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Contents

Executive summary

The Study Group on Baltic Sea Productivity issues (SGPROD) met January 22–25 in Riga, Latvia. Part of the meeting was organized jointly with the HELCOM MONAS Zooplankton Expert Network (ZEN). The meeting was attended by 17 participants from 8 countries.

The group updated the status description of the lower trophic levels in the Baltic Proper and the Gulf of Riga for the year 2007 and winter 2007/2008 for the use of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic (WGIAB) and the Baltic Fisheries Assessment Working Group (WGBFAS).

SGPROD summarized the zooplankton indicators developed during the Baltic Sea Regional Project (BSRP). The analysis showed that in the Baltic Sea, zooplankton indicators can contribute to the prediction of fish stock recruitment.

Results of a zooplankton sampling gear intercomparison showed that WP-2 nets with different mesh sizes (55, 100, and 200 μm) and a Juday net (90 μm) reported significantly different abundances. Differences were especially pronounced for rare species and small zooplankton stages.

Preliminary results of zooplankton sampled by CPR at the Finnish Institute of Marine Research (FIMR) and the Institute of Meteorology and Water Management (IMWM) in Poland suggested differences from vertical WP-2 net hauls even when the same mesh sizes were used for the gear. Nevertheless, CPR transects have potential to show the spatial distribution of zooplankton in the Baltic surface water.

A ring-test organized by the HELCOM MONAS Zooplankton Monitoring Expert Network showed good zooplankton identification skills among the Baltic monitoring and research institutes. Problems only occurred with the identification of rare species. The ring-test also showed that the reporting of zooplankton nauplii should be standardized among the monitoring laboratories.

SGPROD further discussed the status of primary productivity measurements in the Baltic Sea. The group welcomed the extended SMHI monitoring programme and proposed to organize a sea-going workshop to compare and test different methods used for primary productivity measurements in the Baltic Sea.

The case study to test approaches to assess Baltic marine primary productivity, which aims at exploring the role of total, new and regenerated production for the transfer of organic matter to higher trophic levels in the Baltic, was continued. The group agreed on a list of areas and parameters to include into the case study and identified data sources and potential contributors.

1 Opening of the meeting

SGPROD co-chair Bärbel Müller-Karulis welcomed the participants to the meeting and thanked the HELCOM MONAS Zooplankton Expert Network, especially Lutz Postel and Juha Flinkman, for their interest and cooperation.

2 Adoption of the agenda

SGPROD aimed to discuss the following ToRs:

a) update lower trophic level (hydrography, nutrient, phyto- and zooplankton) indicator time-series for the use of WGIAB and fisheries assessment groups;

b) summarize and report on the zooplankton indicators developed during the Baltic Sea Regional Project;

c) present preliminary results from Baltic zooplankton data collected by CPR in comparison to WP-2 nets;

d) initiate a case study to test approaches to assess Baltic marine primary productivity.

Bärbel Müller-Karulis proposed to organize the meeting into a joint SGRPOD/ZEN plenary to discuss issues related to zooplankton sampling and zooplankton indicators (SGPROD ToRs b and c), as well as specific ZEN ToRs. Afterwards, the meeting should split into two major working groups, discussing ToRs a (update lower trophic level indicator time-series) and d (Baltic marine primary productivity case study), interlinked with a series of plenary presentations and discussions. The proposed agenda (Annex 2) was adopted.

3 Discussion of the terms of reference

3.1 Status of lower trophic levels in the Baltic Proper and Gulf of Riga

ToR a) update lower trophic level (hydrography, nutrient, phyto- and zooplankton) indicator time-series for the use of WGIAB and fisheries assessment groups

3.1.1 Review of the status description in the 2007 SGPROD report

SGPROD briefly reviewed the description of the status of the lower trophic levels in the Baltic that was presented in the 2007 SGPROD report. The group agreed that there is large overlap between the subsystem descriptions produced by WGIAB and SGPROD. It has also not been possible to expand the spatial coverage of the status description to include other sub-basins besides the Eastern Gotland Sea, Bornholm Basin and Gulf of Riga. Therefore the group decided to discontinue the annual updating of the status of the lower trophic levels. WGIAB planned to produce status descriptions for the Baltic Sea sub-basins on a regular basis in the future.

However, there was considerable interest in the zooplankton time-series used to characterize the status of secondary producers. The group listed several stations and areas in the Baltic Sea from which long-term zooplankton time-series are available (Kattegat, Bornholm Basin, Eastern Gotland Basin, Western Gotland Basin, Gulf of Riga, Gulf of Finland). SGPROD proposes to provide an overview of the existing long-term time-series during the 2009 meeting and to analyze, whether the regime shift observed e.g. in the Baltic Proper and Gulf of Riga time-series (ICES 2007) is visible also in other areas.

Further, during the meeting, data describing the oceanographic conditions, nutrient state, phytoplankton and zooplankton communities in the Eastern Gotland Sea, the Bornholm Basin and the Gulf of Riga in 2007 were analyzed. The resulting status description of the lower trophic levels (Annex 6) was provided to WGBFAS prior to their 2008 meeting.

3.1.2 Status of the lower trophic levels in 2007

In the Bornholm and Eastern Gotland Basin (see Annex 6) the series of mild winters continued also during 2006/2007 and 2007/2008., followed by warm summer surface and winter water temperatures. Oxygen conditions in the bottom water, which had improved after the 2003 inflow, declined in both basins to approximately 0.4 ml/l in the halocline region of the Eastern Gotland Basin and 0.5 ml/l in the bottom water of the Bornholm Basin measured in summer 2007. Winter nutrient conditions were characterized by a DIP surplus enhanced by the steady decline of winter DIN concentrations. Data on the extent of surface cyanobacterial blooms in summer 2007 are uncertain because high cloud cover interfered with satellite observations. The zooplankton community in the Eastern Gotland Basin remained dominated by *Temora longicornis* and *Acartia* spp., with low biomass of *Pseudocalanus acuspes*. Occurrence of the invasive species *Mnemiopsis leidyi* was reported from most Baltic sub-basins (see Annex 7).

In the Gulf of Riga (see Annex 6), summer chlorophyll *a* concentrations remained high in summer 2007. Spring biomasses of *Acartia* and *Eurytermora* were high and dropped below the long-term average in summer. Winter nutrient concentrations in early 2008 declined for both DIN and DIP.

References

ICES. 2007. Report of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB), 12–16 March 2007, Hamburg, Germany. ICES CM 2007/BCC:04. 71 pp.

3.2 Zooplankton productivity assessment

3.2.1 Zooplankton indicators developed during the Baltic Sea Regional Project

ToR b) summarize and report on the zooplankton indicators developed during the Baltic Sea Regional Project

A full description of the zooplankton indicator analysis in the Baltic Sea Regional Project was already presented at the 2007 SGPROD meeting (ICES 2007, Annex 8). Results were summarized as a contribution to the 2007 ICES Annual Science Conference (Margoński *et al.*, 'Zooplankton indicators of eutrophication and productivity for the Baltic Sea', ICES CM 2007/C:03, see Annex 9 in this report). This paper provided selected up-to-date information regarding results of the Baltic Sea Regional Project analyses leading to identify reliable zooplankton indicators. Relationships between zooplankton time-series and parameters characterizing the climatic conditions (water temperature, salinity), status of primary producers (winter nutrients, chlorophyll *a*), as well as stocks of planktivorous fish were analyzed by principal component analysis, linear models, and generalized additive models. Data covered the Eastern Gotland Basin, the Gulf of Finland and the Gulf of Riga from the mid-1970ies to present.

Basically, the results presented only limited correlation of zooplankton time-series with potential 'eutrophication' factors like winter nutrient concentrations, Secchi depth or chlorophyll *a* concentrations. On the other hand zooplankton might be very useful indicator of productivity of fish, being significantly related with recruitment of numerous fish stocks.

