fishing fleet should be in balance with available resources."

"The Action Plan covers the following priority areas: (1) To reduce nutrient inputs to the sea to acceptable levels; (2) To preserve natural zones and biodiversity including fisheries; (3) To reduce the use and impact of hazardous substances; (4) To become a model region for clean shipping; (5) To mitigate and adapt to climate change."

## Literature

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions concerning the European Union Strategy for the Baltic Sea Region" "Main issues concerning the marine environment. Commission to the European Communities, Brussels, 10.6.2009 COM (2009) 248 final.

European Commission (2010) Marine Strategy Framework Directive – Task Group 8 Report Contaminants and pollution effects. Author(s): R. Law, G. Hanke, M. Angelidis *et al.* Luxembourg: Office for Official Publications of the European Communities. EUR – Scientific and Technical Research series – ISSN 1018-5593. ISBN 978-92-79-15648-9. DOI 10.2788/85887. 161 pp

## 10 ToR g) Review the concept of ecosystem health concerning the Baltic Sea in particular and its implementation in HELCOM BSAP

In the Baltic Sea Action Plan (BSAP), indicators for the ecological objective "Healthy wildlife" have been identified as in Table 10.1. SGEH notes that the indicators represent only effects measured at higher biological levels, both in regard to food web as

well as biological response. SGEH points out that effects at lower trophic levels and below-individual levels (e.g. biomarkers) are indicative of disturbances in ecosystem/individual health. Deviations exceeding natural variability at a given site observed in benthic communities and dynamics in phyto- and zooplankton can be used as indicators of disturbance. In regard to biomarkers, e.g. lysosomal membrane stability (LMS) is generally accepted as a health indicator at the sub-cellular level (e.g. Dagnino *et al.* 2007).

**Table 10.1. Baltic Sea Action Plan. Ecological objectives (EO) for hazardous substances: Indicators and Targets for EO "Healthy wildlife" (HELCOM 2007)**

<b>Table 3. Indicators for ecological objective "Healthy wildlife"</b>	
<b>Indicator</b>	<b>Target</b>
Predatory bird health: White tailed sea eagle (and/or osprey) for different sub-regions of Baltic Sea * Proportion of successfully reproducing pairs * Mean brood size	targets need to be defined
Fish health: * Fish Disease Index	target needs to be defined
Seal health: Grey seal for entire Baltic and ringed seal for northern Baltic, also harbour porpoise proposed for the consideration of Seal Group - rate of pregnancy (CA) - rate of fecundity (CL) - occurrence of uterine pathology (occlusion, stenosis, "myoma") - occurrence of intestinal ulcers in 1-3 year-old seals	- normal pregnancy rate (to be defined) - normal fecundity rate (to be defined) - normal level of uterine pathology (to be defined) - normal occurrence of intestinal ulcers in 1-3 year-old seals

SGEH points out that in the BSAP it has been mentioned that:

"WE FURTHER AGREE starting in 2008 to develop biological effects monitoring to facilitate a reliable ecosystem health assessment" (HELCOM 2007)."

SGEH sees that further developments are indeed urgently needed and recommends the consideration of the methods above to be included in the list of "Indicators", and their application, including definitions of targets, should be further developed. It is also noted that, in any case, the Table 10.1. is incomplete in regard to the definition of "Targets" even when concerning predatory bird health and the Fish Disease Index.

Reproductive disorders in fish and invertebrates such as imposex in gastropod snails, intersex in eelpout, M74 syndrome in Baltic salmon, skewed sex ratios in fish larvae, malformations, reduced fecundity and brood survival in benthic amphipods etc. represent health effects potentially connected to anthropogenic hazardous substances. Most of these parameters can be included in a holistic assessment of ecosystem health in the Baltic Sea.

SGEH also points out that extensive toxic algal blooms are indicators of ecological disturbance, and are driven by changes in nutrient balance, eutrophication in general, community structure changes, and abiotic factors. The possible connection between hazardous substances and intensification of toxic blooms is also unclear. This means that information on cyanobacterial blooms, concentrations of algal toxins and their biological effects should be considered as parameters in EH assessments.

### Literature

Dagnino A, Allen JL, Moore M, Broeg K, Canesi L, Viarengo A (2007) Integration of biomarker data into an organism health index: development of an expert system and its validation with field and laboratory data in mussels. *Biomarkers* 12:155–172

HELCOM (2007) HELCOM Baltic Sea Action Plan. HELCOM Ministerial Meeting, Krakow, Poland, 15 November 2007

## 11 Planning of intersessional work, contributions to the implementation of HELCOM BSAP, and key topics of next year's SGEH meeting

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The SGEH discussed, identified and agreed upon the following intersessional work and ToRs for the meeting in 2011:

- a) review progress in the BEAST project,
- b) develop background documents for biological effects methods in the Baltic Sea,
- c) examine the status of assessment criteria for biological effects parameters in the Baltic Sea,
- d) review developments in MSFD related to the implementation of biological effects methods,
- e) propose a list of biological effect methods for integrated monitoring and assessments in the Baltic Sea,
- f) update project planning for the BONUS-169 call in 2011,
- g) review biological effects methods applied in ERAs, EIAs and "post-accident" studies,
- h) biological effects of perfluorinated compounds relevant to the Baltic Sea,
- i) continue compilation of effects of hazardous substances on biodiversity in the Baltic Sea,
- j) assess fish diseases as in indicator of ecosystem health.

