ICES SGEH REPORT 2007

ICES BALTIC COMMITTEE

CM 2007/BCC:01

Ref. ACE

REPORT OF THE STUDY GROUP ON BALTIC ECOSYSTEM HEALTH (SGEH)

16–18 NOVEMBER 2006

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

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2007. Report of the Study Group on Baltic Ecosystem Health (SGEH), 16–18 November 2006, Tallinn, Estonia. Computer Management. 119 pp. https://doi.org/10.17895/ices.pub.8994

Contents

Executive summary

Highlights

- Indicators of biodiversity;
- Indicators of biological effects of hazardous substances;
- Indicators of eutrophication;
- Indicators of fishery;
- Preliminary compilation of genetic diversity.

The ICES Study Group on Baltic Ecosystem Health Issues in Support of BSRP (SGEH) at its meeting in Tallinn, Estonia, from 16–18 November 2006, reviewed progress on ecosystem-based approaches, discussed and developed tools for ecosystem health assessment of the Baltic Sea. This work was carried out during plenary presentations and plenary discussions as well as in sub-groups. Selected presentations have been prepared by the authors and as Annexes 3–9 to this report:

- Proposal for the ICES/BSRP and HELCOM Demonstration Project on Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland;
- Proposal for a ICES/HELCOM/BSRP workshop on methodologies for monitoring fish diseases/parasites in coastal fish species from the Baltic Sea;
- Determination of sub-regional target/effect levels for biological effects: an exercise on the Gulf of Finland bivalve data;
- Reproductive success in eelpout as an environmental indicator;
- Imposex and intersex in gastropods as indicator in the Baltic Sea;
- The US EPA: Introduction of the Draft National Coastal Condition Report III;
- Some points on genetic diversity in the Baltic Sea.

The Study Group continued its work in two sub-groups:

1) Biodiversity;
2) Hazardous substances.

These sub-groups concentrated on the development of ecosystem health assessment tools for the Baltic Sea: selection of best possible (priority) indicators, establishing target levels for these indicators, discussed and proposed demonstration projects on the ecosystem health assessment. The Gulf of Finland was proposed as the demonstration polygon (see Annex 3). This project will mainly cover biodiversity and biological effects of harmful substances (including fish diseases) and determination of sub-regional target/effect levels for the ecosystem health of the Gulf of Finland.

The Study Group revised and finalized tables of indicators which had been developed by SGEH in previous years. These tables are included to this report as Annexes 10–13:

- Revised Table of Indicators on Habitat destruction and Loss of Biodiversity;
- Revised Table of Indicators on Hazardous Substances and Biological Effects (incl. disease and parasites);
- Revised Table of Indicators on Effects of Eutrophication;
- Revised Table of Indicators on Effects of Fishery.

Reference conditions and target values for some specific indicators were proposed.

The ICES SGEH output is recommended to be used for developing the Baltic monitoring programme and the ecosystem health assessment of the Baltic Sea.

1 Opening and welcome

The ICES Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH) held its meeting from 16–18 November 2006 at the premises of the Estonian Marine Institute (EMI), Tallinn, Estonia.

E. Andrulewicz, the Chair of the Study Group, opened the meeting and welcomed the participants. G. Martin, Research Director of EMI welcomed the participants on behalf of himself and T. Saat, Director of the EMI.

The meeting was attended by participants from all Baltic countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden and Russia) and representatives of HELCOM, BSRP and US EPA. The List of Participants is contained in **Annex 1** to this Report.

2 Matters related to working procedures

2.1 Terms of References and Final Agenda

The Chair of the SGEH meeting presented the Terms of Reference for the meeting:

The **Study Group on Baltic Ecosystem Health Issues in support of the BSRP** [SGEH] (Chair: E. Andrulewicz, Poland) will meet in Tallinn, Estonia, from 16–18 November 2006 to:

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

b) continue to develop the Baltic ecosystem health concept in relation to the main ecological concerns: eutrophication, hazardous substances, overfishing, marine transport and biodiversity (including xenodiversity and habitat destruction);

c) list and rank the deliverables of the SGEH outcome from the last three years;

d) progress towards operationalizing TOR c) by defining reference levels for selected BSRP SGEH indicators of eutrophication, hazardous substances, impacts of fishing, marine transport and loss of biodiversity (including xenodiversity and habitat destruction) for selected demonstration areas.

e) identify and plan potential contributions to 2008 ICES ASC Theme Session related to ecosystem health assessment;

f) evaluate the proposal made by WKFDM to organize a land-based ICES/BSRP workshop in 2007 on methodologies for coastal fish disease monitoring;

g) evaluate the proposal made by WKFDM to organize an international demonstration project in 2008 on the ecosystem health of the Gulf of Finland;

h) discuss how to contribute to the implementation of the HELCOM Baltic Sea Action Plan (BSAP) in relation to: eutrophication, hazardous substances, maritime activities and biodiversity.

SGEH will report by 30 January 2007 for the attention of the Baltic Committee and ACE.

The Chair presented the final agenda for the SGEH meeting (**Annex 2**) and proposed that after plenary presentations (covering ToRs a and b) the work should be continued in sub-groups (covering ToRs: c, d, e, f, and g).

2.2 Establishing Subgroups and working procedures for Subgroups:

When discussing the establishment of sub-groups, A. Andrushaitis suggested the need to limit SGEH approach on ecosystem health and to focus on the most important issues related to the ecosystem health assessment of the Baltic Sea, namely loss of biodiversity and effects of harmful substances. The main reason for this suggestion was limited SGEH expertise and the need to concentrate on issues the most useful for the implementation of the Baltic Sea Action Plan (BSAP). The meeting agreed to this proposal and decided to establish two sub-groups:

Sub-group 1: Loss of Biodiversity (also covering effects of eutrophication and habitat destruction).

Sub-group 2: Hazardous Substances (also covering biological effects of hazardous substances, fish parasites and fish disease issues).

The following co-chairs were proposed for these sub-groups and accepted by the meeting:

Biodiversity: G. Martin and K. Summers

Hazardous substances: K. Lehtonen and T. Lang

It was decided that the main task of the sub-groups is the revision of the indicator lists selected at previous meetings, development/proposition of reference and target values, contribution(s) to ICES ASC 2007 theme session, discussion on SGEH support for BSAP implementation and demonstration projects proposals.

2.3 Election of Rapporteur(s)

The SGEH Chair proposed E. Łysiak–Pastuszak from Poland to act as Rapporteur to the meeting. The meeting unanimously adopted this proposal. H. Backer volunteered to assist in rapporteuring during the meeting.

3 Plenary presentations and discussions (overview of developments of ecosystem-based approaches (ToRs a,b,f, g)

The meeting took note of the timetable and work program of BSRP Phase 1 finalization and starting BSRP Phase 2 presented by A. Andrushaitis, Assistant Cordinator of Component 1 of the BSRP. He pointed out that the finalization of Phase 1 of the Project was postponed until June 2007. He highlighted the achievements of the Phase 1 and stressed the importance of the current meeting to present a package of BSRP deliverables. A. Andrushaitis also pointed out that there might be a gap between the finalization of Phase 1 and implementation of Phase 2 of the BSRP.

3.1 Ongoing HELCOM activities and expectations of HELCOM towards SGEH

The meeting was informed by K. Forsius on the ongoing HELCOM activities for the Baltic Sea Action Plan (BSAP) and its role as the pilot implementation of the European Marine Strategy, as well as HELCOM MONAS and HELCOM HABITAT requests for SGEH work. The meeting agreed that the BSRP SGEH work should be fully coordinated with, and provide necessary input to HELCOM activities aiming at the Baltic Sea Action Plan. The meeting was reminded of the request from HELCOM MONAS to elaborate guidelines on methods for port surveys regarding alien species.

The meeting took note of the indicators and targets agreed at the HELCOM Workshop on Hazardous Substances indicators in Vilnius in September 2006 and agreed to use this outcome as a basis for the work conducted by SGEH.

The meeting took note of the presentation by H. Backer of HELCOM aims to produce Biodiversity Assessment by 2009 and agreed that both SGEH and BSRP should actively participate in this activity by producing biodiversity relevant indicator products in the fields of expertise relevant for SGEH. A summary of Mr Hermanni's presentation on on-going HELCOM activities and expectations of HELCOM towards SGEH is given below:

The ongoing HELCOM work in various thematic groups and workshops is very much focusing on the development of the HELCOM Baltic Sea Action Plan.

Most of the work on indicators in priority areas is in the pipeline and even finalized, especially regarding eutrophication. The work done within BSRP thematic groups has contributed substantially to the development of indicators and subregional targets.

However, HELCOM specified the request for continued support of e.g. the SGEH group especially with regard to the development of indicators for fish health as well as biological effects monitoring of hazardous substances. The assessment of biodiversity and nature protection, to be produced within the HELCOM BIO project by 2009, is another field where the work by SGEH (and participating BSRP Lead Laboratories) would be valuable to HELCOM.

HELCOM MONAS 9/2006 considered the activities of BSRP and:

HELCOM MONAS welcomed the detailed information on the current activities of Component 1 of the BSRP and on the plans for the anticipated second phase, which is expected to start in mid 2007 - giving for the first time HELCOM MONAS a comprehensive picture of the important work of BSRP/C1. The Meeting underlined the need for full harmonization between the monitoring and assessment activities of the BSRP and HELCOM.

HELCOM MONAS appreciated the work carried by the Coordination Center for Ecosystem Health, especially in developing ecological objectives, indicators and biological effects monitoring. The Meeting recommended that SGEH:

- cooperates closely with ICES, HELCOM PEG and ZEN in developing taxonomic inventories of plants and animals, taking into account databases serving pan-European purposes,
- cooperates with habitat mapping activities with e.g. the BALANCE project,
- prepares guidelines on methods for carrying out port surveys, including development of criteria for the selection of ports for full and partial sampling surveys as well as a standardised port sampling protocol,
- starts the work for a HELCOM expert network on invasive alien species,
- initiates elaboration of a programme for monitoring of alien species and their impacts for the development of the HELCOM COMBINE Programme,
- carries out activities related to biological effects monitoring,
- carries out activities related to ecosystem health assessment in two demonstration areas: Gulf of Finland and Gulf of Gdansk,
- carries out activities related to the assessment of fisheries impacts on the Baltic ecosystem.

HELCOM MONAS also considered the proposal for a HELCOM Project "Indicators of effects of hazardous substances in various sub-regions of the Baltic Sea" and supported in general the idea to develop biological effects monitoring in the Baltic Sea as presented in a document submitted by Finland and Sweden. Furthermore, the Meeting considered important the project's input to the development of the Baltic Sea Action Plan.

The Meeting emphasised the need to fully integrate the activities in the project with the related work ongoing in the BSRP SGEH group and appreciated the offer by the SGEH to take this issue fully onboard and arrange the needed meetings/workshops in line with the project proposal.

The Meeting was of the opinion that at least the start of the project could be carried out without funding from the HELCOM budget and it should be carried out in two steps:

a) The first step would be a preparation meeting to be held in Tallinn, Estonia on 16–18 November 2006 in connection with the SGEH meeting followed by arrangement of a preparatory workshop in spring 2007 in line with the proposal. The spring workshop should be included in the SGEH work programme.

b) The second step would include the arrangement of a practical workshop to demonstrate some of the chosen methods and discuss a screening project for biomarkers. The Meeting was of the opinion that HELCOM MONAS should decide by correspondence on this step based on the results of the spring 2007 preparatory workshop.

The Meeting took note that the SGEH work which is funded by GEF does not involve Finland, Sweden, Denmark and Germany, and that for a successful outcome of the project the input and participation from these countries is crucial. The Meeting welcomed the following potential participants in addition to SGEH contacts from BSRP countries:

- Finland: K. Lehtonen;
- Sweden: B. Hedlund and B. Nyström;
- Germany: T. Lang;
- Denmark: J. Strand.

The Meeting stressed the need for all Contracting Parties to participate in the work and urged them to nominate and confirm contact persons for the project to the Secretariat.

All the above mentioned persons as well as D. Schiedek have confirmed their participation in the activity.

The Meeting further emphasised the need to establish collaboration and full coordination with the related ongoing work in OSPAR through ICES WKIMON. The Meeting encouraged the contact persons to participate in the Tallinn meeting and welcomed the offer by Sweden, with the support of Finland and the Secretariat, to co-lead the Project.

3.2 Ecosystem units and local populations in the Baltic Sea

The meeting took note of information by E. Ojaveer concerning a review and evaluation of methods to subdivide the Baltic Sea, including a relation to biodiversity assessment. The meeting welcomed the offer by E. Ojaveer to provide a copy of the scientific article to BSRP SGEH participants when published. A short summary of his presentation on the ecosystem units and local populations in the Baltic Sea (paper to be published by E. Ojaveer and M. Kalejs) follows:

Regional ecosystem units have been established in the Baltic Sea basing on the system of currents, location of intense mixing areas of water layers and differences between the sea areas as regards environmental conditions. In the open part of the sea the zones of divergence between the density-driven cyclonic currents controlling the hydrology in the deeps and wind-driven currents in shallow areas separate deepwater regions. Also in large gulfs specific regions have been distinguished. The regions differ in salinity, temperature, oxygen concentration in water layers, dynamics and level of biological production, biodiversity and other characteristics.

The natural regions in the Baltic Sea area can be divided into three groups – the macroregions. The Kattegat, the Sound together with the Belts and the Arkona Sea regions constitute the transition area macroregion between the Baltic and the North Sea. The Baltic Proper macroregion comprises the Southwest, Eastern and Northwest regions. The Large Gulfs macroregion includes the Gulf of Riga, Gulf of Finland, Bothnian Sea and Bothnian Bay regions. The natural regions can be subdivided into subregions.

Both, the ecosystems in separate regions of the sea and the populations adapted to these sea areas, should be assessed and managed separately as the natural units.

3.3 Demonstration Project for an Integrated Multidisciplinary Assessment of the Gulf of Finland Ecosystem Health (ToR g)

K. Lehtonen presented a proposal of a "Demonstration Project for an Integrated Multidisciplinary Assessment of the Gulf of Finland Ecosystem Health", concentrating on hazardous substances and their biological effects. The meeting strongly supported this proposal. The SGEH meeting invited K.Lehtonen to prepare a special meeting to draft a project proposal, possibly back-to-back with the WGIAB Workshop in Hamburg (12–16 March, 2007). From both, the scientific and monitoring strategy points of view the demonstration project programme should cover as many parameters/indicators measured as possible. The meeting pointed out that in order to carry out the project it is necessary to receive contributions from Finland and Germany in the form of the necessary ship-time onboard r/v "Walther Herwig III" and r/v "Aranda". BSRP was invited to provide financial support for the participants. A short description of "Proposal of ICES/BSRP and HELCOM Demonstration Project on the Integrated Multidisciplinary Assessment of the Gulf of Finland Ecosystem Health" by K. Lehtonen (Finnish Institute of Marine Research, Helsinki, Finland) and T. Lang (Federal Research Centre for Fisheries, Institute for Fishery Ecology, Cuxhaven, Germany) is given below:

A proposal to organize a joint international demonstration project in 2008 or 2009 on the ecosystem health of the Gulf of Finland was presented to the SGEH meeting. The project aims at (1) assessing the current health status of the Gulf of Finland marine ecosystem, (2) providing baseline data, (3) evaluating the feasibility of co-ordinated sample collection and analysis, (4) arranging practical workshops, and (5) providing a contact niche for stakeholders, media and researchers in the form of a joint seminar. The proposal is based on the implementation of the revised HELCOM monitoring programme concerning hazardous substances, with focus on their biological effects on the Baltic Sea ecosystem and the application of ecosystem health indicators developed in the BSRP SGEH. The project would serve to (1) develop integrated chemical-biological monitoring of hazardous substances in the Baltic Sea (2) enable an ecosystem-based approach of the joint Baltic Sea implementation of the future EC Marine Strategy, (3) give support to the HELCOM Baltic Sea Action Plan (BSAP) to identify the main pollution characteristics in each sub-region. The main aims of the project are (1) identification of suitable indicators of effects of hazardous substances at different biological levels in the Gulf of Finland, (2) assessing the ecosystem health of the Gulf of Finland, (3) developing a strategy for integrated environmental monitoring of the Gulf of Finland marine environment. The project should be fully co-ordinated with activities of the BSRP SGEH. A core group of the project was formed to plan and arrange a workshop in spring 2007 for the preparation of the demonstration project.

A more detailed, however, still draft description of the project can be found in **Annex 5.**

3.4 SGEH activities related to fish disease monitoring in the Baltic Sea (ToR f)

The meeting reviewed the work done by the ICES/BSRP "Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM)" (5–12 December 2005, onboard r/v "Walther Herwig III") presented by T. Lang. The outcomes of the Workshop, in the form of the ICES Report (ICES CM 2006/BCC:02) and draft guidelines for externally visible fish diseases and parasites monitoring were highly appreciated by the meeting.

T. Lang addressed SGEH Term of Reference f) to evaluate a proposal made by WKFDM to organize a land-based ICES/BSRP workshop in 2007 on methodologies for coastal fish disease monitoring and presented a proposal summarised below (more details are provided in **Annex 4**).

The proposal was developed by G. Rodjuk (AtlantNIRO, Kaliningrad, Russia, BSRP Lead Laboratory for fish diseases) and T. Lang (Fed. Res. Centre for Fisheries, Cuxhaven, Germany) and is based on a recommendation from the 2005 ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM) (ICES 2006) and on a request from HELCOM MONAS directed to SGEH

Reasons for holding the workshop are:

- The 2005 WKFDM focused on fishes from offshore areas. However, the HELCOM fish monitoring activities are largely related to coastal fish species.
- There are plans to widen the scope of the coastal fish monitoring and to integrate it with other coastal monitoring programmes in order to provide a basis for estimating the ecological status of the coastal fish compartment (HELCOM 2006) as part of a more holistic ecosystem approach and related management objectives.
- The ICES SGEH, together with the HELCOM coastal fish monitoring experts, were requested to develop an indicator for fish disease with target levels in order to meet the demands of the Baltic Sea Action Plan.

The workshop shall be held for 4-5 days in late 2007 (or early 2008) with G. Rodjuk, T. Lang and an expert representing the group of HELCOM/BSRP Coastal Fish Monitoring Experts as co-chairs. It will consist of two tiers: (a) lectures and seminars providing background information and for discussions and drafting purposes and (b) practical work in the lab with fresh material (key fish species from sampling sites representing different environmental conditions) and preserved samples (e.g. parasite specimens). It is anticipated that, for logistic reasons, the maximum number of participants will not exceed 20 persons. Participants should preferably represent all Baltic Sea countries and will consist of trainees and a number of invited trainers (possibly including western experts and experts from countries outside the Baltic Sea) as well as of representatives of the co-sponsoring organisations.

The major objectives of the workshop will be to:

- provide baseline data on diseases and parasites in key fish species from coastal areas in the Baltic Sea to be used for future fish health assessments as part of the coastal fish monitoring;
- provide training and intercalibration of methodologies related to the diagnosis of diseases;
- produce draft guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in the coastal fish monitoring programme, and
- propose indicators and target levels for diseases of coastal fish species to be used in Baltic Sea ecosystem health assessments.

Expected deliverables are:

- baseline data on diseases and parasites of coastal fish species in the Baltic Sea to be used for future assessments,
- guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in coastal fish monitoring programmes,
- proposals for disease indicators and related reference/target levels for coastal fish species in the Baltic Sea, and

- training and intercalibration of methodologies for disease studies in coastal fish species.

The SGEH welcomed the proposal and adopted it after discussion. It was recommended by SGEH that ICES, HELCOM and BSRP act as co-sponsors of the workshop because there is interest in these organisations/projects in the issue of diseases in Baltic coastal fish species and in order to achieven a wide recognition of the workshop as well as a commitment of the Baltic Sea countries to contribute to the workshop. It was pointed out by the HELCOM representatives that, if the workshop is going to be held in autumn 2007 prior to the 2007 meeting of HELCOM MONAS, HELCOM's co-sponsorship would have to be confirmed by correspondence.

With regard to the objective of the workshop to develop proposals for disease indicators and related reference/target levels, it was noted that the timing of the workshop (late 2007 or 2008) is in conflict with the timing of the finalisation and adoption of the HELCOM Baltic Sea Action Plan (BSAP) which is envisaged for June 2007. This means that the fish disease indicators and related reference/target value requested by HELCOM and developed by the workshop will not be available for the BSAP. However, it was stressed that the development of the BSAP should be seen as a dynamic process rather than as being 'carved in stone', providing the opportunity to incorporate elements required for future ecosystem health assessments at a later stage.

The SGEH accepted the proposal to nominate three co-chairs (G. Rodjuk, T. Lang and a coastal fish monitoring expert to be identified). H. Ojaveer volunteered to establish contact with appropriate representatives from the HELCOM coastal fish monitoring experts. There was further consensus that the first priority regarding the venue of the workshop should be given to the BSRP Lead Laboratory for fish disease issues at the AtlantNIRO, Kaliningrad, Russia.

The requirements that need to be met for the workshop were noted. Regarding the funding it was pointed out that one of the contributors could be the BSRP. Other contributions are expected from countries involved.

Recommendation

The SGEH recommends:

i) that a workshop on methodologies for monitoring fish diseases/parasites in coastal fish species from the Baltic Sea be organised in late 2007 or early 2008 under the co-sponsorship of ICES, HELCOM and the BSRP, preferably at the BSRP Lead Laboratory for fish disease issues, AtlantNIRO, Kaliningrad, Russia. G. Rodjuk, T. Lang and a representative of the HELOM coastal fish monitoring experts should act as co-chairs. The main objectives of the workshop should be to:

  - provide baseline data on diseases and parasites in key fish species from coastal areas in the Baltic Sea to be used for future fish health assessments as part of the coastal fish monitoring;
  - provide training and intercalibration of methodologies related to the diagnosis of diseases;
  - produce draft guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in the coastal fish monitoring programme, and
  - propose indicators and target levels for diseases of coastal fish species to be used in Baltic Sea ecosystem health assessments.

Literature cited

ICES 2006. Report of the ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea. ICES CM 2005/BCC: 02. (http://www.ices.dk/reports/BCC/2006/WKFDM06.pdf)

3.5 Biological effects of hazardous substances

As part of the activities of the SGEH Sub-group 2 on Hazardous Substances, in relation to the development of monitoring activities for biological effects of hazardous substances in the Baltic Sea, K. Lehtonen presented a document on "Determination of sub-regional target/effect levels for biological effects: an exercise on the Gulf of Finland bivalve data substances in the Baltic Sea" (see **Annex 3**).

As part of the activities of the SGEH Sub-group 2 on Hazardous Substances, J. Strand presented two documents: 1) "Reproductive success in eelpout as an environmental indicator" and 2) "Imposex and Intersex in gastropos as an indicator of biological effects in the Baltic Sea" which are included to this Report as **Annexes 6 and 7.**

3.6 ICES/HELCOM/BSRP Working Group on Integrated Assessment in the Baltic Sea (WKIAB)

B. Müller–Karulis presented the results of the ICES/HELCOM/BSRP Working Group on Integrated Assessment in the Baltic Sea (WKIAB). The meeting appreciated the work done by the group. The meeting expressed an opinion that Integrated Assessment could be also a tool to derive indices for biodiversity assessment.

3.7 Environmental conditions in the Gulf of Gdansk

The meeting took note of information about environmental conditions in the Gulf of Gdańsk, one of the proposed demonstration areas for Ecosystem Health Assessment, presented by E. Łysiak-Pastuszak. The meeting took note that the Gulf of Gdańsk ecosystem health assessment will be done basing on the existing monitoring/scientific projects data and no additional fieldwork is anticipated. The meeting was of the opinion that the project had good prospects to succeed due to the good data availability. K. Lehtonen and D. Schiedek indicated that biological effect measurements data from the finalised BEEP project could be made available for the Gulf of Gdańsk assessment.

3.8 Deliverables from the BSRP LL Biodiversity activities

N. Aladin, BSRP Local Project Manager on biodiversity, presented activities of his Lead Laboratory and informed the meeting of the deliverables from this Laboratory:

- List of experts in taxonomy of animals and plants of the Baltic Sea and user friendly list of useful publications on taxonomy of the Baltic Sea animals and plants **(Annex 8);**
- Assessment of biological diversity of Russian part of the Gulf of Finland using BSRP SGEH indicators **(Annex 9);**
- Influence of salinity change on the Baltic Sea biodiversity **(Annex 10)**

3.9 US EPA assessment criteria for coastal waters

The meeting took note of the US EPA assessment criteria for coastal waters presented by K. Summers. It was pointed out in the presentation that "bench mark" values (reference values) of indices or indicators were set basing on expectations of good environmental conditions in the US circa 1950s. These values were determined by a variety of techniques including advanced statistical analysis (e.g. Canonical Discriminant Analysis). The approach of US EPA to target levels is based on practicality of achievement (circa 1950s) rather than setting them to pristine conditions (pre-colonial). A description of the US EPA approach is given in **Annex 11.** A summary of the presentation is given below:

The statistical design used by the NCA is probabilistically based with the area of the estuarine resources of the U.S. as the base population, and specific estuarine areas associated with each of 23 states and 4 island territories/commonwealths as specific subpopulations. In addition, special subpopulations associated with each of the U.S. National Estuaries were created. The importance of probabilistic sampling designs are that they: (1) permit survey results that are applicable to the entire population of U.S. estuaries as well as results that are applicable to each subpopulation, and (2) that the uncertainty associated with each of the survey estimates. Most surveys are based on judgmental sampling locations representing sites specifically chosen to represent certain conditions (e.g., the end of piers, off bridges, special areas of interest, specific environmental types like sediment type, salinity regime or depth contours). These surveys based on judgmentally selected sites, while serving a very specific service, cannot represent the larger base population of interest nor can the uncertainty of these estimates be calculated. It was recommended that BSRP consider probabilistic sampling in its upcoming survey demonstration in the Gulf of Finland.

Indicators used in NCA consist of five indexes each made up multiple elements. These include:

1) Water Quality Index: comprised of dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity, chlorophyll a and dissolved oxygen;

2) Sediments Quality Index: comprised of bulk chemistry of surface sediments, sediment toxicity and the percentage of total organic carbon present in the sediments;

3) Habitat Index: comprised of historical decadal wetland loss rates and present decade loss rates;

4) Benthic Index: comprised of measures of biodiversity of benthic organisms and proportional abundance of pollution sensitive and pollution-tolerant target species;

5) Fish Contaminant Index: comprised of the concentrations of contaminants in whole fish and muscle tissue for target fish species.

The criteria for the selection of these indicators were described at the SGEH 3 meeting in Kaliningrad and will not be restated here. Additional secondary criteria were offered that have been of a practical and logical nature for NCA including cost-effectiveness, sampling unit stability, availability of collection and analysis methods, and the availability of historical records and analyses.

The process of the development of reference condition values for each of the NCA indicators was described, and the positive and negative impacts of regionalization of reference values were discussed. NCA uses regionalized reference for several of its indicators but, as a rule, prefers to utilize reference values that are broadly applicable to the entire population of interest. The distribution of system-wide and regional reference condition values are listed below:

1) Dissolved inorganic nitrogen: Regional based on geography;

2) Dissolved inorganic phosphorus: Regional based on geography;

3) Water Clarity: Regional based on habitat type;

4) Chlorophyll a: Regional based on geography;

5) Dissolved oxygen: System-wide;

6) Sediment chemistry: System-wide for each contaminant;
7) Sediment toxicity: System-wide;
8) Sediment TOC: System-wide;
9) Decadal wetland loss: System-wide;
10) Benthic index: Regional based on geography;
11) Fish contaminant index: System-wide for each contaminant.

The ramifications of regionalization on reference conditions were discussed and the recommendation to avoid regionalization where possible was made. However, ensuing discussion suggested that many of the indicators for the Baltic Sea region would likely be regionalized.

A discussion of simple ways to present environmental monitoring data in order to be useful to management was provided. Simple maps, “traffic light” and “gas gauge” renditions of survey results of the NCA III (2001–2002) were shown and described. Simple applications of hypothetical survey results were shown for the Baltic Sea using a five regional subpopulation approach: Kattegat, Baltic Basin, Gulf of Riga, Gulf of Finland, and Bothnian Basin. Suggestions were made regarding how to make the anticipated Gulf of Finland demonstration survey most useful for managers.

3.10 Genetic diversity in the Baltic Sea

J. Baršienė gave a presentation “Some points on genetic diversity in the Baltic Sea”. The meeting was of the opinion that the study gives clear signal on practical implications of the observed genetic uniqueness of the Baltic Sea populations and the Baltic Sea ecosystem serving as a refuge for unique genetic lineages, e.g. mapping areas of decreased genetic diversity. The meeting pointed out that genetic diversity as a part of biodiversity in general is a quickly developing field of science and noted that this activity should be coordinated with other projects, e.g. the BALANCE project, so that SGEH input will contribute to the assessment of the ecological coherence of the HELCOM BSPA network to be finalized by 2010. An extended version of Baršienė’s presentation can be found in **Annex 12.**

3.11 Theme Sessions at the ICES Annual Science Conference 2007

The meeting was encouraged by D. Schiedek and K. Lehtonen to participate in the ICES Annual Science Conference in Helsinki 2007 – Theme Session "Effects of hazardous substances on ecosystem health in coastal and brackish-water ecosystems: present research, monitoring strategies and future requirements”, co-convened by D. Schiedek, K. Lehtonen and C. Couillard.

4 Outcome of work in sub-groups (ToRs c, d, e, f, g)

4.1 Sub-group 1: Loss of biodiversity (including habitat destruction)

Sub-group members: G. Martin (co-chair), K. Summers (co-chair), H. Backer, N. Kovaltshuk, H. Ojaveer, M. Pliksh, K. Roszkowska

The discussions in the subgroup were based on following documents:

1) List of Biodiversity indicators developed by SGEH previous meetings
2) Draft chapter on Biodiversity of HELCOM Baltic Sea Action Plan

Biodiversity indicator table

The table (list) of biodiversity indicators for ecosystem health developed during previous SGEH meetings was discussed and took as a basis for further discussions. The general opinion was that the list of indicators has been very useful and helped development of understanding the ecosystem health concept in relation to biodiversity. The tasks for the subgroups included revision of the existing list of indicators and create ranking of different indicators according to their immediate applicability in biodiversity assessment and discuss possible reference conditions for different indicators.

It was decided that for further development of the indicator list only those indicators would be used where the indicators are developed to most extent including definitions, data availability, quality of indicator and availability or possibility to establish relevant reference conditions.

So several indicators listed by previous meetings were left out and further discussions were concentrated on the shortened list of indicators (see **Annex 13**).

Discussion on refernce conditions and possible target values

Sub-group discussed the possibility of defining reference conditions for selected indicators. The common conclusion was that development of reference conditions is very ambitious task and should be carried out extremely carefully and with high competence. As reference values(levels) are the crucial points in any assessment scheme the values should be based on solid information and concrete concepts. Group was on the opinion that development of reference conditions of selected indicators should be done by highly competent specialists and has to be based on relevant background information. Separate project or other form of activity should be arranged for this purpose and group was of the opinion that these values can not be proposed by current group during the meeting.

Group agreed that the possible task for the group could be evaluation of data availability for establishment of refernce conditions and target levels. Relevant remarks were added to the existing indicator table. For most of the selected indicators defining the target levels was possible and in most cases the possible target levels were proposed.

Discussion on Draft chapter on Baltic Sea Action Plan

The current state of the development of Baltic Sea Action Plan was presented by lead countries and the current draft version was discussed by the participants. Members of thr group gave several relevant comments to the development of the structure of the BSAP and based on these comments the new improved version of the biodiversity section was developed.

Development of list of recommendations

The group had been tasked to develop a list of recommendations emerging from the discussions on different matters connected to biodiversity issues. The list of developed recommendations is as follows:

- Provide the list of indicators developed by SGEH for consideration to HELCOM BIO to use in Baltic Sea biodiversity assessment;
- Consider including indicators developed by SGEH Biodiversity, Eutrophication and Fisheries groups into demonstration projects carried out in Gulf of Finland and Gulf of Gdansk;
- BSRP should actively participate in HELCOM Biodiversity and Nature Protection activity (HELCOM BIO);
- Establish links between HELCOM BIO and ICES Study Group on Baltic Fish and Fisheries Dynamics and ICES/HELCOM WG on Integrated Assessment of

the Baltic Sea to be able to include the fisheries related indicators in the assessment;

- Habitat classification and mapping activities should be harmonised on the Baltic Sea level planned BSRP LL (BALANCE, EUNIS, Baltic Life project) to be able to develop Baltic Sea habitat classification and inventory (maps).