BSRP work was also very much in line with various recent activities focused on including environmental factors into fisheries assessment, e.g. the EU funded project 'Incorporating extrinsic drivers into fisheries management' (InExFish). Attempts to include zooplankton into stock-recruitment models are being continued within ICES by the series of workshops: ICES/BSRP Workshop on Recruitment Processes of Baltic Sea herring stocks (WKHRPB, 2007) and the ICES/BSRP Workshop on Developing and Testing Environmentally-Sensitive Stock-recruitment Relationships of Baltic Herring and Sprat stocks (WKSSRB, 2008). Both workshop results as well as the results of data analysis during the Baltic Sea Regional Project indicate the significance of zooplankton as a useful recruitment predictor of numerous Baltic Sea small pelagic stocks.

References

ICES. 2007. Report of the Study Group on Baltic Sea Productivity (SGPROD), 23–26 January 2007, Gdynia, Poland. ICES CM 2007/BCC:02. 70 pp.

3.2.2 Intercomparison of nets used for zooplankton sampling in Baltic monitoring programmes (SGRPOD/ZEN)

Piotr Margoński presented an overview of the net intercomparison organized during the Baltic Sea Regional Project (see Annex 9 for a detailed description). Sampling with three WP-2 nets of different mesh sizes (55, 100, and 200 μm) and a Juday-net (90 μm) was carried out on August 17, 2006 at station BY-38 in the Western Gotland Sea (Karlsö Deep) during a RV "Aranda" cruise. Three hauls with each net from 20 – 0 m were taken. All the nets were equipped with TSK flowmeter. Samples were taken by the same team and subsequently all of them were analyzed by one zooplankton expert.

All the samples were dominated by cladocerans of the genera *Bosmina* and *Evadne* and copepods representing the genera *Acartia*, *Centropages*, and *Eurytemora* with a different share in particular nets. Comparison of individuals counted in each net indicates a different level of variance between particular hauls of the same gear.

For most taxonomic groups, the WP-2 net with 55 μm mesh size sampled the highest abundances, combined with lowest variability between the individual hauls. Single factor ANOVA showed that for many species the average abundance significantly differed between the gears tested (table 1). In particular, despite the small mesh size, the Juday net behaved closer to the 200 μm WP-2 net then to the WP-2 nets with similar mesh sizes.

Table 1: Significance level for differences in average species abundance sampled by different gears (single factor ANOVA).

Species	WP-2 55 um Juday 90 um	WP-2 55 um WP-2 100 um	WP-2 55 um WP-2 200 um	Juday 90 um WP-2 100 um	Juday 90 um WP-2 200 um	WP-2 100 um WP-2 200 um
Acartia bifilosa F	0.08	0.05	0.01	0.61	0.72	0.19
Acartia bifilosa M	0.16	0.55	0.58	0.43	0.09	0.30
Acartia longiremis M	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Acartia spp.CI-III	0.00	0.00	0.02	0.00	0.79	0.10
Acartia spp.CIV-V	0.05	0.20	0.91	0.96	0.32	0.37
Acartia spp.N	0.01	0.00	0.03	0.01	0.06	0.04
Acartia tonsa F	0.00	0.00	0.00	0.01	0.71	0.01
Acartia tonsa M	0.00	0.00	0.00	0.01	0.11	0.02
Balanus (cipris)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bivalvia larvae	0.00	0.00	0.25	0.00	0.01	0.58
Bosmina spp.	0.00	0.00	0.02	0.00	0.02	0.00
Centropages hamatus CIV-V	0.33	0.42	n.a.	0.55	0.67	1.00
Centropages hamatus eggs	0.00	0.00	0.02	0.08	0.22	0.06
Centropages hamatus F	0.00	0.08	0.01	0.28	0.18	0.77
Centropages hamatus M	0.00	0.00	0.00	0.23	0.57	0.42
Centropages hamatus N	0.30	0.27	1.00	n.a.	n.a.	n.a.
Eurytemora affinis CI-III	0.00	0.00	0.00	0.55	0.04	0.04
Eurytemora affinis CIV-V	0.01	0.80	0.15	0.16	0.51	0.39
Eurytemora affinis F	0.01	0.06	0.00	0.01	0.67	0.00
Eurytemora affinis M	0.01	0.51	0.02	0.04	0.39	0.07
Eurytemora affinis N	0.01	0.16	1.00	0.78	1.00	1.00
Evadne spp.	0.00	0.00	0.00	0.03	0.97	0.08
Gastropoda larvae	0.33	0.66	0.21	0.62	n.a.	0.53
Keratella cruciformis	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Keratella qudrata	n.a.	n.a.	0.21	n.a.	n.a.	n.a.
Pleopsis polyphemoides	0.01	0.01	0.15	0.00	0.04	0.00
Podon intermedius	0.01	0.07	0.00	0.03	0.43	0.00
Podon juv.	0.01	0.08	0.01	0.01	0.68	0.00
Pseudocalanus spp. F	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pseudocalanus spp.CI-III	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pseudocalanus spp.CIV-V	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Temora longicornis CIV-V	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Temora longicornis F	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Temora longicornis M	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Cluster analysis (Figure 1) confirms different levels of similarity between the tested gears, depending if dominating or rare species are playing the main role. When grouping was dominated by the most abundant species (values/no transformation), the most different results were achieved by Juday net (similarity 40 %). At similarity level 60 % the WP-2 nets are divided into two groups (200 µm vs. 100 µm and 55 µm). 100 µm and 55 µm WP-2 nets are finally differentiated only at a similarity level of ~ 70 %. The only 'accident' is grouping of the third Juday net haul with WP-2 200 µm.

A completely different picture was received when the role of rare species increased by $\sqrt[4]{\;}$ transformation of relative species abundance in the respective hauls. Nets are now divided into two groups with bigger and smaller mesh sizes (200 µm and 100 µm vs. 55 µm and Juday) at 83% similarity.