The SGEH will meet in mid-April 2011 in Riga (Latvia), hosted by Elmira Boikova (Institute of Biology, University of Latvia) and Maija Balode (Latvian Institute of Aquatic Ecology).

## 12 Any other business

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### 12.1 ICES Science Steering Group Regional Sea Programmes (SSGRSP)

In ICES, SGEH is grouped in Science Steering Group Regional Sea Programmes (SSGRSP). The Chair of SSGRSP, Yvonne Walther, informed the SGEH about the framework, its visions and future plans.

#### 12.1.1 Terms of reference for SSGRSP

- a) Provide guidance to constituent Expert Groups (EGs) to ensure relevance to the Science Plan
- b) Identify gaps and overlaps in the EG base, and consolidate and form new EGs as appropriate
- c) Review the scientific products delivered by EGs to ensure the maintenance of appropriate quality standards

- d) Advise SCICOM on the form and substance of the ASC, symposia and workshops
- e) Ensure communication among Steering Groups and their constituent EGs
- f) Establish and nurture collaborations within and outside the ICES community

### **12.1.2 General visions**

The Steering Group is foremost a forum to co-ordinate Expert Group work and create new Expert Groups when needed. As the concept of a Regional Programmes Group is new it is a dynamic forum where all views and ideas are highly appreciated.

The meetings will foremost take place during the ICES Annual Science Conference but also through WebEx conferences a couple of times each year. But contributions or suggestions for the SSGRSP can be sent to the Chair of SSGRSP (Yvonne Walther) or the chair of an Expert Group under the SSGRSP framework at any time.

The Regional Sea Programmes defined during their first meeting in ICES ASC 2009 an overall vision. The mandate given was to create Regional Programmes starting with Baltic and North Sea. To use the advance made in Integrated Assessments particularly in the Baltic for application in other areas that may be interested in creating similar programmes

The challenge is to identify real world application of science with a spatial interest at Regional Sea level. The first key issue will be creating guidelines for IEAs and provide means to perform them on a regional level. Currently there are three groups working on IEAs in different Regional Areas (Baltic, North Sea and NW Atlantic) and under construction Bay of Biscay/IBISROOS.

### **12.1.3 Milestones for SSGRSP work 2010–2011**

The Integrated Assessment Working Group for the Baltic (WGIAB) will have its meeting back to back with the assessment group for the Baltic Sea (WGBFAS) in Copenhagen in April 2010. WGIAB has a strong connection with the BONUS+ project AMBER.

The Baltic Programme has the SGEH in the Baltic very well interlinked with the BONUS+ BEAST project. This is a high focal area and investigates effects of anthropogenic contaminants on different biological levels. The work will be developed during 2010 and connected with the IEA work.

Introduction of ecological-economical modelling into management tools has started through the Workshop on Introducing Coupled Ecological-Economic modelling and risk assessment into management tools (WKIMM). The group will have their first meeting in Kiel University, 16–18 June 2010.

The Working Group on Large Marine Ecosystem Program Best Practices (WGLME-BP) is overviewed by the SSGRSP and holds its meeting in March 2010. This will provide an interesting aspect of connecting Regional Seas within the ICES area to other areas.

SSGRSP will plan for reviving the former work of WGRED (Working Group on Ecosystem Description).

ICES has sponsored the ESASS (Ecosystem Studies of Sub-Arctic Seas) symposium in 2011 and SSGRSP will represent ICES.

ICES has made a commitment to BSAS “Taking the pulse of the Baltic Sea” (Annex 5). This includes creating advanced observing systems for the Baltic Sea. Future activities under this commitment will be performed in co-operation with the EGs in the Regional Sea Programmes.

#### **12.1.4 Expert Groups under SSGRSP**

- ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB)
- Study Group on data requirements and assessment needs for Baltic Sea trout (SGBALANST)
- Study Group for the development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH)
- Workshop on Introducing Coupled Ecological-Economic modelling and risk assessment into management tools (WKIMM)
- Workshop on Including Socio-economic considerations into the Climate-recruitment framework developed for clupeids in the Baltic Sea (WKSE-CRET)
- Working Group on Holistic Assessment of Marine Ecosystems (WGHAME)
- Workshop on anchovy, sardine and climate variability in the North Sea and adjacent areas (WKANSARNS)
- Working Group on the Northwest Atlantic Regional Sea (WGNARS)
- Working Group on Large Marine Ecosystem Program Best Practices (WGLMEBP)

The meeting dates and venues for the Expert Groups can be found in the ICES meeting calendar at:

<http://www.ices.dk/reports/general/2010/2010Meeting%20Calendar.pdf>

#### **12.1.5 SSGRSP meetings and membership**

SSGRSP has two open sessions at the ICES Annual Science conference. This year the meeting will be held in Nantes, France, 20–25 September. The Steering Group meetings are open to all who register for the conference. SSGRSP also has 2–3 WebEx meetings each year, where operational issues and the status of the Expert Groups are discussed.