Final remarks

The group considered the work carried out so far by the SGEH concerning the biodiversity as very useful and constructive. The continuation of the developing of the ecosystem health concept should be carried out in close connection with HELCOM BSAP and Biodiversity assessment process.

4.2 Sub-group 2: Hazardous Substances and Biological Effects (including diseases and parasites)

Sub-group members: K. Lehtonen (co-chair), T. Lang (co-chair), J. Baršienė, B. Hedlund, G. Rodjuk, D. Schiedek and J. Strand.

Task 1: Revision of the list of priority indicators (see Annex 14)

The subgroup revised the tables originally created at the 2005 SGEH meeting (ICES 2006), taking into account the outcome of the 2006 Expert Workshop on Indicators and Targets for the Hazardous Substances Goal of the HELCOM Baltic Sea Action Plan and the amendments subsequently made at the 2006 HELCOM MONAS meeting.

The subgroup agreed that some of the indicators that were included in the original table by the SGEH subgroup but were later not considered in the outcome of the above workshop and the HELCOM MONAS meeting should retain in table because of their significance in the context of ecosystem health monitoring and assessment.

Note: The subgroup noted that there are a lot of errors in the table published in the SGEH report 2005 (ICES 2006), largely resulting from formatting problems.

Changes made in Table A: Hazardous Substances (Annex 14)

All indicators related to contaminants in seawater (incl. suspended matter) were deleted.

Changes made in Table B: Bioassays (Annex 14)

The name of the indicator was changed because a large variety of bioassays is now available that can be applied on a routine basis.

Changes made in Table C: Biological Effects (Annex 14)

Only minor changes were made, largely in the scores for the indicator diagnosis. The indicators were re-arranged according to the scores for the indicator diagnosis. For indicators with seals as target organisms, a reference is made to the HELCOM expert group on seals. The SGEH subgroup emphasised that contacts to this group as well as to the seabird experts should be established in order to coordinate efforts.

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

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

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

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

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

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

Note: The subgroup wishes to emphasise that a promising way to assess biological effects of contaminants is to apply an integrated biomarker assessment by calculating indices combining results of measurement of a range of biomarkers in an individual target organism. Approaches applied so far are, e.g., the Integrated Biomarker Response (IBR) (Beliaeff and Burgeot, 2002) and the Bioeffect Assessment Index (Broeg *et al*. 2005). Both have been tested as part of the EU-funded BEEP project (Broeg and Lehtonen, 2006).

Task 2: Reference/target values

The subgroup was requested to define reference and target values for the indicators listed in Tables A, B and C of **Annex 14**

A. Hazardous substances

The sub-group was of the opinion that the strategy to define reference values of anthropogenic hazardous substances is comparatively simple, because the HELCOM objective (target) is to achieve concentrations that are close to background levels (reference), which are ‘0’ for those substances that are purely man-made.

In the EU Water Framework Directive (EU 2000, 2001), reference and target values (environmental quality standards, EQS) for a high and good ecological status have been suggested for concentrations of priority substances mainly in seawater (EU Directive 2000/60/EC). However, these values are not applicable to the present monitoring programmes in the Baltic Sea because the latter are focusing on contaminants in sediments and biota. The subgroup emphasised that contaminants in sediments and biota are regarded as much more consistent indicators of spatial and temporal ecological change than the more variable levels in seawater.

The subgroup suggests that the definition of target values could be based on an approach developed by the Swedish EPA (EPA 2000), deduced from contaminant concentration measured in sediment and biota along the Swedish east coast. The subgroup noted that different classification systems have been developed by other Baltic Sea countries. It is recommended that SGEH members submit the relevant classification systems to the subgroup chairs for comparison with the Swedish system.

Examples of the Swedish EPA classification system for organic compounds in sediment and fish (Table 4.2.1 and reference values for sediment and fish (Table 4.2.2) are given below. The report presents also to contaminant values in other biota (e.g. blues mussels, *Mytilus edulis*; perch, *Perca fluviatilis*). It has to be taken into account that the classification system was derived on the basis of purely statistical distribution approach and does include ecotoxicological interpretations.

The subgroup recommends using the designed system for the assessment of other areas of the Baltic Sea. However, an evaluation of its applicability on a broader scale is required.

Table 4.2.1. Classification system for organic compounds in sediments and herring (*Clupea harengus*) liver (EPA 2000).

Matrix	Compound	Unit	Class 1 (0 level)	Class 2 (Low level)	Class 3 (Medium level)	Class 4 (High level)	Class 5 (Very high level)
Sediment	PAH (BaP)	µg/kg D.W.	0	0–20	20–60	60–180	> 180
	Σ PAH	"	0	0–280	280–800	800–2500	> 2500
	Σ PCB	"	0	0–1.3	1.3–4	4–15	> 15
	Σ DDT	"	0	0–0.2	0.2–1	1–6	> 6
	Σ HCH	"	0	0–0.03	0.03–0.3	0.3–3	> 3
Herring liver	Σ DDT	mg/kg L.W.	0	0–0.03	0.03–0.2	0.2–1	> 1
	a-HCH	"	0	0–0.008	0.008–0.02	0.02–0.04	> 0.04
	g-HCH	"	0	0–0.007	0.007–0.02	0.02–0.03	> 0.03
	HCB	"	0	0–0.006	0.006–0.02	0.02–0.05	> 0.05
	PCB 153	"	0	0–0.02	0.02–0.08	0.08–0.3	> 0.3

Table 4.2.2. Reference values for metals in sediments and fish (herring, *Clupea harengus*) (Swedish EPA 2000) (reference values are based on the 5th percentile of reference/offshore data).

Matrix	Compound	Unit	Reference value
Sediment	Cd	mg/kg D.W.	0.2
	Cu	"	15.0
	Hg	"	0.04
	Pb	"	25.0
Herring liver	Cd	"	0.3
Herring liver	Cu	"	7.0
Herring liver	Pb	"	0.05
Herring muscle	Hg	"	0.01

B. Bioassays

The subgroup took note of the US EPA approach to classify sediment toxicity with mortality of test organisms as endpoint:

Good condition: 0–20 % mortality

Poor condition: > 20 % mortality

It was concluded that this approach may also be useful for bioassays carried out with the Baltic Sea sediments. However, an evaluation is needed. The subgroup emphasized that other bioassays using other endpoints (e.g., estrogenic activity, CALUX) have been developed and validated that may be of use for the Baltic Sea assessments.

C. Biological effects

According to the 2005 ICES WGBEC report (ICES 2005), background responses (= reference values) have an important role in integrating biological effect parameters into assessments of the environmental conditions in the marine environment. The general philosophy is that elevated levels compared to a background response indicate that unintended/unacceptable levels of biological effects caused by hazardous substances occur in the ecosystem.

It is important that the natural variability between individuals within a selected bioindicator species, which can be due to factors like differences in physiological conditions and seasonal/reproductive cycles, are included in the background responses.

For most biomarkers, the use of specific species, sex, age/size classes, sampling time of the year etc. have been recommended in the standard operational procedures to minimise their influence on the variability. The subgroup emphasised the importance of this point, which is crucial for the establishment of reference/target values.

The WGBEC suggested that the background responses can be used as a basis for defining three classes of effect levels: Healthy, Uncertain and Affected.

These presented criteria can be integrated into assessments of the environmental risks of contaminants effects, for instance by integration with assessments of contaminant levels and/or changes in ecosystem structure or functions. However, the integrative approaches, which can be conducted by multivariate data analyses, need further attention.

The subgroup endorsed the WGBEC approach. However, a number of comments were made:

- It has to be recognised that the approach to define reference values for single indicator has to be specific depending, e.g., on the nature of the biological response to be measured, the availability of data, and statistical requirements.
- Some doubts were raised that it will not be possible to establish 'absolute' reference/background values for biological effects. For instance, most of the areas of the Baltic Sea have been contaminated for a long time and it is, thus, difficult to establish reference values reflecting values characteristic for natural background in an undisturbed environment.
- Since the Baltic Sea is characterised by strong abiotic and biotic variations, a sub-regional approach for reference/target values estimation will be needed for most biological effects indicators.
- At present there is insufficient data available for the estimation of reliable sub-regional numeric reference/target values as regards many indicators of biological effects. A considerable amount of time will, therefore, be needed to finalise the task.

- For some of the indicators of biological effects, only more general statements on targets to be achieved within the framework of the Baltic Sea Action Plan will be possible at present.

Annex 3 provides information on the procedure to obtain reference values for biomarkers in bivalves from Finnish waters.

In Table 4.2.3, comments are made on the sub-roup's opinion on the possibilities to establish reference/target values for the biological effects indicators listed in Table C, Annex 14.

Table 4.2.3. Definition of reference/target values (r/t) for biological effects indicators .

Indicator	Biomarker/Parameter	Remarks
"General/non-specific stress" biomarkers	Lysosomal stability	Robust method, the definition of r/t values should be possible with more data
	Micronuclei frequency	Robust method, needs considerable training Subgroup proposal (unit: ‰): Good status: < 0.1 (fish), < 1 (mussel) Fair status: 0.1–0.4 (fish), 1–4 (mussel) Poor status: > 0.4 (fish), > 4 (mussel) (for organisms at their temperature optimum)
	AChE	Salinity and temperature dependent
	Macrophage activity	More information is needed
	Oxidative stress enzymes	Salinity and temperature dependent
"Contaminant-specific" biomarkers	EROD/CYP 1A	Particularly dependent on site- and host specific factors, e.g., temperature, reproductive stage, sex. The definition of r/t values is difficult.
	PAH metabolites in bile	Robust and universal method, definition of target values should be possibly. However, there are methodological problems (e.g., due to different settings of the analytic set up). Reference value should be close to zero or below the detection limit. Significant deviations (in relative figures) from the reference condition should be used as target values.
	DNA adducts	Robust method, the definition of r/t values should be possible with more data
	ALA-D	Robust method, the definition of r/t values should be possible with more data
	VTG	Robust method, Subgroup proposal: r value for males should be 0 or below detection level, t value should be based on the proportion of males with elevated VTG levels in a sample (e.g., 5-10 %)
	GST	Rather robust method, the definition of r/t values should be possible with more data.
	MT	Dependent on reproductive stage and salinity.

INDICATOR	BIOMARKER/PARAMETER	REMARKS
Health effect	Externally visible diseases/parasites in fish	A Fish Disease Index (FDI) to be used as an assessment tool summarising disease data (type of diseases present, severity grades) for individuals is under development (ICES WGPDMO) (ICES 2006). The lowest observed FDIs from areas with low anthropogenic impact could be used as r values. T values are hard to define, e.g. because of relatively high natural variability in prevalence. A strategy could be to use significant trends in FDI as targets.
	Pathology (histopathology: fish liver, bivalve soft body; pathology: seal intestinal tract)	For histopathology in fish liver (Baltic flounder) a liver lesion index (developed as part of the BEEP project, Lang *et al*. 2006) can be used for establishing r/t values. For seals, information is needed from the HELCOM seal expert group
Reproductive disorders	Imposex/intersex in gastropods	Robust method, a proposal has been developed for reference values (see Annex 14)
	Reproductive success in *Monoporeia affinis*	More information needed.
	Reproductive success in eelpout	Robust method, a proposal has been developed for reference values (see Annex 14)
	Gonad histopathology (fish and shellfish)	Lack of information and data.
	Shell thickness of guillemot eggs	Information is needed from the bird experts.
	Breeding success/brood size of white-tailed eagle	Information is needed from the bird experts.
	Histopathology in seal reproductive organs	Information is needed from the HELCOM seal expert group.
	Reproductive success in seals	Information is needed from the HELCOM seal expert group.
Quantitative population/community change	Biodiversity indices (phyto- and zooplankton, benthos, fish, mammals and birds)	Work is underway, the SGEH subgroup on biodiversity should be able to provide input.
	Abundance and biomass	

Task 3: Contributions to the 2007 ICES ASC Theme Session on effects of hazardous substances on ecosystem health in coastal and brackish-water ecosystems

The subgroup was not in position to recommend specific topics for the 2007 Theme Session. However, it was felt that the results from the EU-funded BEEP project and from the Lithuanian/Finnish D6 project would be suitable. Furthermore, it was highlighted that contributions dealing with the development of reference/target values and with strategies for integrated monitoring and assessment of contaminants and their effects would be welcome.

Task 4: Comments and recommendations

The subgroup intentionally highlighted the following issues:

- More time and data are needed for the estimation of reference/target values for biological effects of contaminants. Thus, it is recognised as a highly important issue that a research project establishing seasonal and sub-regional target/effects level values of biological effects parameters in target species is initiated as a joint effort between the Baltic Sea countries;
- In order to focus on reference/target values for biological effects indicators related to seals, the subgroup was of the opinion that a contact with the HELCOM expert groups on seals and on birds to coordinate activities is highly advisable;
- Since the 2007 ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-sea Areas (WKIMON III) (16–18 January 2007, ICES Headquarters, Copenhagen) will also deal with the issue of reference/target values attention should be paid to the SGEH deliberations;
- Closer links between the SGEH and other Expert Groups within ICES (e.g., WG on Biological Effects of Contaminants [WGBEC)], WG on Pathology and Diseases of Marine Organisms [WGPDMO], WG on Integrated Assessment of the Baltic Sea [WGIAB]) should be established.

Literature cited

Beliaeff, B., and Burgeot, T. 2002. Integrated biomarker response (IBR): a useful geographical tool for ecological risk assessment. Environmental Toxicology and Chemistry, 21: 1316–1322.

Broeg, K., and Lehtonen, K.K. 2006. Indces for the assessment of environmental pollution of the Baltic Sea coasts: Integrated assessment of a multi-biomarker approach. Marine Pollution Bulletin, 53: 508–522.

Broeg, K., von Westernhagen, H., Zander, S., Körting, W., Köhler, A. 2005. The Bioeffect Assessment Index – a concept fort he quantification of effects of marine pollution by an integrated biomarker approach. Marine Pollution Bulletin, 50: 495–503.

EU. 2000. Establishing a framework for community action in the field of water policy. Directive 2000/60/EC of the European Parliament and of the Council. Official Journal of the European Communities L327, 22/12-2000.

EU. 2001. Establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC. Decision no 2455/2001/EC of the European parliament and of the council of 20 November 2001. Official Journal of the European Communities L331, 15/12-2001.

ICES. 2005. Report of the Working Group on Biological Effects of Contaminants. ICES CM 2005/E:08

ICES. 2006. Report of the Study Group on Baltic Ecosystem Health Issues in Support of the BSRRP. ICES CM 2006/BCC:01.

ICES. 2006. Report of the Working Group on Pathology and Diseases of Marine Organisms. ICES CM 2006/MCC:01.

Lang, T., Wosniok, W., Barsiene, J., Broeg, K., Kopecka, J., Parkkonen, J. 2006. Liver histopathology in Baltic flounder (*Platichthys flesus*) as indicator of biological effects of contaminants- Marine Pollution Bulletin 53: 488–496.

Swedish EPA 2000. Environmental Quality Criteria. Coast and Sea. Swedish Environmental Protection Agency Report 5052, 138 pp.

5 Finalizing the list priority indicators and drafting preliminary proposals for operational indicators (ToRs: c and d)

The results of revision of the SGEH Tables of Indicators selected at previous SGEH meetings are given in **Annexes 13-16.**

Table of Indicators of Habitat Destruction and Loss of Biodiversity is given in **Annex 13.** Only minor changes were made in the indicators table, mainly regarding the scores for the indicator diagnosis. The indicators were re-arranged according to the scores for the indicator diagnosis. For indicator related to seals species populations, a reference is made to the HELCOM expert group on seals. The SGEH subgroup emphasized that contacts to this group should be established in order to coordinate efforts.

Table of Indicators on Hazardous Substances and Biological is given in **Annex 14.** The subgroup noted that a number of errors appeared in the table published in the SGEH report 2005, mainly resulting from editorial/formatting problems. All indicators related to contaminants in seawater (incl. suspended matter) were rejected/deleted. The name of indicator was changed because a large variety of bioassays is now available that can be applied.

Table of Indicators on Effects of Eutrophication (revised by E. Łysiak-Pastuszak and B. Müller-Karulis) is given in **Annex 15**.

Table of Indicators on Effects of Fishery (revised by M. Pliksh and H. Ojaveer) is given in **Annex 16**.

6 Discussion on BSRP input to the Baltic Sea Action Plan (ToR h)

It has been pointed out that BSRP SGEH will be involved in support of two components of the Baltic Sea Action Plan (BSAP): Biodiversity and Hazardous substances**.**

Planned demonstration projects on ecosystem health assessment of the Gulf of Finland and the Gulf of Gdansk should serve as an exercise following principles of BSAP. Due to the limited resources, only Gulf of Finland is planned to be the subject of the field studies (and therefore testing of indicators and producing a new results). The Gulf of Gdansk is planned to be assessed based on available results.

7 SGEH Terms of Reference for the next meeting

Following plenary discussion, the SGEH 2006, agreed to the following preliminary set of ToRs for the SGEH 2007 meeting:

The Study Group on Baltic Ecosystem Health Issues [SGEH] (Chair: E. Andrulewicz, Poland) should meet [in Helsinki, Finland] in early November 2007 to:

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

b) continue to develop the Baltic ecosystem health concept in relation to effects of hazardous substances and biodiversity (including effects of eutrophication, effects of maritime activities, effects of fishing, and habitat alteration);

c) review the progress towards operationalizing priority indicators by defining reference and target levels for: concentrations and effects of hazardous substances (including fish diseases), biodiversity (including effects of eutrophication, effects of maritime activities, effects of fishing and habitat alteration);

d) review progress made with regard to the ICES/HELCOM/BSRP workshop on monitoring of diseases and parasites in coastal fish species of the Baltic Sea;

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

f) (..) review the outcomes of BSRP Workshop on Eastern Gulf of Finland biodiversity assessment versus possible outcomes of HELCOM BIO projects];

g) discuss how to contribute to the implementation of the HELCOM Baltic Sea Action Plan (BSAP) in relation to sustaining Baltic Sea ecosystem health, in particular regarding preserving its biodiversity, and preventing effects of hazardous substances.

SGEH will report by [month] 2008 for the attention of the Baltic Committee and ACE.

8 Venue and date of the next SGEH meeting

The SGEH group will meet in Helsinki in early November 2007. The SGEH Chair will approach the director of the Finnish Institute of Marine Research (FIMR) to investigate whether SGEH can be invited to FIMR.

9 Other business

List of SGEH Recommendations from the meeting is given in Annex 17.

It had been stressed that the meeting time was too short to discuss and respond to ToRs and therefore a lot of work has to be done intersessionally.

10 Closing of the meeting

The Chair thanked all the participants for valuable contributions and lively discussions and closed the meeting at 14:40 on 18 November 2006. The Chair particularly thanked the sub-group Chairs for their effort in chairing the subgroup meetings.

Annex 1: List of participants

ICES Study Group on Baltic Ecosystem Health Issues (SGEH)

Tallinn, Estonia, 16–18 November, 2006

NAME	ADDRESS	PHONE/FAX
Nick Aladin BSRP/LL Biodiversity	Institute of Zoology of Russian Academy of Sciences, St. Petersburg 199034, Russia	Tel: + 7 812 328 4609 Fax: + 7 812 328 2941 aral@zin.ru
Eugeniusz Andrulewicz SGEH Chair	Sea Fisheries Institute in Gdynia Department of Fisheries Oceanography and Marine Ecology ul. Kollataja 1 PL - 81-332 Gdynia, Poland	TEL: +48 58 7356 146 FAX: +48 58 7356 110 eugene@mir.gdynia.pl
Andris Andrusaitis – BSRP C1 Assistant Coordinator	Daugavgrivas 8 LV-1048 Riga Latvia	TEL: +371 7 610 850 FAX: +371 7 601 995 Mobile: +371 2 92 30 333 andris@hydro.edu.lv
Hermanni Backer – HELCOM, Harmony Project Researcher	Baltic Marine Environment Protection Commission (Helsinki Commission) Katajanokanlaituri 6B FIN-00160 Helsinki, Finland	TEL: +358 9 6220 2220 FAX: +358 (0) 207 412 620 hermanni.backer@helcom.fi
Maija Balode	Latvian Institute of Aquatic Ecology, Department of Experimental Hydrobiology, 8 Daugavgrivas, LV-1048 Riga, Latvia	TEL: +371 9471 203 FAX: +371 7601 995 E-mail: maija@hydro.edu.lv
Janina Baršienė	Institute of Ecology of Vilnius University Akademijos 2 LT-2600 Vilnius, Lithuania	TEL: +370 5 27 29 895 (office) + 370 6 82 60 979 (mobile) FAX: +370 5 2729257 E-mail: janbar@ekoi.lt
Elmira Boikova by correspondence	Institute of Biology Salaspils, Miera Street 3 LV – 2169 Riga, Latvia	TEL: +371 79 45 418 FAX: +371 79 45 405 elmira@hydro.edu.lv
Kaj Forsius HELCOM Professional Secretary	Kaj Forsius Katajanokanlaituri 6 B, FI-00160 Helsinki, Finland	Phone/Fax/SMS +358 (0)207 412 621 e-mail kaj.forsius@helcom.fi
Britta Hedlund	Environmental Monitoring Section Swedish Environmental Protection Agency SE-106 48 Stockholm, Sweden	E-mail: britta.hedlund@naturvardsverket.se Tel. +46-8-698 12 08 Fax. +46-8-698 15 85
Nikolay Kovalchuk	Laboratory of Algology Komarov Botanical Institute of RAS Prof. Popov Str., 2 St. Petersburg, 197376 Russia	Tel: (+7 812) 346 44 28 Fax: (+7 812) 234 10 90 nickkovaltchouk@rambler.ru
Thomas Lang	Federal Research Centre for Fisheries, Institute of Fishery Ecology Deichstr. 12, D-27472 Cuxhaven Germany	Tel.: +49 (0)4721 38034, Fax: +49 (0)4721 53583, thomas.lang@ifo.bfa-fisch.de
Kari Lehtonen	Finnish Institute of Marine Research POB 33 FIN-00931 Helsinki, Finland	TEL : +35 89 613 941 FAX : +35 89 61394 494 lehtonen@fimr.fi
Elżbieta Łysiak-Pastuszak - Rappoteur	Institute of Meteorology and Water Management Ul. Waszyngtona 42, 81-342 Gdynia, Poland	TEL : +48 58 6288252; FAX : +48 58 6288163; elzbieta.lysiak-pastuszak@imgw.pl

NAME	ADDRESS	PHONE/FAX
Georg Martin LL Phytobenthos	Estonian Marine Institute, University of Tartu, Mäealuse 10a EE-12618 Tallinn, Estonia	TEL: +372 678 19 01 TEL: +372 516 39 43 (mobile) FAX: + E-mail: georg.martin@ut.ee georgm@hot.ee
Baerbel Mueller-Karulis CC Productivity	Latvian Institute of Aquatic Ecology, Daugavgrivas 8 LV-1048 Riga, Latvia	TEL: +371 7 610 850 FAX: +371 76 01 995 baerbel@latnet.lv
Henn Ojaveer LL Coastal Activities	Estonian Marine Institute, University of Tartu, Vana-Sauga 28 80031 Pärnu, Estonia	TEL: +372 44 33800 FAX: +372 44 33800 henn.ojaveer@ut.ee
Evald Ojaveer	Estonian Marine Institute, University of Tartu, Mäealuse 10° EE-12618 Tallinn, Estonia	TEL.: + 372 67 18 905 FAX: + 372 67 18 900 E-mail: e.ojaveer@ness.sea.ee
Maris Plikshs – CC on Fish and Fisheries	Latvian Fish Resource Agency (LATFRA), Daugavgrivas 8, LV-1048, Riga, Latvia	TEL: + 371 7610 766 FAX: +371 7616 946 GSM: + 371 2 921 5653 maris.plikss@latzra.lv
Galina Rodjuk LL on Histopathology, Parasitology and Fish Diseases	AtlantNIRO Parasitology Laboratory AtlantNIRO 5, Dmitry Donskoy Str. Kaliningrad, 236000, Russia	Tel.: +7 4012 925782 Fax: +7 4012 219997 E-mail: rodjuk@atlant.baltnet.ru mailto:rodjuk@atlant.baltnet.ru
Katarzyna Roszkowska	Chief Inspectorate for Environmental Protection, Department of International Cooperation and European Integration, Wawelska 52/54, 00-922 Warsaw, Poland	TEL: +48 22 579 2590, FAX: +48 22 825 9775 E-mail: k.roszkowska@gios.gov.pl
Doris Schiedek	Baltic Sea Research Institute Warnemuende Seestrasse 15, D-181119 Rostock, Germany	Tel.: + 49 381 51 07 205 Fax: + 49 381 51 97 211 E-mail: Doris.schiedek@io-warnemuende.de
Jakob Strand	National Environmental Research Institute Dept MAR Frederiksborgvej 399 4000 Roskilde, Denmark	TEL: + 45 46 30 1865 FAX: + 45 46 30 12 14 E-mail: jak@dmu.dk
Kevin Summers	USEPA,ORD/NHEERL/GED 1 Sabine Island Drive Gulf Breeze, FL 32561 USA	TEL: 001 850 934 9244 Mobile: 001 516 0183 FAX: 001 850 934 2406 Summers.Kevin@epamail.epa.gov
Jan Marcin Węsławski – by correspondence	Polish Academy of Sciences Institute of Oceanology, P.O. Box 68, ul. Powstańców Warszawy 55 PL- 81-712 Sopot, Poland	TEL: +48 58 551 72 83 FAX: +48 58 551 21 30 weslaw@iopan.gda.pl

Annex 2: SGEH Agenda , 16-18 November 2006

1) Opening and welcome

2) Matters related to SGEH ToRs and working procedures

  2.1) Terms of References and Final Agenda

  2.2) Election of Rapporteur(s)

  2.3) Establishment of Sub-groups and appointment of Sub-group chairs:

3) Plenary presentations - overview on developments of ecosystem-based approaches (ToR a, b, f, g)

- Hermanni Backer: Ongoing HELCOM activities related to ecosystem health (ref.: BSAP, HELCOM HABITAT 8, and HELCOM MONAS 9) and HELCOM expectations from SGEH
- Evald Ojaveer: Ecosystem units and local populations in the Baltic Sea
- Kari Lehtonen: Information on the development of Biological Effects Monitoring in the Baltic Sea
- Thomas Lang: Summary of the 2005 ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM) and Proposal for a land-based ICES/BSRP/HELCOM Workshop on monitoring of diseases and parasites in coastal fish species
- Baerbel Mueller-Karulis: WKIAB [and EUTRO-PRO] outcome
- Elżbieta Łysiak-Pastuszak: The Gulf of Gdansk as the demonstration area for the ecosystem health assessment
- Nickolay Aladin: 1.User Friendly list of useful publications on taxonomy of the Baltic Sea animals and plants 2. List of experts in taxonomy of animals and plants of the Baltic Sea, 3. Assessment of biological diversity of the Eastern Gulf of Finland using BSRP SGEH indicators
- Kevin Summers: [US EPA methodology: Indicators/Indices and Reference Points]
- Janina Barsienie: An approach to assess Baltic genetic diversity

4) Results of work in Sub–groups on ToRs: c, d , e, f, g

- Review and finalise the list of ICES/BSRP SGEH indicators (ToR c)
- Define reference levels for priority ICES/BSRP SGEH indicators (ToR d) for relevant environmental concern: effects of eutrophication, hazardous substances, effects of fishery and loss of biodiversity)
- Identify and offer contributions to 2007 ICES ASC Theme Session (ToR e)
- Matters related to proposal made by WKFDM (ToRs: f, g)

5) Finalising the list priority indicators, drafting preliminary list of operational indicators and discussion on demonstration areas

6) Discussion on BSRP input to the Baltic Sea Action Plan (ToR h)

7) SGEH Terms of Reference for the next meeting

8) Venue and date of the next SGEH meeting

9) Other business

10) Closing of the meeting

Annex 3: Determination of sub-regional reference/target and effect levels for biomarkers: an exercise on Gulf of Finland bivalve data

by K. K. Lehtonen

An attempt to develop methods for the determination of sub-regional reference/target and effect levels of biomarkers was made using data from two bivalve species in the Gulf of Finland. Data on seasonal variability on four biomarkers, acetylcholinesterase activity (AChE), metallothionein induction (MT), glutathione *S*-transferase activity (GST) and catalase activity (CAT) in the blue mussel (*Mytilus edulis*) and the Baltic clam (*Macoma balthica*) collected from a clean area (Tvärminne Zoological Station, Hanko) (Leiniö and Lehtonen 2005) were used for this purpose. Biomarker data (Lehtonen *et al.*, 2006) obtained from the two bivalve species collected along suspected pollution gradients in Hanko Peninsula and Archipelago Sea (SW Finland), both areas considered to represent the same Baltic sub-region, were used to study the sensitivity of the approach to detect polluted sites.

Establishment of biomarker reference/target and effect levels

In this exercise, sub-regional reference/target and effect values were calculated in the following way:

1) Calculation of the mean and standard deviation of the mean (SD) for each biomarker parameter for each month (April to November).

2) To obtain a "reference" (or "target") value, SD/2 was added to the monthly mean value of each parameter.

3) For each biomarker, the "Effect Level 1" value was established by adding 20% of the "reference" value obtained above to the value itself. "Effect Level 2" and "Effect Level 3" were established by adding 30% and 40%.

In case when decreasing values are taken as biomarker responses (e.g. AChE inhibition) the SD/2 is deducted from the parameter mean value to obtain the "reference" value. Subsequently, the different "effect levels" are established by deducting 20, 30 and 40% of the "reference" values.

Field validation

The pollution gradient study was carried out in May 2001; accordingly, biomarker "reference" and "effect level" levels calculated for May were used for evaluation.

The method used was able to detect effects in selected biomarkers at certain sites (see Table):

Station A1:

- Response in *M. edulis* MT content with the mean level of 426 µg/g wet wt observed equaling "Effect Level 2" established here for this species in May (> 425 µg/g wet wt; "reference" level 327 µg/g wet wt).
    - Station A1 (Koverhar steel factory) is characterized by elevated concentrations of heavy metals, e.g. in this study the levels of Zn measured in *M. balthica* were 2-3.5 times higher than those measured at the Archipelago Sea stations (B1-B3). However, in *M. edulis* the metal levels were not elevated at this station.

Station A4:

- Possible response in *M. edulis* CAT activity with the mean level of 144 µmol/min/mg protein observed almost equaling "Effect Level 1" established for this species in May (> 148 µmol/min/mg protein; "reference" level 123 µmol/min/mg protein).

- Station A4 is a presumably clean outer archipelago station; reason for increased CAT activity CAT possibly related to spring phytoplankton bloom.

Station B1:

- Response in *M. edulis* MT content with the mean level of 405 µg/g wet wt observed surpassing "Effect Level 1" established here for this species in May (> 392 µg g/wet wt; "reference" level 327 µg/g wet wt).
- Response in *M. balthica* MT content with the mean level of 542 µg/g wet wt observed surpassing "Effect Level 2" established here for this species in May (> 540 µg/g wet wt; "reference" level 415 µg/g wet wt).
- Response in *M. balthica* GST activity with the mean level of 3078 nmol/min/mg protein observed surpassing "Effect Level 3" established here for this species in May (>3046 nmol/min/mg protein; "reference" level 2176 nmol/min/mg protein).
    - Station B1 (close to Aura river mouth, City of Turku) is under the influence of extensive river runoff and maritime traffic. In this study, the tissue levels of PCBs and DDTs in *M. balthica* were 2-3 times higher than those measured at all other stations. Elevated levels of organic contaminants are likely behind the increased GST in *M. balthica* activity and may also influence MT induction through increased oxidative stress.

Note: since this presentation is merely an exercise along the road in developing "reference/target" and "effect" levels of biomarkers in the Baltic Sea, the values given here should not be used as a reference in any official context concerning monitoring and assessment of the marine environment.

References

Leiniö, S., and Lehtonen, K. K. 2005. Seasonal variability in biomarkers in the bivalves *Mytilus edulis* and *Macoma balthica* from the northern Baltic Sea. Comparative Biochemistry and Physiology C, 140: 408–421.