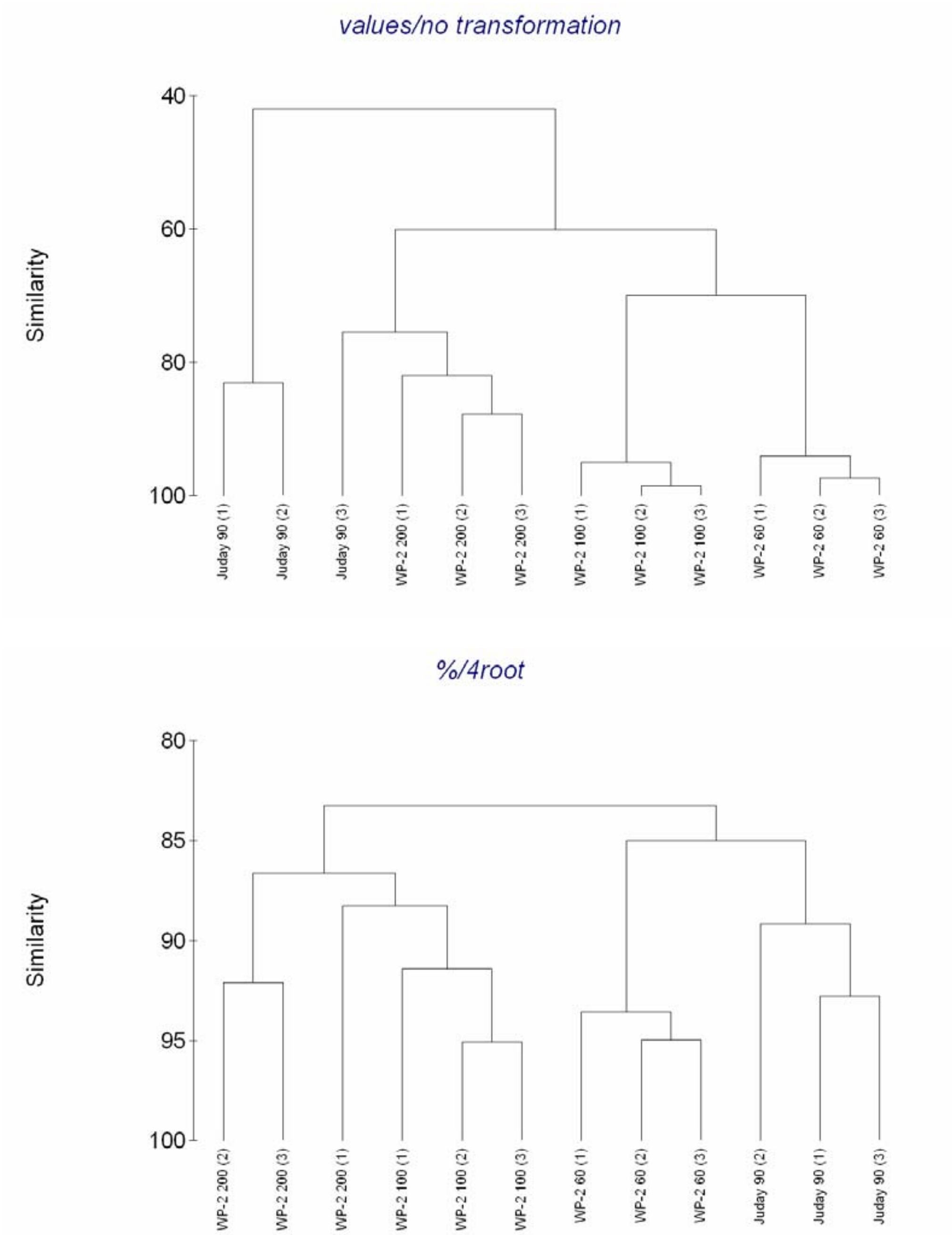

Figure 1: Cluster analysis of the individual net hauls using untransformed abundance data (top) and $\sqrt[4]{\ }$ transformation of relative abundance (bottom).

To summarize it needs to be stated that such intercomparisons carried out in 'natural conditions' are characterized by internal variance. The experiment lasted for several hours and it is hard to assume that we were sampling exactly the same zooplankton community all the time. This fact might explain some of the 'strange' results. Second, it seems that the WP-2 net with 55 μm mesh size was the best gear in the conditions experienced, presenting the highest abundances in most of the taxonomic groups and characterized by the lowest inter-haul variability (in most of the cases). Finally, in many cases performance of the Juday net 90 μm was closest to that of WP-2 200 μm, which means to the net with two times larger mesh size (and 5 times larger mesh opening). One of the possible explanations is that the smaller entrance of the Juday net would increase the rate of avoidance especially by adult copepods. Additionally, installing of relatively large TSK flowmeter in the opening of nets will seriously affect the performance of the smallest gear (Juday net).

The group briefly discussed that the historical zooplankton time-series in the Bornholm and Eastern Gotland Basin are collected by Juday nets. Currently, Juday net sampling is not continued in the Bornholm basin, whereas HELCOM monitoring data are sampled by WP-2 nets with 100 µm mesh size. The net intercomparison suggests that data from both net types are not comparable and conversion factors between both net types have not been developed and tested.

3.2.3 CPR/WP-2 comparison for Baltic zooplankton

ToR c) present preliminary results from Baltic zooplankton data collected by CPR in comparison to WP-2 nets

Currently, both the Finnish Institute of Marine Research (FIMR) and the Institute of Meteorology and Water Management (IMWM) in Poland test continuous plankton recorders (CPR) for zooplankton monitoring in the Baltic Sea. Both instruments use a standard CPR body equipped with a Chelsea Autonomous Plankton Sampler using 100 µm net materials instead of silk. FIMR has tested the CPR performing transects from Finland to Germany on a ship of opportunity (three transects in 2005 and 2006 each). Since the ferry towing the instrument was moved in 2006, no replacement has been found and the CPR is used on RV "Aranda" cruises. IMWM has started CPR tests with RV "Baltica" in 2007, focusing on the comparability of zooplankton abundance measured by CPR and standard WP-2 nets. A detailed description of the intercomparison is presented in Annex 9.

A RV "Baltica" HELCOM COMBINE cruise took place in 29–31 January 2007. During this cruise CPR samples were collected. To enable the intercomparison between CPR and the regular WP-2 net monitoring gear, the, samples were taken at both ends of CPR profiles. The Continuous Plankton Recorder operates in the upper 10 m layer and according to guidelines the standard depth of the WP-2 net near-surface sample is 0 m to thermocline (or 0–25 m). Therefore two kinds of WP-2 net samples were collected in January: 0–10 m and 0–25 m. Dr. Juha Flinkman from the Finnish Institute of Marine Research kindly agreed to participate in the cruise supervising samples collection and providing the on-board training. The next CPR samples were collected during a regular monitoring cruise (March/April 2007). There were three tows and unfortunately only one WP-2 net sample taken. Both gears were equipped with nylon mesh (100 µm).

In January, in all the cases when CPR tows were compared with WP-2 net results, abundances calculated from CPR samples were lower or much lower. The only two exceptions were the CPR abundance of *Acartia spp*. c IV-V (177 %) and *Fritillaria borealis* (220 %) when related to station P-5 (0 – 25 m) results.

CPR performance was much better in April. There were several taxa/stages with abundance higher in CPR than in WP-2 samples: *Acartia bifilosa* F, *Acartia bifilosa* M, *Acartia longiremis* M, *Acartia spp*. C IV-V, *Centropages hamatus* M, *Centropages hamatus* N, *Pseudocalanus spp*. N, *Temora longicornis* M, *Temora longicornis* c I-III, *Fritillaria borealis.* The abundance of tintinnids and *Centropages hamatus* eggs was 22 times higher and for copepod eggs calculated values were even 37 times higher.

The great advantage of CPR sampling is that we are receiving much more information regarding the high natural variance in zooplankton distribution. This can be illustrated on the basis of abundance of e.g. *Acartia longiremis* females, *Acartia* nauplii, and *Pseudocalanus* copepodite IV-V in January, and *Fritillaria borealis* in April. With vertical net sampling we usually assume that the abundance of organisms collected at 1–3 stations is representative for the whole area/basin. The CPR gives us a clue regarding the scale of distribution variability (especially when programmed for shorter silk advances).

Apparently, there is a need to use reliable flowmeters during WP-2 sampling. Differences between water volume estimates calculated on the basis of flowmeter counts and filtered water layer thickness were substantial in our case even we did not expect clogging (January!!!). CPR also needs to be equipped with flowmeters counting the volume of water passing through the sampling mechanism.

One of the most important outcomes of this intercomparison is that CPR sampling cannot replace a regular WP-2 data collection as the CPR operates in the near-surface layers only and no information is provided regarding deeper waters. However, it is a valuable additional source of data on mesoscale patchiness and long-term changes when used long enough in the same area.

Juha Flinkman (FIMR) reported clogging problems with the 100 µm mesh used in the CPR. He therefore plans to replace the net material by 200 µm mesh size, which should still be sufficient to sample adult copepods. Since the comparability between WP-2 samples and CPR data is limited even when the same mesh sizes are used, Juha Flinkman suggests optimizing the mesh size for the conditions of the CPR, regardless of the standard mesh size in Baltic Sea monitoring with WP-2 nets.

3.2.4 Zooplankton ring test (SGPROD/ZEN)

As part of the HELCOM Monitoring and Assessment Programme for the Baltic Sea the HELCOM MONAS Zooplankton Monitoring Expert Network initiated a proficiency comparison to assess and document the comparability of zooplankton data in 2007.