Membership in the SSGRSP is open on Chair's invitation. Currently it consists of two SCICOM members, two from the ICES secretariat and all EG chairs (on a voluntary basis).

#### **Members of SSGRSP 2010**

Yvonne Walther (Chair)

Georg Kornilovs (SCICOM)

Dariusz Fey (SCICOM)

Christian Möllmann (WGIAB)

Anna Gårdmark (WGIAB)

Thorsten Blenckner (WGIAB)

Bärbel Müller-Karulis (SGPROD)

Kari Lehtonen (SGEH)

Jörn Schmidt (WKIMM)

Steven Cadrin (WGNARS)

Andrew Kenny (WGHAME)

Pascal Laffargue (IFREMER coordinator WGWEASS)

Michael O'Toole (WGLMEBP)

Maria Lifentseva (ICES)

Wojciech Wawrzynski (ICES)

Stig Pedersen (SGBALANST)

Piotr Margonski (WKSECRET)

Mark Dickey-Collas (WKANSARNS)

Kari Lehtonen presented the PowerPoint document prepared by Yvonne Walther, the chair of the Steering Group on Regional Sea Programmes (SSGRSP). SGEH examined the themes of groups put under the Regional Seas Programme (RSP) and discussed the possibilities of collaboration with those that appeared to be relevant to the work of SGEH.

#### **12.1.6 Comments and suggestions by SGEH**

WGIAB: The most obvious one, WGIAB, has not included chemical contaminants in their work and the objectives are in most cases very much fish stock assessment driven. It was discussed that it is likely that "SGEH needs WGIAB more than the other way around". The "traffic-light" analysis showing a regime shift in the Baltic Sea between 1974–2007 is basically a description of change with no assessment of the health status. SGEH suggests to expand the excellent work achieved by WGIAB by including contaminant and biological effects (although very little data on the latter exists), where available, to the analysis, and further apply an index approach to assess changes in the health status of the sub-regions according to the methodology expected to be developed during the BEAST project. Part of the work could be done in connection with the BONUS+ BEAST project. SGEH expresses its wish to start this collaboration with WGIAB in 2010.

WGHAME, WGNARS, WGWEASS: SGEH briefly examined the targets of the other RSP groups and identified such groups as Working Group on Holistic Assessments of Regional Marine Ecosystems (WGHAME), Working Group on the Northwest Atlantic Regional Sea (WGNARS) and WGWEASS (under construction 2010) as the ones with obvious overlap and potential collaborating options. The SGEH suggests the idea of forming a cluster of expert groups of the RSP dealing with integrated assessments in different regional seas to ensure would ensure that the basic approaches would be more-or-less consistent between the regions to achieve comparability of the assessments.. The suggested "core groups" dedicated to this work could consist of WGIAB, SGEH, WGHAME and WGNARS, while the remaining RSP groups collaborate mainly with the best fitting ones. The best ways of collaboration between the four groups and even re-organisation might have to be considered.

SGEH discussed about the future work of SGEH in serving Ecological Risk Assessment (ERA) and Environmental Impact Assessments (EIA). Toxic algal blooms,



chemical accidents including oil spills, construction activities (pipelines, traffic links and channels, offshore wind parks, oil platforms, legal dumping, sand and gravel extraction), environmental offenses, and even increased terrorism among other disturbances threaten health status of the seas. Most of these cause permanent or temporary changes in abiotic and biotic conditions, habitats, and affect organisms at different biological levels. The SGEH recognized the importance of the development of monitoring and assessment methods to be applied also in ERAs and EIAs. Accordingly, for next year's meeting a specific ToR concerning ERA and EIA was formulated.

The aims and expertise of the current SGEH encompass issues related to contaminants and especially their biological effects at different levels of biological organisation, including biodiversity. However, SGEH points out that for a full assessment of ecosystem health the work should be shared with experts from groups such as those dealing with eutrophication, biodiversity or impacts on fishery in the Baltic Sea.

SGEH recommends that other expert groups dealing with eutrophication, dynamics of fish communities, effects of maritime activities and biodiversity issues in the Baltic Sea area will become actively involved in building a common ecosystem health assessment strategy for the Baltic. SGEH – or its possible successor starting in 2012 – could in the future act as a "focal point" for collecting information on indicators most relevant indicators of ecosystem health concerning the different fields. The basic structure and strategy in the development of kind of an "Ecosystem Health Assessment Manual" (for each sub-region of the Baltic) would be presented to different expert groups of ICES and HELCOM. A request of assessment of indicators and assessment criteria (if available) will be distributed to relevant expert groups. The gathered information will be reviewed in the next meeting of SGEH.

## **12.2 Specific presentations**

Several members contributed to the general themes of the SGEH with presentations covering the following issues: "Biodiversity use for environmental quality indication" - Jan Marcin Węśławski, "Thiamine as a biomarker" – Pekka J. Vuorinen, "Developments in the Fish Disease Index: communication from ICES WGPDMO" – Magdalena Podolska, and "Biosensor early warning systems (EWS) for water quality monitoring based on benthic invertebrates physiological state assessment" – Sergey Kholodkevich and Tatiana Kuznetsova.