Lehtonen, K. K., Leiniö, S., Schneider, R., and Leivuori, M. 2006. Biomarkers of pollution effects in the bivalves *Mytilus edulis* and *Macoma balthica* collected from the southern coast of Finland (Baltic Sea). Marine Ecology Progress Series, 322: 155–168.

Seasonal data from a reference area

	AChE	SD	MT	SD	GST	SD	CAT	SD
M. edulis								
Apr	26	*5*	334	*38*	410	*123*	69	*18*
May	**23**	*3*	**303**	*48*	**472**	*208*	**105**	*37*
Jun	29	*4*	294	*35*	350	*139*	113	*32*
Jul	34	*3*	338	*28*	472	*212*	55	*36*
Aug	25	*8*	287	*22*	314	*83*	88	*29*
Sep	38	*12*	277	*9*	291	*112*	80	*17*
Oct	25	*4*	241	*19*	162	*26*	78	*12*
Nov	29	*5*	269	*28*	242	*70*	71	*30*
M. balthica								
Apr	15	*4*	421	*56*	1146	*408*	112	*29*
May	**18**	*4*	**392**	*47*	**1905**	*541*	**341**	*168*
Jun	18	*4*	521	*105*	1188	*197*	173	*42*
Jul	22	*3*	404	*73*	1677	*324*	53	*20*
Aug	28	*6*	340	*42*	1987	*943*	224	*117*
Sep	18	*3*	322	*20*	1342	*187*	135	*48*
Oct	17	*4*	372	*14*	796	*431*	134	*89*
Nov	22	*9*	409	*21*	784	*153*	130	*34*

Reference value Mean + 1/2 SD

	AChE	MT	GST	CAT
M. edulis				
Apr	23	353	472	78
May	**21**	**327**	**576**	**123**
Jun	27	311	420	129
Jul	32	352	579	73
Aug	21	298	356	102
Sep	32	281	347	89
Oct	23	251	175	84
Nov	26	283	277	86
M. balthica				
Apr	13	449	1350	126
May	**16**	**415**	**2176**	**425**
Jun	16	573	1286	194
Jul	21	440	1839	63
Aug	25	361	2459	283
Sep	17	332	1435	159
Oct	15	379	1012	178
Nov	18	419	861	147

Effect level 1 +20% response

	AChE	MT	GST	CAT
M. edulis				
Apr	19	424	566	93
May	**17**	**392**	**691**	**148**
Jun	22	374	504	155
Jul	26	422	694	88
Aug	17	357	427	123
Sep	26	337	417	107
Oct	19	301	210	101
Nov	21	339	332	104
M. balthica				
Apr	10	539	1620	152
May	**13**	**498**	**2611**	**510**
Jun	13	688	1544	233
Jul	17	528	2207	75
Aug	20	433	2950	340
Sep	13	398	1722	191
Oct	12	455	1214	214
Nov	14	503	1033	176

Effect level 2 +30% response

	AChE	MT	GST	CAT
M. edulis				
Apr	16	460	613	101
May	**15**	**425**	**749**	**160**
Jun	19	405	546	168
Jul	23	457	752	95
Aug	15	387	463	133
Sep	22	365	452	116
Oct	16	326	228	109
Nov	18	367	360	112
M. balthica				
Apr	9	584	1755	164
May	**11**	**540**	**2828**	**552**
Jun	11	745	1672	252
Jul	15	572	2391	81
Aug	18	469	3196	368
Sep	12	432	1866	207
Oct	11	493	1315	232
Nov	12	545	1119	191

Effect level 3 +40% response

	AChE	MT	GST	CAT
M. edulis				
Apr	14	495	660	109
May	**13**	**458**	**807**	**173**
Jun	16	436	588	180
Jul	19	493	810	102
Aug	13	417	498	143
Sep	19	393	486	125
Oct	14	351	246	118
Nov	16	396	388	121
M. balthica				
Apr	8	629	1890	177
May	**10**	**581**	**3046**	**595**
Jun	10	803	1801	271
Jul	13	616	2575	88
Aug	15	505	3442	396
Sep	10	465	2009	223
Oct	9	531	1416	250
Nov	11	587	1205	206

Field sampling: May 2001

Biomarker units

AChE - nmol ACTC/min/mg protein

MT - µg/g wet weight

GST - nmol/min/mg protein

CAT - µmol/min/mg protein

	AChE	MT	GST	CAT
M. edulis				
Station A1	**26**	**426**	**339**	**111**
Station A2	**21**	**366**	**382**	**125**
Station A3	**23**	**303**	**472**	**105**
Station A4	**19**	**311**	**409**	**144**
Station B1	**21**	**405**	**427**	**118**
Station B2	nd	nd	**392**	**115**
Station B3	**21**	**345**	**472**	**113**
M. balthica				
Station A1	**19**	**396**	**1852**	**277**
Station A2	**18**	**436**	**1468**	**300**
Station A3	**18**	**392**	**1905**	**341**
Station A4	**22**	**460**	**1926**	**379**
Station B1	**20**	**542**	**3078**	**412**
Station B2	**18**	**458**	**1998**	**270**
Station B3	**18**	**413**	**1416**	**269**

Effect level 1:

	AChE	MT	GST	CAT
M. edulis				
Station A1	-	+	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	(+)
Station B1	-	+	-	-
Station B2	-	-	-	-
Station B3	-	-	-	-
M. balthica				
Station A1	-	-	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	-
Station B1	-	+	+	-
Station B2	-	-	-	-
Station B3	-	-	-	-

Effect level 2:

	AChE	MT	GST	CAT
M. edulis				
Station A1	-	+	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	-
Station B1	-	-	-	-
Station B2	-	-	-	-
Station B3	-	-	-	-
M. balthica				
Station A1	-	-	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	-
Station B1	-	+	+	-
Station B2	-	-	-	-
Station B3	-	-	-	-

Effect level 3:

	AChE	MT	GST	CAT
M. edulis				
Station A1	-	-	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	-
Station B1	-	-	-	-
Station B2	-	-	-	-
Station B3	-	-	-	-
M. balthica				
Station A1	-	-	-	-
Station A2	-	-	-	-
Station A3	-	-	-	-
Station A4	-	-	-	-
Station B1	-	-	+	-
Station B2	-	-	-	-
Station B3	-	-	-	-

Annex 4: Proposal for a Workshop on Monitoring of Diseases and Parasites in Coastal Fish Species of the Baltic Sea

T. Lang and G. Rodjuk

Abstract

Based on a recommendation from the 2005 ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM) and on requests from HELCOM, a land-based workshop is proposed on methodologies for monitoring diseases and parasites in coastal fish species of the Baltic Sea. The workshop shall be held for 4-5 days in 2007 (or 2008) at the BSRP Lead Laboratory for Fish Diseases and Histopathology, AtlantNIRO, Kaliningrad, Russia (priority 1) or at the Estonian Marine Institute, Tallinn, Estonia (priority 2). Expected deliverable are (a) baseline data on diseases and parasites of coastal fish species in the Baltic Sea to be used for future assessments, (b) training and intercalibration of methodologies for disease studies, (c) guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in coastal fish monitoring programmes, and (d) proposals for disease indicators and target levels for coastal fish species in the Baltic Sea.

Introduction and Rationale

In December 2005, the ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM) was held on board RV 'Walther Herwig III'. Its main objectives were to

- provide training and intercalibration related to methodologies applied in fish disease monitoring in the Baltic Sea,
- further develop and assess health indicators and indices appropriate for monitoring and assessment purposes,
- establish a closer collaboration between institutes involved in fish disease monitoring in the Baltic Sea,
- build the basis for incorporation of fish disease surveys into the revised HELCOM monitoring programme.

As a major output of the workshop, draft guidelines for fish disease monitoring in the Baltic Sea were provided (ICES 2005) (http://www.ices.dk/reports/BCC/2006/WKFDM06.pdf). However, it was clearly recognised that these guidelines are mainly applicable to studies carried out in offshore areas of the Baltic Sea, with cod (*Gadus morhua*), flounder (*Platichthys flesus*) and herring (*Clupea harengus*) as major target species, and cannot directly be used for studies in coastal fish communities, largely consisting of different fish species that may be affected by different diseases (incl. parasites). In order to fill this gap and to establish a link to the existing coordinated HELCOM coastal fish monitoring programme in the Baltic Sea, the WKFDM recommended that:

- *ICES/BSRP organise a land-based workshop on methodologies for coastal fish disease monitoring to be held in 2006 or 2007 at the AtlantNIRO, Kaliningrad, Russia, or at the Estonian Marine Institute, Tallinn.*

The present monitoring and assessment of coastal fish in the Baltic Sea is part of the HELCOM and BSRP activities and is coordinated by the Co-ordination Organ for Baltic Reference Areas (COBRA). Three coastal fish monitoring workshops were held under the auspices of HELCOM and the BSRP in the years 2004-2006. The coastal fish monitoring is carried out annually (in August) in up to 15 coastal sampling locations, encompassing areas around the entire Baltic Sea. COBRA maintains a database with time series data (partly since 22 years) submitted by countries participating on the programme (HELCOM 2006). So far, the data provide numeric information on spatial and temporal patterns in fish population characteristics (e.g., species abundance and richness, biomass, catch per unit effort), enabling an assessment of population/community changes and, by utilising biotic and abiotic data, of the role of environmental factors.

However, new perspectives on marine ecosystem management and conservation, including an ecosystem approach to coastal zone management, as well as recent EU directives such as the Water Framework Directive and the Habitats Directive, call for revised objectives in monitoring practices (HELCOM 2006). From originally being focused on mainly detecting the effects of local pollution, including toxic substances and eutrophication, coastal fish monitoring should be developed to provide a basis for estimating the ecological status of the coastal fish compartment (HELCOM 2006) as part of an ecosystem approach and related management objectives. Amongst other management objectives, HELCOM (2006) has identified the following:

- *to restore and maintain healthy fish on an individual level and to ensure healthy fish populations, without causing harm either to other marine biota or to human populations*

This management objective is in line with the Baltic Sea Action Plan objective related to hazardous substances that no health problems among animals should occur.

It has further been emphasised (HELCOM 2006) that relevant indicators for coastal fish management objectives should be further developed and that coastal fish monitoring should be integrated with other coastal monitoring programmes. It seems evident that the coastal fish monitoring should, amongst others, be linked to the monitoring and assessment of hazardous substances and their biological effects.

In this context, as an outcome of the 2004 HELCOM Workshop on Coastal Fish Monitoring, a number of indicators to be used for ecological assessments was proposed, amongst others the prevalence of diseases and parasites as health/stress indicator (also included in the strategy proposed for hazardous substances). Furthermore, at the 2006 HELCOM/BSRP Workshop on Coastal Fish Monitoring, there was consensus that biomarkers (including health indicators and indicators for reproductive success) fit well to the coastal fish monitoring programme and that further research should be supported, e.g. as part of the BONUS-169 programme.

(http://sea.helcom.fi/dps/docs/documents/Monitoring%20and%20Assessment%20Group%20(MONAS)/BSRP-HELCOM%20Coastal%20Fish%20Monitoring%202,%202005/2-2.pdf).

(http://sea.helcom.fi/dps/docs/documents/Monitoring%20and%20Assessment%20Group%20(MONAS)/MONAS%20Coastal%20Fish%20Monitoring%203,%202006/FINAL%20MINUTES.pdf).

In the Minutes of the 9th Meeting of HELCOM MONAS (2-6 October 2006), the ICES/BSRP SGEH and the HELCOM/BSRP Coastal Fish Monitoring Experts were requested to develop an indicator for fish disease with target levels for the Baltic Sea Action Plan.

For the reasons highlighted above and as a consequent next step in the development of appropriate ecosystem health objectives and indicators for fish health, a workshop is proposed focusing explicitly on diseases and parasites in coastal fish species and on related methodological aspects relevant for monitoring and assessment. The workshop could be co-sponsored by ICES, BSRP and HELCOM.

Objectives of the workshop

The major objectives of the workshop are to

- provide baseline data on diseases and parasites in key fish species from coastal areas in the Baltic Sea to be used for future fish health assessments as part of the coastal fish monitoring;

- provide training and intercalibration of methodologies related to the diagnosis of diseases;
- draft guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in the coastal fish monitoring programme, and
- propose indicators and target levels for diseases of coastal fish species to be used in Baltic Sea ecosystem health assessments.

Organisation of the workshop

It is proposed to organise the land-based workshop to be held either at the BSRP Lead Laboratory for Fish Diseases and Histopathology, AtlantNIRO, Kaliningrad, Russia (priority 1) or the Estonian Marine Institute, Tallinn, Estonia (priority 2). The workshop should be held for approx. 4-5 days in late 2007 (or early 2008) under the co-chairmanship of G. Rodjuk (AtlantNIRO, Kaliningrad, Russia) and T. Lang (Fed. Res. Centre for Fisheries, Cuxhaven, Germany). It is recommended to identify a third co-chair representing the group of HELCOM/BSRP Coastal Fish Monitoring Experts. ICES, BSRP and HELCOM may act as co-sponsors of the workshop.

Participants should preferably represent all of the Baltic Sea countries and should consist of trainees and a number of invited trainers (possibly including experts from countries outside the Baltic Sea). Representatives of the co-sponsoring organisation are welcome. It is anticipated that, for logistic reasons, the maximum number of participants should not exceed 20 persons.

The workshop should consist of two tiers: (a) lectures and seminars providing background information and for discussions and drafting purposes and (b) practical work in the lab with fresh material (key fish species) and preserved samples (e.g. parasite specimens).

Requirements for the workshop

Amongst others, the following requirements have to be met:

- The ICES/BSRP SGEH has to endorse the plan to organise the workshop.
- A steering group consisting of at least three dedicated experts (e.g., the co-chairs) should be identified at the 2006 SGEH meeting and should start working by correspondence to plan details of the workshop.
- Co-sponsors have to be identified who have to adopt the plans for the workshop and to provide support in the planning phase and during the workshop.
- A final decision has to be made on the venue and on the workshop dates.
- The hosting institute has to provide equipment needed (e.g., meeting rooms, lab, microscopes, fresh material for dissection, specimens collections) and logistic support.
- Potential experts acting as trainers have to be identified and contacted.
- Participants (trainees) have to be identified, preferably representing all Baltic Sea countries and institutes therein engaged in coastal fish monitoring.
- Funding sources have to be identified. It is hoped that a considerable contribution from the BSRP will be available, including support for western experts if required. Further contributions are expected from Baltic Sea countries (and ICES, HELCOM ?).

Expected deliverables of the workshop

It is expected that the following products will be generated:

- a full (ICES) report with all information generated by the workshop and with recommendations for further actions;
- a compilation of available background data on diseases and parasites of coastal fish species in the Baltic Sea to be used a reference for future assessments;
- training and intercalibration of methodologies;
- national reports from Baltic Sea countries on the status of relevant activities;
- draft guidelines for monitoring of diseases and parasites in coastal fish species in the Baltic Sea;
- proposals for indicators and target levels related to diseases in coastal fish species in the Baltic Sea to fulfil the demands of the HELCOM Baltic Sea Action Plan.

Literature cited

HELCOM 2006. Assessment of Coastal Fish Species in the Baltic Sea. Baltic Sea Environment Proceedings No. 103 A.

ICES 2005. Report of the ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea. ICES CM 2005/BCC: 02.

Annex 5: Proposal for a joint ICES/BSRP and HELCOM Demonstration Project on the Integrated Multidisciplinary Assessment of the Ecosystem Health of the Gulf of Finland

Working name: GOF-ECOHEALTH

Presented by: Kari K. Lehtonen (Finnish Institute of Marine Research, Helsinki, Finland) and Thomas Lang (Federal Research Centre for Fisheries, Institute for Fishery Ecology, Cuxhaven, Germany)

ICES/BSRP, HELCOM and partner Baltic Sea countries consider to organize in 2008 a joint international demonstration project on the Ecosystem Health of the Gulf of Finland with the aims of (1) providing baseline data, (2) assessment of current state of the sea area, (3) evaluating the feasibility of coordinated sample collection and analysis, (4) arranging practical workshops, and (6) providing a contact niche for stakeholders, media and researchers in the form of a joint seminar.

Introduction

The coming up marine strategies are aiming at an ecosystem-based approach to monitoring with the goal to find suitable indicators for a healthy ecosystem and appropriate measures for its sustainability. Monitoring of hazardous substances has traditionally been focussed on measurements of the occurrence of a certain number of well-known toxic compounds. There are, however, a number of signs that such a strategy is not sufficient to protect the Baltic Sea marine ecosystem. Unknown or unintentionally occurring toxic compounds may explain or be partially responsible for some of the negative effects observed in biota, like decreasing reproductive success of some fish populations, diseases in fish and marine mammals, unexplained mass deaths of marine birds like the sea-gull, population declines and community changes in benthos, etc. These effects might prove to have natural causes or can be explained by other factors like over-fishing, eutrophication or hypoxia, but screening studies in the Baltic suggest that toxic chemicals, other than known point-source chemicals, act as stressors on marine biota in the Baltic; this was evidenced recently also in the large EU project BEEP.

The effects listed above belong to "individual-and-above" levels in biological hierarchy. They generally have high ecological relevance when assessing the damage caused by hazardous substances on the ecosystem. What they lack is a quick response time. Lower level molecular, biochemical, cellular and physiological indicators, called biomarkers, can therefore be used as complementary to chemicals monitoring. Where these "early-warning" indicators give signs of toxic impact of chemicals, a more advanced or in-depth battery of indicators on the individual and population level can be applied. Inventories of known point sources and emissions may also give guidance where to concentrate chemical monitoring and biomonitoring.

The proposal is based on the implementation of the revised HELCOM monitoring programme concerning hazardous substances, with focus on their biological effects on the Baltic Sea ecosystem. The revision has been elaborated during the HELCOM MON-PRO project and ICES/BSRP Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH), with the latest update provided by the HELCOM Expert Workshop aimed at the elaboration of indicators and targets for the hazardous substances goal of the HELCOM Baltic Sea Action Plan (BSAP) (Vilnius 9/06), as well as the outcome of the extensive EU Project BEEP (Biological Effects of Environmental Pollution on Marine Coastal Ecosystems) Baltic Sea Biomonitoring component.

The idea to organise a demonstration project on the Gulf of Finland ecosystem health was first developed during the 2005 ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM) as a consequence of the discussions on the need for the implementation of an integrated chemical and biological monitoring programme in the Baltic

Sea. WKFDM provided three recommendations that are of relevance in this context (http://www.ices.dk/reports/BCC/2006/WKFDM06.pdf):

- Baltic Sea countries harmonise the components of their national marine monitoring and assessment programmes in order to implement an integrated programme on contaminants (and other anthropogenic stressors) and their biological effects;
- Baltic Sea countries and HELCOM investigate the potential for an internationally coordinated integrated monitoring programme in the Baltic Sea, encompassing joint sampling campaigns and the involvement of appointed expert laboratories in the Baltic countries responsible for the conduct of specific analytical measurements;
- ICES/BSRP, HELCOM and Baltic Sea countries consider to organise an international demonstration project in 2007 or 2008 on the ecosystem health of the Gulf of Finland, providing baseline data and assessing the feasibility of coordinated sample collection and analysis.

Objectives of the Gulf of Finland demonstration project

The ultimate goals of the project are to:

- develop integrated chemical-biological monitoring of hazardous substances in the Baltic Sea;
- enable an ecosystem-based approach implementation of the future EC Marine Strategy within the Baltic Sea region;
- give support to the HELCOM Baltic Sea Action Plan (BSAP) by identification of the main pollution characteristics in each sub-region.

The main aims are:

- identification of suitable indicators of effects of hazardous substances at different biological levels in the Gulf of Finland;
- assessment of the "ecosystem health" of the Gulf of Finland;
- development of strategy for integrated environmental monitoring of the Gulf of Finland marine environment.

Field sampling programme:

- Hydrography
- Hydrochemistry
- Benthos
- Phytoplankton
- Zooplankton
- Benthic and pelagic fish
- Sediment chemistry (contaminants).

Project outline:

- The project should be fully co-ordinated with BSRP SGEH activities ;
- In addition to BSRP funding, the project has to receive national support from the participating Baltic Sea countries;
- Field sampling is planned to be carried out in late summer–autumn 2008 as an extensive coastal–open sea sampling network in the Gulf of Finland;
- A project steering group is set to plan and arrange a workshop in spring 2007 for the preparation of the demonstration project.

Research vessels involved:

- R/V Aranda (Finland) – oceanographic sampling;
- R/V Walther Herwig III (Germany) – fish trawling;
- Local coastal vessels (Estonia, Finland, Russia).

Special workshops will be arranged encompassing:

- external fish disease identification and data analysis;
- biomarker measurements and intercalibration.
- Special seminars will be arranged encompassing:
- strengthening Baltic networking in biological effects research, assessment and monitoring;
- communication between ecotoxicology, fisheries and ecology;
- communication between researchers, stakeholders and media.

The workshops and seminars will be arranged to demonstrate some of the suitable methods, inviting participants from all the HELCOM Contracting Parties, with the emphasis on field-staff and monitoring experts.

Approximate costs

- some of the costs are expected to be covered by the BSRP;
- costs for the project steering group to make preparations for the demonstration project;
- planning meetings can hopefully be hosted by one of the CPs;
- costs for arranging the practical workshops;
- the workshops can hopefully be hosted by research institutions in one of the CPs;
- sampling and material;
- ship costs covered by national budgets.

Annex 6: Reproductive success in eelpout as an environmental indicator

by J. Strand

Studies of reproductive success in the viviparous fish eelpout (*Zoarces viviparus*) have been performed in Sweden, Denmark, Germany and Poland, covering several subregions in the Baltic Sea and have been included also in some monitoring programmes. The method description is included in the current HELCOM guidelines for coastal fish monitoring.

The presence of abnormal development of embryo and larvae in eelpout broods has been suggested as an indicator of impaired fish reproduction in the marine environment, as chronic exposure to various contaminants has the potential to induce adverse developmental effects in fish.

Reference values of impaired larvae development (i.e. malformed, dead and retarded larvae) have been suggested in a document presented at the 2006 ICES WKIMON meeting (ICES 2006). The reference values are based on the 90th-percentile determined out of 52 data sets from 14 sampling stations regarded as reference sites mainly in the Baltic Sea.

The reference values include both mean frequencies of abnormal larvae development and the frequency of broods with elevated levels (>5%) of abnormal larvae development.

Table 1. Reference values for abnormal larvae and brood with elevated levels of abnormal larvae in eelpout (*Zoarces viviparous*)

Reference values	Mean frequency of abnormal larvae	Frequency of broods with elevated levels (>5%) of abnormal larvae
Mean frequency of malformed larvae	1%	5%
Mean frequency of late dead larvae	2%	5%
Mean frequency of growth retarded larvae	4%	?

Reference

ICES. 2006. Report of the ICES/OSPAR Workshop on integrated monitoring of contaminants and their effects in coastal and open-sea areas (WKIMON II). ICES CM 2006/ACME:02.

Annex 7: Imposex and intersex in gastropods as indicators in the Baltic Sea

by J. Strand

Imposex/intersex measurements provide information on the degree of exposure to TBT compounds and on the direct consequences of that exposure to gastropod mollusc populations. The information should be interpreted in relation to the aims of the hazardous substances strategy (zero, or close to zero concentrations of anthropogenic compounds such as TBT) and also the consequences of exposure to TBT (and other compounds) for marine organisms.

The objectives in environmental assessment of TBT effects in gastropods are:

a) "To investigate the intensity of TBT effects and their geographical scale (i.e. the spread of effects away from point sources), the imposex (superimposition of penis and/or vas deferens on prosobranch females) and intersex condition (pathological alterations in the oviduct of littorinids and replacement of female by male organs) have been proved sensitive biomarkers for the determination of the degree of environmental organotin and especially tributyltin (TBT) pollution in coastal waters."

b) "Broad-scale surveys describing the intensity of TBT impact in coastal waters would allow comparisons to be made between various stretches of coast and assessment of the potential for TBT-affected species to recover."

Biological assessment criteria for imposex/intersex have been developed for assessing specific effects of tributyltin (TBT) on five species of marine gastropods used in monitoring programmes in the OSPAR region, i.e. the North Sea and the North Atlantic; *Nucella lapillus*, *Buccinum undatum*, *Neptunea antiqua*, *Nassarius* (*Hinia*) *reticulata* and *Littorina littorea* (Table 1).

Table 1. OSPAR Biological effect assessment criteria for TBT. Assessment criteria for imposex in *Nucella lapillus* (regarded as representing more sensitive species) are presented alongside equivalent VDSI/ISI values for sympatric populations of other relevant species (OSPAR 2004)

ASSESSMENT CLASS	*NUCELLA*	*NASSARIUS*	*BUCCINUM*	*NEPTUNEA*	*LITTORINA*
	VDSI	VDSI	VDSI	VDSI	ISI
A	< 0.3			< 0.3	
B	0.3–<2.0	< 0.3	< 0.3	0.3–<2.0	
C	2.0 <4.0	0.3 < 2.0	0.3 < 2.0	2.0–<4.0	< 0.3
D	4.0–5.0 sterilty occurs	2.0–3.5	2.0–3.5	4.0	0.3–< 0.5
E	>5.0	> 3.5	> 3.5		0.5–1.2 sterility occurs
F	-				> 1.2

It is suggested that also the reference levels of imposex/intersex in all species in the HELCOM region set to be VDSI-values <0.3 (Table 2).

Four of these species are also living in the western part of the HELCOM region, i.e. the Kattegat, The Belt Sea and the Sound and the western Baltic Sea, and these species are among other used in monitoring programmes and research studies in Denmark, Sweden and Germany. The OSPAR assessment criteria can therefore also be applied for assessing the TBT effects in gastropods in this region.

Imposex in other gastropod species like *Hydrobia ulvae* (Schlute-Oehlmann *et al*., 1997, 1998) can be included as indicator in these assessment criteria so also the more eastern part of the Baltic Sea can be assessed according to these assessment criteria. However, further studies are needed for establishing the interspecies correlations, for instance between imposex levels in *Hydrobia ulvae* and *Hinia reticulata*.

The OSPAR assessment criteria have for instance been used in a broad-scale study on the distribution of TBT and TBT effects in the Skagerrak and the Kattegat, where TBT levels and TBT effects have been combined in a GIS-based analysis (Figure 1).

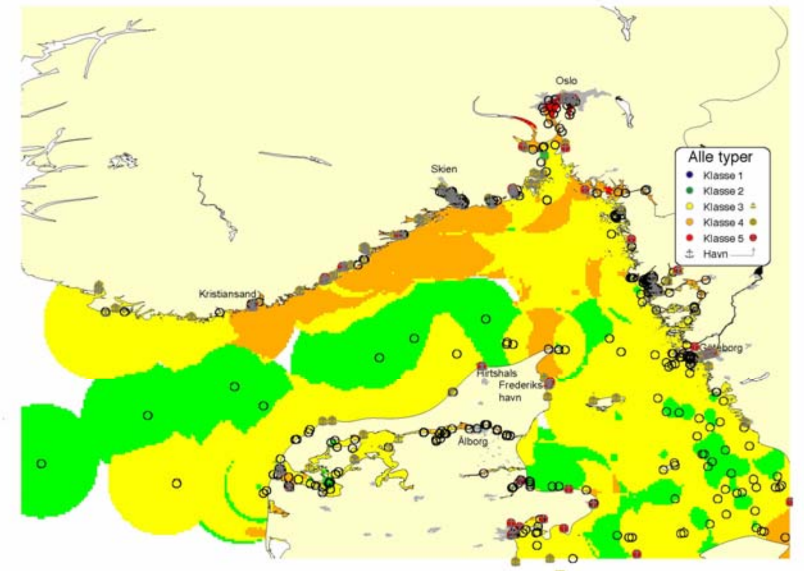

Figure 1. Classification of TBT levels in the Skagerrak and the Kattegat by combining data for TBT in sediment, TBT in molluscs and imposex/intersex levels in marine gastropods. (Clases 1: Blue, 2: Green, 3: Yellow, 4: Orange, 5: Red.

Table 2. Reference levels of imposex and intersex in marine gastropods.

METHOD SPECIES UNIT	THE KATTEGAT	BELT SEA AND THE SOUND	WESTERN BALTIC SEA	MORE EASTERN PARTS OF THE BALTIC SEA
Imposex *Hinia reticulata* VDSI	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)	species not occurring
Imposex *Buccinum undatum* VDSI	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)	species not occurring
Imposex *Neptunea antiqua* VDSI	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)	species not occurring
Imposex *Hydrobia ulvae* VDSI	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)
Intersex *Littorina littorea* ISI	Zero (< 0.3)	Zero (< 0.3)	Zero (< 0.3)	species not occurring

Recommendation

It is recommended that the OSPAR assessment criteria are applied for the Kattegat, the Belt Sea and the Sound and the western Baltic Sea. However, further studies are needed for establishing the interspecies correlations, for instance between imposex levels in *Hydrobia ulvae* and *Hinia reticulata*, so such indicator also can be applied in the more eastern part of the Baltic Sea.

References

OSPAR. 2004. Provisional JAMP Assessment Criteria for TBT – Specific Biological Effects. OSPAR agreement 2004–2015. http://www.ospar.org.

Schulte-Ohehlmann, U., Oehlmann, J., Fioroni, P., Bauer, B. 1997. Imposex and reproductive failure in *Hydrobia ulvae* (Gastropoda: Prosobranchia). Marine biology, 128: 257–266.

Schulte-Ohehlmann, U., Oehlmann, J., Bauer, B., Fioroni, P., Leffler, U-S. 1998. Toxico-kinetic and -dynamic aspects of TBT-induced imposex in *Hydrobia ulvae* compared with intersex in *Littorina littorea* (Gastropoda, Prosobranchia). Hydrobiologia, 378: 215–225.

Strand, J., and Jacobsen, J.A. 2002. Imposex in Two Sublittoral Neogastropods from the Kattegat and Skagerrak: the Common Whelk *Buccinum undatum* and the Red Whelk *Neptunea antiqua*. Marine Ecology Progress Series, 244: 171–177.

Strand, J., Larsen, M.M., Næs, K., Cato, I., and Dahllöf, I. 2006. Tributyltin (TBT). Forekomst og effekter i Skagerrak. Uddevalla, Sweden: Forum Skagerrak II. 39 s. (In Danish). http://www.forumskagerrak.com/download/503/x/TBT%20web%20ver2.pdf.

Annex 8: List of experts in taxonomy of animals and plants of the Baltic Sea and user friendly list of useful publications on taxonomy of the Baltic Sea animals and plants

Aladin N.V., Dianov M.B., Plotnikov I.S.

Zoological Institute of Russian Academy of Sciences

For fulfilling these tasks list of experts both in Russian Federation and foreign countries were made. Both lists are published in Internet:

http://www.zin.ru/projects/baltdiv/experts_russia.html

http://www.zin.ru/projects/baltdiv/experts_foreign.html

We asked our experts to provide us with the opinion about most reputed taxonomists known to them regardless Baltic Sea. Besides that we asked to let us know what kind of taxonoimic publication on the Baltic Sea animals and plants could be helpful. We got some replies and summarized them.

We also added some info received via Internet.

Both lists were published in Internet in the middle of June in order to receive comments from HELCOM-BSRP colleagues and from all other scientists involved in Baltic Sea biodiversity studies.

List of taxonomists: http://www.zin.ru/projects/baltdiv/taxonomists.asp

List of useful publications on taxonomy: http://www.zin.ru/projects/baltdiv/publications.html

Some more names of taxonomists and useful taxonomical publications recently (beginning of November 2006) came from our foreign experts. This info will be added later this month after its revision. We keep waiting for more input from our distinguished colleagues in order to complete 100% both lists in Internet. In parallel we would like also continue our search on this matter in Internet.

Annex 9: Assessment of biological diversity of Russian part of Gulf of Finland using BSRP SGEH indicators

Aladin N.V., Dianov M.B., Plotnikov I.S.

Zoological Institute of Russian Academy of Sciences

Using publication of Eugeniusz Andrulewicz and Jan Marcin Węsławski entitled "An illustrative framework for assessing biological diversity of the Gulf of Gdańsk applying ICES/BSRP SGEH priority indicators" we prepared our own present study on the Russian part of Gulf of Finland.

In the paper about Gulf of Gdansk both authors from Poland from the list of about 24 SGEH biodiversity indicators (ICES/BSRP SGEH 2005), after assessing them with the US EPA selection criteria (US EPA 2002), only seven indicators had been recommended as priority/operational indicators. They are related to: phytobenthos, zoobenthos, alien species, fish, birds, mammals and the status of the Baltic Sea Protected Areas.