This zooplankton ring test on species identification, counting and biomass determination of a zooplankton sample of the Baltic Sea was supported by the Baltic Sea Regional Project (BSRP) and the Federal Environment Agency Dessau-Roßlau/Berlin. The ring test design for checking the accuracy of the analysis procedures and the taxonomic skills of the participants was carefully prepared by the ZEN. BSRP took over the funding for the sample preparations by the Sea Fisheries Institute in Gdynia. The statistical elaboration of the analysis results is carried out by the Quality Assurance Panel of the German Marine Monitoring Programme in cooperation with the quodata GmbH.

The aims of this zooplankton ring test were:

- to assess identification skills of the participants,
- to assess the accuracy of counting zooplankton taxa and
- to check the proposal of the Baltic Research Institute of carbon mass determination aiming at updating the HELCOM COMBINE Manual Annex C-7 Mesozooplankton.

Finally 22 employees of 15 institutes from Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden took part in this ring test. The average time per participant needed for all steps of the ring test (counting, species and biomass determination, data entry) was approximately 20 hours.

Only about half the participants have used Bogorov chambers of different sizes, the others have been used Utermöhl chambers or homemade chambers for counting. For the length measurements most participants used eyepiece micrometres.

Most of the participants have good identification skills; some of them have even very good identification skills. The following taxa have been identified correctly by all participants:

- *Bosmina* sp.
- *Temora longicornis* (adult)
- *Evadne* sp.
- *Pseudocalanus* sp. (adult)

The identification of *Fritillaria borealis, Keratella* sp., *Synchaeta* sp., and *Bivalvia* larvae seems to be difficult for some participants. The identification of the following taxa caused considerable problems in most cases for more than half of participants: *Podon intermedius, Acartia tonsa, Oithona similis* and *Pleopsis polyphemoides*. This has to be verified by further detailed statistical analysis. Thereby it should be kept in mind that the chance to identify a taxon correctly also depends on the number of individuals contained in the sample; the greater the number of individuals of a taxon the higher the chance to identify it.

The assessment of results of development stages (nauplia, C I – III and C IV – V) was more difficult because it was handled very different by the ring test participants depending on their experience and the considered species. Only one participant reported that nauplia generally were not reported to species level and a second participant stated that nauplia were not counted. It was argued that for the Baltic Sea Monitoring Programme the species identification of these development stages should be omitted to save the simplicity and cost-effectiveness of zooplankton studies. If the plankton net WP-2 with 100 µm mesh size is used as recommended by HELCOM, than the study of nauplia is not indicated due to the high mesh width and the therewith linked losses of nauplia. For improving the comparability of data the fact that nevertheless quantitative data of nauplia are reported should be discussed in the zooplankton expert groups. A more standardized procedure how to deal with development stages should be established and elaborated in the HELCOM COMBINE Manual.

Currently, an assessment of the performance by applying *Zu* scores is not yet finalized. An explorative analysis of the abundance data of this ring test exhibited a high variability and showed that most of the abundance results are not distributed symmetrically and do not follow the normal distribution. Therefore, no assessment of the participant's performance based on the classical Z scores is possible. A log-transformation of right-skewed data (right tail is longer and the mass of the measured abundances is concentrated on the left) could approximate normal distribution. However, the explorative analysis showed that the distributions of the abundance values of only some of the analysed taxa are right-skewed. An alternative to the log-transformation and an assessment via Z scores is the application of a robust method and adjusted Z score - termed *Zu* score. These *Zu* scores are based on an asymmetrical tolerance interval and ensure at the same time that the lower tolerance limit never equals zero (see Uhlig and Henschel, 1997). *Zu* scores can be calculated for abundance data of taxa which fulfil the requirement of sufficient sample homogeneity, which are:

- *Bosmina* sp. (all), corr.*
- *Acartia* sp. adult (all) and *Acartia* sp. adult (all), corr., *Acartia* sp. juv. (all) and *Acartia* sp. juv. (all), corr., *Acartia bifilosa* (all), *Acartia longiremis* (all) and *Acartia longiremis*, corr.
- *Centropages* sp. juv. (all) and *Centropages* sp. juv. (all), corr.
- *Eurytemora* sp. adult (all), *Eurytemora affinis* juv. (all) and *Eurytemora affinis* adult (all)
- *Temora* sp. adult (all), corr. and *Temora longicornis* adult, corr.
- *Oithona* sp. adult (all) and *Oithona similis* adult
- *Keratella quadrata*
- *Appendicularia*, corr.

*** For taxa/categories with a mean reference abundance greater than 30, a correction has been carried out based on the correction factors derived in the homogeneity analysis. These results are highlighted with the abbreviation "corr.".**

The finalized ring-test results will further be reported to STGQAB.

SGPROD/ZEN further discussed the need for taxonomical training. The group agreed that taxonomical training and intercalibration would only be needed for rare and regional species, as common species were generally identified correctly.

The group also briefly discussed the need to use current taxonomy in reporting species names. Here, the genus *Podon* spp. LILLJEBORG, 1853 comprises *Podon leuckartii* SARS, 1853, *Podon intermedius* LILLJEBORG, 1853, as well as *Podon polyphemoides* LEUCKART, 1859, the synonym for the current designation *Pleopsis polyphemoides* LEUCKART, 1859.

References

Uhlig, S., Henschel P. 1997. Limits of tolerance and z-scores in ring tests. Fresenius J. Anal. Chem., 358: 761–766.

3.3 ToR d) initiate a case study to test approaches to assess Baltic marine primary productivity

3.3.1 Primary productivity monitoring

Discussions at previous SGPROD meetings have shown that the assessment of Baltic marine primary productivity (PP) is hampered by practical problems conducting incubations with C-14 in monitoring surveys, as well as by difficulties in using the observations as an indicator of marine productivity in the Baltic. Consequently, when SGPROD inventorized the existing primary productivity time-series for Baltic monitoring stations (ICES, 2007), only Sweden had retained PP measurements in marine monitoring programme. Kristin Andreasson (SMHI) further gave a presentation of the Swedish PP monitoring programme, which has recently been expanded (see Annex 11). SGRPOD very much welcomed the Swedish monitoring effort, especially since the group stated in its 2007 report that the data coverage in Baltic monitoring programmes is insufficient to quantify PP on shorter (e.g. annual) time-scales in Baltic sub-basins.

Even though in many institutes PP measurements are at the moment only used within research surveys, there was considerable interest within the group to improve PP measurements as well as to test new technologies. SGPROD therefore decided to organize a sea-going workshop to compare the methods used by different monitoring and research institutes. Tentatively, FIMR has offered to take a group of 8–10 scientists on board a leg of the RV "Aranda" cruise in the Gulf of Finland in August 2009. A first announcement to members of SGPROD has shown that institutes in the USA, Finland, Poland, Denmark, Sweden and Estonia are interested in participating. It is planned to prepare the seagoing workshop intersessionally and to discuss and present its results at the 2009 SGPROD meeting.

ICES. 2007. Report of the Study Group on Baltic Sea Productivity (SGPROD), 23-26 January 2007, Gdynia, Poland. ICES CM 2007/BCC:02. 70 pp.

3.3.2 Primary productivity indicator development

At the 2007 meeting SGPROD suggested to organize a comparative case study to investigate how new, regenerated and total primary production describe the biomass production and the transfer to higher trophic levels in the major Baltic sub-basins. The case study is motivated by the high share of regenerated production in the total Baltic primary production. Regenerated production is traditionally considered not to be harvestable from the ecosystem without disturbing its equilibrium (Dugdale and Goering, 1967), in contrast to new production, which can be transferred to higher trophic levels in a sustainable way. By comparing the magnitude and fate of new and regenerated primary production in different Baltic sub-basins the group wants to investigate how well different productivity indicators (total, new and regenerated primary production, standing stock of phyto- and zooplankton) describe the flux of organic matter available to the higher trophic levels.