### **12.2.1 Biodiversity use for environmental quality indication**

Due to the international alert on the issue of biodiversity loss, there is a tendency to use the diversity of life as universal and most important indicator of the quality (health) of the environment. Still, the concept of biodiversity (from genes through species to habitats) is based on objects counting within given category (whatever is the category from genes to habitats). Counting objects may be misleading, as it assumes that all objects within category are equal, and it is their number that is of importance. Such approach is not taking into consideration that species are not equal, and their functions are important.

Traditional approach of most biologists, based on environmental ethics says that all creatures are equal, if it is so, more species the better. Functional Ecology says that some species are important for many other species as habitat builders, key stone elements of food web or bioturbators. In such way some functions are also more important than other (e.g. how many other species are based on the performance of given function).

Once we accept that species are not equal, we may assess the biological value of given area in more sophisticated way than just objects count. The biological valuation, contrary to socioeconomic one, does not take into consideration the user (man) point of view. It presents the intrinsic value, coherence, naturalness and completeness of analysed area (habitat). The methodology was recently described by Derous *et al.* 2007, and used for the Baltic seabed habitats in paper by Weslawski *et al.* (2009).

### Literature

Derous S, Agardy T, Hillewaert H, Hostens K, Jamieson G, Lieberknecht L, Mees J, Moulaert I, Olenin S, Paelinckx D, Rabaut M, Rachor E, Roff J, Stienen EWM, van der Wal JT, van Lancker V, Verfaillie E, Vincx M, Weslawski JM, Degraer S, 2007 A concept for biological valuation in the marine environment, *Oceanologia* 49 (1): 99-128

Weslawski JM, Warzocha J, Wiktor J, Urbanski J, Radtke K, Kryla L, Tatarek A, Kotwicki L, Piwowarczyk J. 2009. Biological valorisation of the southern Baltic Sea (Polish Exclusive Economic Zone) *Oceanologia* 2009, no. 51(3), pp. 415-435

### 12.2.2 Thiamine as a biomarker

Concentrations of dioxin-like organochlorines in female salmon muscle have been demonstrated to correlate with the increase in mortality of offspring at the yolk-sac fry stage, i.e., with the M74 syndrome (Vuorinen *et al.* 1997, 2002). The syndrome appear to be interrelated with the decrease in thiamine concentrations in Baltic salmon and in its eggs, and the egg thiamine concentration have appeared to be a good biomarker for the severity of M74 (Amcoff *et al.* 1998, Vuorinen and Keinänen 1999). Change in the availability of thiamine related to alterations in the composition of the food web (e.g. changes in plankton community structure due to shifts in salinity due to the pulses of saline water to the Baltic Sea) has also been hypothesised.

SGEH concluded that whatever the cause(s) of serious reproductive disorders observed in Baltic salmon related to thiamine deficiency are, thiamine levels could potentially be used as an indicator of ecosystem health in the Baltic Sea. The M74-syndrome has so far been observed only in salmonids in the Baltic Sea and the Great Lakes (EMS [Early Mortality Syndrome]), both having numerous environmental characteristics in common. SGEH supports more research on thiamine in different levels of the food web to examine this possibility.

### Literature

Amcoff P, Börjeson H, Lindeberg J, Norrgren L 1998. Thiamine concentrations in feral Baltic salmon exhibiting the M74 syndrome. In Early life stage mortality syndrome in fishes of the Great Lakes and Baltic Sea. American Fisheries Society, Symposium 21, Bethesda, Maryland (G. McDonald, J. D. Fitzsimons and D. C. Honeyfield, Eds.), pp. 82-89.

Vuorinen PJ, Keinänen M 1999. Environmental toxicants and thiamine in connection with the M74 syndrome in Baltic salmon (*Salmo salar*). In *Nordic Research Cooperation on Reproductive Disturbances in Fish. Report from the Redfish project*. TemaNord 1999:530 (B.-E. Bengtsson, C. Hill and S. Nellbring, Eds.), pp. 25-37.

Vuorinen PJ, Parmanne R, Vartiainen T, Keinänen M, Kiviranta H, Kotovuori O, Halling F 2002. PCDD, PCDF, PCB and thiamine in Baltic herring (*Clupea harengus* L.) and sprat (*Sprattus sprattus* (L.)) as a background to the M74 syndrome of Baltic salmon (*Salmo salar* L.). *ICES J. Mar. Sci.* 59: 480-496.

Vuorinen PJ, Paasivirta J, Keinänen M, Koistinen J, Rantio T, Hyötyläinen T, Welling, L. 1997. The M74 syndrome of Baltic salmon (*Salmo salar*) and organochlorine concentrations in the muscle of female salmon. *Chemosphere* 34: 1151-1166.

### 12.2.3 Developments in the Fish Disease Index: communication from ICES WGPDMO

Fish diseases are considered as ecosystem health indicators, reflecting ecologically relevant effects of environmental stressors at the individual and population levels.