In our study we apply practically the same indicators as our distinguished Polish colleagues. Besides that we distinguished for the whole Baltic Sea 5 main types of Baltic Sea ecosystems regarding salinity factor: freshwater ecosystems, transitional freshwater-brackishwater ecosystems, brackishwater ecosystems, transitional brackishwater-marine ecosystems and marine ecosystems.

We also analyzed changing of the species number following salinity gradient starting with publication of A. Remane and following those of J. Välikangas, S. Segerstrâle, O. Kinne, V. Khlebovich, A. Jarvekulg, B.-O. Jansson and some other well known scientists, that showed decreasing of marine species biodiversity following decreasing of Baltic Sea salinity.

In our present study we analyzed number of fishes, free-living invertebrates and plants without micro-Metazoa, Protozoa and Bacteria. We did this analysis not only for Gulf of Finland but also for Baltic Sea Proper, Bay of Bothnia, Bothnian Sea, Gulf of Riga and Kattegat. We also calculated number of species using acad. A. Alimov formula ($n=199.21*S^{0.155}$). Number of species received from scientific literature or by expert evaluation was the same only for Gulf of Finland, Bay of Bothnia, Bothnian Sea and Gulf of Riga. Number of species in Baltic Sea Proper is twice lower but in Kattegat it is 4 times higher than according this formula. We are concluding that formula could be used only for freshwater ecosystems and transitional freshwater-brackishwater ecosystems. Thus this formula is fully applicable to Russian part of Gulf of Finland.

Gulf of Finland is narrow water basin. Length from the West to the East 410 km. Total length of the coastline in Russian Federation >512 km. Coastline of island about 170 km. Run-off from Neva River is about 80 km^3/year and significantly influence on the salinity. Surface water in the Neva estuary is practically fresh. At Gogland Island water salinity is 3-5‰ at the surface and 7-8‰ at the bottom.

In our presentation following publications of different authors and one of the last publication (Pogrebov, Sagitov, 2006) we are giving the following information: zoning of Russian part of Gulf of Finland; distribution of planktonic Cyanobacteria in spring; distribution of main dominating species complexes of zooplankton in summer; distribution of macro-zoobenthos in summer.

After analysis of this data we are concluding with published information on ichthyofauna. In the Gulf of Finland there are about 70 species of marine, diadromous and freshwater fishes. The most significant for fishery is Baltic herring – 72% of the catches. Other fishes in the catches: sprat (*Sprattus sprattus*) – 8.2%, smelt (*Osmerus eperlanus*) – 8.1%, ruff (*Gymnocephalus cernua*) – 6.9%, roach (*Rutilus rutilus*) – 1.%, zander (*Stizostedion lucioperca*) – 0.6%, bream (*Abramis brama*) – 0.8%, perch (*Perca fluviatilis*) – 0.5%, lamprey (*Lampetra fluviatilis*) – 0.2%, whitefish (*Coregonus albula*) – 0.2%, cisco (*Coregonus lavaretus lavaretus*) – 0.04%, salmon (*Salmo salar*) – 0.03%.

We discussed available published data (Pogrebov, Sagitov, 2006) on distribution of Baltic herring (*Clupea harengus membras*) in summer and distribution of smelt (*Osmerus eperlanus*).

We also continue our assessment using published information on avifauna. In the Gulf of Finland there are following species of birds: *Gavia arctica*, *G. stellata*, *G. adamsi*, *Podiceps nigricollis*, *P. ruficollis*, *P. auritus*, *P. griseigena*, *P. cristatus*, *Phalacrocorax carbo*, *Cygnus olor*, *Anser anser*, *Branta leucopsis*, *Tadorna tadorna*, *Melanitta fusca*, *Clangula hyemalis*, *Aythya marina*, *A. fuligula*, *A. ferina*, *Fulica atra*, *Calidris alpina shinzii*, *Arenaria interpres*, *Heamatopus ostralegus*, *Tringa totanus*, *Calidris* spp., *Charadrius* spp., *Limosa* spp., *Tringa* spp., *Larus fuscus*, *L. marinus*, *L. minutus*, *Sterna paradisaea*, *S. caspia*, *S. sandwicensis*, *Cepphus grylle*, *Alca torda*, *Motacilla alba*, *Oenanthe oenanthe*, *Acrocephalus* spp., *Emberiza sheniclus*.

Key ornithological areas (IBAs) of the worldwide and European significance were shown for the Russian part of Gulf of Finland.

In the Gulf of Finland there are following species of marine mammals: Baltic seal (*Phoca hispida hispida*), Grey seal (*Halichoerus grypus*). Both species of seals are in the Red Books. In the beginning of XX century both species were numerous, but since the middle of century their number has decreased catastrophically not only due to hunting but due to pollution with pesticides.

Distribution of Baltic seal (*Phoca hispida botnica*) in spring was shown.

After discussing above mentioned data we analyzed protected areas: wetlands, preserves and natural monuments.

Specially was indicated that some above reported data has some serious disagreements with results obtained in Zoological Institute RAS. At present under leadership of Acad. A. Alimov and Dr. S. Golubkov a special presentation on Eastern part of Gulf of Finland is under preparation. It will be published soon in Internet in the Zoological Institute RAS web-site http://www.zin.ru

The present study is concluded by a huge list of publications on the Gulf of Finland published by scientists from Zoological Institute as evidence that forthcoming projects on Gulf of Finland ecological assessment should have participants from above mentioned institute.

Annex 10: Influence of salinity change on the Baltic Sea biodiversity

Aladin N.V., Plotnikov I.S., Dianov M.B in co-operation with Alimov A.F., Khlebovich V.V. & Peter Kjaerboe

Zoological Institute of RAS, St. Petersburg

The present study is just a summary of some key chapters of forthcoming book on Baltic Sea biodiversity concept. For more information please visit http://www.zin.ru/projects/baltdiv/biodiversity_concept.html

Baltic Sea is semi-closed, shallow, brackish water body having smooth salinity gradient and unique fauna and flora. It is a young sea and in glacial time it was a cold lake. Baltic Sea until now retains many features of lake. Biodiversity of Baltic Sea is relatively low while in its own way is unique and needs special measures for its preservation.

At present the following 9 sub-regions of Baltic Sea are usually considered: Baltic proper, Kattegat, The Sound, Western Baltic, Bothnian Bay, Bothnian Sea, Archipelago Sea, Gulf of Finland and Gulf of Riga.

Main rivers of Baltic Sea basin are giving the huge freshwater input making this inland sea very diluted with very smooth salinity gradient from riverine fresh waters up to fully saline ocean waters. The following rivers we consider in our study: in Kattegat – Götaälv; in Baltic proper – Göta Kanal, Oder, Vistula, Nemunas; in Bothnian Sea – Dalälven, Ångermanälven, Kokemaenjoki; in Bothnian Bay – Skellefteälv, Muonioalv, Kemijoki, Livajoki, Oulujoki; in Gulf of Finland – Neva, Narva; in Gulf of Riga – Daugava.

River run-off to the Baltic Sea and its various subcatchments from 1950 to 1998 we analyzed following HELCOM publication (HELCOM 2002). Riverine waters are giving considerable contribution practically to all water areas of the Baltic Sea.

In the Baltic Sea there are oligohaline and mesohaline water areas, and each of them has its own specific flora and fauna. The most freshened areas there are Gulf of Finland and Gulf of Bothnia.

Central water area of Baltic Sea has pronounced mesohaline character. Only in Kattegat and Sound polyhaline conditions can be found.

Beginning from S. Ekman various publications we are showing that near-bottom and surface salinities in the Baltic Sea are different. Very often salinity at surface is much less than near the bottom. We used P. Hunfer (1982) surface salinity data for making our ecosystem zoning in the Baltic Sea.

We distinguished for the whole Baltic Sea 5 main types of Baltic Sea ecosystems regarding salinity factor: freshwater ecosystems, transitional freshwater-brackishwater ecosystems, brackishwater ecosystems, transitional brackishwater-marine ecosystems and marine ecosystems.

We also analyzed changing of the species number following salinity gradient starting with publication of A. Remane and following those of J. Välikangas, S. Segersträle, O. Kinne, V. Khlebovich, A. Jarvekulg, B.-O. Jansson and some other well known scientists, that showed decreasing of marine species biodiversity following decreasing of Baltic Sea salinity.

In our present study we analyzed number of fishes, free-living invertebrates and plants without micro-Metazoa, Protozoa and Bacteria. We did this analysis not only for Gulf of Finland but also for Baltic Sea Proper, Bay of Bothnia, Bothnian Sea, Gulf of Riga and Kattegat. We also calculated number of species using acad. A. Alimov formula ($n=199.21*S^{0.155}$). Number of species received from scientific literature or by expert evaluation was the same only for Gulf of Finland, Bay of Bothnia, Bothnian Sea and Gulf of Riga. Number of species in Baltic Sea Proper is twice lower but in Kattegat it is 4 times higher than according this formula. We are concluding that formula could be used only for freshwater ecosystems and transitional freshwater-brackishwater ecosystems.

The largest contributions for studying salinity influence on biodiversity made 2 scientists: Prof. Otto Kinne and his theory on horohalinicum, Prof. Vladislav Khlebovich and his theory of critical salinity.

In the beginning of 20th century the number of works on the Baltic Sea biodiversity has increased. There were publications by Ekman (1913), Petersen (1913, 1914) and Thulin (1922). Later there were studies by Demel with co-authors (Demel et al., 1927-1954), by Remane (1933-1955), by Segersträle (1932-1958) and by Välikangas (1926-1933), by Kinne (1949-1970) and others.

Biodiversity of Baltic Sea is studied intensively since the middle of 19th century. Studies of Swedish zoologist Loven (1864) could be considered as pioneer. It is to mention works of Möbius (1873) and Heinke (Möbius, Heinke, 1883), and also by Brandt (1897) and Nordquist (1890).

Russian and soviet scientists also contributed to the studies of Baltic Sea biodiversity. We shall notice only some of them and years of their major scientific publications: Derjugin (1923-1924, 1934-1935), Nikolaev (1949-1985), Shurin (1957), Zenkevich (1963), Khlebovich (1974), Jarvekulg (1960-1999) and many others.

Above-mentioned scientists from Baltic Sea states have demonstrated that biodiversity of this young sea was formed in postglacial time and is highly heterogeneous by its composition. It consists of three main components: marine, freshwater, brackishwater (sensu stricta).

The first group is the main part of Baltic Sea biota. It includes relicts if previous geological times and immigrants from remote marine water bodies. The second group includes large number of Baltic Sea inhabitants, which come together with freshwater inflow. The third group is represented by large number of species and in its turn is divided into 2 subgroups: 1) ancient brackishwater arctic relicts (pseudorelicts-immigrants) formed in the glacial time in freshened areas of arctic basin and migrated into Baltic Sea in postglacial time from the North-East and East possibly via fresh waters; 2) Brackishwater forms originated from freshwater ones.

We are discussing classification of osmoconformers and osmoregulators.

General table of osmoconformers and osmoregulators is presented. Very briefly the following groups are analyzed:

Osmoconformers – majority of recent primary marine hydrobionts: Coeletnterata, Vermes, Mollusca, Arthropoda, Echinodermata, etc.

Confohyperosmotics – majority of recent widely euryhaline primary marine hydrobionts: Polychaeta, Gastropoda, Crustacea, etc.

Hyperosmotics – majority of recent freshwater hydrobionts: Oligochaeta, Rotatoria, Mollusca, Crustacea, Insecta, freshwater Pisces, etc.

Amphyosmotics – some Crustacea, some Insecta, anadrom Pisces.

Hypoosmotics – some secondary marine Crustacea, majority of recent secondary marine Pisces.

Evolution of all known types of osmoregulation is analyzed too following their hierarchy:

A0 – Hypothetic ancestral osmoconformer

A1 – Stenohaline marine hydrobionts (osmoconformers I)

A2 – Marine hydrobionts (osmoconformers II)

A3 – Euryhaline marine hydrobionts (osmoconformers III)

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I)

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II)

C1 – Freshwater hydrobionts (hyperosmotics I)

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics)

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I)

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II)

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III)

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV)

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics)

Before discussing situation in the Baltic Sea the percentage of different types of osmoconformers and osmoregulators in the World Ocean and fully saline seas as Barents Sea, Sea of Japan, etc. were analyzed:

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 30%

A2 – Marine hydrobionts (osmoconformers II) - 25%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 15%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 5%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 3%

C1 – Freshwater hydrobionts (hyperosmotics I) – 0%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 1%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 0%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 1%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 20%

In addition to the earlier mentioned analysis percentage of different types of osmoconformers and osmoregulators in brackish water seas as Black Sea, Sea of Azov, etc. were investigated:

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 3%

A2 – Marine hydrobionts (osmoconformers II) - 5%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 10%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 10%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 15%

C1 – Freshwater hydrobionts (hyperosmotics I) – 5%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 10%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 5%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 5%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 2%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 30%

In order to complete our preparation for the Baltic Sea analysis percentage of different types of osmoconformers and osmoregulators in freshwater lakes as Ladoga, Onega, etc. were calculated:

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) –0%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 0%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 0%

C1 – Freshwater hydrobionts (hyperosmotics I) – 98%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 1%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 1%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 0%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 0%

After this preliminary investigation we now calculated the percentage of different types of osmoconformers and osmoregulators in the whole Baltic Sea:

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 5%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 15%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 24%

C1 – Freshwater hydrobionts (hyperosmotics I) – 14%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 9%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 9%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 10%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 14%

Now and further down we shall calculate the same parameters for the different water areas of the Baltic Sea.

Let's start from the percentage of different types of osmoconformers and osmoregulators in the Western Baltic, Baltic Sea proper and Archipelago Sea

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 10%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 20%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 25%

C1 – Freshwater hydrobionts (hyperosmotics I) – 2%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 5%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 10%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 10%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 23%

Now we would like to calculate the percentage of different types of osmoconformers and osmoregulators in the Kattegat and the Sound

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 15%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 25%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 15%

C1 – Freshwater hydrobionts (hyperosmotics I) – 0%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 3%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 5%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 15%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 22%

Let's continue with the percentage of different types of osmoconformers and osmoregulators in the Bothnian Bay and Bothnian Sea

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 1%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 10%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 25%

C1 – Freshwater hydrobionts (hyperosmotics I) – 30%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 15%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 10%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 5%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 4%

Let's calculate the percentage of different types of osmoconformers and osmoregulators in the Gulf of Finland

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 2%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 15%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 30%

C1 – Freshwater hydrobionts (hyperosmotics I) – 20%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 10%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 5%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 10%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 8%

Let's calculate the percentage of different types of osmoconformers and osmoregulators in Neva bay

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 0%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 1%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 1%

C1 – Freshwater hydrobionts (hyperosmotics I) – 96%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 1%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 1%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 0%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 0%

Let's finally calculate the percentage of different types of osmoconformers and osmoregulators in the Gulf of Riga

A1 – Stenohaline marine hydrobionts (osmoconformers I) – 0%

A2 – Marine hydrobionts (osmoconformers II) - 0%

A3 – Euryhaline marine hydrobionts (osmoconformers III) – 5%

B1 – Widely euryhaline marine hydrobionts (confohyperosmotics I) – 17%

B2 – Brackish water hydrobionts of marine origin (confohyperosmotics II) – 25%

C1 – Freshwater hydrobionts (hyperosmotics I) – 15%

C2 – Brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics) – 10%

D1 – Some Caspian Brackish water hydrobionts (amphiosmotics I) – 8%

D2 – Some euryhaline Australian hydrobionts of freshwater origin (amphiosmotics II) – 0%

D3 – Euryhaline hydrobionts of freshwater origin (amphiosmotics III) – 10%

D4 – Widely euryhaline hydrobionts of freshwater origin (amphiosmotics IV) – 0%

E – Euryhaline marine hydrobionts of freshwater origin (hypoosmotics) – 10%

We could conclude that euryhaline marine hydrobionts (osmoconformers III) could spread all over Baltic Sea, excluding strongly freshened areas of estuaries

We could conclude that widely euryhaline marine hydrobionts (confohyperosmotics I) could spread all over Baltic Sea including estuaries.

We could conclude that brackish water hydrobionts of marine origin (confohyperosmotics II) could spread all over Baltic Sea including estuaries

We could conclude that freshwater hydrobionts (hyperosmotics I) could spread Only in estuaries and freshened gulfs of the Baltic Sea, not available in Kattegat and the Sound

We could conclude that euryhaline hydrobionts of freshwater origin (amphiosmotics III) could spread all over Baltic Sea including strongly freshened estuaries

We could conclude that euryhaline marine hydrobionts of freshwater origin (hypoosmotics) could spread all over Baltic Sea excluding strongly freshened estuaries

We are giving special attention to recent invader to the Baltic Sea *Evadne anonyx*. Parthenogenetic females with developing embryos in the closed brood pouch could conquer not only the whole Baltic Sea but also invade Skagerrak and may be the North Sea quite soon. *Evadne anonyx* as some other Caspian Brackish water hydrobionts has amphiosmotics I type of osmoregulation. So this recent invader could spread in the distant future even all over World Ocean, except of strongly freshened areas of estuaries and cold waters of Arctic and Antarctic oceans. “Old” invader to the Baltic Sea *Cercopagis pengoi* could conquer only brackish and fresh water localities of the Baltic Sea and will never conquer Danish straits and Kattegat. *Cercopagis* is brackish water hydrobionts of freshwater origin (hyperosmotics II or secondary confohyperosmotics). This old invader is not Caspian Sea endemic. In the contrast to this *Evadne anonyx* is a true Caspian endemic and its invasion story could be bigger and wider that those of *Cercopagis*. In the nearest future one more Cladocera *Podonevadne camptonyx* could appear in the Baltic Sea. It has the same type of osmoregulation as *Evadne anonyx*.

When you are looking for possible invaders to the Baltic Sea you need to know their osmoregulation capacities. Availability of resting stage is increasing the risk of invasion. Representatives of populations from Sea of Azov have the closest living conditions to those of the Baltic Sea and risk of their invasion is the highest.

At present the main source of immigrants to the Baltic Sea from seas and lakes – remnants of Paratethys are: Black Sea, Sea of Azov, Caspian Lake. The average salinity of all this water bodies is very close to those of Baltic Sea: Black Sea – 18 ‰, Sea of Azov – 10 ‰, Caspian Lake – 12 ‰.

Finally let’s consider zones of barrier salinities and tolerance ranges of hydrobionts from marine and continental waters.

Barrier salinities of marine waters: 5 –8‰ – first, 16–20‰ – second, 26–30‰ – third, 36–40‰ – fourth, 50–55‰ – fifth;

barrier salinities of continental waters: 5–20‰ – first, 50–60‰ – second, 100–300‰ and higher – third.

Unfortunately Baltic Sea is about to be a dying sea. We are very lucky that our sea is not a dead sea yet. In order to improve the situation we need to have some urgent measures. Some of them are already proposed by scientists and decision makers from Baltic Sea littoral states. As example I could refer to suggested measures to oxygenize the deeper salt water of The Baltic Sea made by Peter Kjaerboe and his team (http://o2gruppen.se).

As is obvious from afore given data, Baltic Sea is very rich in hydrobionts with various types of osmoregulation. In fact there are no only stenohaline marine hydrobionts of freshwater origin (osmoconformers-I, II) and also euryhaline Australian hydrobionts of freshwater origin (amphiosmotics-II). As a result in the Baltic Sea it is possible to find practically all barrier salinities. Barrier salinities of lower salinity range are expressed in the estuaries of Baltic rivers, and those of the higher one are expressed in Kattegat and the Sound. Urgent measures are needed to improve environmental condition in the Baltic Sea. For deep-water zone project proposed by Peter Kjaerboe and his team is considered to be of great importance.

Annex 11: The US EPA: Draft National Coastal Condition Report III – Introduction

This document contains the Introduction of the Draft National Coastal Condition Report III. The entire report can be downloaded from ***http://www.epa.gov/owow/oceans/nccr3/index.html***

Draft National Coastal Condition Report III

Introduction

March 2007

Chapter 1

Introduction

The *National Coastal Condition Report* series assesses the condition of the estuarine waters and coastal fisheries of the United States The first *National Coastal Condition Report* (NCCR I; U.S. EPA, 2001) assessed the condition of the nation's coasts using data collected from 1990 to 1996 that were provided by several existing coastal programs, including the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP), the U.S. Fish and Wildlife Service's (FWS's) National Wetlands Inventory (NWI), and the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends (NS&T) Program. The second *National Coastal Condition Report* (NCCR II; U.S. EPA, 2004) provided information similar to the information covered in the NCCR I, but contained more recent (1997–2000) data from these monitoring programs, as well as data from EPA's National Coastal Assessment (NCA) and NOAA's National Marine Fisheries Service (NMFS). The data provided by these programs allowed for the development of coastal condition indicators for 100% of the coastal area of the conterminous 48 states and Puerto Rico.

This third *National Coastal Condition Report* (NCCR III) is a collaborative effort among EPA, NOAA, FWS, and the U.S. Geological Survey (USGS), in cooperation with other agencies representing states and tribes. The NCCR III continues the *National Coastal Condition Report* series by providing updated regional and national assessments of the condition of the nation's coastal waters, including portions of the coastal waters of Alaska and Hawaii, based primarily on NCA data collected in 2001 and 2002. No new information was available for the regions of Puerto Rico or the Great Lakes; therefore, the chapters covering these regions represent summaries of the assessments presented in the NCCR II. The assessment of coastal fisheries provided in this report is based on long-term data collected since monitoring of the individual fisheries began. In addition, this report examines national and regional (Northeast, Southeast, and Gulf coasts) trends in coastal condition from the early 1990s to 2002.

NCA surveys of the nation's estuarine and coastal waters have been conducted annually from 2000 to 2006. The results of surveys conducted after 2002 will be available in 2008 and will be presented in the fourth *National Coastal Condition Report* (NCCR IV) in 2009.

Purpose of This Report

The purpose of the NCCR III is to present a broad baseline picture of coastal condition across the United States for 2001 to 2002 and, where available, snapshots of the condition of offshore waters. This report uses currently available data sets to discuss the condition of the nation's coastal waters and is not intended to be a comprehensive literature review of coastal information. Instead, this report uses NCA and other monitoring data on a variety of indicators to provide insight into current coastal condition. The NCCR III also examines national and regional trends in coastal condition from the early 1990s to 2002. The NCCR III will serve as a continuing benchmark for analyzing the progress of coastal programs and will be followed in subsequent years by reports on more specialized coastal issues. It will also serve as a reminder of the data gaps and other pitfalls that natural resource managers face and must try to overcome to make reliable assessments of how the condition of the nation's coastal resources may change with time.

This report also includes special Highlight articles that describe several exemplary programs related to coastal condition at the federal, state, and local levels. These Highlights are not intended to be comprehensive or exhaustive of all coastal programs, but are presented to show that information about the health of coastal systems is being collected for decision making at the local, state, regional, and national levels.

The final chapter of this report explores the connections between the condition indicators and human uses of coastal areas. Although the type of assessment described in Chapter 9 cannot be conducted on scales larger than a single estuary, it is important to address coastal condition at several spatial scales (e.g., national, regional, state, and local). Chapter 9 also complements the national/regional approach by combining the site-specific information for a specific estuary, Narragansett Bay, with the NCA results for this estuary to evaluate estuarine conditions.

Why Are Coastal Waters Important?

Coastal Waters are Valuable and Productive Natural Ecosystems

Coastal waters include estuaries, coastal wetlands, seagrass meadows, coral reefs, mangrove and kelp forests, and upwelling areas. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. The coasts also provide essential nesting, resting, feeding, and breeding habitat for 75% of U.S. waterfowl and other migratory birds (U.S. EPA, 1998).

Estuaries are bodies of water that receive freshwater and sediment influx from rivers and tidal influx from the oceans, thus providing transition zones between the fresh water of a river and the saline environment of the sea. This interaction produces a unique environment that supports wildlife and fisheries and contributes substantially to the economy of coastal areas. Estuaries also supply water for industrial uses; lose water to freshwater diversions for drinking and irrigation; are the critical terminals of the nation's marine transportation system and the U.S. Navy; provide a point of discharge for municipalities and industries; and are the downstream recipient of non-point source runoff.

Coastal wetlands are the interface between the aquatic and terrestrial components of estuarine systems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife, and help improve surface water quality by filtering residential, agricultural, and industrial wastes. Wetlands also buffer coastal areas against storm and wave damage; however, because of their close interface with terrestrial systems, wetlands are vulnerable to land-based sources of pollutant discharges and other human activities.

Coastal Waters Have Many Human Uses

Coastal areas are the most developed areas in the United States. This narrow fringe of land—only 17% of the total contiguous U.S. land area—is home to more than 53% of the nation's population (Figure 1-1). Total coastal population between the years 1980 and 2003 increased by 33 million people (28%), which is roughly consistent with the nation's rate of increase; however, this continued population growth in the limited coastal land area results in increased population density and pressure on coastal resources. The majority of the nation's most densely populated areas are located along the coast. In fact, 23 of the 25 most densely populated U.S. counties are coastal counties. The population density of U.S. coastal counties averages 300 persons/mi^2, much higher than the national average of 98 persons/mi^2 (Crossett et al., 2004).

Figure 1-1. Population distribution in the United States based on 2000 U.S. Census Bureau data (U.S. Census Bureau, 2001).

In addition to being a popular place to live, the nation's coasts are of great recreational value. Beaches have become one of the most popular vacation destinations in the United States, with 180 million people visiting the nation's coasts each year (Cunningham and Walker, 1996). From 1999 to 2000, more than 43% of the U.S. population participated in marine recreational activities, including sport fishing, boating, swimming, and diving (Leeworthy and Wiley, 2001).

Human use of coastal areas also provides commercial services for the nation. The 425 U.S. coastal counties generate $1.3 trillion of the gross national product (GNP), and coastal and marine waters support for more than 28 million jobs (Leeworthy, 2000; U.S. Senate, 2003). The annual catch of U.S. commercial fisheries was 5 million metric tons (mt) from 2001 through 2003, approximately 4.1% of the world's annual catch (NMFS, 2002; 2003; 2004). Roughly 35% of the nation's commercial catch occurs within 3 miles of shore (NMFS, 2004).

Why Be Concerned about Coastal Condition?

Because a disproportionate percentage of the nation's population lives in coastal areas, the activities of municipalities, commerce, industry, and tourism have created environmental pressures that threaten the very resources that make coastal living desirable. Population pressures include increased solid waste production; higher volumes of urban non-point source runoff; loss of green space and wildlife habitat; declines in ambient water and sediment quality; and increased demands for wastewater treatment, irrigation and potable water, and energy supplies. Development pressures have resulted in substantial physical changes along many areas of the coastal zone. Coastal wetlands continue to be lost to residential and commercial development, and the quantity and timing of freshwater flow, which is critical to riverine and estuarine function, continue to be altered. In effect, the same human uses that are desired of coastal habitats also have the potential to lessen their value. This report not only discusses indicators of coastal condition that gauge the extent to which coastal habitats and resources have been altered, but also addresses connections between coastal condition and the ability of coastal areas to meet human expectations for their use.

Assessment of Coastal Condition

Three sources of estuarine information use nationally consistent data-collection designs and methods— EPA's NCA, NOAA's NS&T Program, and FWS's NWI. The NCA collects data from all coastal areas in the United States, except the Great Lakes region, and these data are representative of all coastal waters. The NS&T Program collects data from all coastal regions in the United States; however, the design of this survey does not permit extrapolation of the data to represent all coastal waters. The NWI provides estimates of wetland acreage (including coastal wetlands) by wetland type based on satellite reconnaissance of all U.S. states and territories.

This report examines several available data sets from different agencies and areas of the country and summarizes them to present a broad baseline picture of the condition of the nation's coastal waters. Three types of data are presented in this report:

- Coastal monitoring data from programs such as EPA's EMAP and NCA, NOAA's NS&T Program, and FWS's NWI, along with data from the Great Lakes National Program Office (GLNPO), have been analyzed for this report and are used to develop indices of coastal condition.
- Fisheries data for Large Marine Ecosystems (LMEs) from NOAA's NMFS.
- Assessment and advisory data provided by states or other regulatory agencies and compiled in national EPA databases.

This report presents available coastal monitoring information on a national scale for the 50 states and Puerto Rico; these data are then broken down and analyzed at six geographic levels: Northeast Coast; Southeast Coast; Gulf Coast; West Coast; Great Lakes; and Alaska, Hawaii, and Island Territories (Figure 1-2). These geographic regions are comparable to the LME classifications used by the NOAA (Table 1-1). Assessment and advisory data for the regions are presented at the end of each chapter. Although inconsistencies in the way different state agencies collect and provide assessment and advisory data prevent their use for comparing conditions between coastal areas, this information is valuable because it helps identify and illuminate some of the causes of coastal impairment, as well as the impacts of these impairments on human uses.

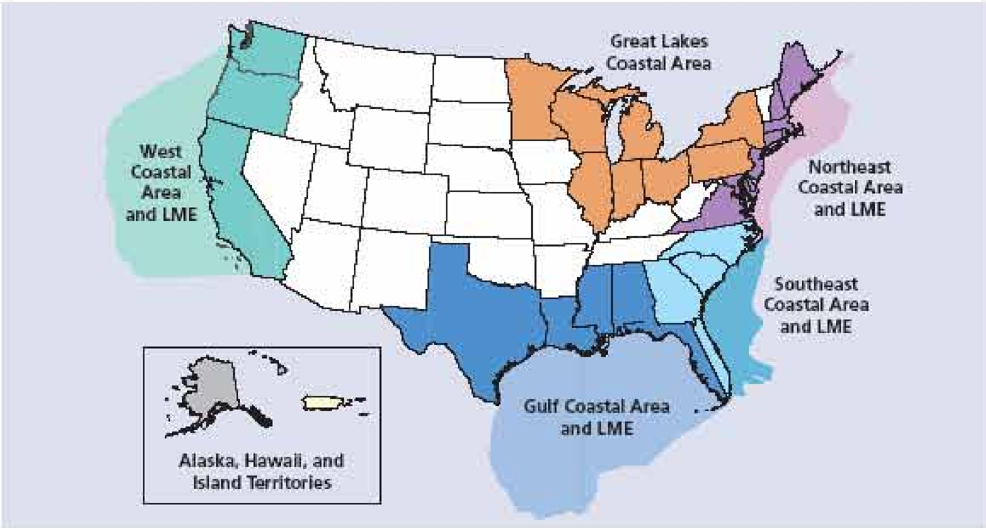

Figure 1-2. Coastal and Large Marine Ecosystem (LME) areas presented in the chapters of this report.

Table 1-1. Comparison of NCA's Reporting Regions and NOAA's LMEs

NCA Reporting Regions	NOAA's LMEs
Northeast Coast	Northeast U.S. Continental Shelf LME
Southeast Coast	Southeast U.S. Continental Shelf LME
Gulf Coast	Gulf of Mexico LME
West Coast	California Current LME
Alaska, Hawaii, and Island Territories	East Bering Sea LME, Gulf of Alaska LME, Chukchi Sea LME, Beaufort Sea LME, Insular Pacific-Hawaii LME

Coastal Monitoring Data

A large percentage of the data used in this assessment of coastal condition comes from programs administered by EPA and NOAA. EPA's NCA provides representative data on biota (e.g., plankton, benthos, and fish) and environmental stressors (e.g., water quality, sediment quality, and tissue bioaccumulation) for all coastal states (except states in the Great Lakes region) and Puerto Rico. NOAA's NS&T Program provides site-specific data on toxic contaminants and their ecological effects for all coastal regions and Puerto Rico. Coastal condition is also evaluated using information from the NWI, which provides information on the status of the nation's wetlands acreage.

Five primary indices of environmental condition were created using data available from these national coastal programs: a water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. The five indices were selected because of the availability of relatively consistent data sets for these parameters for most of the country. The indices do not address all of the estuarine and coastal-water characteristics that are valued by society, but they do provide information on both ecological condition and human use of estuaries. Component indicators for the water quality index (dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], chlorophyll a, water clarity, and dissolved oxygen) and the sediment quality index (sediment toxicity, sediment contaminants, and sediment total organic carbon [TOC]) are also assessed in the report.