Based on data availability and on expertise within the group, SGPROD decided to include the Kattegat, Bornholm Basin, Eastern and Western Gotland Basin, Bothnian Sea, Gulf of Finland, Gulf of Riga, and the Mariager Fjord, a Danish coastal area, into the case study. The group agreed on a list of parameters that should characterize the supply of new nutrients and the magnitude of new production (riverine N load, winter DIN concentration, atmospheric N deposition, N fixation, entrainment), total primary production (phytoplankton biomass, chlorophyll *a*, PP measurements, total nitrogen concentration), secondary production (biomass of mesozooplankton during the productive season), as well as the production of the major fish species. Also temperature data will be included into the system comparison as a proxy for the climatic conditions. To a large extend these data are available from publications (e.g. total primary production, N fixation), HELCOM reports (N loads, atmospheric N deposition), the ICES oceanographic database (temperature, chlorophyll *a*), biological monitoring data (e.g. phytoplankton and mesozooplankton biomass), and reports of ICES study and working groups (WGIAB, SGMAB – fish biomass and production proxies).

SGRPOD plans to complete the characterization of the different sub-basins intersessionally and to analyze the data during the 2009 meeting.

References

Dugdale, R. C., and Goering, J. J. 1967. Uptake of new and regenerated forms of nitrogen in primary productivity. Limnology and Oceanography, 12: 196–206.

4 ToRs for 2009

SGPROD will close its work in 2009. So far, it has contributed to the design and analysis of zooplankton indicators and has tested a format for reporting on the status of the lower trophic levels. The status description of the lower trophic levels is now well accommodated within the tasks of WGIAB and will thus also in the future be available to other interested groups. Also with respect to zooplankton indicator testing, the group considered its work as finalized. Our analysis has shown that zooplankton provides useful information for predicting the recruitment of fish stocks. Incorporation of zooplankton and other environmental indicators into fish stock management is currently discussed within ICES workshops and EU funded research projects. However, there was large interest within the group, as well as within ZEN, to assemble the existing long-term zooplankton time-series in the Baltic sub-basins. Therefore, if possible, the next SGRPOD meeting will be organized again in cooperation with ZEN. Besides, the group wants to focus its activities on primary production assessment, including preparation and evaluation of a seagoing workshop, and on its use as indicator in the Baltic Sea.

SGRPOD therefore proposes the following ToRs for 2009:

- prepare a seagoing workshop on methods to measure primary productivity in the Baltic and summarize its results
- finalize the case study to test approaches to assess Baltic marine primary productivity.
- collect and compare long-term zooplankton time-series from Baltic Sea sub-basins.

Annex 1: List of participants

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Annex 2: Agenda

Tuesday, January 22

9:00 Welcome, introduction of participants and adoption of the draft agenda (Bärbel Müller-Karulis, Michael Olesen, Lutz Postel)

9:30 HELCOM MONAS Zooplankton Expert Network/SGPROD zooplankton ToR discussion

1) Report on the comparison of HELCOM MONAS sampling procedures during the ARANDA summer cruise in 2006 (Piotr Margoński), conclusions

2) Outcome of the WP-2/CPR comparison studies (Juha Flinkman, Piotr Margoński)

11:00 Coffee break

3) Report on the current stage of the mesozooplankton biomass determination by carbon factors and length to carbon content ratios (Lutz Postel), conclusions

4) Report on the current stage of the ring test analysis by Petra Schilling *et al.* (Lutz Postel), conclusions

13:00 Lunch break

5) Status of the zooplankton indicators search (Piotr Margoński)

6) Status description of zooplankton and lower trophic levels in SGPROD 2007 (Bärbel Müller-Karulis)

7) Report on the current stage of the preparations of the Baltic Sea Zooplankton Atlas within BMB WG 29 (Zooplankton Diversity) by Irena Telesh *et al.* (Lutz Postel)

15:00 Coffee break

8) Terms of reference of the HELCOM MONAS Zooplankton Expert Network

- Quality assurance of HELCOM MONAS zooplankton programme
- Sampling (Maintenance of standard methods)
- Analysis (Maintenance of standard methods and improving taxonomic skills)
- Updating of HELCOM MONAS Guidelines of zooplankton sampling and analysis
- Regularly assessments

9) Participation at HELCOM BIO (Project manager Ulla Li Zweifel) – Who is informed ? Who is going to participate?

10) Requests by ICES (Marilynn Sørensen) in respect to data management – Who is informed (participants of the ICES WGZE Riga 2007)?

11) SGRPOD zooplankton ToRs for 2009

Wednesday, January 23

9:00 Discussion of ToRs a) and d)

- ToR a) update lower trophic level (hydrography, nutrient, phyto- and zooplankton) indicator time-series for the use of WGIAB and fisheries assessment groups;
- ToR d) initiate a case study to test approaches to assess Baltic marine primary productivity
- Lower trophic level status description (Bärbel Müller-Karulis), improvements for 2008
- Introduction to the productivity case study (Michael Olesen)

10:30 Coffee break

Split into working groups

- updating of lower trophic level indicator time-series
- productivity indicator case study

13:00 Lunch break

Working group discussions continued

15:00 Coffee break

Thursday, January 24

9:00 Plenary presentations:

- SMHI primary productivity monitoring programme (Kristin Andreasson)
- Modelling approaches to describe regenerated production (Bärbel Müller-Karulis)
- Relationships between zooplankton, hydrography and fish in the Northern Baltic (Juha Flinkman)

10:30 Coffee break

Working group discussions continued

13:00 Lunch break

Plenary: Working group status (Michael Olesen, Phillip Axe)

Working group discussions continued

15:00 Coffee break

Working group discussions continued

Friday, January 25

9:00 Presentation of working group results

- Productivity case study
- Status of lower trophic levels

10:30 Coffee break

Discussion of ToRs for 2009

Reporting format and deadlines

13:00 Closure of the meeting

Annex 3: SGPROD Terms of Reference for this meeting

2007/2/BCC02 The **Study Group on Baltic Sea Productivity** [SGPROD] (Chairs: B. Müller-Karulis, Latvia, and M. Olesen*, Denmark) will meet in Jūrmala, Latvia, from 22–25 January 2008 to:

a) update lower trophic level (hydrography, nutrient, phyto- and zooplankton) indicator time-series for the use of WGIAB and fisheries assessment groups;

b) summarize and report on the zooplankton indicators developed during the Baltic Sea Regional Project;

c) present preliminary results from Baltic zooplankton data collected by CPR in comparison to WP-2 nets;

d) initiate a case study to test approaches to assess Baltic marine primary productivity.

SGPROD will report by 1 March 2008 for the attention of the Baltic Committee.

Supporting Information

Priority:	SGPROD was founded as Study Group on Baltic Sea Productivity Issues in Support of the BSRP. Within the new Baltic related study and working group structure proposed by WKIAB it should continue its work, strengthening productivity indicator development and supplying lower trophic level information for both fishery management and integrated assessment purposes. Work of the group should therefore be given high priority.
Scientific justification and relation to action plan:	**a)** The integrated assessments for the Central Baltic and Gulf of Riga at WKIAB of the previous year showed that raw data time-series could be integrated into basin and process specific indicators by scientific experts. SGPROD will continue to describe the hydrographic, nutrient, phytoplankton and zooplankton indicator time-series required by the Baltic integrated assessment processes and make the relevant indicator time-series available to fisheries related groups, as an important step to organize the information flow for Baltic Sea integrated assessments. **b)** Discussions at the 2006 SGPROD meeting showed a very active group of experts involved in zooplanktion indicator testing within the BSRP. Indicator testing results are expected to be finalized in summer 2007 with the closure of phase I of the BSRP. SGPROD will take the opportunity to discuss and review the results. **c)** Continuos plankton recorders (CPR) have been successfully and cost-efficiently applied in asessing zooplankton in the world oceans. In the Baltic Sea the applicability of CPR has been questioned because of the small zooplankton in relation to the standard CPR mesh-size. SGPROD will discuss the results of intercomparisons of modified CPRs with WP-2 nets and the potential for their application in the Baltic Sea, based on recent CPR trials in the Baltic Sea. **d)** SGPROD has also previously pointed out that in order to assess Baltic primary productivity, not only improved coverage of primary productivity data is needed, but that also that the applicability and ecological significance of different primary productivity indicators (e.g. total, new and regnerated production) should be reviewed. In order to refine Baltic primary productivity indicators, SGPROD will initiate a case study based on published literature and conceptual modeling in several Baltic sub-basins to a) investigate the role of new/tergenerated production for the ecological transfer efficiency to higher trophic levels, b) test the sensitivity of productivity indicators proposed earlier, c) propose measurement methods for new and regenerated production in the Baltic.