- 1) Externally visible symptoms of diseases:
  - Viral (lymphocystis), bacterial (ulceration) and parasitic infections
- 2) Liver histopathology:
  - non-specific lesions – for assessment of general health effects
  - contaminant-specific lesions and
  - macroscopic liver neoplasms (tumours) – for assessment of contaminant-specific health effects

FDI approach is ready for inclusion in relevant programmes (e.g. the OSPAR Coordinated Environmental Monitoring Programme, CEMP) as an appropriate method to analyse and assess changes in the diseases status of wild fish populations. However, because of a lack of data, the assessment was restricted to 8 EVD of dab (lymphocystis, epidermal hyperplasia/papilloma, acute/healing skin ulceration, x-cell gill disease, hyperpigmentation, *Stephanostomum baccatum* (Digenea), *Lepeophtheirus pectoralis* (Copepoda: Caligidae), *Acanthochondria cornuta* (Copepoda).

The FDI approach should be applied to other fish species for which data exist in the ICES Environmental Database. Candidate species are flounder (*Platichthys flesus*; North Sea and Baltic Sea) and cod (*Gadus morhua*; Baltic Sea). Some disease data on other fish species (e.g. flounder, cod) are also available in the ICES fish disease database. However, the amount of data are at present regarded as insufficient for an assessment.

### 12.2.4 Biosensor early warning systems (EWS) for water quality monitoring based on benthic invertebrates physiological state assessment

An early warning system (EWS) is an integrated system for monitoring, analyzing, interpreting, and communicating monitoring data, which can then be used to make decisions that are protective of public (or ecosystem) health and minimize unnecessary concern and inconvenience to the public. To become a widely used, effective, and reliable part of a water distribution security and quality monitoring system, an ideal integrated EWS should demonstrate a number of characteristics, such as the following (EPA 2005):

- provides a rapid response
- includes a sufficiently wide range of potential contaminants that can be detected
- exhibits a significant degree of automation, including automatic sample archiving
- allows acquisition, maintenance, and upgrades at an affordable cost
- requires low skill and training
- identifies the source of the contaminant and allows accurate prediction of the location and concentration downstream of the detection point
- demonstrates sufficient sensitivity to detect contaminants
- permits minimal false-positives/false-negatives

- exhibits robustness and ruggedness in continually operating in a water environment
- allows remote operation and adjustment
- functions continuously
- allows for third party testing, evaluation, and verification

### **State-of-the-art systems and current research and development**

#### **Biosensors**

Biosensors work to reveal water toxicity by using whole-organism or cellular response approaches. Biosensors measure changes in physiology or behaviour of living organisms resulting from stresses induced by the polluted water. This type of biosensor does not identify the specific toxin, but indicates that there is an unusual condition in the water. The overall rationale is that the organism can respond with sensitivity to all the factors that contribute to stress. Fast acting hazardous substances associated with acute effects are most quickly detected.

#### **Mollusks as biosensors**

Live organisms have been long used as biosensors. The International Organization for Standardization (ISO) has approved the List of biosensor organisms and test reactions

(<http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?COMMID=3729>), in which bivalve mollusks occupy an important place. Mollusks possess a high sensitivity and respond relatively rapidly (by valve closing) to contamination, and therefore a change in their movement activity is used for estimation of the environment state (<http://www.mosselmonitor.nl>).

#### **Systems**

##### **MosselMonitor®**

In a number of countries EWSs for early alarm on contaminant level in water medium were mounted. For sea water there is “MusselMonitor”, for fresh water - “DreissenaMonitor” system. These systems were developed in Holland in 1990s. Delta Consult (Netherlands) has a commercially available MosselMonitor®.

Mussels will change their behaviour in response to impact, such as closing their shells to reduce exposure to hazardous substances. Thus, the frequency of valve opening and closing can be monitored to indicate pollution. The MosselMonitor® can be run online continuously for up to two to three months before replacement of mussels is necessary. The data presentation software allows for near real-time graphical presentation at a remote location or on the Internet. Only eight mussels are required because each mussel’s behaviour is analyzed against its own previous behaviours, then the combined results from all eight mussels are analyzed. There are some variants of such devices but the main scheme is similar. They consist of Hall sensor and are based on signal variations during changes in the valve gape of mollusks.

The MosselMonitor® has been used by Waterworks of Budapest (Hungary), Poznan (Poland), etc. to monitor chlorinated drinking water.

##### **Clam Biomonitor**

Similar to MosselMonitor® other groups are investigating using **clam** responses to detect water quality issues that affect clam behaviour. However, these approaches

have been limited to source water monitoring. The University of North Texas, Little Miami, Inc. (Milford, OH), and EPA have a joint project to develop a Clam Biomonitoring System. The gap of 15 clams is measured at one-minute intervals and is plotted along with temperature, pH, conductivity, and dissolved oxygen. A cellular modem is used to connect to the Internet for data relay. The system is installed on the Little Miami River in Miamiville.