Characterizing coastal areas using each of the five indices involves two steps. The first step is to assess condition at an individual monitoring site for each index and component indicator. The site condition rating criteria for each index and component indicator are determined based on existing criteria, guidelines, or the interpretation of scientific literature. For example, dissolved oxygen conditions (a component indicator of the water quality index) are considered poor if the dissolved oxygen concentrations at a site are less than 2 mg/L. This value is widely accepted as representative of hypoxic conditions; therefore, this benchmark for poor condition is strongly supported by scientific evidence (Diaz and Rosenberg, 1995; U.S. EPA, 2000a).

The second step is to assign a regional index rating based on the condition of the monitoring sites within the region. For example, for a region to be rated poor for the dissolved oxygen component indicator, more than 15% of the coastal area in the region must have measured dissolved oxygen concentrations less than 2 mg/L. The regional criteria boundaries (i.e., percentages used to rate each index of estuarine condition) were determined as a median of responses provided through a survey of environmental managers, resource experts, and the knowledgeable public. The following sections provide detailed descriptions of each index and component indicator, as well as the criteria for determining the regional ratings for the five indices as good, fair, or poor.

Shortcomings of Available Data

Coastal surveys of Hawaii and the Alaskan Province of Alaska were completed in 2002, and assessments of these estuaries are included in this report. Estuarine condition in Alaska is difficult to assess because very little information is available for most of the state to support the type of analysis used in this report (i.e., spatial estimates of condition based on the indices and component indicators measured consistently across broad regions). Nearly 75% of the area of all the bays, sounds, and estuaries in the United States is located in Alaska, and no national report on estuarine condition can be complete without information on the condition of the living resources and ecological health of these waters. Similarly, information to support estimates of condition based on the indices and component indicators used in this report is limited for Hawaii, the Pacific island territories (American Samoa, Northern Marianas Islands, and Guam), and the U.S. Virgin Islands. Although these latter systems make up only a small portion of the nation's estuarine area, they represent a unique set of estuarine subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States, except for the Florida Keys and the Flower Gardens off the Texas/Louisiana coast. A survey of Puerto Rico's estuarine condition was completed in 2000 and reported in the NCCR II. No new information has been collected for Puerto Rico since the NCCR II; therefore, a summary of that report's assessment is included in this report.

In order to attain consistent reporting for all the coastal ecosystems of the United States, fiscal and intellectual resources need to be invested in the creation of a national coastal monitoring program. The conceptual framework for such a program is outlined in the National Coastal Research and Monitoring Strategy (http://www.epa.gov/owow/oceans/nccr/H2Ofin.pdf), which calls for a national program that is organized at the state level and carried out by a partnership between federal departments and agencies (e.g., EPA, NOAA, the U.S. Department of the Interior [DOI], and the U.S. Department of Agriculture [USDA]), state natural resource agencies, and academia and industry. Such a monitoring program would provide the capability to measure, understand, analyze, and forecast ecological change at national, regional, and local scales. A first step in the development of this type of program was the initiation of EPA's NCA, a national estuarine monitoring program organized and executed at the state level; however, the NCA is merely a starting point for developing a comprehensive national coastal monitoring program that can offer a coastal assessment of the entire nation at all appropriate spatial scales. One approach for examining coastal data at a more local scale (an individual estuarine system) is presented in the assessment of Narragansett Bay provided in Chapter 9.

Indices Used to Measure Coastal Condition

Water Quality Index

The water quality index is based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Some nutrient inputs to coastal waters (such as DIN and DIP) are necessary for a healthy, functioning estuarine ecosystem; however, when nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, their concentration can increase beyond natural background levels. This increase in the rate of supply of organic matter is called eutrophication and may result in a host of undesirable water quality conditions (Figure 1-3), including excess plant production (phytoplankton or algae) and increased chlorophyll *a* concentrations, which can decrease water clarity and lower concentrations of dissolved oxygen.

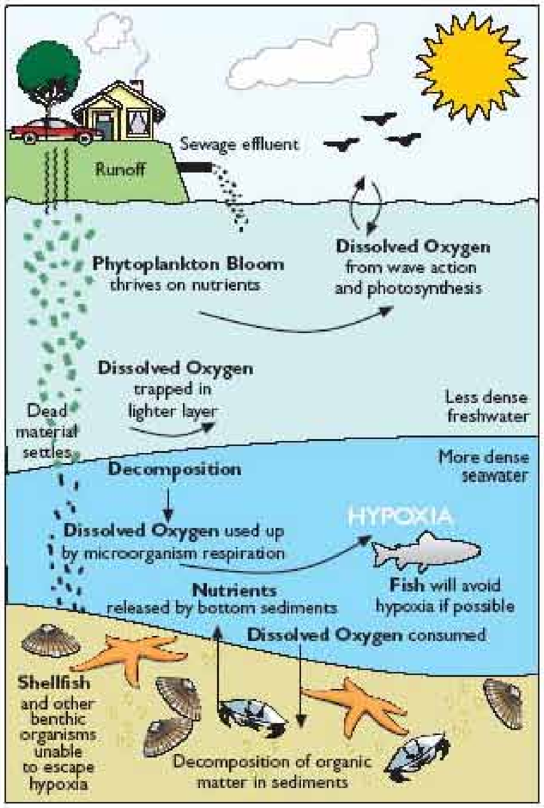

Figure 1-3. Eutrophication can occur when the concentration of available nutrients increases beyond normal levels.

The water quality index used in this report is intended to characterize acutely degraded water quality conditions and does not consistently identify sites experiencing occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity. As a result, a rating of poor for the water quality index means that the site is likely to have consistently poor condition during the monitoring period. If a site is designated as fair or good, the site did not experience poor condition on the date sampled, but could be characterized by poor condition for short time periods. In order to assess the level of variability in the index at a specific site, increased or supplemental sampling would be needed.

Nutrients: Nitrogen and Phosphorus

DIN and DIP are necessary and natural nutrients required for the growth of phytoplankton, the primary producers that form the base of an estuary's food chain; however, excessive levels of DIN and DIP can result in large, undesirable phytoplankton blooms. DIN is the nutrient type most responsible for eutrophication in open estuarine and marine waters, whereas DIP is more likely to promote algal growth in tidal-fresh parts of estuaries. For the NCCR I, DIN and DIP information were determined through a survey of estuarine experts conducted by NOAA (Bricker et al., 1999). In the NOAA report, surface maximum total dissolved nitrogen (TDN) values were assessed as high if they were equal to or greater than 1 mg/L; medium if they were less than 1 mg/L, but equal to or greater than 0.1 mg/L; and low if they were less than 0.1 mg/L. Surface maximum total dissolved phosphorus (TDP) values were assessed as high if they were equal to or greater than 0.1 mg/L; medium if they were less than 0.1 mg/L, but equal to or greater than 0.01 mg/L; and low if they were less than 0.01 mg/L. The NOAA report included data from all months of the year.

For the NCCR II and this report, DIN and DIP, which represent portions of TDN and TDP, were determined chemically through the collection of filtered surface water at each site. The NCA analyses provided for this report differs from results provided in the NOAA report because the nutrient assessment for the NCA surveys is based on summer concentrations, rather than annual average concentrations (NOAA). Due to phytoplankton uptake and growth, nutrient concentrations in summer are generally expected to be lower than at other times of the year for most of the country (however, on the West Coast, Pacific upwelling events in summer often produce the year's highest nutrient concentrations). As a result, the DIN and DIP reference surface concentrations used to assess coastal condition in this report are generally lower than those in the NOAA report because of the natural reduction in nutrient concentrations due to uptake by phytoplankton from spring to summer for the production of chlorophyll. Coastal monitoring sites were rated good, fair, or poor for DIN and DIP using the criteria shown in Tables 1-2 and 1-3. The site ratings were then used to calculate an overall rating for each region.

Table 1-2. Criteria for Assessing Dissolved Inorganic Nitrogen (DIN).

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast and Alaska sites	< 0.5 mg/L	0.5–1.0 mg/L	> 1 mg/L
Hawaii, Puerto Rico, and Florida Bay sites	< 0.05 mg/L	0.05–0.1 mg/L	> 0.1 mg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Table 1-3. Criteria for Assessing Dissolved Inorganic Phosphorus (DIP)

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.01 mg/L	0.01–0.05 mg/L	> 0.05 mg/L
West Coast and Alaska sites	< 0.01 mg/L	0.01–0.1 mg/L	> 0.1 mg/L
Hawaii, Puerto Rico, and Florida Bay sites	< 0.005 mg/L	0.005–0.01 mg/L	> 0.01 mg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Chlorophyll *a*

One of the symptoms of degraded water quality condition is the increase of phytoplankton production as measured by the concentration of chlorophyll *a*. Chlorophyll *a* is a measure used to indicate the amount of microscopic algae (or phytoplankton) growing in a waterbody. High concentrations of chlorophyll *a* indicate the potential for problems related to overproduction of algae. For this report, surface concentrations of chlorophyll *a* were determined from a filtered portion of water collected at each site. Surface chlorophyll *a* concentrations at a site were rated good, fair, or poor using the criteria shown in Table 1-4. The site ratings were then used to calculate an overall chlorophyll *a* rating for each region.

Table 1-4. Criteria for Assessing Chlorophyll *a*

Area	Good	Fair	Poor
East/Gulf/West Coast sites	< 5 µg/L	5–20 µg/L	> 20 µg/L
Hawaii, Puerto Rico, and Florida Bay sites	< 0.5 µg/L	0.5–1 µg/L	> 1 µg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 20% of the coastal area is in poor condition.

Water Clarity

Clear waters are valued by society and contribute to the maintenance of healthy and productive ecosystems. Light penetration into coastal waters is important for submerged aquatic vegetation (SAV), which serves as food and habitat for the resident biota. Water clarity is affected by suspended sediments, particulate matter, dissolved organics measured as color, and phytoplankton. Estuaries are naturally turbid environments. Turbid waters supply building materials for maintaining estuarine structures and provide food and protection to resident organisms; however, the extensive particle loads of turbid waters are harmful if they bury benthic communities, inhibit filter feeders, or block light needed by seagrasses. NCA estimates water clarity using specialized equipment that compares the amount and type of light reaching the water surface to the light at a depth of 1 meter, as well as by using a Secchi disk. Water clarity varies naturally among various parts of the nation; therefore, the water clarity indicator (WCI) is based on a ratio of observed clarity compared to regional reference conditions at 1 meter: WCI = (observed clarity at 1 meter/regional reference clarity at 1 meter). The regional reference conditions were determined by examining available data for each of the U.S. regions. Conditions were set at 10% of incident light available at a depth of 1 meter for normally turbid locations (most of the United States), 5% for locations with naturally high turbidity (Alabama, Louisiana, South Carolina, Georgia, and Delaware Bay), and 20% for regions of the country with significant SAV beds or active programs for SAV restoration (southern Laguna Madre, the Big Bend region of Florida, the region from Tampa Bay to Florida Bay, the Indian River Lagoon, and portions of Chesapeake Bay). Table 1-5 summarizes the rating criteria for water clarity for each monitoring station and for the regions.

Table 1-5. Criteria for Assessing Water Clarity

Area	Good	Fair	Poor
Coastal waters with naturally high turbidity	> 10% light at 1 m	5–10% light at 1 m	< 5% light at 1 m
Coastal waters with normal turbidity	> 20% light at 1 m	10–20% light at 1 m	< 10% light at 1 m
Coastal waters that support SAV	> 40% light at 1 m	20–40% light at 1 m	< 20% light at 1 m
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Dissolved Oxygen

Dissolved oxygen is necessary for all aquatic life. Often, low dissolved oxygen occurs as a result of large algal blooms that sink to the bottom, where bacteria use oxygen during the process of decay. In addition, low dissolved oxygen concentrations can be the result of stratification due to strong freshwater river discharge on the surface, which overrides the heavier, saltier bottom water of a coastal waterbody. Many states use a dissolved oxygen threshold average concentration of 4 to 5 mg/L to set their coastal water quality standards, and concentrations below 2 mg/L are thought to be stressful to many organisms (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). These low levels (hypoxia) or a lack of oxygen (anoxia) most often occur in bottom waters and affect the organisms that live in the sediments and frequently accompany the onset of severe bacterial degradation, sometimes resulting in the presence of algal scums and noxious odors. However, in some coastal waters, low dissolved oxygen levels occur periodically or may be a part of the waterbody's natural ecology. Therefore, although it is easy to show a snapshot of the conditions of the nation's coastal waters concerning oxygen concentrations, it is difficult to interpret whether this snapshot is representative of all summertime periods (e.g., representative of variable daily conditions) or the result of natural physical processes. Unless otherwise noted, the dissolved oxygen data presented in this report were collected by NCA at 1 meter above the sediment. Dissolved oxygen concentrations at individual monitoring sites and over regions were rated good, fair, or poor using the criteria shown in Table 1-6.

Temporal variations in dissolved oxygen depletion can have adverse biological effects (Coiro et al., 2000). Stressful hypoxia may occur for a few hours before dawn in productive surface waters, when respiration depletes dissolved oxygen faster than it is replenished. The NCA does not measure these events because most samples are taken later in the day. The NCA estimates do not apply to dystrophic systems, in which dissolved oxygen levels are acceptable during daylight hours, but decrease to low (even unacceptable) levels during the night. Many of these systems and the biota associated with them are adapted to this cycle—a natural process of oxygen production during the day and respiration at night— which is common in wetland, swamp, and blackwater ecosystems. In addition, year-to-year variations in dissolved oxygen levels in estuaries can be substantial as a result of a variety of factors, including variations in freshwater inflow, factors affecting water column stratification, and changes in nutrient delivery.

Table 1-6. Criteria for Assessing Dissolved Oxygen

Area	Good	Fair	Poor
Individual sampling sites	> 5 mg/L	2–5 mg/L	< 2 mg/L
Regions	Less than 5% of the coastal area is in poor condition, and more than 50% is in good condition.	5% to 15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 15% of the coastal area is in poor condition.

Calculating the Water Quality Index

Once DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen were assessed for a given site, the water quality index rating was calculated for the site based on these five component indicators. The index was rated good, fair, poor, or missing using the criteria shown in Table 1-7. A water quality index was then calculated for each region using the criteria shown in Table 1-8.

Table 1-7. Criteria for Determining the Water Quality Index Rating by Site

Rating	Criteria
Good	A maximum of one component indicator is rated fair, and no component indicators are rated poor.
Fair	One of the component indicators is rated poor, or two or more component indicators are rated fair.
Poor	Two or more of the five component indicators are rated poor.
Missing	Two component indicators are missing, and the available component indicators do not suggest a fair or poor rating.

Table 1-8. Criteria for Determining the Water Quality Index Rating by Region

Rating	Criteria
Good	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.
Fair	10% to 20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined fair and poor condition.
Poor	More than 20% of the coastal area is in poor condition.

Sediment Quality Index

Another issue of major environmental concern in coastal waters is the contamination of sediments with toxic chemicals. A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides, are discharged into coastal waters from urban, agricultural, and industrial sources in a watershed. These contaminants adsorb onto suspended particles and eventually accumulate in depositional basins, where they can disrupt the benthic community of invertebrates, shellfish, and crustaceans that live in or on the sediments. To the extent that the contaminants become concentrated in the organisms, they pose a risk to organisms throughout the food web—including humans.

Several factors influence the extent and severity of contamination. Fine-grained, organic-rich sediments are likely to become resuspended and transported to distant locations and are also efficient at scavenging pollutants. Thus, silty sediments high in TOC are potential sources of contamination. Conversely, organic-rich particles bind some toxicants so strongly that the threat to organisms can be greatly reduced. The NCA measured the concentrations of 91 chemical constituents in sediments and evaluated sediment toxicity by measuring the survival of the marine amphipod *Ampelisca abdita* following a 10-day exposure to the sediments under laboratory conditions. The results of these evaluations may be used to identify the most polluted areas and provide clues regarding the sources of contamination.

The physical and chemical characteristics of surface sediments are the result of interacting forces controlling chemical input and particle dynamics at any particular site. When assessing coastal condition, researchers measure the potential for sediments to affect bottomdwelling organisms. The sediment quality index is based on measurements of three component indicators of sediment condition: sediment toxicity, sediment contaminants, and sediment TOC.

Sediment Contaminant Criteria (Long et al., 1995)

ERM (Effects Range Median)—Determined for each chemical as the 50th percentile (median) in a database of ascending concentrations associated with adverse biological effects.

ERL (Effects Range Low)—Determined values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

Alternative Views for a Sediment Quality Index

Some resource managers object to using ERM and ERL values to calculate the sediment quality index because the index is also based on actual measurements of toxicity. Because ERMs are acknowledged to be no greater than 50% predictive of toxicity, these managers believe that the same weight should not be given to a non-toxic sample with an ERM exceedance as is given to a sample that is actually toxic. O'Connor et al. (1998), using a 1,508-sample EPA and NOAA database, found that 38% of ERM exceedances coincided with amphipod toxicity (i.e., were toxic), 13% of the ERL exceedances (no ERM exceedance) were toxic; and only 5% of the samples that did not exceed ERL values were toxic. O'Connor and Paul (2000) expanded the 1,508-sample data set to 2,475 samples, and the results remained relatively unchanged (41% of the ERM exceedances were toxic, and only 5% of the nonexceedances were toxic). As a result, these researchers and managers believe that the sediment quality index used in this report should not result in a poor rating if sediment contaminant criteria are exceeded, but the sediment is not toxic.

Some researchers and managers would prefer that the sediment triad (sediment chemistry, sediment toxicity, and benthic communities) be used to assess sediment condition (poor condition would require all three elements to be poor), or that poor sediment condition be determined based on the joint occurrence of elevated sediment contaminant concentrations and high sediment toxicity (see text box). However, benthic community attributes are included in this assessment of coastal condition as an independent variable rather than as a component of sediment quality.

In this report, the focus of the sediment quality index is on sediment condition, not just sediment toxicity. Attributes of sediments other than toxicity can result in unacceptable changes in biotic communities. For example, organic enrichment through wastewater disposal can have an undesired effect on biota, and elevated contaminant levels can have undesirable ecological effects (e.g., changes in benthic community structure) that are not directly related to acute toxicity (as measured by the *Ampelisca* test). For these reasons, the sediment quality index in this report uses the combination of sediment toxicity, sediment contaminants, and sediment TOC to assess sediment condition. Sediment condition is assessed as poor (high potential for exposure effects on biota) at a site if any one of the component indicators is categorized as poor; assessed as fair if the sediment contaminants indicator is rated fair; and assessed as good if all three component indicators are at levels that would be unlikely to result in adverse biological effects due to sediment quality.

Sediment Toxicity

Researchers applied a standard direct test of toxicity at thousands of sites to measure the survival of amphipods (commonly found, shrimp-like benthic crustaceans) exposed to sediments for 10 days under laboratory conditions. As in all tests of toxicity, survival was measured relative to that of amphipods exposed to uncontaminated reference sediment. The criteria for rating sediment toxicity based on amphipod survival for each sampling site are shown in Table 1-9. Table 1-10 shows how these site data were used to evaluate sediment toxicity by region. It should be noted that for this component indicator, unlike the others outlined in this report, only a good or poor rating is possible—there is no fair rating.

Table 1-9. Criteria for Assessing Sediment Toxicity by Site

Rating	Criteria
Good	The amphipod survival rate is greater than or equal to 80%.
Poor	The amphipod survival rate is less than 80%.

Table 1-10. Criteria for Assessing Sediment Toxicity by Region

Rating	Criteria
Good	Less than 5% of the coastal area is in poor condition.
Poor	5% or more of the coastal area is in poor condition.

Sediment Contaminants

There are no absolute chemical concentrations that correspond to sediment toxicity, but ERL and ERM values (Long et al., 1995) are used as guidelines in assessing sediment contamination (Table 1-11). ERM is the median concentration (50th percentile) of a contaminant observed to have adverse biological effects in the literature studies examined. A more protective indicator of contaminant concentration is the ERL criterion, which is the 10th percentile concentration of a contaminant represented by studies demonstrating adverse biological effects in the literature. Ecological effects are not likely to occur at contaminant concentrations below the ERL criterion. The criteria for rating sediment contaminants at individual sampling sites are shown in Table 1-12, and Table 1-13 shows how these data were used to create regional ratings for the sediment contaminants component indicator.

Table 1-11. ERM and ERL Guidance Values in Sediments (Long et al., 1995)

Metal*	ERL	ERM
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Lead	46.7	218
Mercury	0.15	0.71
Nickel	20.9	51.6
Silver	1	3.7
Zinc	150	410
Analyte**	**ERL**	**ERM**
Acenaphthene	16	500
Acenapthylene	44	640
Anthracene	85.3	1,100
Flourene	19	540
2-Methyl napthalene	70	670
Napthalene	160	2,100
Analyte**	**ERL**	**ERM**
Phenanthrene	240	1,500
Benz(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Pyrene	665	2,600
Low molecular-weight PAH	552	3,160
High molecular-weight PAH	1,700	9,600
Total PAHs	4,020	44,800
4,4'-DDE	2.2	27
Total DDT	1.6	46.1
Total PCBs	22.7	180

* units are ug/g dry sediment, equivalent to ppm
** units are ng/g dry sediment, equivalent to ppb

Table 1-12. Criteria for Assessing Sediment Contaminants by Site

Rating	Criteria
Good	No ERM concentrations are exceeded, and less than five ERL concentrations are exceeded.
Fair	No ERM concentrations are exceeded, and five or more ERL concentrations are exceeded.
Poor	An ERM concentration is exceeded for one or more contaminants.

Table 1-13. Criteria for Assessing Sediment Contaminants by Region

Rating	Criteria
Good	Less than 5% of the coastal area is in poor condition.
Fair	5% to 15% of the coastal area is in poor condition.
Poor	More than 15% of the coastal area is in poor condition.

Sediment TOC

Sediment contaminant availability or organic enrichment can be altered in areas where there is considerable deposition of organic matter. Although TOC exists naturally in coastal sediments and is the result of the degradation of autochthonous and allochthonous organic materials (e.g., phytoplankton, leaves, twigs, dead organisms), anthropogenic sources (e.g., organic industrial wastes, untreated or only primary-treated sewage) can significantly elevate the level of TOC in sediments. TOC in coastal sediments is often a source of food for some benthic organisms, and high levels of TOC in coastal sediments can result in significant changes in benthic community structure and in the predominance of pollution-tolerant species. Increased levels of sediment TOC can also reduce the general availability of organic contaminants (e.g., PAHs, PCBs, pesticides); however, increases in temperature or decreases in dissolved oxygen can sometimes result in the release of these TOC-bound and unavailable contaminants. Sediment toxicity from organic matter is assessed by measuring TOC. Regions of high TOC content are likely to be depositional sites for fine sediments. If there are pollution sources nearby, these depositional sites are likely to be hot spots for contaminated sediments. The criteria for rating TOC at individual sampling sites are shown in Table 1-14, and Table 1-15 shows how these data were used to create a regional ranking.

Table 1-14. Criteria for Assessing TOC by Site (concentrations on a dry-weight basis)

Rating	Criteria
Good	The TOC concentration is less than 2%.
Fair	The TOC concentration is between 2% and 5%.
Poor	The TOC concentration is greater than 5%.

Table 1-15. Criteria for Assessing TOC by Region

Rating	Criteria
Good	Less than 20% of the coastal area is in poor condition.
Fair	20% to 30% of the coastal area is in poor condition.
Poor	More than 30% of the coastal area is in poor condition.

Calculating the Sediment Quality Index

Once all three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC) are assessed for a given site, a sediment quality index rating is calculated for the site. The sediment quality index was rated good to poor for each site using the criteria shown in Table 1-16.

Table 1-16. Criteria for Determining the Sediment Quality Index by Site

Rating	Criteria
Good	None of the individual component indicators is rated poor, and the sediment contaminants indicator is rated good.
Fair	None of the component indicators is rated poor, and the sediment contaminants indicator is fair.
Poor	One or more of the component indicators is rated poor.

The sediment quality index was then calculated for each region using the criteria shown in Table 1-17.

Table 1-17. Criteria for Determining the Sediment Quality Index by Region

Rating	Criteria
Good	Less than 5% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.
Fair	5% to 15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.
Poor	More than 15% of the coastal area is in poor condition.

Benthic Index

The worms, clams, crustaceans, and other invertebrates that inhabit the bottom substrates of coastal are collectively called benthic macroinvertebrates, or benthos. These organisms play a vital role in maintaining sediment and water quality and are an important food source for bottom-feeding fish, shrimp, ducks, and marsh birds. Benthos are often used as indicators of disturbances in coastal environments because they are not very mobile and thus cannot avoid environmental problems. Benthic population and community characteristics are sensitive to chemical-contaminant and dissolved-oxygen stress, salinity fluctuations, and sediment disturbance and serve as reliable indicators of coastal environmental quality. To distinguish degraded benthic habitats from undegraded benthic habitats, EMAP and NCA have developed regional (Southeast, Northeast, and Gulf coasts) benthic indices of environmental condition (Engle et al., 1994; Weisberg et al., 1997; Engle and Summers, 1999; Van Dolah et al., 1999; Hale and Heltshe, 2006). These indices reflect changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive species. A high benthic index rating for benthos means that samples taken from a waterbody's sediments contain a wide variety of species, as well as a low proportion of pollution-tolerant species and a high proportion of pollution-sensitive species. A low benthic index rating indicates that the benthic communities are less diverse than expected, are populated by more pollution-tolerant species than expected, and contain fewer pollution-sensitive species than expected. The benthic condition data presented throughout this report were collected by the NCA unless otherwise noted. Indices vary by region because species assemblages depend on prevailing temperatures, salinities, and the silt-clay content of sediments. The benthic index was rated poor at a site when the index values for the Northeast, Southeast, and Gulf coasts' diversity or species richness, abundance of pollution-sensitive species, and abundance of pollution-tolerant species fell below a certain threshold.

Not all regions included in this report have developed benthic indices. Indices for the West Coast, Puerto Rico, Alaska, and Hawaii are under development and were unavailable for reporting at this time. In these regions, benthic community diversity was determined for each site as a surrogate for the benthic index. Values for community diversity were examined regionally to determine if diversity varied directly with either salinity or sediment silt-clay content (the two natural variables most likely to influence coastal benthic diversity). If there was no significant relationship between diversity and these natural gradients in the region (as in Puerto Rico), then a surrogate benthic index was used based on the lower 95% confidence limit for the mean benthic diversity measures. If there was a significant relationship between diversity and either of these natural gradients in the region (as in the West Coast, Alaska, and Hawaii), then a surrogate benthic index was used based on the ratio of observed to expected diversity. Expected diversity was determined based on the statistical relationship of site diversity to site salinity (or silt-clay content). Poor condition was defined as less than 75% of the expected benthic diversity at a particular salinity (expected diversity was determined by a regression between diversity and salinity). Table 1-18 shows the good, fair, and poor rating criteria for the different regions of the country, which were used to calculate an overall benthic condition rating for each region.

Table 1-18. Criteria for Assessing Benthic Index

Area	Good	Fair	Poor
Northeast Coast sites			
Acadian Province	Benthic index score is greater than or equal to 5.0.	Benthic index score greater than or equal to 4.0 and less than 5.0.	Benthic index score is less than 4.0.
Virginian Province	Benthic index score is greater than 0.0.	NA*	Benthic index score is less than 0.0.
Southeast Coast sites	Benthic index score is greater than 2.5.	Benthic index score is between 2.0 and 2.5.	Benthic index score is less than 2.0.
Gulf Coast sites	Benthic index score is greater than 5.0.	Benthic index score is between 3.0 and 5.0.	Benthic index score is less than 3.0.

Table 1-18. (Continued)

West Coast, Alaska, and Hawaii sites (compared to expected diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of expected mean diversity for a specific salinity.	Benthic index score is between 75% and 90% of the lower limit of expected mean diversity for a specific salinity.	Less than 75% of observations had expected diversity.
Puerto Rico sites (compared to upper 95% confidence interval for mean regional benthic diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of mean diversity in unstressed habitats in Puerto Rico.	Benthic index score is between 75% and 90% of the lower limit of mean diversity in unstressed habitats in Puerto Rico.	Benthic index score is less than 75% of the lower limit of mean diversity for unstressed habitats in Puerto Rico.
Regions	Less than 10% of the coastal area has a poor benthic index score, and more than 50% of the coastal area has a good benthic index score.	10% to 20% of the coastal area has a poor benthic index score, or more than 50% of the coastal area has a combined poor and fair benthic index score.	More than 20% of the coastal area has a poor benthic index score.

*By design, this index discriminates between good and poor conditions only.

Coastal Habitat Index

Coastal wetlands are the vegetated interface between the aquatic and terrestrial components of coastal ecosystems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife. These habitats filter and process residential, agricultural, and industrial wastes, thereby improving surface water quality. Wetlands also buffer coastal areas against storm and wave damage. A large portion of commercial and sport fish spend a portion of their life cycles in coastal wetland and estuarine habitats. Adult stocks of commercially harvested shrimp, blue crabs, oysters, and other species throughout the United States are directly related to wetland quality and quantity (Turner and Boesch, 1988). Wetlands throughout the United States have been and are being rapidly destroyed by human activities (e.g., flood control, agriculture, waste disposal, real estate development, shipping, commercial fishing, oil/gas exploration and production) and natural processes (e.g., sea level rise, sediment compaction, droughts, hurricanes, floods). In the late 1970s and early 1980s, the country was losing wetlands at an estimated rate of 300,000 acres per year. The Clean Water Act, state wetland protection programs, and programs such as Swampbuster (USDA) have helped decrease wetland losses to an estimated 70,000 to 90,000 acres per year. Strong wetland protection must continue to be a national priority; otherwise, fisheries that support more than a million jobs and contribute billions of dollars to the national economy are at risk (Turner and Boesch, 1988; Stedman and Hanson, 2000), as are the ecological functions provided by wetlands (e.g., nursery areas, flood control, and water quality improvement).

Coastal wetlands, as defined here, include only estuarine and marine intertidal wetlands (e.g., salt and brackish marshes; mangroves and other shrub-scrub habitats; intertidal oyster reefs; and tidal flats, such as macroalgal flats, shoals, spits, and bars). This indicator does not include subtidal SAV, coral reefs, subtidal oyster reefs, worm reefs, artificial reefs, or freshwater/palustrine wetlands. For more information about wetlands, refer to EPA's wetlands Web site at http://www.epa.gov/owow/wetlands.

Because no new information on U.S. wetlands was available from the NWI, the assessment of coastal habitat from the NCCR II was used in this report. The NWI (2002) contains data on estuarine emergent and tidal flat wetland acreage from 1990 and 2000 for all coastal states, except Hawaii and Puerto Rico. Data for Hawaii and Puerto Rico are available for 1980 and 1990. The proportional change in regional coastal wetlands over the 10-year time period was determined for each region and combined with the long-term decadal loss rates for the period 1780 to 1990. The average of these two loss rates (historic and present) multiplied by 100 is the regional value of the coastal habitat index. The national value of the coastal habitat index is a weighted mean that reflects the extent of wetlands existing in each region (different than the distribution of the extent of coastal area). Table 1-19 shows the rating criteria used for the coastal habitat index.

Table 1-19. Criteria for Determining the Coastal Habitat Index

Rating	Criteria
Good	The index score is less than 1.0.
Fair	The index score is between 1.0 and 1.25.
Poor	The index score is greater than 1.25.

The NWI estimates represent regional assessments and do not apply to individual sites or individual wetlands. Before individual wetland sites can be assessed, rigorous methodologies for estimating the quantity and the quality of wetlands must be developed. Until these methods are available and implemented, only regional assessments of quantity losses can be made. Although a 1% loss rate per decade may seem small (or even acceptable), continued wetland losses at this rate cannot be sustained indefinitely and still leave enough wetlands to maintain their present ecological functions.

Fish Tissue Contaminants Index

Chemical contaminants may enter a marine organism in several ways: direct uptake from contaminated water, consumption of contaminated sediment, or consumption of previously contaminated organisms. Once these contaminants enter an organism, they tend to remain in the animal's tissues and may build up with subsequent feedings. When fish consume contaminated organisms, they may "inherit" the levels of contaminants in the organisms they consume. The same inheritance of contaminants occurs when humans consume fish with contaminated tissues. Contaminant residues can be examined in the fillets, whole-body portions, or specific organs of target fish and shellfish species and are compared with risk-based EPA Advisory Guidance values (U.S. EPA, 2000b).