Resource requirements:	None
Participants:	The group was attended by 22 participants from seven countries in 2007.
Secretariat facilities:	None
Financial:	
Linkages to advisory committees:	ACOM. In the consideration of indicator issues, the Group will closely follow the guidelines prepared by ACOM.
Linkages to other committees or groups:	There are close working relationships to SGEH, to Baltic Integrated Assessment activities (WGIAB), to the HELCOM/ICES zooplankton expert network as well as to ongoing HELCOM assessment activities (HELCOM EUTRO-PRO). Contacts are also established to the HELCOM phytoplankton expert network.
Linkages to other organizations:	HELCOM

Annex 4: SGPROD Terms of Reference for the next meeting

The **Study Group on Baltic Sea Productivity** [SGRPOD] (Chairs: B. Müller-Karulis, Latvia, M. Olesen, Denmark) will meet in Helsinki, Finland, from 17–20 November 2008 to:

a) prepare a seagoing workshop on methods to measure primary productivity in the Baltic and summarize its results

b) finalize the case study to test approaches to assess Baltic marine primary productivity.

c) collect and compare long-term zooplankton time-series from Baltic Sea sub-basins

SGROD will report by DATE to the attention of the XXXXX Committee.

Supporting Information

Priority:	SGPROD was founded as Study Group on Baltic Sea Productivity Issues in Support of the BSRP. Within the new Baltic related study and working group structure proposed by WKIAB it should continue its work, strengthening productivity indicator development and supplying lower trophic level information for both fishery management and integrated assessment purposes. Work of the group should therefore be given high priority.
Scientific justification and relation to action plan:	a) In the Baltic Sea, primary productivity is currently measured by a number of reasearch and monitoring intsitutes, using a variety of methods. Therefore the group was interested to organize a sea-going workshop to intercompare different methods. The workshop will help to promote innovative measurement technologies as well as contribute to harmonizing the different 14-C incubation methods predominantly used. b) SGPROD has also previously pointed out that in order to assess Baltic primary productivity, not only improved coverage of primary productivity data is needed, but that also that the applicability and ecological significance of different primary productivity indicators (e.g. total, new and regnerated production) should be reviewed. In order to refine Baltic primary productivity indicators, SGPROD will initiate a case study based on published literature and conceptual modelling in several Baltic sub-basins to a) investigate the role of new/regenerated production for the ecological transfer efficiency to higher trophic levels, b) test the sensitivity of productivity indicators proposed earlier, c) propose measurement methods for new and regenerated production in the Baltic c) Long-term changes in the Baltic Proper zooplankton community are currently assessed based on time-series from the Eastern Gotland Basin, collected by the Latvian Fish Resource Agency. SGPROD/ZEN participants pointed out that long-term data are available at various research institutes also for other sea areas of the Baltic Proper (Bornholm Basin, Western Gotland Sea), as well as for other Baltic sub-basins. Zooplankton has proven to be an important indicator that clearly depicts the regime shifts in the Baltic ecosystem. Therefore the group proposes to assemble and summarize also the remaining archived time-series to achieve a more detailed view of changes in the Baltic foodweb.
Resource requirements:	None
Participants:	The group was attended by 17 participants from eight countries in 2008.
Secretariat facilities:	None
Financial:	No financial implications.

Linkages to advisory committees:	ACE, ACME. In the consideration of indicator issues, the Group will closely follow the guidelines prepared by ACE.
Linkages to other committees or groups:	There are close working relationships to Baltic Integrated Assessment activities (WGIAB), and to the HELCOM/ICES zooplankton expert network. Contacts are also established to the HELCOM phytoplankton expert network.
Linkages to other organizations:	HELCOM

Annex 5: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
1.Continue a regular description of the status of the lower trophic levels in the major Baltic Sea sub-basins for the use of the Baltic fisheries assessment groups and other interested expert groups	WGIAB

Annex 6: State of the lower trophic levels

1. Central Baltic Sea

1.1 Eastern Gotland basin

Hydrography

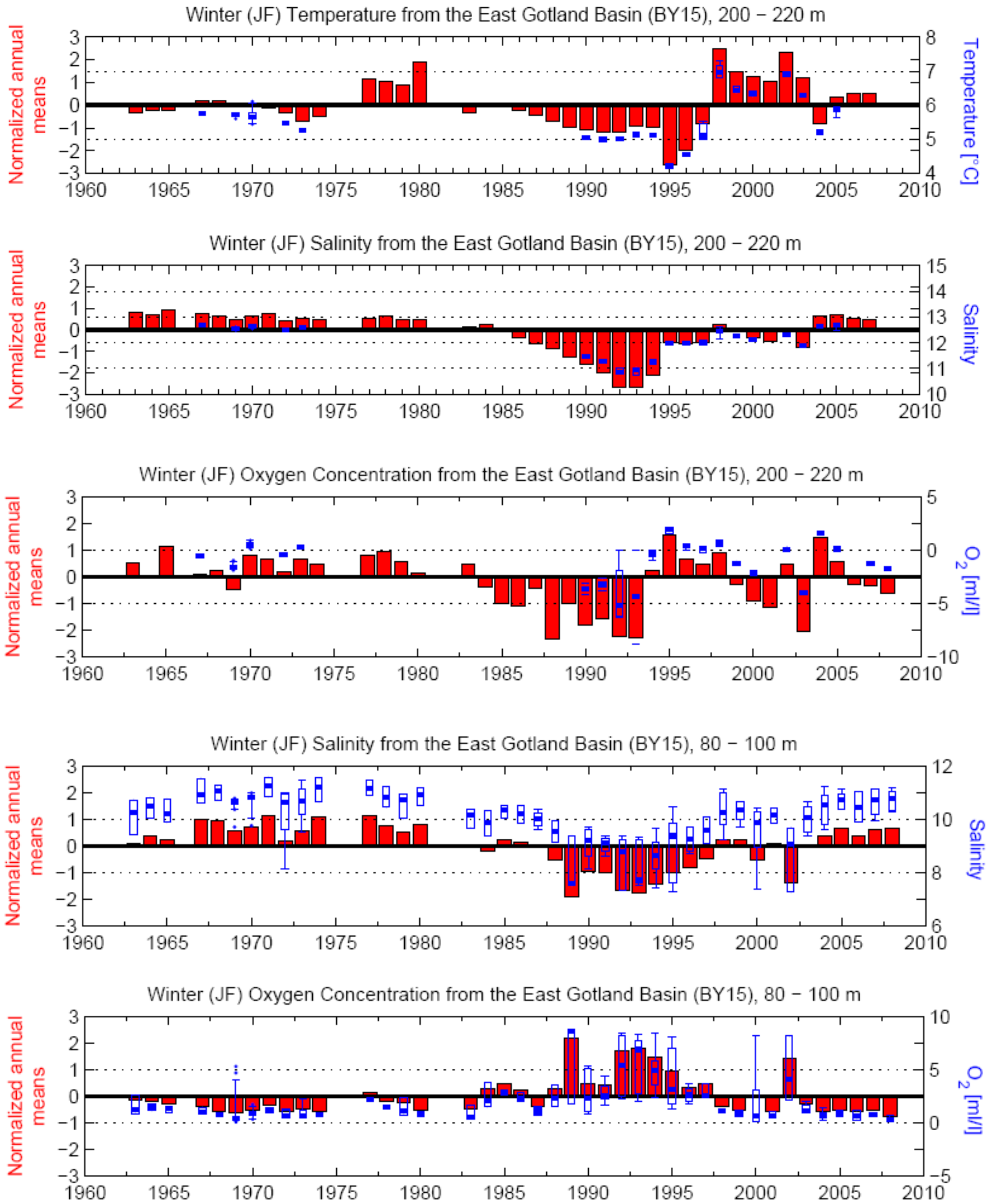

Figure 1: Temperature, salinity and oxygen concentrations in the bottom water (200 – 220 m) and the halocline region (80 – 100 m) of the Eastern Gotland Basin.