#### **CAPMON (Continuous Automated Permanent Monitoring)**

Depledge and Andersen (1990) in Plymouth laboratory of marine biology developed a new method and infra-red technique for non-invasive monitoring of invertebrates (blue mussel and crabs) cardiac activity (average heart rate–HR, beats/min). The authors approbated the developed method for assessment of physiological state of crabs taken from aquatoria differed by ecological status. Authors used mechanical vibration as stressor to test the state of organism's health from different aquatoria.

Fiber-optic bioelectronic system for on-line cardiac activity monitoring (SRCES system).

The fiber-optic method was developed in 1999. Multi-channel fiber-optic photoplethysmograph (Kholodkevich *et al.*, 2007) allows to measure HR simultaneously in 7 species. Obtained plethysmograms were analyzed with the use of special software in real time on the base of variational pulsometry method (Baevsky and Berse-neva, 1997) adapted to the invertebrates (Kholodkevich *et al.*, 2008). The latter allows to have detailed assessment of variability of heart rate and stress-index which indicate the exertion of cardio-regulatory systems. Nowadays SRCES RAS scientific group uses the followings cardiac activity biomarkers for invertebrate physiological state assessment:

- $\Delta\text{HR}$  – heart rate change (%);
- SD – standard deviation of cardiac interval sample;
- $d\text{HR}/dt$  – derivative of HR;
- SI – stress-index.

During 2009 lab and field studies of species (*Mytilus edulis*, *Carcinus maenas*, *Macoma balthica*) taken from different in ecological status sites we obtained data on different recovery time and course of HR changes in recovery (return to initial condition) period. The tendency for rapid recovery period of HR, as we suppose, can characterize good physiological status of studied organisms as having good adaptive abilities to restore their state after test-stimuli treatments (changes of salinity, temperature, etc.). The latter fact can give us an opportunity to assess ecosystem health status for studied sites. The obtained results allowed SRCES RAS scientific group to propose the following new cardiac activity biomarkers:

- Value of  $\Delta\text{HR}$  (evoked by standard test-stimuli) dispersion;
- Time of organism recovery after test-stimuli (which characterize organism adaptive capacities).

#### **Conclusions**

- The methods are based on valve gaping or heart rate variation analysis of invertebrates *Crustacea* (Decapoda) and *Mollusca*. The systems are successfully applied to on-line monitoring of surface water quality as well as for biologically-purified waste water control.

- The physiological method for some invertebrates is considered to be suitable for involving the animal-biosensor in automated systems for continuous real-time environmental monitoring.
- The system developed in SRCES RAS is suitable for both fresh water and marine areas uses.
- Automated bioelectronic system can be applied to provide ecological state assessment based on cardiac activity characteristics (as an essential characteristics of organism physiological state) of the invertebrates from different marine aquatoria.

**Further research needs:**

- Standardized methods/guidance for data analysis and interpretation of data
- Large-scale data storage
- Verified baseline data to calibrate EWS
- Validation of event detection algorithms
- Existing system should be adapted for use as “tool ”for ecosystem health assessment.

SGEH discussed the review of Sergey Kholodkevich and Tatiana Kuznetsova concerning the use of cardiac activity and shell gaping of organisms as a physiological biomarker. Various technical aspects of the method and new developments have already been made under the BEAST project using mussels, the clam *Macoma balthica* and the shore crab *Carcinus maenas* from the Baltic Sea. The developments look interesting and the SGEH supports further studies.

## **13 Closing of the meeting**

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The meeting closed on 5 March 2010 at 14:00.

**Annex 1: List of participants**

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## Annex 2: Agenda

### 1–5 March 2010, Sea Fisheries Institute (SFI), Gdynia, Poland

- 1) opening of the meeting, including welcome address from the Director of SFI, Dr. Tomasz Linkowski;
- 2) adoption of the agenda;
- 3) appointment of rapporteurs;
- 4) review the outcome of the BEAST project Data Treatment and Index Testing & Development Workshop (early 2010);
- 5) review the progress in the BONUS+ BEAST project;
- 6) examine the review of (a) literature on basic & applied research on biological effects of contaminants and (b) chemical contamination in the Baltic Sea;
- 7) evaluate of relevance of the literature review above for the development of integrated biological chemical monitoring and assessment criteria;
- 8) follow-up of the BEAST/SGEH input to the HELCOM HOLAS Thematic Assessment concerning hazardous substances in the Baltic Sea;
- 9) 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;
- 10) review the concept of ecosystem health concerning the Baltic Sea in particular and its implementation in HELCOM BSAP;
- 11) any other business;
- 12) recommendations and action list;
- 13) adoption of the report and closure of the meeting.