For the NCA surveys, target fish were collected from all sites where fish were available, and whole-body contaminant burdens were determined. No EPA Advisory Guidance values exist to assess the ecological risk of whole-body contaminants for fish, but EPA Advisory Guidance values can be used as a basis for estimating advisory determinations, even if the data are based on whole-fish or organ-specific body burdens (Table 1-20) (U.S. EPA, 2000b). The whole-fish contaminant information collected by NCA for U.S. coastal waters was compared with risk-based thresholds based on a 154-pound adult human's consumption of four 8-ounce meals per month for selected contaminants (approach used by most state advisory programs) and assessed for non-cancer and cancer health endpoints (U.S. EPA, 2000b). Table 1-21 shows the rating criteria for the fish tissue contaminants index for each site, and Table 1-22 shows how these site ratings were used to create a regional rating.

Table 1-20. Risk-based EPA Advisory Guidance Values for Recreational Fishers (U.S. EPA, 2000b)

Contaminant	EPA Advisory Guidelines Concentration Range (ppm)[a]	Health Endpoint
Arsenic (inorganic)[b]	0.35–0.70	non-cancer
Cadmium	0.35–0.70	non-cancer
Mercury	0.12–0.23	non-cancer
Selenium	5.9–12.0	non-cancer
Chlordane	0.59–1.2	non-cancer
DDT	0.059–0.12	non-cancer
Dieldrin	0.059–0.12	non-cancer
Endosulfan	7.0–14.0	non-cancer
Endrin	0.35–0.70	non-cancer
Heptachlor epoxide	0.015–0.031	non-cancer
Hexachlorobenzene	0.94–1.9	non-cancer
Lindane	0.35–0.70	non-cancer
Mirex	0.23–0.47	non-cancer
Toxaphene	0.29–0.59	non-cancer
PAH (Benzo(a)pyrene)	0.0016–0.0032	cancer[c]
PCB	0.023–0.04	non-cancer

[a] Range of concentrations associated with non-cancer and cancer health endpoint risk for consumption of four 8-oz meals per month.

[b] Inorganic arsenic estimated as 2% of total arsenic.

[c] A non-cancer concentration range for PAHs does not exist.

Table 1-21. Criteria for Determining the Fish Tissue Contaminants Index by Site

Rating	Criteria
Good	For all chemical contaminants listed in Table 1-20, the index scores fall below the range of the EPA Advisory Guidance* values for risk-based consumption associated with four 8-ounce meals per month.
Fair	For at least one chemical contaminant listed in Table 1-20, the index score falls within the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.
Poor	For at least one chemical contaminant listed in Table 1-20, the index score exceeds the maximum value in the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.

* The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAHs (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-20).

Table 1-22. Criteria for Determining the Fish Tissue Contaminants Index by Region

Rating	Criteria
Good	Less than 10% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, and more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in good condition.
Fair	10% to 20% of the fish samples analyzed (Northeast Coast region) or monitoring stations where fish were caught (all other regions) are in poor condition, or more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in combined poor and fair condition.
Poor	More than 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition.

Summary of Rating Criteria

The rating criteria used in this report are summarized in Table 1-23 (primary indices) and Tables 1-24 and 1-25 (component indicators).

Table 1-23. NCA Indices Used to Assess Coastal Condition

Ecological Condition by Site	Ranking by Region
Water Quality Index – This index is based on measurements of five water quality component indicators (DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen).	
Ecological Condition by Site	**Ranking by Region**
Good: No component indicators are rated poor, and a maximum of 1 is rated fair. **Fair:** One component indicator is rated poor, or 2 or more component indicators are fair. **Poor:** Two or more component indicators are rated poor.	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** Between 10% and 20% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 20% of the coastal area is in poor condition.
Sediment Quality Index – This index is based on measurements of three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC).	
Ecological Condition by Site	**Ranking by Region**
Good: No component indicators are rated poor, and the sediment contaminants indicator is rated good. **Fair:** No component indicators are rated poor, and the sediment contaminants indicator is rated fair. **Poor:** One or more component indicators are rated poor.	**Good:** Less than 5% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** Between 5% and 15% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined poor and fair condition. **Poor:** More than 15% of the coastal area is in poor condition.
Benthic Index (or a surrogate measure) – This index indicates the condition of the benthic community (organisms living in coastal sediments) and can include measures of benthic community diversity, the presence and abundance of pollution-tolerant species, and the presence and abundance of pollution-sensitive species.	
Ecological Condition by Site	**Ranking by Region**
Good, **fair**, and **poor** were determined using regionally dependent benthic index scores.	**Good:** Less than 10% of the coastal area has a poor benthic index score, **and** more than 50% of the coastal area has a good benthic index score. **Fair:** Between 10% and 20% of the coastal area has a poor benthic index score, **or** more than 50% of the coastal area has a combined poor and fair benthic index score. **Poor:** More than 20% of the coastal area has a poor benthic index score.
Coastal Habitat Index – This index is evaluated using the data from the NWI (NWI, 2002), which contains data on estuarine emergent and tidal flat acreage for all coastal states (except Hawaii and Puerto Rico) for 1780 through 2000.	
Ecological Condition by Site	**Ranking by Region**
The average of the mean long-term, decadal wetland loss rate (1780–1990) and the present decadal wetland loss rate (1990–2000) was determined for each region of the United States and multiplied by 100 to create a coastal habitat index score.	**Good:** The coastal habitat index score is less than 1.0. **Fair:** The coastal habitat index is between 1.0 and 1.25. **Poor:** The coastal habitat index is greater than 1.25.

Table 1-23. (Continued)

Fish Tissue Contaminants Index – This index indicates the level of chemical contamination in target fish/shellfish species.	
Ecological Condition by Site	**Ranking by Region**
Good: For all chemical contaminants listed in Table 1-20, the index scores fall below the range of the EPA Advisory Guidance* values for risk-based consumption associated with four 8-ounce meals per month. **Fair:** For at least one chemical contaminant listed in Table 1-20, the index score falls within the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month. **Poor:** For at least one chemical contaminant listed in Table 1-20, the index score exceeds the maximum value in the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.	**Good:** Less than 10% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, and more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in good condition. **Fair:** 10% to 20% of the fish samples analyzed (Northeast Coast region) or monitoring stations where fish were caught (all other regions) are in poor condition, or more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in combined poor and fair condition. **Poor:** More than 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition.

* The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAHs (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-20).

Table 1-24. NCA Criteria for the Five Component Indicators Used in the Water Quality Index to Assess Coastal Condition

Dissolved Inorganic Nitrogen (DIN)	
Ecological Condition by Site	**Ranking by Region**
Good: Surface concentrations are less than 0.1 mg/L (NE, SE, Gulf), 0.5 mg/L (West, Alaska), or 0.05 mg/L (tropical*). **Fair:** Surface concentrations are 0.1–0.5 mg/L (NE, SE, Gulf), 0.5–1.0 mg/L (West, Alaska), or 0.05–0.1 mg/L (tropical*). **Poor:** Surface concentrations are greater than 0.5 mg/L (NE, SE, Gulf), 1.0 mg/L (West, Alaska), or 0.1 mg/L (tropical*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.

Table 1-24. (Continued)

Ecological Condition by Site	Ranking by Region
Dissolved Inorganic Phosphorus (DIP)	
Good: Surface concentrations are less than 0.01 mg/L (NE, SE, Gulf), 0.01 mg/L (West, Alaska), or 0.005 mg/L (tropical*). **Fair:** Surface concentrations are 0.01–0.05 mg/L (NE, SE, Gulf), 0.01–0.1 mg/L (West, Alaska), or 0.005–0.01 mg/L (tropical*). **Poor:** Surface concentrations are greater than 0.05 mg/L (NE, SE, Gulf), 0.1 mg/L (West, Alaska), or 0.01 mg/L (tropical*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.
Chlorophyll *a*	
Good: Surface concentrations are less than 5 µg/L (less than 0.5 µg/L for tropical ecosystems*). **Fair:** Surface concentrations are between 5 µg/L and 20 µg/L (between 0.5 µg/L and 1 µg/L for tropical ecosystems*). **Poor:** Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for tropical ecosystems*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 20% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 20% of the coastal area is in poor condition.
Water Clarity	
Good: Amount of light at 1 meter is greater than 10% (coastal waters with high turbidity), 20% (coastal waters with normal turbidity), or 40% (coastal waters that support SAV) of surface illumination. **Fair:** Amount of light at 1 meter is 5–10% (coastal waters with high turbidity), 10–20% (coastal waters with normal turbidity), or 20–40% (coastal waters that support SAV) of surface illumination. **Poor:** Amount of light at 1 meter is less than 5% (coastal waters with high turbidity), 10% (coastal waters with normal turbidity), or 20% (coastal waters that support SAV) of surface illumination.	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.
Dissolved Oxygen	
Good: Concentrations are greater than 5 mg/L. **Fair:** Concentrations are between 2 mg/L and 5 mg/L. **Poor:** Concentrations are less than 2 mg/L.	**Good:** Less than 5% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 5% to 15% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 15% of the coastal area is in poor condition.

*Tropical ecosystems include Hawaii, Puerto Rico, and Florida Bay sites.

Table 1-25. NCA Criteria for the Three Component Indicators Used in the Sediment Quality Index to Assess Coastal Condition

Ecological Condition by Site	Ranking by Region
Sediment Toxicity is evaluated as part of the sediment quality index using a 10-day static toxicity test with the organism *Ampelisca abdita*.	
Ecological Condition by Site	**Ranking by Region**
Good: Mortality* is less than or equal to 20%. **Poor:** Mortality is greater than 20%.	**Good:** Less than 5% of the coastal area is in poor condition. **Poor:** 5% or more of the coastal area is in poor condition.
Sediment Contamination is evaluated as part of the sediment quality index using ERM and ERL guidelines.	
Ecological Condition by Site	**Ranking by Region**
Good: No ERM values are exceeded, and fewer than five ERL values are exceeded. **Fair:** No ERM values are exceeded, and five or more ERL values are exceeded. **Poor:** One or more ERM values are exceeded.	**Good:** Less than 5% of the coastal area is in poor condition. **Fair:** 5% to 15% of the coastal area is in poor condition. **Poor:** More than 15% of the coastal area is in poor condition.
Sediment Total Organic Carbon (TOC)	
Ecological Condition by Site	**Ranking by Region**
Good: The TOC concentration is less than 2%. **Fair:** The TOC concentration is between 2% and 5%. **Poor:** The TOC concentration is greater than 5%.	**Good:** Less than 20% of the coastal area is in poor condition. **Fair:** 20% to 30% of the coastal area is in poor condition. **Poor:** More than 30% of the coastal area is in poor condition.

*Test mortality is adjusted for control mortality.

How the Indices Are Summarized

Overall condition for each region was calculated by summing the scores for the available indices and dividing by the number of available indices (i.e., equally weighted), where good = 5; fair = 4, 3, or 2 (based on position in percent range); and poor = 1. The Southeast Coast, for example, received the following scores:

Indices	Score
Water Quality Index	3
Sediment Quality Index	3
Benthic Index	5
Coastal Habitat Index	3
Fish Tissue Contaminants Index	4
Total Score Divided by 5 = Overall Score	**19/5 = 3.6**

The overall condition and index scores for the nation are calculated based on a weighted average of the regional scores for each index. The national ratings for overall condition and each index are then assigned based on these calculated scores, rather than on the percentage of area in good, fair, or poor condition. The indices were weighted based on the coastal area contributed by each geographic area. For example, the weighted average for the water quality index was calculated by summing the products of the regional water quality index scores and the area contributed by each region (Figure 1-4). These weighting factors were used for all indices except the coastal habitat index, which used the geographic distribution of total area of coastal wetlands (Figure 1-5). The national overall condition score was then calculated by summing each national index score and dividing by five.

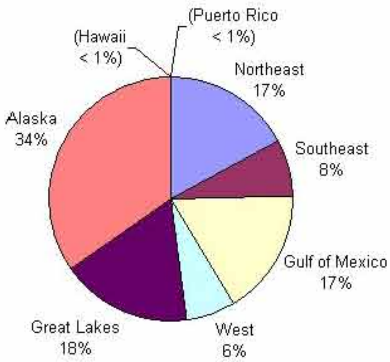

Figure 1-4. Percentage of coastal area contributed by each geographic region assessed in this report.

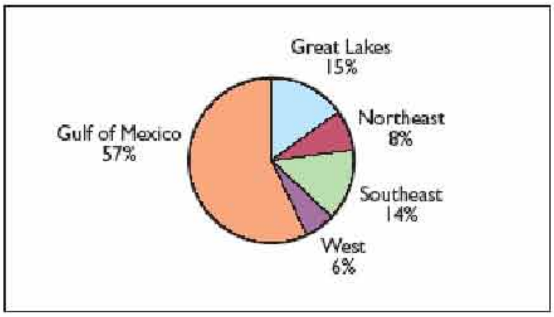

Figure 1-5. Percentage of coastal wetland area contributed by each geographic region assessed in this report.

Large Marine Ecosystem Fisheries Data

In addition to coastal monitoring data, a second type of data used to assess coastal condition in this report is LME fisheries data from the NMFS. The waters adjacent (3 to 200 nautical miles offshore) to the coastal waters and wetlands of the United States constitute the U.S. Exclusive Economic Zone (EEZ). Waters within and adjoining the U.S. EEZ have been designated as LMEs based on their distinct bathymetry, hydrography, productivity, and trophic relationships (NOAA, 1988). The NMFS regulates fisheries on the Atlantic, Pacific, and Gulf coasts within the boundaries of U.S. LMEs. Information on the status of the fish stocks comes from NMFS assessment data for nine LMEs, including the Northeast Shelf, Southeast Shelf, Gulf of Mexico, California Current, Gulf of Alaska, East Bering Sea, and Insular Pacific LMEs. Ultimately, the Secretary of Commerce has management responsibility for most marine life in U.S. waters. Fishery resources are managed largely by fishery management councils through extensive consultation with state and federal agencies, affected industry sectors, public interest groups, and, in some cases, international science and management organizations. Information provided for this report on living marine resources within U.S. LMEs was compiled from the NMFS productivity data and the report *Our Living Oceans* (NMFS, 2006), which is issued periodically by the NMFS and covers most living marine resources of interest for commercial, recreational, subsistence, and aesthetic or intrinsic reasons to the United States.

Marine Fisheries Fuel the U.S. Economy

More than one-fifth of the world's most productive marine waters lie within the LMEs of the U.S. EEZ. The value of both commercial and recreational fishing is significant to the U.S. economy, thousands of private firms, and individuals, families, and communities. As shown in Figure 1-6, in 2004

- U.S. commercial fishermen landed 9.6 billion pounds of fish and shellfish, valued at $3.7 billion.
- The commercial marine fishing industry contributed an estimated $31.6 billion (in value added) to the nation's GNP.
- U.S. consumers spent an estimated $61.9 billion for fishery products (NMFS, 2005).

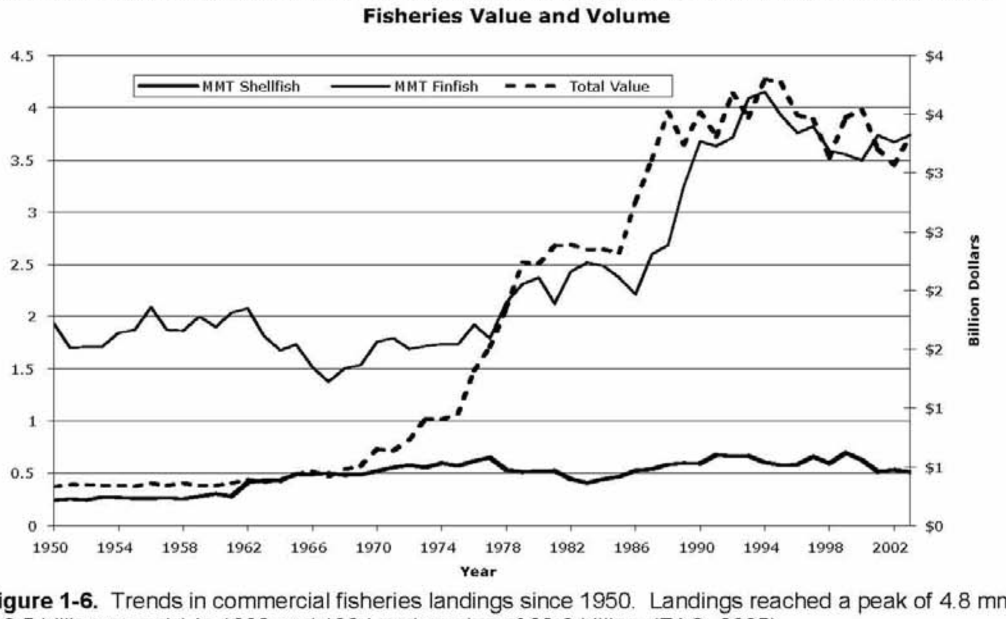

Figure 1-6. Trends in commercial fisheries landings since 1950. Landings reached a peak of 4.8 mmt (10.5 billion pounds) in 1993 and 1994 and a value of $3.8 billion. (FAO, 2005).

Assessment and Advisory Data

Assessment and advisory data provided by states or other regulatory agencies are the third set of data used in this report to assess coastal condition. Several EPA programs, including the Clean Water Act Section 305(b) Assessment Program, the National Listing of Fish Advisories (NLFA) Program, and the Beaches Environmental Assessment, Closure, and Health (BEACH) Program, maintain databases that are repositories for information about how well coastal waters support their designated or desired uses. These uses are important factors in the public's perception of coastal condition and also address the condition of the coast as it relates to public health. The data for these programs are collected from multiple state agencies, and data collection and reporting methods differ among states. Because of these inconsistencies, data generated by these programs are not included in the estimates of coastal condition.

Clean Water Act Section 305(b) Assessments

States report water quality assessment information and water quality impairments under Section 305(b) of the Clean Water Act. States and tribes rate water quality by comparing measured values to their state and tribal water quality standards. The 305(b) assessment data (submitted by the states in 2002) are stored in EPA's National Assessment Database (NAD) and are useful for evaluating the success of state water quality improvement efforts; however, it should be emphasized that each state monitors water quality parameters differently, so it is difficult to make generalized statements about the condition of the nation's coasts based on these data alone. For the 2002 reporting cycle, several states and island territories with estuarine and coastal marine waters did not submit 305(b) assessment information to EPA. For the states of North Carolina and Washington, as well as the island territories of American Samoa, Guam, and the Northern Marianas Island, no data were available for the 2002 reporting cycle in the NAD. Because the reporting of 305(b) information was not complete for all coastal states and territories, it was decided that this information would not be summarized for inclusion in the NCCR III. For this report, only data from EPA's NLFA database and BEACH PRogram tracking, beach Advisories, Water quality standards, and Nutrients (PRAWN) database are presented for calendar year 2003.

National Listing of Fish Advisories

States, U.S. territories, and tribes have primary responsibility for protecting their residents from the health risks of consuming contaminated, noncommercially caught fish and shellfish. Sale of commercial fish in interstate commerce is regulated by the U.S. Food and Drug Administration (FDA). Resource managers protect residents by issuing consumption advisories for the general population, including recreational and subsistence fishers, as well as for sensitive groups (e.g., pregnant women, nursing mothers, children, and individuals with compromised immune systems). These advisories inform the public that high concentrations of chemical contaminants (such as mercury and PCBs) have been found in local fish and shellfish. The advisories include recommendations to limit or avoid consumption of certain fish and shellfish species from specific waterbodies or, in some cases, from specific waterbody types (e.g., all coastal waters within a state).

The 2003 NLFA is a database—available from EPA and searchable on the Internet at http://www.epa.gov/waterscience/fish—that contains fish advisory information provided to EPA by the states and tribes. The NLFA database can generate national, regional, and state maps that illustrate any combination of advisory parameters.

Beach Advisories and Closures

There is growing concern in the United States about public health risks posed by polluted bathing beaches. Scientific evidence documenting the rise of infectious diseases caused by microbial organisms in recreational waters continues to grow; however, not enough information is currently available to define the extent of beach pollution throughout the country. EPA's BEACH Program, established in 1997, is working with state and local governments to compile information on beach pollution that will help define the national extent of the problem.

From 1997 through 2002, beach monitoring data was collected and submitted to EPA on a voluntary basis. During this time, sampled areas included coastal, Great Lakes, and some inland waters. Beginning with the 2003 season, the BEACH Act required that states submit data to EPA for beaches that are in coastal and Great Lakes waters and for all other beaches, as available. Due to the new reporting requirements, the 2003 and 2004 data cannot easily be compared to data gathered from 1997 through 2002, and long-term patterns are difficult to establish.

A few states have comprehensive beach monitoring programs to test the safety of water for swimming. Many other states have only limited beach monitoring programs, and some states have no monitoring programs linked directly to water safety at swimmable beaches. The number of beach closings and swimming advisories that continue to be issued annually, however, indicate that beach pollution is a persistent problem. In 2003, there were 839 beach closures and advisories in coastal and Great Lakes waters (U.S. EPA, 2006).

Connections with Human Uses

The first eight chapters of this report address the condition of the nation's coastal waters in terms of how well these waters meet ecological criteria. A related, but separate consideration is how well coasts are meeting human expectations in terms of services they provide for transportation, development, fishing, recreation, and other uses. Human use does not necessarily compromise ecological condition, but there are inherent conflicts between human activities that alter the natural state of the coast (e.g., marine transportation) and activities (e.g., fishing) that rely on the bounty of nature. In Chapter 9 of this report, the emphasis is on human uses for a particular estuary, Rhode Island's Narragansett Bay, and how well these uses are met. Because this approach relies on local information, it can be pursued only at the level of an individual estuary. The corresponding chapter in the NCCR II centered on Galveston Bay, TX.. The choice of Narragansett Bay is to a large extent dictated by the availability of long-term data on the abundances of commercial and recreational fishes for this estuary. Fishing is not the only human use of an estuary, but it is an important use thought to be strongly connected with ecological indicators.

References

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando, and D.R.G. Farrow. 1999. *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries.* Prepared for the National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science, Silver Spring, MD.

Coiro, L., S.L. Poucher, and D. Miller. 2000. Hypoxic effects on growth of *Palaemonetes vulgaris* larvae and other species: Using constant exposure data to estimate cyclic exposure response. *Journal of Experimental Biology and Ecology 247*:243–255.

Crosset, K.M., T.J. Culliton, P.C. Wiley, and T.R. Goodspeed. 2004. *Population Trends along the Coastal United States: 1980 – 2008*. National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects. Silver Spring, MD. 54 p.

Cunningham, C., and K. Walker. 1996. Enhancing public access to the coast through the CZMA. Current: *The Journal of Marine Education* 14(1):8–12.

Diaz, R.J., and R. Rosenberg. 1995. Marine benthic hypoxia: A review of it ecological effects and the behavioral responses of benthic macrofauna. *Oceanography and Marine Biology Annual Review* 33:245–303.

Engle, V.D., J.K. Summers, and G.R. Gaston. 1994. A benthic index of environmental condition of Gulf of Mexico estuaries. *Estuaries* 17:372–384.

Engle, V.D., and J.K. Summers. 1999. Refinement, validation, and application of a benthic condition index for northern Gulf of Mexico estuaries. *Estuaries* 22(3A):624–635.

FAO (Food and Agriculture Organization of the United Nations). 2005. Fishery Country Profiles: USA. Feb. 2005 (http://www.fao.org/fi/fcp/en/USA/profile.htm accessed 8 June 2006)

Hale, S.S. and J.F. Heltshe. 2006. A Benthic Index for the Nearshore Gulf of Maine: Evaluating Ecological Indicators with Signal Detection Theory. Submitted to *Ecological Indicators*.

Leeworthy, V.R. 2000. *Preliminary Estimates from Versions 1-6: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE)*. National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office, Silver Spring, MD.

Leeworthy, V.R. and P.C. Wiley. 2001. *Current Participation Patterns in Marine Recreation, National Survey of Recreation and the Environment (NSRE) 2000*. National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects, Silver Spring, MD. 47 p.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19(1):81–97.

NOAA (National Oceanic and Atmospheric Administration). 1988. A National Atlas: Health and Use of Coastal Waters, United States of America. Fishery Resource Assessment Programs and Large Marine Ecosystems, Folio Map No. 7. National Ocean Service, Office of Oceanography and Marine Assessment.

NMFS (National Marine Fisheries Service). 2002. *Fisheries of the United States 2001*. U.S. Department of Commerce, NOAA National Marine Fisheries Service, Silver Spring, MD. Available at: http://www.st.nmfs.gov/st1/publications.html

NMFS (National Marine Fisheries Service). 2003. *Fisheries of the United States 2002*. U.S. Department of Commerce, NOAA National Marine Fisheries Service, Silver Spring, MD. Available at: http://www.st.nmfs.gov/st1/publications.html

NMFS (National Marine Fisheries Service). 2004. *Fisheries of the United States 2003*. U.S. Department of Commerce, NOAA National Marine Fisheries Service, Silver Spring, MD. Available at: http://www.st.nmfs.gov/st1/publications.html

NMFS (National Marine Fisheries Service). 2005. *Fisheries of the United States 2004*. U.S. Department of Commerce, NOAA National Marine Fisheries Service, Silver Spring, MD. Available at: http://www.st.nmfs.gov/st1/publications.html

NMFS (National Marine Fisheries Service). 2006 In press *Our Living Oceans: Report on the Status of U.S. Living Marine Resources, 2006*. U.S. Department of Commerce, NOAA National Marine Fisheries Service, Silver Spring, MD.

NWI (National Wetlands Inventory). 2002. Results of the 2000 wetlands inventory. Personal Communication from Tom Dahl, U.S. Fish and Wildlife Service, National Wetland Inventory.

O'Connor, T.P., K.D. Daskalakis, J.L. Hyland, J.F. Paul, and J.K. Sumers. 1998. Comparisons of sediment toxicity with predictions based on chemical guidelines. *Environmental Toxicology and Chemistry* 17(3):468–471.

O'Connor, T.P., and J.F. Paul. 2000. Misfit between sediment toxicity and chemistry. *Marine Pollution Bulletin* 40:59–64.

Stedman, S.M., and J. Hanson. 2000. *Habitat Connections: Wetlands, Fisheries and Economics in the South Atlantic Coastal States*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Web site at http://www.nmfs.noaa.gov/habitat/habitatconservation/publications/habitatconections/num2.htm.

Turner, R.E. and D.F. Boesch. 1988. Aquatic animal protection and wetland relationships: Insights gleaned following wetland loss or gain. In *The Ecology and Management of Wetlands. Volume 1: Ecology of Wetlands*. D.D. Hook, W.H. McKee, Jr., H.K. Smith, J. Gregory, V.G. Burrell, Jr., M.R. Devoe, R.E. Sojka, S. Gilbert, R. Banks, L.H. Stolzy, C. Brooks, T.D. Matthews, and T.H. Shear (eds.). Portland, OR: Timber Press.

U.S. EPA (U.S. Environmental Protection Agency). 1998. *The Beach and Your Coastal Watershed*. EPA 842-F-98-10. U.S. Environmental Protection Agency, Office of Water, Washington, DC. Available at: http://www.epa.gov/owow/oceans/factsheets/fact2.html

U.S. EPA (U.S. Environmental Protection Agency). 2000a. *Ambient Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*. EPA-822-R-00-012. Office of Water, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2000b. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2: Risk Assessment and Fish Consumption Limits. EPA-823-B-00-008. Office of Water, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2001. *National Coastal Condition Report.* EPA-620/R-01/005. Office of Research and Development and Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2004. *National Coastal Condition Report II.* EPA-620/R-03/002. U.S. Environmental Protection Agency, Office of Research and Development and Office of Water, Washington, D.C. 286 p. Available at: http://www.epa.gov/nccr/2005/downloads.html

U.S. EPA (U.S. Environmental Protection Agency). 2006. *PRAWN Database (September 11, 2006).* U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

U.S. Senate. 2003. *Coastal and Estuarine Land Protection Act. (to accompany S. 861)* (S. Rpt. 108–158). U.S. Senate, Committee on Commerce, Science and Transportation. Government Printing Office, Washington, D.C.

Van Dolah, R.F., J.L. Hyland, A.F. Holland, J.S. Rosen, and T.T. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern USA. *Marine Environmental Research* 48:(4–5):269–283.

Weisberg, S.B., J.A. Ranasinghe, D.D. Dauer, L.C. Schnaffer, R.J. Diaz, and J.B. Frithsen. 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. *Estuaries* 20(1):149–158.

Annex 12: Some points on genetic diversity in the Baltic Sea

Janina Baršienė

Institute of Ecology of Vilnius University, Akademijos 2, 08412 Vilnius, Lithuania, Email: janbar@ekoi.lt

Abstract

The main aim of this review is to collect some dispersed literature published about various aspects of genetic diversity and unique of the fish and bivalve mollusc populations that inhabit the Baltic Sea, ecologically and geographically marginal environment. The study presents in brief literature data, considering the molecular genetic variation (mitochondrial, microsatellite DNA loci) as well as allozyme loci in certain commercial fish species and bivalves. Genetic diversity within the Baltic populations, differentiation between Baltic and Atlantic populations and existence of hybridization zones was also highlightened. Short overlook of genetic differences in reared and wild populations is also presented. The latter elaboration of the subject will include discussion on possible management and conservation ways of the Baltic genetic resources. In addition, a preliminary list of the publications on genetic diversity in the Baltic Sea was compiled.

Introduction

The Baltic Sea is a specific marine environment, geographically peripheral, connected to the North Sea by narrow and shallow sills in the Őresund and Danish Belts. The specificity of physical conditions circumstanced a low species richness inhabiting this sea and low diversity, existence of geographically and ecologically marginal populations with genetically clear deviations from other populations in the North Sea and Atlantic Ocean (Nilsson *et al*., 2001). Ecologically marginal populations usually experience extremely high pressure of selection which could result in genetically impoverished resource pool. Furthermore, species with a relatively poor dispersal capacity have in the Baltic Sea less effective gene flow from core populations and become more isolated with a lower scale of genetic variation (Schwartz *et al*., 2003).

It should be stressed that the use of multi-locus allozyme approaches and recently increased the application of molecular techniques have provided new insight into the knowledge of population divergence in marine species. Growing evidence confirm that many marine species are subdivided into genetically discrete groups, often possessing distinct evolutionary histories and with introgression between the groups. The combination of allozyme loci and molecular tools of both nuclear and mitochondrial DNA provide reliable approach to understanding the evolutionary dynamics of these interacting populations (Hilbish, 1996).

A large portion of our present knowledge regarding the genetic structure of populations has been derived using protein electrophoretic studies. Techniques for analyzing allozyme loci are presumed not to be of great interest to marine fish population genetics nowadays, but if the particularly changeable population structure defined by DNA tools; the allozyme tool may be advantageous as compared to minisatellite DNA structure rearrangements Nevertheless it was pointed out that it is ideal to compile information gained from many different types of genetic markers and to compare population divergence on the basis of both allozyme and various DNA markers (Laikre *et al*., 1995).

In the last decade, an increased attention was paid to gene arrangement in the mitochondrial (mt) genome. This is evidently feasible, as mtDNA is a useful model to study genome evolution, phylogenetic relationships or structural rearrangements in genetic material of organisms. Mitochondrial genome is small in size with comparatively conserved gene profiles and has been increasingly analyzed in different groups of organisms, including marine animals

(Avise, 2000). Certain marine organisms served as models for the analysis of mt gene rearrangements and the literature data on near-complete mtDNA sequences are available for some bivalves including genera *Mytilus, Macoma*, which are widely distributed in the Baltic Sea. In addition to the highly changeable gene order and content of the mtDNA, bivalves have an unusual doubly uniparental inheritance of mtDNA lineages. Two distinct and independent types of mtDNA lineages are sex-dependent phenomenon (Quesada *et al.*, 1996; Burzynski *et al*., 2003; Serb, Lydeard, 2003).

The present study attempts to provide an easy-to-follow description of various aspects of genetic diversity in the Baltic Sea with special points to the uniqueness of some Baltic populations. The latter elaboration of the subject will include discussion on possible management and conservation measures of the Baltic genetic resources. Peripheral populations are likely treated to extreme genetic perturbations and share lower genetic diversity as compared to core populations of the same species. In addition, genetic effects of pollution in certain areas of the Baltic Sea, as well as "wasting/degrading?" of some fish populations by gene flow from domesticated to wild populations are subject's ad-hoc style. However, not many studies addressed the issue populations could be restored after the stressful conditions have occurred. The presented reference list is composed of cited and recommended publications, which could be useful for those interested in general knowledge or going into the depth of the subject.