Also during 2007, the bottom water in the Eastern Gotland Basin remained stagnant. Therefore, similar to 2007, also in winter 2008 the bottom waters in the Eastern Gotland basin were relatively warm and saline, but oxygen-free (Figure 1). In 200–220 m depth H2S was present in concentrations about 2 ml/l, and in the halocline region (80–100 m) oxygen concentrations further decreased to only 0.4 ml/l. The last major Baltic inflow in 2003 obviously had improved the oxygen conditions in the Eastern

Gotland Basin only temporally. The inflow had pushed the halocline upwards, noticeable by the increased salinity in the 80–100 m water layer, but with the upward movement of the halocline, also the oxygen poor waters extended upwards.

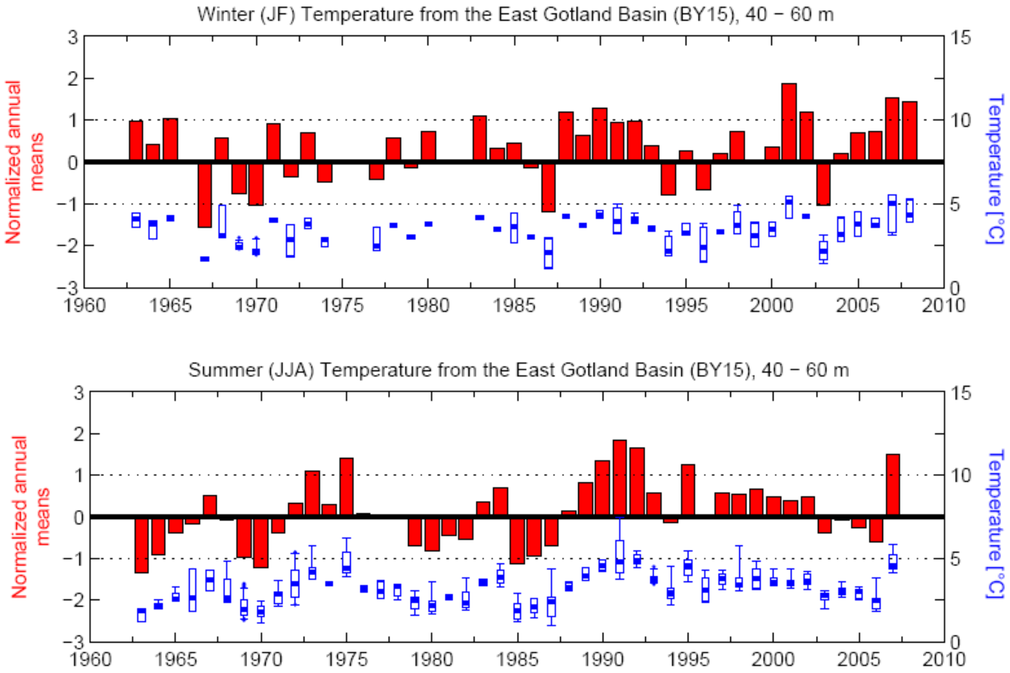

Figure 2: Winter water (40 – 60 m) temperatures in winter and summer in the Eastern Gotland basin.

The temperature dynamics of the Eastern Gotland Basin winter water (40–60 m layer) were exceptional during 2005 and 2006 (Figure 2). While the winter water remained relatively warm until January/February, temperatures dropped below average before summer. This reflects the warm autumn conditions in the Baltic in 2005 and 2006, followed by harsh, prolonged winters. Also during the 2006/2007 winter 2007 temperatures were exceptionally warm, followed by mild late winter air temperatures which caused the warm winter waters observed in summer 2007. For 2008 we except a similar pattern, since the mild conditions at the beginning of 2008 will preserve a warm winter water layer.

Summer surface water (0–10 m) temperatures (Figure 3) have continued their long-term increase also in 2007, even though surface layer temperatures were slightly lower than in 2006, which had the highest median summer temperatures in the measurement series in the Eastern Gotland basin.

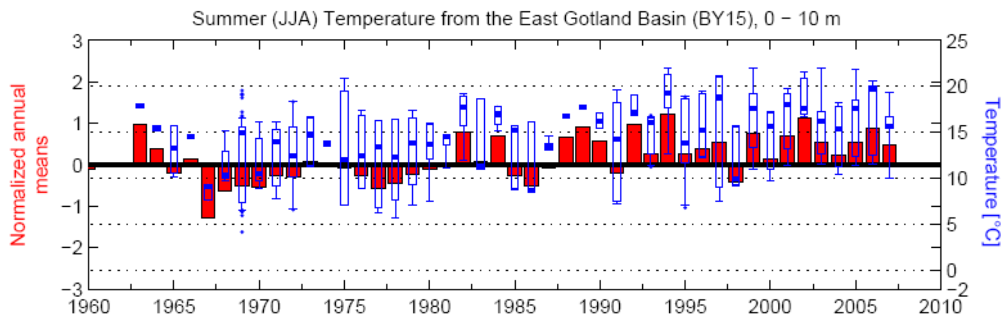

Figure 3: Summer surface layer (0 – 10 m) temperatures in the Eastern Gotland Basin.

Nutrients

Winter DIP and DIN concentrations in the surface layer of the Eastern Gotland basin show diverging trends since 1991 (Figure 4). While winter DIN concentrations decreased, winter DIP concentrations were again high in 2003 – 2008. Based on the high DIP surplus in the surface layer (DIN/DIP = 4.8) compared to the Redfield ratio 2008 will again be favourable to cyanobacteria blooms.

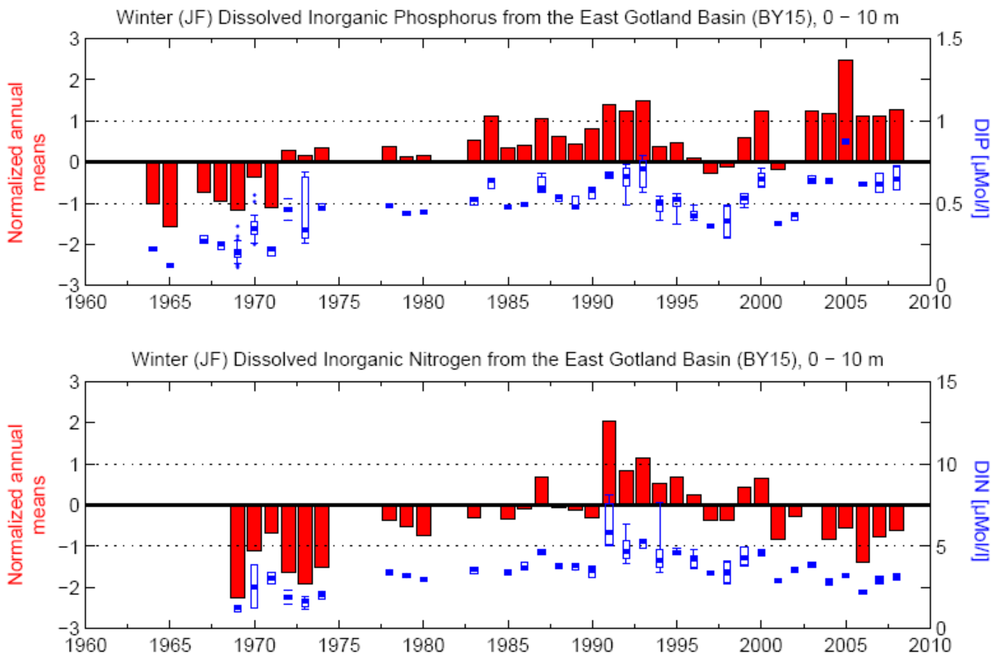

Figure 4: Winter DIN and DIP concentrations in the Eastern Gotland Basin (0 - 10 m).