Date	Est. time	Item	Issue	Lead contributor
Monday, March 1	9:30	1	Opening of the meeting; welcome address; tour de table, etc.	Kari Lehtonen
		2	Adoption of agenda	Kari Lehtonen
		3	Appointment of rapporteurs	Kari Lehtonen
		4	Review of the outcome of the BEAST project Data Treatment and Index Testing & Development Workshop (ToR a)	Kari Lehtonen ( <i>corresp. Doris Schiedek</i> )
	10:45		COFFEE BREAK	
	11:15	5	Review of the progress in the BONUS+ BEAST project (ToR b) a. BEAST at the 5 <sup>th</sup> HELCOM Stakeholder Meeting	Kari Lehtonen
	12:30		LUNCH BREAK	
	13:30	11	Biodiversity issues	Jan Marcin Weslawski
	14:00	6	Examination of the review of (a) literature on basic & applied research on biological effects of contaminants and (b) chemical contamination in the Baltic Sea (ToR c)	Rolf Schneider Pekka Vuorinen

			a. chemical contamination b. organohalogens in fish c. biological effects	(corresp. Doris Schiedek)
	15:15		COFFEE BREAK	
	15:45	7	Evaluate of relevance of the literature review above for the development of integrated biological chemical monitoring and assessment criteria (ToR d)	(corresp. Doris Schiedek)
Tuesday, March 2	9:00	8	Follow-up of the BEAST/SGEH input to the HELCOM HOLAS Thematic Assessment concerning hazardous substances in the Baltic Sea (ToR e) a. chemical contamination – CHASE tool b. biological effects	Rolf Schneider (corresp. Jakob Strand)
	10:45		COFFEE BREAK	
	11:15	8	Item 8 Contd.	
	12:30		LUNCH BREAK	
	13:30	9	Review of the progress in the BONUS+ BEAST project (ToR b)	Kari Lehtonen (corresp. Brita Sundelin) (corresp. Thomas Lang) (corresp. Doris Schiedek)
	15:15		COFFEE BREAK	
	15:45	9	Item 9 Contnd.	
	17:30		RECEPTION AT SFI	
Wednesday, March 3	9:30	10	Item 10 Contd. a. assessment criteria for PAH metabolites b. update of progress in SGIMC integrated monitoring	Ulrike Kammann Ulrike Kammann
	10:45		COFFEE BREAK	
	10:15	10	Discussion of methodological standards and criteria suggested to the EU Commission within the Marine Strategy Framework Directive concerning qualitative descriptors for determining good environmental status (ToR f) a. MSFD	Kari Lehtonen (corresp. Brita Sundelin, Petra Wallberg)
	12:30		LUNCH BREAK	
	13:30	11	a. Evaluation of the relevance of the literature review above (Item 6) for the development of integrated biological chemical monitoring and assessment criteria (ToR d)	(corresp. Doris Schiedek)
	15:15		COFFEE BREAK	
		11	b. review of literature on biomonitoring of physiologi-	Sergey Kholodkevich/

		11	cal status/cardiac activity of invertebrates	Tatiana Kuznetsova
Thursday, March 4	9:00	10	Item 10 Contnd.	Pekka Vuorinen
	9:30	11	Thiamin as a biomarker	
			c. targets and work of SCICOM Steering Group on Regional Sea Programmes (SSGRSP)	Kari Lehtonen (corresp. Yvonne Walther)
	10:45		COFFEE BREAK	
	11:15	12	Recommendations and action list	Kari Lehtonen
	12:30		LUNCH BREAK	
	13:30	12	Review the concept of ecosystem health concerning the Baltic Sea in particular and its implementation in HEL-COM BSAP (ToR g)	SGEH group effort
	15:15		COFFEE BREAK	
	15:45		Item 12 Contd.	
	17:00		CLOSURE OF BUSINESS	
Friday, March 5	9:30	13	Adoption of the report and closure of the meeting	Kari Lehtonen
	12:30		LUNCH BREAK	
	13:30	13	Item 13 Contd.	
	15:00	13	CLOSURE OF THE MEETING	

### Annex 3: SGEH draft resolution for the next meeting

The ICES Study Group for the Development of Integrated Monitoring and Assessment of Ecosystem Health in the Baltic Sea (SGEH), chaired by Kari Lehtonen, Finland, will meet in Riga, Latvia, mid-April 2011 (to be announced) to:

- a) review progress in the BEAST project;
- b) develop background documents for biological effects methods in the Baltic Sea;
- c) examine the status of assessment criteria for biological effects parameters in the Baltic Sea;
- d) review developments in MSFD related to the implementation of biological effects methods;
- e) propose a list of biological effect methods for integrated monitoring and assessments in the Baltic Sea;
- f) update project planning for the BONUS-169 call in 2011;
- g) review biological effects methods applied in ERAs, EIAs and "post-accident" studies;
- h) biological effects of perfluorinated compounds relevant to the Baltic Sea;
- i) continue compilation of effects of hazardous substances on biodiversity in the Baltic Sea;
- j) assess fish diseases as in indicator of ecosystem health.

Material and data relevant to the meeting must be available to the group no later than 14 days prior to the starting date.

SGEH will report by 31 May 2011 (via SSGRSP) for the attention of SCICOM.