Genetic diversity in the Baltic Sea organisms

Many marine species have the capacity to spread in various habitats and disperse widely over thousands of kilometers. It is known, that several mechanisms might be important for population differentiation in environmental gradients or genetic characteristics. Previous genetic studies in fish from the Baltic Sea have presented evidence on mechanical mixing (admixture), spawning waves, hybrid zones, genetic heterogeneity along a transect from the North Sea to the Baltic Sea, genetic divergence within the populations and between populations, etc. There are some laboratories in the Baltic countries, extensively working on scientific background of the subject, which have produced publications on certain commercial fish species (Atlantic cod, Atlantic herring, Atlantic salmon, turbot, northern pike) and bivalves from the genera of *Mytilus* and *Macoma balthica.*

A comprehensive and professionally presented overview on genetic diversity in the Baltic Sea was published by K.Johannessson and C. Andre in 2006. The analysis of literature data on allozyme and DNA markers of 29 species from the Baltic Sea and northeastern Atlantic allowed the confirmation of the hypothesis on lower genetic diversity and uniqueness of organisms inhabiting the Baltic Sea as compared to Atlantic populations of the same species. The authors compared genetic diversity within the Baltic and Atlantic populations, to regularities of differentiation between the populations, described the loss of diversity through genetic drift and asexual reproduction, as well as identified the primary and secondary zones of hybridization. The special merit of the review is the elaboration of genetic trajectories of 20 species based on pairwise F_{ST} estimates between certain Baltic populations and the others from the Atlantic zones. The overview of genetic differentiation in various Baltic-Atlantic populations has presented two general conclusions: the first one considers lower genetic diversity in the Baltic Sea in compared to Atlantic populations, and the other –is derived from clear evidences on greater level of genetic differentiation in the transitional zones between the Baltic and North Sea (Johannesson, Andre, 2006).

The main objective of the current study is a short overview of literature data on genetic diversity in the Baltic Sea. More exhaustive attention will be put to investigations carried out in Atlantic cod, salmon and herring (Tables 1–3), also, in mytiliid and teliniid bivalves, considering their economic and ecological importance and the managerial issues.

Genetic diversity in the Baltic Sea bivalves

A number of studies have demonstrated the existence of genetically differentiated populations, or sibling species complexes in mussels with broad geographical distribution. Comparative analyses of certain morpho-physiological changes and genetic analyses showed a rather varying picture, leading to the conclusion that in brackish waters some species of marine origin are often presented by many different forms at various levels of differentiation.

Variable rates of admixture and introgression have been described for the *Mytilus* spp assemblages in western waters of Europe. The hybrid zone separates two mytiliid populations (Vöinölä, Hvilson 1991). Bierne *et al*. (2003) provided evidence for genetic differentiation in two types of loci (allozyme and noncoding DNA markers) across a *Mytilus* hybrid zone. Riginos *et al*. (2002) presented data on allele frequency differences for the Baltic *Mytilus edulis* at five allozyme loci, a mitochondrial DNA locus and four nuclear DNA loci. The presence of a hybrid zones has been recently described with microsatellite loci in the acorn barnacle(*Semibalanus balanoides)* (Dufresne *et al*., 2002), in the Atlantic cod(*Gadus morhua)* (Nielsen *et al*., 2003), turbot(*Scophthalmus maximus)* (Nielsen *et al*., 2004). Moreover, it was suggested that multiple hybrid zones are a common phenomenon for the transitional zone between the North Sea and the Baltic Sea marine environment (Nielsen *et al*., 2004).

Genetic variation in marine osmoconforming invertebrates is often restricted to their physiological differentiation regarding response to habitat salinity. Since there is significant salinity gradient in the brackish Baltic Sea, the euryhaline invertebrates, like molluscs are able to reproduce differently in separate zones of the ecosystem. There are two species of epibenthic blue mussel genus *Mytilus – M. edulis* and *M. trossulus,* which are widely distributed in the Baltic Sea. *M. edulis* isn ihabiting mesohaline and marine environment and it is better adapted physiologically to the life in estuarine conditions (Gardner, Thompson, 2001). *M. trossulus* habitats are restricted to the zones of 5-15 (Smietanka *et al*., 2004; Riginos, Cunningham, 2005). The analysis of the intracellular free amino acids in tissues of molluscs from no specified *Mytilus* spp. and *Macoma balthica* confirmed the genetic differentiation of the bivalves. In both bivalves, free amino acids profiles split into a northern Baltic, southern Baltic and Atlantic types (Kube *et al*., 2006).

Therefore, the intra-Baltic subdivision of bivalves has been proved using various approaches. Differences in *Mytilus* allozyme loci and DNA markers revealed existence of mussel sub-units regarding geographical and ecological conditions (McDonald *et al*., 1991; Vöinölä, Hvilsom, 1991; Hummel *et al*., 2001; Bierne *et al*., 2003; Smietanka *et al*., 2004; Kijewski *et al*., 2006). Kattegat populations are characterized by intermediate allozyme loci frequencies between the North Sea and Baltic mussels (Vöinölä, Hvilsom, 1991). The analysis of allozyme loci showed divergence process across the Scandinavian zone of the Baltic Sea. Investigations of mitochondrial DNA profiles revealed an extensive gene flow between *Mytilus edulis* and *Mytilus trossulus* (Rawson, Hilbish, 1998; Quesada *et al*., 1999; Riginos, Cunningham, 2005).

Many bivalve species possess two mtDNA genomes, one of which is inherited maternally (F genome), the other inherited paternally (M genome). Males are usually heteroplasmic as a composition of both genome types, females are homoplasmic (Skibinski *et al*., 1994; Rawson *et al*., 1996; Zauros *et al*., 1994; Wenne, Skibinski, 1995; Stewart *et al*., 1995; Quesada *et al*., 1995, 1996, 1999). The clear evidence of mtDNA recombination in *Mytilus* has been reported in *Mytilus trossulus* from the Gulf of Gdansk of the southern Baltic Sea. The frequency of two recombinant mtDNA genomes (composed of F-like and M-like mtDNA sequences) in homoplasmic sperm was 5% and 36%; nevertheless behave as M genomes in homoplasmic sperm was 5% and 36% behave as M genome (Burzynski *et al*., 2003). Earlier studies presented the evidence of introgression of *M. edulis* mtDNA into Baltic (the Gulf of Gdansk) *M. trossulus* (Quesada *et al*., 1995; Burzynski *et al*., 2003; Kijewski *et al*., 2006). Noteworthy to stress is the fact that in *M. trossulus* from this population, both genomes are similar to the F genome of relative species *M. edulis* (Burzynski *et al*., 2006).

Furthermore, the analyses of three nuclear genes (*Glu 5', MAL-I* and *ITS*) and allozyme loci in Baltic Sea populations disclosed that the majority of mussels (up to 96%) were hybrids with different extent of genotypes from *Mytilus edulis* and *Mytilus trossulus* profiles (Riginos *et al*., 2002; Riginos, Cunningham, 2005).

The other bivalve species *Macoma balthica*, is a common marine mollusc, that inhabits soft coastal sediments of the northern hemisphere. Allozyme studies of the species have indicated genetic differentiation among European populations. The Baltic fauna is generally supposed to be relative to eastern Atlantic populations. However, genetic differentiation data in the Baltic clam do not support this presumption. It should be pointed out, that populations inhabiting the Baltic Sea strongly differ from other European populations of *M. balthica* (Vöinölä, Varvio, 1989; Hummel *et al*., 1995, 1998, 2000).

Nevertheless, bivalves are suitable organisms for molecular ecology studies. DNA markers could be used as a reliable tool to evaluate how genetic divergence occurs among populations of *M. balthica.* Three different mtDNA genotypes across Europe (North Atlantic, South Atlantic and Baltic) have been described. Literature data allow to state, that exist the substantial genetic differentiation among European populations and spatial pattern of highly divergent mtDNA lineages are distributed in the Baltic Sea population. Interestingly, the Baltic mt DNA haplotypes are very similar to *M. balthica* from Alaska.

Moreover, specific mtDNA haplotype was found in Baltic clams with geographic trend of its distribution indicating secondary admixture between Atlantic and Baltic subunits. The level of secondary admixture was equal to zero in clams from Tvärmine (Finland), up to 13% in clams from the Gulf of Riga (Latvia), and up to 47% in clams from the Gulf of Gdansk (Poland), and to 100% in clams from German coast by the Ruegen (Luttikhuizen *et al*., 2003a). Similar data have been obtained in the case of *M. balthica* allozyme analysis (Vöinölä, Varvio, 1989; Hummel *et al*., 2000). The geographical distribution of genetic markers in relation to morphological variation in *Macoma balthica* has also been described (Luttikhuizen *et al*., 2003b).

Strong differences found between the Baltic Sea *Macoma balthica* and other European populations of this species could be explained by multiple colonization of the Atlantic Ocean from the Pacific. Furthermore, the sympatric occurrence of the highly diverged mitochondrial lineages in western parts of the Baltic Sea could be addressed to the secondary admixture (Luttikhuizen *et al*., 2003).

Genetic diversity in the Baltic Sea fish

A special review on allozyme studies in marine fish was presented by Verspoor *et al*., 2005, and some exhaustive publications describing genetic differentiation in Atlantic cod were published by Arnason and Palson (1996), Arnason *et al*.(1998); Nielsen *et al*.(2003, 2006), Poulsen *et al*.(2006), on Baltic herring (King *et al*., 1987; Jorgensen *et al*., 2005; Bekkevold *et al*., 2005; Larson *et al*., 2006), turbot (Nielsen *et al*., 2004, Florin, Hoglund, 2007), northern pike (Laikre *et al*., 2005), Atlantic salmon (Koljonen, Pella, 1997; Koljonen *et al*., 1999, 2002; Nilsson *et al*., 2001; Vasemägi *et al*., 2001; Koljonen, 2006), perch (Nesbo *et al*., 1998), brown trout (Was, Wenne, 2002, 2003; Ostergaard *et al*., 2003) .

Table 1. Comprehensive studies on genetic diversity in the Atlantic cod *Gadus morhua*).

GENETIC DIVERSITY STUDIES	REFERENCE
Nine highly variable microsatellite loci were analyzed in the Atlantic cod from the transitional zone between the North and Baltic Seas. Results: the level of genetic differentiation between cod from the North and Baltic Sea increase along a transect to the Baltic Proper. Western Baltic forms, a central hybrid, genetically divergent zone for cod that inhabit the ecotone of salinity gradient.	Nielsen *et al*., 2003
Eleven microsatellite DNA markers were analyzed in the salmon samples from the Baltic Sea, North Sea, Barents Sea and Newfoundland. Results: one Gmo 132 locus showed elevated genetic differentiation and possible hitch-hiking selection has been investigated at this and other microsatellite loci in Atlantic cod. The recommendation to use a higher number of microsatellite loci to demonstrate population genetic structure in marine fish was underlined.	Nielsen *et al*., 2006
A novel method of single nucleotide polymorphism (SNP) analysis was applied for the first time in marine fish. Results:The nucleotide polymorphisms were demonstrated in the Atlantic cod *Gadus morhua* at mtDNA D-loop and nuclear transferrin genes. Significant differences in haplotype frequency at a D-loop SNP were observed between cod from the Baltic and Atlantic populations.	O'Leary *et al*., 2006
The analysis of DNA from otoliths was used to demonstrate temporal stability of genetic composition of two cod populations from the Bornholm Basin (Baltic Sea) sampled in 1928 and 1997. Results: no loss of genetic variability via genetic bottleneck and weak but significant genetic changes over time were detected for the Bornholm Basin population.	Poulsen *et al*., 2006
In order to investigate potential interbreeding between hatchery and wild cod, a genetically homozygotic, for a rare allele (*GPI-1*30*), cod strain was developed.	Jorstad *et al*., 2004
Analytical screening of 10 polymorphic microsatellite loci in cod. Results: a weak, but consistent, differentiation at all 10 loci has been detected. The current study data have demonstrated that genetically differentiated populations can appear and survive in the absence of physical barriers or being isolated by large distance.	Knutsen *et al*., 2003

The other papers on Atlantic cod provide data on genetic differentiation based by mtDNA and microsatellite analysis (Arnason, Palsson, 1996; Arnason *et al*., 1998; Arnason, 2004; O'Leary *et al*., 2006).

High genetic differentiation among various populations of the Atlantic salmon has been described in the Baltic Sea (Koljonen *et al*., 1999, 2002; Nilsson *et al*., 2001; Koljonen, 2006). Nevertheless, the reduction of genetic variability was shown within salmon hatchery stocks (Stahl, 1983). Since the large-scale salmon hatcheries industry is well developed in the Baltic Sea and extensive straying from geographically distant hatchery releases into Baltic wild salmon population, the existence of genetic risk was emphasized (Vasemagi *et al*., 2005). Literature data show that hatcheries can release approximately nine times more salmon smolts into the Baltic Sea than is reproduced by wild populations (ICES, 1998). Consequently, the recolonization and gene flow from the reared salmon populations can impoverish genetic heterogeneity of wild populations. The occurence of first-generation hybrids between wild and hatchery salmon individuals was described by Vasemagi *et al*. (2001, 2005).

Table 2. Comprehensive studies on genetic diversity in the Atlantic salmon *Salmo salar.*

GENETIC DIVERSITY STUDIES	REFERENCES
Polymerase chain reaction–restriction fragment length polymorphism (PCR–RFLP) analysis of the mitochondrial ND1 region was performed in 60 salmon populations in Northern Europe (in 3095 specimens). Main findings: there are three ND1 haplotypes within the Baltic Sea and the differences are pointed out between the Swedish west-coast populations and those from the southern Baltic.	Nilsson *et al*., 2001
Mitochondrial mtDNA and six microsatellite loci analysed in salmon. Background: Hatchery industry produce about 90% of salmon smolts in the Baltic Sea and present genetic risk for the wild populations via immigration of reared salmon into wild populations. Results: gene flow from hatcheries poses a serious threat to the genetic diversity of wild populations in the Baltic Sea.	Vasemagi, 2004
Genetic diversity assessed using mtDNA and microsatellite markers. Results: the rate and impact of immigration from the hatchery stocks of Atlantic salmon in the Gulf of Bothnia into the largest wild salmon populations in the Baltic Sea has been detected during the surveys carried out for 18 years (1985-2003).	Vasemagi *et al*., 2005a
Eight microsatellite loci and six gene-associated markers (micro- and mini-satellites) analysed. Results: patterns of genetic diversity and differentiation among five wild and four hatchery populations of Atlantic salmon in the Baltic Sea are described.	Vasemagi *et al*., 2005b

Table 3. Comprehensive studies on genetic diversity in the Baltic herring *Clupea harengus.*

DNA MARKERS	REFERENCES
Analysis of variability at nine microsatellite loci in 11 spring-spawning locations collected throughout the Baltic Sea. Results: sympatrically spawning but genetically divergent “spawning waves” of herring in the environmentally heterogenic Baltic Sea are described. The two Baltic zones with lowered gene flow were concordant in principle with the environmental gradient, herring migration pattern and subdivision of the Baltic Sea into major basins.	Jorgensen *et al*., 2005
Two regions of the mtDNA of Atlantic herring, *ND3/4* and *ND5/6* indicated genetic differences between Baltic Sea and Celtic Sea herring.	Hauser *et al*., 2001

Summing up, it should be stressed, that because marine pollution has received little attention in the sense of genetic diversity, direct effects including negative impacts of heavy metals, polycyclic aromatic hydrocarbons (PAH), chlorinated organic and other mutagenic compounds should be in focus as potential hazard to the Baltic fish and other organisms. The mentioned causes are likely to be complementary rather than exclusive. The use of bivalves in pollution monitoring has prompted the genomic study of the cell and organism responses to xenobiotics, which should expand into the field of phytoplankton toxins. Future work should also pay more attention to the larval stages, and to basic processes such as growth, sex-determination, and gonad development.

Scientists should concentrate on the fact that the Pacific oyster (*Crassostrea gigas*) is now the focus of an international genome-sequencing consortium. Therefore, the mollusc can serve as a model organism to study many aspects of environmental pollution and genotoxic impacts in the Baltic Sea. The Baltic environmental genotoxicity was analysed in different fish and mollusc species inhabiting offshore and coastal zones in Sweden, Germany, Poland and Lithuania (Baršienė, Baršytė Lovejoy, 2000; Baršienė, 2002; Baršienė *et al*., 2004, 2005, 2006a, 2006b; Schiedek *et al*., 2006; Kopecka *et al*., 2006). The highest level of genotoxicity was observed in fish and mussels from the Gulf of Gdansk. Furthermore, high levels of contaminant accumulation, morphological alterations and prevalence of carcinogenesis in *Macoma balthica* from the Gulf of Gdansk has been described earlier (Sokolowski *et al*., 2002, 2004).

The history of aquatic environmental pollution goes back very deeply; however, the subject did not receive much attention until a threshold level was reached with adverse consequences on different levels of biological organization. Marine pollution has become a global concern and knowledge of the pollution impacts on ecosystem is important for better understanding the ecosystem responses to pollutants but also to create prevention measures and appropriate managementdecisions.

References

Almodóvar, A., Incola, G.G., Elvira, B., Garcia-Martin, J.L. 2006. Introgression variability among Iberian brown trout Evolutionary Significant Units: the influence of local management and environmental features. Freshwater Biology, 51: 1175–1187.

Árnason, E., and Palsson, S. 1996. Mitochondrial cytochrome *b* DNA sequence variation of Atlantic cod *Gadus morhua*, from Norway. Mol. Ecol. 5: 715–724.

Árnason, E., Palsson, S., Petersen, P.H. 1998. Mitochondrial cytochrome *b* DNA sequence variation of Atlantic cod, *Gadus morhua*, from the Baltic Sea and the White Sea. Hereditas, 129: 37–43.

Árnason, E. 2004. Mitochondrial cytochrome *b* DNA variation in the high-fecundity Atlantic cod: trans-Atlantic clines and shallow gene genealogy. Genetics, 166: 1871–1885.

Avise, J.C. 2000. Phylogeography: the history and formation of species. Harvard University Press, Cambridge, Mass.

Ayllon, F., Martinez, J.L., Garcia-Vazquez, E. 2006. Loss of regional population structure in Atlantic salmon, *Salmo salar* L., following stocking. ICES J. Marine Sci, 2006, 63: 1269–1273.

Baršienė, J, Baršytė, and Lovejoy, D. 2000. Peculiarities of environmental genotoxicity in Klaipėda port area. International Review of Hydrobiology, 85, 5–6, p. 659–668.

Baršienė, J. 2002. Genotoxic impacts in Klaipėda port and Būtingė oil terminal areas (Baltic Sea). Marine Environmental Research, 54, 3–5: 475–479.

Baršienė, J., Lazutka, J., Šyvokienė, J., Dedonytė, V., Rybakovas, A., Bagdonas, E., Bjornstad, A., Andersen, O.K. 2004. Analysis of micronuclei in blue mussels and fish from the Baltic and North Seas. Environmental Toxicology, 19: 365–371.

Baršienė J., Dedonytė, V., Rybakovas, A., Broeg, K., Forlin, L. , Gercken, J., Kopecka, J., and Balk, L. 2005a. Environmental mutagenesis in different zones of the Baltic Sea. Acta Zoologica Lituanica, 15: 90–95.

Baršienė J., Schiedek D., Rybakovas A., Šyvokienė J., Kopecka J., and Forlin L. 2006d. Cytogenetic and cytotoxic effects in gill cells of the blue mussel *Mytilus spp.* from different zones of the Baltic Sea. Marine Pollution Bulletin, 53: 469–478.

Baršienė, J., Lehtonen, K., Koehler, A., Broeg, K., Vourinen, P.J., Lang, T., Pempkowiak, J., Šyvokienė, J., Dedonytė, V., Rybakovas, A., Repečka, R., Vountisjarvi, H., Kopecka, J. 2006e. Biomarker responses in flounder (*Platichthys flesus*) and mussel (*Mytilus edulis*) in the Klaipėda-Būtingė area (Baltic Sea). Marine Pollution Bulletin, 53: 422–436.

Schiedek, D., Broeg, K., Baršienė, J., Lehtonen, K.K., Gercken, J., Pfeifer, S., Vountisjarvi H., Vuorinen, P.J., Dedonytė, V., Koehler, A., Balk, L., Schneider, R. 2006. Biomarker responses as indication of contaminant effects in blue mussel (*Mytilus edulis*) and female eelpout (*Zoarces viviparus*) from the south-western Baltic Sea. Marine Pollution Bulletin, 53: 387–405.

Kopecka, J., Lehtonen, K., Baršienė, J., Broeg, K., Vuorinen, P.J., Gercken, J., Pempkowiak, J. 2006. Measurements of biomarker levels in flounder (*Platichthys flesus*) and mussel (*Mytilus trossulus*) from the Gulf of Gdańsk (southern Baltic). Marine Pollution Bulletin, 53: 406–421.

Bazin, E., Glemin, S., Galtier, N. 2006. Population size does not influence mitochondrial genetic diversity in animals. Science, 2006, 28, 312(5773): 570–572.

Bekkevold, D, Andre, C, Dahlgren, TG, Clausen, LA, Torstensen, E, Mosegaard H, Carvalho GR, Christensen TB, Norlinder E, Ruzzante DE. 2005. Environmental correlates of population differentiation in Atlantic herring. Evolution Int J. Org Evolution, 59(12): 2656–2668.

Bekkevold, D., Hansen, M.M., and Nielsen, E.E. 2006. Genetic impact of gadoid culture on wild fish populations: predictions, lessons from salmonids, and possibilities for minimizing adverse effects. ICES J. Mar. Sci., 63: 198–208.

Bergstrom, L., Tatarenkov, A., Johannesson, K., Jonsson, R.B., Kautsky, L. 2005. Genetic and morphological identification of *Fucus radicans* sp. Nov. (Fucales, Phaeophyceae) in the brackish Baltic Sea. Journal of Physiology, 41: 1025–1038.

Bierne, N., Daguin, C., Bonhomme, F., David, P., and Borsa, P. 2003. Direct selection on allozymes is not required to explain heterogeneity among marker loci across a *Mytilus* hybrid zone. Molecular Ecology, 12: 2505–2510.

Borsa P., Blanquer A., Berrebi P. 1997. Genetic structure of the flounders *Platichthys flesus* and *P. stellatus* at different geographic scales. Marine Biology, 129: 233–246.

Bulnheim H-P., and Scholl A. 1981. Genetic variation between geographic populations of the amphipods *Gammarus zaddachi* and *G. salinus*. Marine Biology, 64: 105–115.

Burzyński A., Zbawicka M., Skibinski D.O.F., Wenne R. 2003. Evidence for recombination of mtDNA in the marine mussel *Mytilus trossulus* from the Baltic. Molecular Biology and Evolution, 20(3): 388–392.

Burzyński A., Zbawicka M., Skibinski D.O.F., Wenne R. 2006. Doubly uniparental inheritance is associated with high polymorphism for rearranged and recombinant control region haplotypes in Baltic *Mytilus trossulus*. Genetics, doi:10.1534/genetics.106.063180 Critescu M.E.A., Hebert P.D.N., MacIsaac H.J., Grigorovish I.A. 2001. An invasion history for *Cercopagis pengoi* based on mitochondrial gene sequences. Limnology and Oceanography, 46: 224–229.

Cognetti G., Maltagliati, F. 2000. Biodiversity and Adaptive Mechanisms in Brackish Water Fauna. Marine Poll. Bull. 2000, 40: 7–14.

Cognetti, G., and Maltagliati, F. 2004. Strategies of genetic biodiversity conservation in the marine environment. Marine Poll. Bull., 48 (9–10): 811–812.

Florin A-B., Hoglung J. 2007. Absence of population structure of turbot (*Psetta maxima*) in the Baltic Sea. Mol. Ecol. 16(1): 115–126.

Fritzer N.G., Hansen M.M., Madsen S.S., Kristiansen K. 2001. Use of microesatellite markers for identification of indigenous brown trout in a geographical region heavily influenced by stocked domensticated trout. J.Fish Biol. 58: 1197–1202.

Furman E. 1989. Enzyme genetic variation in *Balanus improvisus* Darwin (Crustacea: cirripedia) in the Baltic Sea. Ophelia, 30: 35–45.

Garcia-Vazquez E., Izquierdo J.I., Perez J. 2006. Genetic variation at ribosomal genes supports the existence of two different European subspecies in the megrim *Lepidorhombus whiffiagonis.* Journal of Sea Research, 56: 59–64.

Gardner J.P.A., Thompson R.J. 2001. The effects of coastal and estuarine conditions on the physiology and survivorship of the mussels *Mytilus edulis*, *M. trossulus* and their hybrids. J. Exper. Marine Biol. Ecol., 265: 119–140.

Gilbey J., Knox D., O'Sullivan M., Verspoor E. 2005. Novel DNA markers for rapid, accurate, and cost-effective discrimination of the continental origin of Atlantic salmon (*Salmo salar* L.). ICES J. Marine Sci., 62: 1609–1616.

Goodman S.J. 1998. Patterns of extensive genetic differentiation and variation among European harbor seals (*Phoca vitulina*) revealed using Microsatellite DNA polymorphisms. Molecular Biology and Evolution. 15: 104–118.

Hansen M.M., Loeschcke V., Rasmussen G., Simonsen V. 1993. Genetic Differentiation among Danish Brown Trout (*Salmo trutta*) Populations. Hereditas 118: 177–185.

Hansen M.M., Ruzzante D.E., Nielsen E.E., Mensberg K.D. 2000. Microsatellite and mitochondrial DNA polymorphism reveals life-history dependent interbreeding between hatchery and wild brown trout (*Salmo trutta* L.). Molecular Ecology, 9: 583–594.

Hansen M.M., Nielsen E.E., Bekkevold D., Mensberg K.L.D.2001. Admixture analysis and stocking impact assessment in brown trout (*Salmo trutta* L.), estimating with incomplete baseline data. Canadian Journal of Fishery and Aquatic Sciences, 58: 1853–1860.

Hansen M.M., Kenchington E., Nielsen E.E. 2001. Assigning individual fish to populations using microsatellite DNA markers. Fish and Fischeries, 2: 93–112.

Hansen M.M. 2002. Estimating the long-term effects of stocking domesticated trout into wild brown trout (*Salmo trutta*) populations: an approach using microsatellite DNA analysis of historical and contemporary samples. Molecular Ecology, 11: 1003–1015.

Hansen M.M., Ruzzante D.E., Nielsen E.E., Bekkevold D., Mensberg K.L.D. 2002. Long-term effective population sizes, temporal stability of genetic composition and potential for local adaptation in anadromous brown trout (*Salmo trutta*) populations. Molecular Ecology, 11: 2523–2535.

Hansen M.M., Bekkevold D., Jensen L.F., Mensberg K.L.D., Nielsen E.E., 2006. Genetic restoration of a stocked brown trout *Salmo trutta* population using microsatellite DNA analysis of historical and contemporary samples. Journal of Applied Ecology, 43: 669–679.

Härkönen T., Harding K.J., Goodman SJ, Johannesson K. 2005. Colonization history of the Baltic harbor seals: integrating archaeological, behavioral and genetic data. Marine Mammal Science, 21: 695–716.

Hauser L., Turan C., Carvalho G.R. 2001. Haplotype frequency distribution and discriminatory power of two mtDNA fragments in a marine pelagic teleost (Atlantic herring, Clupea harengus). Heredity 87: 621–630.

Hindar K., Fleming I. A., McGinnity P., Diserud O. 2006. Genetic and ecological effects of salmon farming on wild salmon: modelling from experimental results. ICES J. Mar. Sci., 63: 1234–1247.

Hilbish T.J. 1996. Population genetics of marine species: the interaction of natural selection and historically differentiated populations. J. Exper. Marine Biol. Ecol., 200: 67–83.

Hoarau G., A. M. -T. Piquet, H. W. van der Veer, A. D. Rijnsdorp, W. T. Stam and J. L. Olsen. 2004. Population structure of plaice (*Pleuronectes platessa* L.) in northern Europe: a comparison of resolving power between microsatellites and mitochondrial DNA data. Journal of Sea Research, 51: 183–190.

Hummel H., Colucci F., Bogaards R.H., Strelkov P. 2001. Genetic traits in the bivalve *Mytilus* from Europe, with an emphasis on Arctic populations. Pol.ar Biol. 24: 44–52.

Hummel H., M. Wolowicz and R. H. Bogaards 1994. Genetic variability and relationships for populations of *Cerastoderma edule* and of the *C. Glaucum* complex. Netherlands J. Sea Research, 33: 81–89.

Hummel H., Bogaards R.H., Amiard-Triquet C., Bachelet G., Desprez M., Marchand J., Rybarczyk H., Sylvand B., de Wit Y., de Wolf L. 1995. Uniform variation in genetic traits of a marine bivalve related to starvation, pollution and geographic clines J.Exper. Marine Biol. Ecol., 191: 133–150.

Hummel H., Bogaards R., Bek T., Polishchuk L., Sokolov K., Amiard-Triquet C., Bachelet G., Desprez M., Naumov A., Strelkov P., Dahle S., Denisenko S., Gantsevich M., de Wolf L. 1998. Growth in the bivalve *Macoma balthica* from its northern to its southern distribution limit: a discontinuity in North Europe because of genetic adaptations in Arctic populations? Comp Bioch. Physiol Part A: Molecular and Integrative Physiol., 120: 133–141.

ICES. 1998. Report of the Baltic salmon and trout assessment working group. ICES Doc. CM 1998/ ACFM: 17. ICES, Copenhagen.

Johannesson K., Kautsky N., Tedengreen M. 1990. Genotypic and phenotypic differences between Baltic and North Sea populations of *Mytilus edulis* evaluated through reciprocal transplantations. II. Genetic variation. Marine Ecology Progress Serries, 59: 211-219.

Johannesson K., Andre C. 2006. Life on the margin: genetic isolation and diversity loss in a peripheral marine ecosystem, Baltic Sea. Molecular Ecology, 15: 2013-2029.

Jørgensen H.B.H., Hansen M.M., Bekkevold D., Ruzzante D.E., Loeschcke V. 2005. Marine landscapes and population genetic structure of herring (*Clupea harengus L.*) in the Baltic Sea. Molecular Ecology, 14: 3219–3234.

Jørgensen H.B.H., Hansen M.M., Loeschcke V. 2005. Spring-spawning herring (*Clupea harengus*) in the south-western Baltic Sea: do they form genetically distinct spawning waves? ICES Journal of Marine Science, 62: 1065–1075.

Jørstad K.E., Nævdal G., Karlsen O., Torkildsen S., Paulsen O.I., Ottera H. 2004. Long-term studies on genetic interaction between wild and ranched cod *Gadus morhua* by use of a genetic marked strain. J. Fish Biol., 65: 318–319.

King, D. P. F., Ferguson, A., and Moffett, I. J. J. 1987. Aspects of the population genetics of herring, *Clupea harengus*, around the British Isles and in the Baltic Sea. Fish Res.,6: 35–52.

Knutsen, H., Jorde, P. E., Andre, C., and Stenseth, N.C. 2003. Fine-scaled geographic population structuring in a highly mobile marine species: the Atlantic cod. Molecular Ecology, 12: 385–394.

Koljonen, M.-L., and Pella, J. J. 1997. The advantage of using smolt age with allozymes for assessing wild stock contributions to Atlantic salmon catches in the Baltic Sea. ICES J. Marine Sci., 54: 1015–1030.

Koljonen, M.-L., Jansson, H., Paaver, T., Vasin, O., Koskiniemi, J. 1999. Phylogeographic lineages and differentiation pattern of Atlantic salmon (*Salmo salar L.*) in the Baltic Sea with management implications. Canadian Journal of Fishery and Aquatic Sciences, 56: 1766–1780.

Koljonen, M.-L., Tähtinen, J., Säisä, M., and Koskiniemi, J. 2002. Maintenance of genetic diversity of Atlantic salmon (*Salmo salar*) by captive breeding programmes and the geographic distribution of microsatellite variation. Aquaculture, 212: 69–92.

Koljonen M.-L. 2006. Annual changes in the proportions of wild and hatchery Atlantic salmon (*Salmo salar*) caught in the Baltic Sea. ICES J Marine Sci., 63: 1274–1285.

Kube, S., Gerber, A., Jansen, J.M., and Schiedek, D. 2006. Patterns of organic osmolytes in two marine bivalves, *Macoma balthica,* and *Mytilus* spp., along their European distribution. Marine Biology, 149: 1387–1396.

Ladoukakis E.D., and Zouros E. 2001. Direct evidence for homologous recombination in mussel (*Mytilus galloprovincialis*) mitochondrial DNA. Mol. Biol. Evol., 18: 1168–1175.

Laikre L., Miller L.M., Palme A., Palm S., Kapuscinski A.R., Thoresson G., Ryman N. 2005. Spatial genetic structure of northern pike (*Esox lucius*) in the Baltic Sea. Molecular Ecology, 14(7): 1955–1964.

Laikre L., Palm S., Ryman N. 2005. Genetic population structure of fishes: implications for coastal zone management. Ambio, 34:111–119.

Langefors A.H. 2005. Adaptive and Neutral Genetic Variation and Colonization History of Atlantic Salmon, *Salmo salar* Environ. Biol of Fishes, 2005, 74: 297–308.

Lasota R., Hummel H., Wolowicz M. 2004. Genetic diversity of European populations of the invasive soft-shell clam *Mya arenaria* (Bivalvia). Journal of the Marine Biological association UK, 84: 1051–1056.

Larsson L.C., Laikre L., Palm S., Andre C., Carvalho G.R., Ryman N. 2007. Concordance of allozyme and microsatellite differentiation in a marine fish, but evidence of selection at a microsatellite locus. Molecular Ecology, in press. doi:10.1111/j.1365–294X.2006.03217.x

Leppakoski E., Gollasch S., Gruszka P., Ojaveer H., Olenin S., Panov V. 2002. The Baltic – a sea of invaders. Canadian Journal of Fisheries and Aquatic Sciences, 59: 1175–1188.

López J.L. 2005. Role of proteomics in taxonomy: the *Mytilus* complex as a model of study. J. Chromatography, 815:261–274.

Luttikhuizen P.C., Pijnacker L.P. 2002. Mosaic haploid-diploid embryos and polyspermy in the tellinid bivalve Macoma balthica. Genome, 2002, 45: 59–62.

Luttikhuizen P.C., Drent J., Baker A.J. 2003. Disjunct distribution of highly diverged mitochondrial lineage clade and population subdivision in a marine bivalve with pelagic larval dispersal. Molecular Ecology, 12: 2215–2229.

Luttikhuizen P.C., Drent J.,Van Delden W., Piersma T. 2003. Spatially structured genetic variation in a broadcast spawning bivalve: quantitative vs. molecular traits. J. Evol. Biol., 16: 260–272.

McKay J.K., Cristian C.E., Harrison S., Rice K.J. 2005. “How local is local?” – A review of practical and conceptual issues in the genetics of restoration. Restoration Ecology, 13: 432–440.

Kijewski T., Zbawicka M., Väinölä R., Wenne R. 2006. Introgression and mitochondrial DNA heteroplasmy in the Baltic populations of mussels Mytilus trossulus and M. edulis. Marine Biology, 149 (6): 1371–1385.

Maes G.E., Pujolar J.M., Hellemans B., Volckaert F.A.M. 2006. Evidence for isolation by time in the European eel (*Anguilla anguilla*). Molecular Ecology, 15: 2095–2107.

Matson C.W., Franson J.C., Hollmen T., Kilpi M., Hario M., Flint P.L., Bickham J.W. 2004. Evidence of chromosomal damage in common eiders (*Somateria mollissima*) from the Baltic Sea. Marine Pollution Bulletin, 49: 1066–1071.

McDonald J.H., Seed R., Koehn R.K. 1991. Allozymes and morphological characters of three species of *Mytilus* in the Northern and Southern Hemispheres. Marine Biol. 111: 323–333.

Mjolnerod I.B., Refseth U.H., Karlsen E., Balstad T., Jacobsen K.S., Hindar K. 1997. Genetic Differences Between Two Wild and One Farmed Population of Atlantic Salmon (*Salmo salar*) Revealed by Three Classes of Genetic Markers. Hereditas 127: 239–248.

Nesbo C.L., Fossheim T., Vollestad L.A., Jacobsen K.S. 1999. Genetic divergence and phylogeographic relationships among european perch (Perca fluviatilis) populations reflect glacial refugia and postglacial colonization. Mol. Ecol. , 8(9): 1387–1404.

Nielsen E.E., Hansen M.M., Ruzzante D.E., Meldrup D., Gronkjaer P. 2003. Evidence of a hybrid-zone in Atlantic cod (*Gadus morhua*) in the Baltic and the Danish Belt Sea revealed by individual admixture analysis. Molecular Ecology, 12: 1497–1508.

Nielsen E.E., Nielsen P.H., Meldrup D., Hansen M.M. 2004. Genetic population structure of turbot (*Scophthalmus maximus L.*) supports the presence of multiple hybrid zones for marine fishes in the transition zone between the Baltic Sea and the North Sea. Molecular Ecology, 13: 585–595.

Nielsen E.E., Hansen M.M., Meldrup D. 2006. Evidence of microsatellite hitch-hiking selection in Atlantic cod (*Gadus morhua*): implications for inferring population structure in nonmodel organisms. Molecular Ecology, 15: 1–9.

Nilsson J., Gross R., Asplund T., Dove O., Jansson H., Kelloniemi J *et al*., 2001. Matrilinear phylogeography of Atlantic salmon (*Salmo salar* L.) in Europe and postglacial colonization of the Baltic Sea area. Molecular Ecology, 10: 89–102.

O'Leary D.B., Coughlan J., McCarthy T.V., Cross T.F. 2006. Application of a rapid method of SNP analysis (glycosylase mediated polymorphism detection) to mtDNA and nuclear DNA of cod *Gadus morhua*. J. Fish Biol., 69: 145–153.

Olsen JL., Stam WT., Coyer JA. 2004. North Atlantic phylogeography and large-scale population differentiation of the seagrass *Zostera marina* L. Molecular Ecology, 13: 1923–1941.

Ostergaard S., Hansen M.M., Loeschke V., Nielsen E.E. 2003. Long-term temporal changes of genetic composition in brown trout (*Salmo trutta L.*) populations inhabiting an unstable environment. Molecular Ecology, 12: 3123–3135.

Pogson G.H., Mesa K.A., Boutilier R.G. 1995. Genetic population structure and gene flow in the Atlantic cod Gadus morhua: a comparison of allozyme and nuclear RFLP loci. Genetics,139(1):375–385.

Poulsen N.A., Nielsen E.E., Schierup M.H., Loeschcke V. Gronjaer P. Long-term stability and effective population size in the North Sea and Baltic Sea cod (*Gadus morhua*). Molecular Ecology, 15: 321–331.

Primmer C.R., Veselov A.J., Zubchenko A., Poututkin A., Bakhmet I. 2006. Isolation by distance within a river system: genetic population structuring of Atlantic salmon, *Salmo salar*, in tributaries of the Varzuga River in northwest Russia. Molecular Ecology, 15: 653–666.

Quesada H., Wenn R., Skibinski D.A.G., 1995. Differential introgression of mitochondrial DNA across species boundaries within the marine mussel genus *Mytilus.* Proc. R. Soc. London B, 262: 51–56.

Quesada H., Skibinski D.A.G., Skibinski D.O.F. 1996. Sex-based heteroplasmy and mitochondrial DNA inheritance in the mussel *Mytilus galloprovincialis* Lmk. Curr. Genet., 29: 423–426.

Quesada H., Wenn R., Skibinski D.A.G., 1999. Interspecific transfer of female mitochondrial DNA is coupled within role-reversals and departure from neutrality in the mussel *Mytilus trossulus*. Mol. Biol. Evol., 16: 655–665.

Rawson P. D., Secor C. L., Hilbish T. J.. 1996.The effects of natural hybridization on the regulation of doubly uniparental mtDNA inheritance in blue mussels (*Mytilus* spp.). Genetics, 144(1): 241–248.

Reed D.C., Frankham R. 2003. Correlation between fitness and genetic diversity. Conservation Biology, 17: 230–237.

Reusch TBH., Ehlers A., Hammerli A., Worm B. 2005. Ecosystem recovery after climatic extremes enhanced by genotypic diversity. Proceedings of the National Academy of Sciences, USA, 102: 2826–2831.

Refseth U.H., Nesbo C.L., Vollestad L.A., Fjeld E., Jacobsen K.S. 1998. Genetic evidence for different migration routes of freshwater fish into Norway revealed by analysis of current perch (*Perca fluviatilis*) populations in Scandinavia. Mol. Ecol. 7: 1015–1027.

Riginos C., Cunningham C.W. 2005. Local adaptation and species segregation in two mussel (*Mytilus edulis* x *Mytilus trossulus*) hybrid zones. Molecular Ecology, 14: 381–400.

Riginos C., Sukhdeo K., Cunningham C.W. 2002. Evidence for selection at multiple allozyme loci across a mussel hybrid zone. Molecular Biology and Evolution, 19: 347–351.

Ringway G., Nævdal G. 2004. Genotypes of *Mytilus* from waters of different salinity around Bergen, Norway. Helgolander Marine Research, 58: 104–109.

Röhner M., Bastrop R., Jürss K. 1996. Genetic differences between two allopatric populations (or sibling species) of the polychaete genus Marenzelleria in Europe. Comp Biochem Physiol, Part B, 1996, 2: 185–192.

Röhner M., Bastrop R., Jurss K. 1997. Genetic differentiation in *Hediste diversicolor* (Polychaeta: Nereididae) for the North Sea and the Baltic Sea. Marine Biology, 130: 171–180.

Roark SA, Nacci D, Coiro L, Champlin D, Guttman SI. 2005. Population genetic structure of a nonmigratory estuarine fish (Fundulus heteroclitus) across a strong gradient of polychlorinated biphenyl contamination. Environ.Toxicol. Chem., 24 (3): 717–725.

Romakkaniemi A., I. Perä, L. Karlsson, E. Jutila, U. Carlsson and T. Pakarinen. 2003. Development of wild Atlantic salmon stocks in the rivers of the northern Baltic Sea in response to management measures. ICES J.of Marine Sci., 60, 2:329–342.

Ruzzante D.E., Hansen M.M., Meldrup D., Ebert K.M. 2004. Stocking impact and migration pattern in an anadromous brown trout (*Salmo trutta*) complex: where have all the stocked spawning sea trout gone? Mol. Ecol. 13: 1433–1445.

Saavedra C., Bachère E. 2006. Bivalve genomics. Aquaculture, 256: 1–14.

Scott D. 2001. Chemical pollution as a factor affecting the sea survival of Atlantic salmon, *Salmo salar* L. Fisheries Management and Ecology, 8: 487–499.

Skibinski D.F., Gallagher C., Quesada H. 1999. On the roles of selection, mutation and drift in the evolution of mitochondrial DNA diversity in British *Mytilus edulis* (Mytilidae; Mollusca) populations. Biological J. of the Linnean Society, 68:195–213.

Śmietanka B., Zbawicka M., Wołowicz M., Wenne R. 2004. Mitochondrial DNA lineages in the European populations of mussels Mytilus. Marine Biology, 146 (1): 79 – 92.

Sokolowski A, Fichet D, Garcia-Meunier P,Radenac G, Wolowicz M,

Blanchard G. 2002. The relationship between metal concentrations and phenotypes in the Baltic clam *Macoma balthica* (L.) from the Gulf of Gdansk, southern Baltic. Chemosphere. 47(5):475–484.

Sokolowski A, Wolowicz M., Hummel H., Smolarz-Gorska K., Fichet D., Radenac G., Thiriot-Quievreux C., Namiesnik J. 2004. Abnormal features of *Macoma balthica* (Bivalvia) in the Baltic Sea: alerting symptoms of environmental adversity. Marine Pollution Bulletin, 49: 17–22.

Stahl G. 1983. Differences in the amount and distribution of genetic variation between natural populations and hatchery stocks of Atlantic salmon. Aquaculture, 33: 23–32.

Stewart D.T., Saavedra C., Stanwood R.R., Ball R.R., Zouros E. 1995. Male and female mitochondrial DNA lineages in the blue mussel (*Mytilus edulis*) species group. Mol. Biol. Evol. 12: 735–747.

Schwartz M.K., Mills L.S., Ortega Y., Ruggiero L.F., Allendorf F.W. 2003. Landscape location affects genetic variation of Canada lynx (*Lynx canadiensis*). Molecular Ecology, 12: 1807–1816.

Tatarenkov A., Bergstrom L., Jonsson RB. *et al*. 2005. Intriguing asexual life in marginal populations of the brown seaweed *Fucus vesiculosus*. Molecular Ecology, 14: 647–651.

Väinölä R. 2003. Repeated trans-Arctic invasions of littoral bivalves: molecular zoogeography of the *Macoma balthica* complex. Marine Biology, 143: 935–946.

Väinölä R., Hvilsom M.M. 1991. Genetic divergence and a hybrid zone between Baltic and North Sea *Mytilus* populations (Mytiliidae: Mollusca). Biological Journal of the Linnean Society, 43: 127–148.

Varvio SL., Koehn RK., Väinölä R. 1988. Evolutionary genetics of the *Mytilus edulis* complex in the North Atlantic region. Marine Biology, 98: 51–60.

Vasemagi A., Gross R., Paaver T., Kangur M., Nilsson J., Eriksson L-O. 2001. Identification of the origin of an Atlantic salmon (*Salmo salar L.*) population in a recently recolonized river in the Baltic Sea. Molecular Ecology, 10: 2877–2882.

Vasemagi A., Gross R., Paaver T., Koljonen M.L., Nilsson J. 2005. Extensive immigration from compensatory hatchery releases into wild Atlantic salmon population in the Baltic sea: spatio-temporal analysis over 18 years. Heredity, 2005, 95: 76–83.

Vasemagi A., Gross R., Paaver T., Koljonen M.L., Säisä M., Nilsson J. 2005. Analysis of gene associated tandem repeat markers in Atlantic salmon (*Salmo salar L.*) populations: implications for restoration and conservation in the Baltic Sea. Conservation Genetics,6: 385–397.

Vasemagi A. 2004. Compensatory releases reduce genetic differentiation among Atlantic salmon populations in the Baltic Sea: evidence from the River Ume-Vindelälven. J. Fish Biol., 65: 324–325.

Vasemagi A., Primmer C.R. 2005. Challenges for identifying functionally important genetic variation: the promise of combining complementary research strategies. Mol. Ecol. 14: 3623–3642.

Venier P., Cristiano De Pittà, Alberto Pallavicini, Francesco Marsano, Laura Varotto, Chiara Romualdi, Francesco Dondero, Aldo Viarengo and Gerolamo Lanfranchi. 2006. Development of mussel mRNA profiling: Can gene expression trends reveal coastal water pollution? Mutat. Res. 602: 121–134.

Verspoor E., Beardmore J.A., Consuegra S., Garcia de Leaniz C., Hindar K., Jordan W.C., Koljonen M.-L., Mahkrov A.A., Paaver T., Sanchez J.A., Skaala Ǿ., Titov S., Cross T.F. 2005. Population structure in the Atlantic salmon: insights from 40 years of research into genetic protein variation. J. Fish Biol., 67: 3–54.

Was A., Wenne R. 2002. Genetic differentiation in hatchery and wild sea trout (*Salmo trutta*) in the southern Baltic at microsatellite loci. Aquaculture, 204: 493–506.

Was A., Wenne R. 2003. Microsatellite DNA polymorphism in intensely enhanced populations of Sea trout (*Salmo trutta*) in the southern Baltic. Marine Biotechnology, 5: 234–243.

Wenne R., Skibinski D.O.F. 1995. Mitochondrial DNA heteroplasmy in European populations of the mussel *Mytilus trossulus*. Marine Biol. 122: 619–624.

Williams T.D., Gensberg K., Minchin S.D., Chipman J.K. 2003. A DNA expression array to detect toxic stress response in European flounder (*Platichthys flesus*). Aquatic Toxicology, 65: 141–157.

Woznicki P. Jankun M., Kucharczyk D., Baron A., Luczynski M. 1999. Cytogenetic characterization of sea trout (*Salmo trutta*) from Poland. Copeia, 2: 501–505.

Wood AR., Beaumont A.R., Skibinski DOF., Turner G. 2003. Analysis of a nuclear_DNA marker for species identification of adults and larvae in the *Mytilus edulis* complex. Journal of Molluscan Studies, 69: 61–66.

Youngson A.F., W. C. Jordan, E. Verspoor, P. McGinnity, T. Cross and A. Ferguson. 2003. Management of salmonid fisheries in the British Isles: towards a practical approach based on population genetics. Fish Res., 62: 193–209.

Zbawicka M., Wenne R., Skibinski DOF. 2003. Mitochondrial DNA variation in populations of the mussel *Mytilus trossulus* from the Southern Baltic. Hydrobiologia, 499: 1–12.

Zbawicka M., Skibinski D.O.F., Wenne R. 2003. Doubly uniparental transmission of mitochondrial DNA length variants in the mussel *Mytilus trossulus*. Marine Biology, 142: 455–460.

Annex 13: Revised table of indicators on Habitat Destruction and Loss of Biodiversity:

(List of selected biodiversity indicators with evaluation of possibilty to establish reference conditions and target levels, revised by Georg Martin ang Henn Ojaveer)

INDICATOR	INDICATOR TYPE	REFERENCE CONDITIOND	TARGET LEVELS	REMARKS
Status of Baltic Sea Protected Areas - Area percentage of the MPA from total Baltic Sea area	D	Not applicable	10% short term 30% long term eastern GoF 20%	
Status of Baltic Sea Protected Areas - Proportion of different depth ranges under protection Temporary indicator!!! Will be replaced by developed	D	Not applicable	20-30 % of each depth interval (habitat) protected Locally the need for protection of shallow areas may be more important.	
Coastal fish species diversity index	S	Data exists, needs to be evaluated on a reagional scale	No negative trend	
Offshore (Marine trophic index of commercial) fish species	S	Data exists, needs to be evaluated on regional scale	No negative trend	
Zoobenthos community structure,	S	Raw data exists, needs to be developed on regional scale	No negative trends in native populations (baseline should be set)	May be problem with raw data in some areas
Internationally managed fish stocks - Spawning Stock Biomass and recruitment	S	ICES reference values	Maintain stocks at reference levels	
Seal species populations	S	Reference levels should established by HELCOM seal expert group	Target levels should be developed by HELCOM seal expert group on regional level	

INDICATOR	INDICATOR TYPE	REFERENCE CONDITION	TARGET LEVELS	REMARKS
Coastal bird species population abundance (key groups)	S	Should be established on regional level and species specific.	No negative trends	
Non-indigenous species (number of new introductions coming from human mediated releases)	S	0/year	0/year	
Structure (taxonomic structure, proportion of annual to perennial species etc) and distribution (proportion of expected habitat occupied, potential vs. actual depth distribution of species etc.) of phytobenthic communities	S	Reference levels should be established on regional/local level. Data partly available.	No negative trends	
By-catch, discard, bottom trawling impact		Data exists. Should be developed. (by-catch 0, discard 0)	Should be agreed fisheries based level. Decreasing trend	
Proportion of mega spawners at sea and in catch	S	Data exists, should be evaluated	Should be developed	
Proportion of mature fish in fish catch	S	Data exists. Should be developed on species level.	Should be developed	

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

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

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

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

Table A. Hazardous Substances

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

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

Table B. Bioassays

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

Table C. Biological Effects

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

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

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

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

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

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

Annex 15: Revised table of indicators on Eutrophication

Table 1. Priority indicators of eutrophication with type specific examples of reference conditions and target values

(Revised by Elżbieta Łysiak Pastuszak and Baerbel Mueller-Karulis)

(Ranking criteria: 1- very important; 2 – moderately important; 3 – not important or showing significant problems with data collection)

Eutrophication indicator	Indica-tor type	Indica-tor diagnosis	Data availability/ source	Reference Condition*	Target value*	Indicator Assessment Criteria				Remarks
						Simple quantificat ion	Index period Stability	Low year-to-year var.	Environ mental impact	
Land based nutrient inputs										
Concentrations of N-tot, P-tot, DIN and DIP in freshwater input	P	1	HELCOM PLC	P-tot 0.6m N-in 71.5m mmol m-3	0.9 107.3	Y	Y(?)	N	Y	Temporal coverage problematic, ref cond mainly by modeling
				?	?					
River runoff	P	1	HELCOM PLC	Vistula 49.1 km3/year	?	Y	Y	N	Y	ref cond mainly by modeling
				?	?					
Atmospheric nutrient inputs										
Atmospheric deposition of nitrogen	P	1	EMEP	80.0m mg N m-2	120.0	Y	Y	N	Y	Quantification by model output, ref cond unclear
				?	?					
Nutrient concentrations										
winter DIN	S	1	HELCOM COMBINE	6.50h mmol m-3	8.25	Y	Y	N	Y	historical data and modelling
				2.5[e] mmol m^{-3}	3.75					
winter DIP	S	1	HELCOM COMBINE	0.40h mmol m-3	0.60	Y	Y	N	Y	historical data

Eutrophication indicator	Indicator type	Indicator diagnosis	Data availability/ source	Reference Condition*	Target value*	Indicator Assessment Criteria				
						Simple quantification	Index period Stability	Low year-to-year var.	Environmental impact	Remarks
				0.30e mmol m-3	0.45					
Phytoplankton										
summer chlorophyll a	S	1	HELCOM COMBINE	2.10e mg m-3	3.15	Y	Y	N	Y	Ref cond mainly modelling
				1.20e mg m-3	1.80					
annual average chlorophyll a	S	1	HELCOM COMBINE	2.20m mg m-3	3.30	Y	Y	N	Y	Ref cond can be derived by modeling
				?	?					
Phytoplankton species compositon/proportion of species groups	S	1	HELCOM COMBINE	?	?	N	N	N	Y	Seasonally stable, but fast changes in spring, ref cond difficult to set, expert judgment
				Aphanizomenon flos-aquae abundance July-August 12500h units l-1	18750					
Macrophytes										
Depth range of submerged vascular plants/macroalgae	S	1	HELCOM COMBINE, EU WFD monitoring	?	?	N	yes	yes	yes	impact of diseases has to be excluded, ref cond on historical data in some areas, can also be derived from modeling
				?	?					

Eutrophication indicator	Indicator type	Indicator diagnosis	Data availability/ source	Reference Condition*	Target value*	Indicator Assessment Criteria: Simple quantification	Index period Stability	Low year-to-year var.	Environmental impact	Remarks
Water clarity										
Summer Secchi depth	S	1	HELCOM COMBINE	6.00^{h} m	4.50	Y	Y	Y	Y	
				8.00^{h} m	6.00					
Spring Secchi depth	S	1-2	HELCOM COMBINE	6.50^{h} m	4.87	Y	?	N	Y	Depends on sampling temporal frequency?
				?	?					
Oxygen conditions										
summer/autumn minimum oxygen concentrations	S	1	HELCOM COMBINE	>6.0 $cm^3 m^{-3}$	3.0	Y	N	N	Y	Sensitive to measurement frequency, upwelling, hydrology
kills of invertebrates	S	1	project based, national data collection	?	?	Y	N	N	Y	
				?	?					

Notations in the table:

***Examples of reference conditions and target values have been selected from the HELCOM EUTRO Report (2005). Fields marked yellow contain values related to the "External Puck Bay" a transitional water body in the Gulf of Gdańsk. Fields marked in blue contain values for the "Gulf of Finland – open sea" area; this area has been selected because HELCOM EUTRO Report cited 3 different coastal type areas with the addition of "Gulf of Finland – Tallinn Bay" and "Gulf of Finland – Narva Bay".**

Methods of RECOND determination:

m – modeling; values taken after Schernewski and Neumann (2005);

e – expert judgment;

h – historical data;

? – no information available at the moment.

The arbitrarily assumed acceptable deviation (target = reference cond. + acceptable dev.) in HELCOM EUTRO was 50% for all indicators with the exception of Secchi depth, where it was 25%.

References

HELCOM EUTRO. 2005. Report: "Development of Tools for Assessment of Eutrophication of the Baltic Sea", Helsinki Commission&DHI Water and Environment, 14 October 2005, 68 pp.

Schernewski G., Neumann T., 2005. The trophic state of the Baltic Sea a century ago: a model simulation study. J. Mar. Systems 53, 109-124.

Annex 16: Revised table of Indicators on fishery

Table 1. Evaluation of fishery indicators (Revised by Maris Plksh and Henn Ojaveer)

INDICATOR	INDICATOR TYPE	INDICATOR DIAGNOSIS	DATA AVAILABILITY/ SOURCE	INDICATOR ASSESSMENT CRITERIA						REMARKS
				REGIONALLY RESPONSIVE	UNAMBIGUOUSLY INTERPRETABLE	SIMPLE QUANTIFICATION	INDEX PERIOD STABILITY	Low year-to-year variation	ENVIRONMENTAL IMPACT	
Sustainable fishery and fisheries impact on ecosystem										
Spawning stock biomass (SSB) of internationally assessed marine fish species (herring, cod, sprat)	S	1	Yes/ICES	Y	Y	Y	Y	Y	Y	Assessments are based on stock units, /VPA type model
Spawning stock biomass (SSB) of nationally assessed marine and coastal fish species	S	1	Yes/ National laboratories	Y	Y	Y	Y	Y	Y	/VPA type model
Fishing mortality (F) of internationally assessed marine fish species (herring, cod, sprat)	S, P	1	Yes/ICES	N?	Y	Y	Y	?	?	Not always regionally responsive: Assessments based on stock units, /VPA type model

INDICATOR	INDICATOR TYPE	INDICATOR DIAGNOSIS	DATA AVAILABILITY/ SOURCE	INDICATOR ASSESSMENT CRITERIA						REMARKS
				REGIONALLY RESPONSIVE	UNAMBIGUOUSLY INTERPRETABLE	SIMPLE QUANTIFICATION	INDEX PERIOD STABILITY	Low year-to-year variation	ENVIRONMENTAL IMPACT	
Fishing mortality (F) of nationally assessed marine and coastal fish species	S, P	1	Yes/ national laboratories	Y	Y	Yes	Yes	?	?	/VPA type mode
Catch per unit of effort (CPUE) for non asessed fish species/stocks	P	1	National laboratories/Commercial fisheries and research survey data; EU data collection program	Y	Y	Y	Y	?	?	
Anadromous fish (salmon, sea trout) wild smolt production by River	S	1	YES/ICES	Y	Y	Y	Y	?	Y	In accordance with IBSFC Salmon action plan: The production of wild Salmon should gradually increase to attain by 2010 for each Salmon river a natural production of wild Baltic Salmon of at least 50% of the best estimate potential and within safe genetic limits, in order to achieve a better balance between wild and reared Salmon
By-catch of marine mammals	P	2	Several national laboratories	Y	Y	?	?	?	?	Suggested as biodiversity indicator (WGECO)

INDICATOR	INDICATOR TYPE	INDICATOR DIAGNOSIS	DATA AVAILABILITY/ SOURCE	INDICATOR ASSESSMENT CRITERIA						REMARKS
				REGIONALLY RESPONSIVE	UNAMBIGUOUSLY INTERPRETABLE	SIMPLE QUANTIFICATION	INDEX PERIOD STABILITY	Low year-to-year variation	ENVIRONMENTAL IMPACT	
By-catch of sea birds	P	2	Several national laboratories	Y	Y	?	?	?	?	Suggested as biodiversity indicator (WGECO)
Fishing effort of different Fleets.	P	3								Not relevant/Socio-economic indicator
Fleet capacity	P	3								Not relevant/Socio-economic indicator
Fish landings by major species by area.	P	3								Not relevant/Socio-economic indicator
Total amount of discards.	P	2	Baltic cod only/Used in Baltic cod assessment	Y	Y	N	N	N	Y	Suggested as biodiversity indicator (WGECO), small number of strata sampled
Amount of discards of high-risk species (or species groups).	P	3	? /EU data collection program	?	?	?	?	?	?	Suggested as biodiversity indicator (WGECO) What is high risk species?
Number of deaths of vulnerable and/or protected species	P	3	?	?	?	?	?	?	?	Not understandable; how to quantify the death of fish species (fishery, natural). Is the list of valuable and protect fish species in Baltic?

INDICATOR	INDICATOR TYPE	INDICATOR DIAGNOSIS	DATA AVAILABILITY/ SOURCE	INDICATOR ASSESSMENT CRITERIA						REMARKS
				REGIONALLY RESPONSIVE	UNAMBIGUOUSLY INTERPRETABLE	SIMPLE QUANTIFICATION	INDEX PERIOD STABILITY	Low year-to-year variation	ENVIRONMENTAL IMPACT	
Area of the fishery impacted by gear	P	3	?	?	?	?	?	?	?	Not relevant, more appropriate for management
Amount of habitat protected by MPAs	P	3	?	?	?	?	?	?	?	Not relevant, more appropriate for management
Size spectrum of fish community (open sea)	P	3	Yes/ICES	?	?	?	?	?	?	Suggested as biodiversity indicator (WGECO); Covered by SSB for open sea species
Size spectrum of fish community (coastal areas)	P	2	Yes/ IC ES and national laboratories	?	?	?	?	?	?	Suggested as biodiversity indicator (WGECO); Can be covered by CPUE for coastal fish species
Area of fish nursery habitat degraded	P	3	?	?	?	?	?	?	?	Not relevant, difficult to quantify. Can be covered by biodiversity
Mean trophic level of catch (open sea)	S	3	Yes/ICES and national labs	?	Y	Y	?	?	?	Can be covered by SSB for open sea species
Mean trophic level of catch (coastal areas eg. Cyprinide-Percide fish ratio)	S	2	Yes/ national labs	Y	Y	Y	?	?	?	Can be covered by CPUE for coastal fish species; need to be tested

Annex 17: SGEH Recommendations

Recommendation	Action
1. To organise a workshop on methodologies for monitoring fish diseases/parasites in coastal fish species from the Baltic Sea [with financial support of BSRP] in late 2007 or early 2008 under the co-sponsorship of ICES, HELCOM and the BSRP, preferably at the BSRP Lead Laboratory for fish disease issues, AtlantNIRO, Kaliningrad, Russia. G. Rodjuk, T. Lang and a representative of the HELCOM coastal fish monitoring experts should act as co-chairs. The main objectives of the workshop should be to: • provide baseline data on diseases and parasites in key fish species from coastal areas in the Baltic Sea to be used for future fish health assessments as part of the coastal fish monitoring; • provide training and intercalibration of methodologies related to the diagnosis of diseases; • produce draft guidelines for fish disease monitoring in coastal fish species in the Baltic Sea to be applied in the coastal fish monitoring programme, and • propose indicators and target levels for diseases of coastal fish species to be used in Baltic Sea ecosystem health assessments.	ICES, SGEH, BSRP; HELCOM
2. To organise sea-going Demonstration Project for an Integrated Multidisciplinary Assessment of the Gulf of Finland Ecosystem Health [with financial support of BSRP]	SGEH and BSRP
3. More data are needed for the estimation of reference/target values for biological effects of contaminants	Joint effort of the the Baltic Sea countries
4. In order to focus on reference/target values for biological effects indicators related to seals, the subgroup was of the opinion that a contact with the HELCOM expert groups on seals and on birds to coordinate activities is highly advisable	ICES SGEH
5. Since the 2007 ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-sea Areas (WKIMON III) (16–18 January 2007, ICES Headquarters, Copenhagen) will also deal with the issue of reference/target values attention should be paid to the SGEH deliberations;	WKIMON III
6. Closer links between the SGEH and other Expert Groups within ICES (e.g., WG on Biological Effects of Contaminants [WGBEC)], WG on Integrated Assessment of the Baltic Sea [WGIAB]) should be established.	WGBEC, WGIAB
7. Provide the list of indicators developed by SGEH for consideration to HELCOM BIO to use in Baltic Sea biodiversity assessment;	ICES SGEH
8. Consider including indicators developed by SGEH Biodiversity, Eutrophication and Fisheries groups into demonstration projects carried out in Gulf of Finland and Gulf of Gdansk;	BSRP CCEH/SGEH
9. BSRP should actively participate in HELCOM Biodiversity and Nature Protection activity (HELCOM BIO);	BSRP CCEH/SGEH
10. Habitat classification and mapping activities should be harmonised on the Baltic Sea level planned BSRP LL (BALANCE, EUNIS, Baltic Life project) to be able to develop Baltic Sea habitat classification and inventory (maps).	BALANCE, EUNIS, Baltic Life project
11. Establish links between HELCOM BIO and ICES Study Group on Baltic Fish and Fisheries Dynamics and ICES/HELCOM WG on Integrated Assessment of the Baltic Sea to be able to include the fisheries	ICES Study Group on Baltic Fish and Fisheries Dynamics