### Supporting Information

Priority	The activities of SGEH 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	<p>Action Plan Nos: 1.2, 2.3, 2.6</p> <p>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 available information in a structured manner and to help WGIAB in selecting appropriate areas for the integrated assessment.</p> <p>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 on-going 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.</p>

	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 very close working relationship the Working Group on Integrated Assessment in the Baltic (WGIAB), WGBEC & SGIMCEB.
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. Interactions and collaboration among groups dealing with integrated assessments should be strengthened with the aim of harmonisation of targets and methodology. This could be achieved by reorganisation or even merging of EG under SSGRSP	SSGRSP and EGs within, SGIMC, HELCOM MONAS
2. The integrated approach for monitoring and assessment should be reflected in participation in SGEH, and ICES Member Countries are encouraged to nominate appropriate national experts to attend the future SGEH meetings.	SSGRSP and EGs within, SGIMC, HELCOM MONAS
3. 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.	HELCOM MONAS
4. SGEH should be considered as a key expert group concerning biological effects of hazardous substances in issues related to the implementation of the BSAP as well as the Marine Strategy Framework Directive.	SSGRSP and EGs within, HELCOM MONAS
5. Biological effects methods should be included in the monitoring and assessment toolbox of HELCOM to support (a) the Marine Strategy Framework Directive and (b) the HELCOM Holistic Assessment of the Baltic Marine Environment, thus to comply with BSAP.	HELCOM MONAS

## Annex 5: ICES Contribution to the BSAS: "Taking the Pulse of the Baltic Sea"

### ICES-ACOM, Intergovernmental Organization Denmark International North Atlantic

Other  
Living marine resources  
Biodiversity  
Environment and habitat quality  
Hydrographic conditions and climate

#### ICES: "Taking the Pulse of the Baltic Sea"

Professional service

The International Council for Exploration of the Sea (ICES) commits to design, coordinate implement together with countries around Baltic Sea, and report on the results of a new integrated ecosystem observing system for the Baltic Sea. The design of the new innovative observing system will use the ongoing work of the ICES Baltic Sea Integrated Assessment Working Group and other ICES expert groups that have worked on observing system technology and design, and ecosystem indicators. The design will take account of:

- Objectives of the Baltic Sea Action Plan,
- The EC Marine Strategy Framework Directive and agreements on indicators of Good Environmental Status (GES)
- The requirements of EC Common Fisheries Policy and Data Collection Framework (DCF)
- Scientific work of HELCOM
- Relevant research and monitoring and scientific programs of countries around Baltic Sea including products of BONUS
- Best practices for data management

The design of an ecosystem observing system will be performed by a series of workshops open to all scientists that can contribute to the goals of the system. The workshops will:

- evaluate requirements to meet objectives of an integrated ecosystem observation system for assessment and management
- identify indicators that are suitable for taking the pulse of the Baltic Sea today, and candidates for more advance diagnostics in the future,
- inventory of existing data collection programs that are candidates for inclusion in the system,
- analyze the overlap and redundancies in existing data collection programs,
- identify gaps that need to be filled by additional observations (by type, area, season, intensity),
- optimize the design in light of the information above, recognizing practical constraints (e.g., on budget, area of operation of individual countries, etc.),
- describe data management and information technology requirements,
- outline processes for routine analysis, interpretation and dissemination of results, and
- propose a governance structure for implementing the integrated ecosystem observing system including processes aim at consensus agreement on the "pulse of the Baltic Sea."

The design of an integrated ecosystem observing system will take place during 2010-2012. Since the design will add value by integrating many existing data collection activities, some elements will be implemented immediately. Full implementation will depend on availability of funds.

The objective of the commitment is to provide a scientific basis for monitoring the state of the Baltic Sea that is:

- Rigorous and sound because it is based on the expertise of a large and diverse scientific community from around the Baltic Sea with input from scientists from throughout Europe, North America, and worldwide;
- Credible because it has been subjected to quality assurance including peer review, and because it is provided by a scientific organization that is independent of management, or non-advocacy;
- Authoritative in the eyes of the governments that are responsible for management and policy since it is adopted by the Intergovernmental Organization with regional scientific competency according to a Convention they ratified.

Being authoritative also increases impetus for the system design to be taken into account in future revisions of the Data Collection Framework that supports the CFP and analogous data collection programs that may be instituted to support the MSFD. It should also be taken into account in domestic decisions on funding for scientific investigations of the Baltic Sea.

In carrying out this Commitment, ICES will welcome cooperation with HELCOM, BONUS and other organizations that want to contribute.

#### **Milestones**

2010 June 30<sup>th</sup>

Workshop for the Design of an Integrated Ecosystem Observing System for the Baltic Sea.

Terms of reference will be prepared and approved by ACOM. A chair or co-chairs will be appointed.

The workshop will be scheduled and registration will be opened to participants. Background materials will be assembled.

#### **Partnership opportunities and contact information for this purpose**

ICES has a worldwide network of scientific partners and agreements with fishery and environmental commissions, including HELCOM, BONUS, and the EC.

Commitment created: 2010 January 26

Expected commitment duration: 24 months, The commitment to the design stage is for two years.

[www.ices.dk](http://www.ices.dk)

Contact person – content: Michael Sissenwine, [m.sissenwine@ices.dk](mailto:m.sissenwine@ices.dk), +4525488868

Contact person – for communication: Gerd Hubold, [gerd@ices.dk](mailto:gerd@ices.dk), +45 2164 67 01