Phytoplankton

Phytoplankton biomass data for 2007 were not available for the Eastern Gotland Basin yet. Biomass data in 2006 report a very low spring bloom, which was most likely an artefact caused by a delayed spring survey (Figure 5). Alg@line observations (see 1.4) show a pronounced spring bloom and high summer chlorophyll a concentrations in 2007, which are also confirmed by the chlorophyll a observations in the ICES oceanographic database. While the species composition of the 2007 summer blooms is still not analyzed, satellite observations recorded only very low surface accumulations of cyanobacteria (see 1.5). However, high cloud cover limited the usefulness of satellite images in 2007.

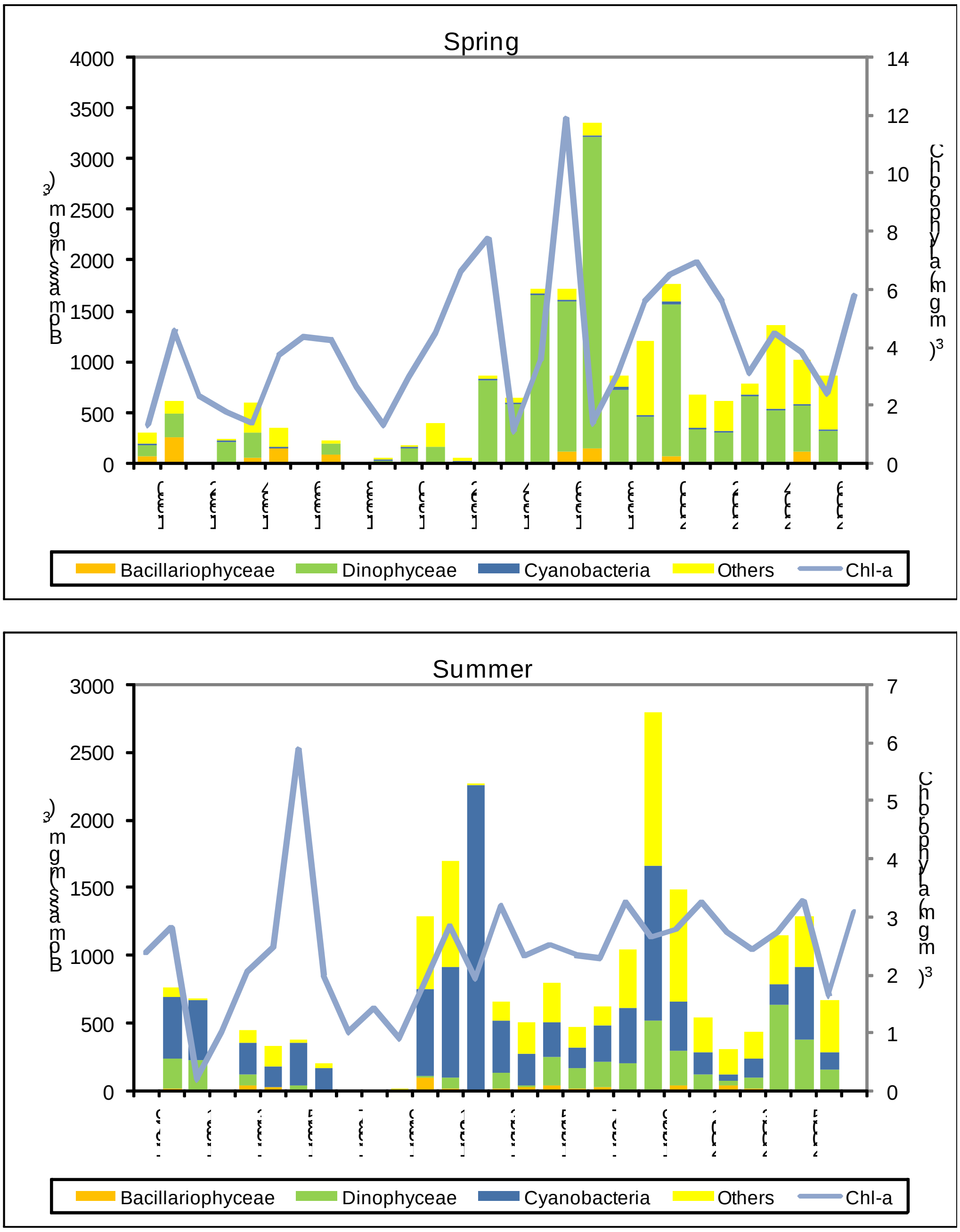

Figure 5: Phytoplankton biomass and chlorophyll a in the Eastern Gotland Basin in spring (left) and summer (right) (IO-Warmenmünde, marine monitoring data, ICES oceanographic database)

Zooplankton

In spring (May, Figure 6) 2007, the total biomass of Copepoda was lower than in the previous year and remained slightly below the long-term average. The low copepod biomass compared to 2006 is mainly caused by a decrease in *Pseudocalanus acuspes*, which dropped to a very low level. Dominant species in the spring community in 2007 was *Temora longicornis*.

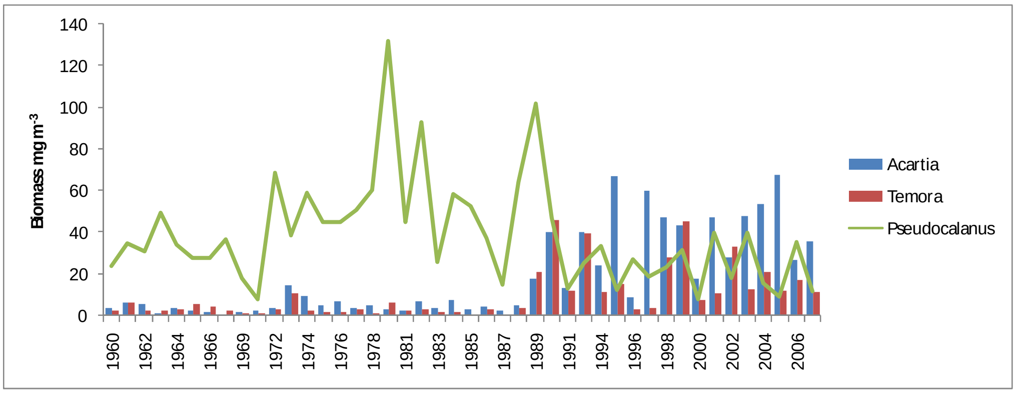

Figure 6: Biomass of the main copepod species in the Eastern Gotland Basin in May.

In summer (August, Figure 7) 2007 the total biomass of Copepoda reached 87% of its long-term average. Compared to the low copepod biomasses in 2006, especially the biomasses of *Acartia* spp. and *Temora longicornis* had increased again.

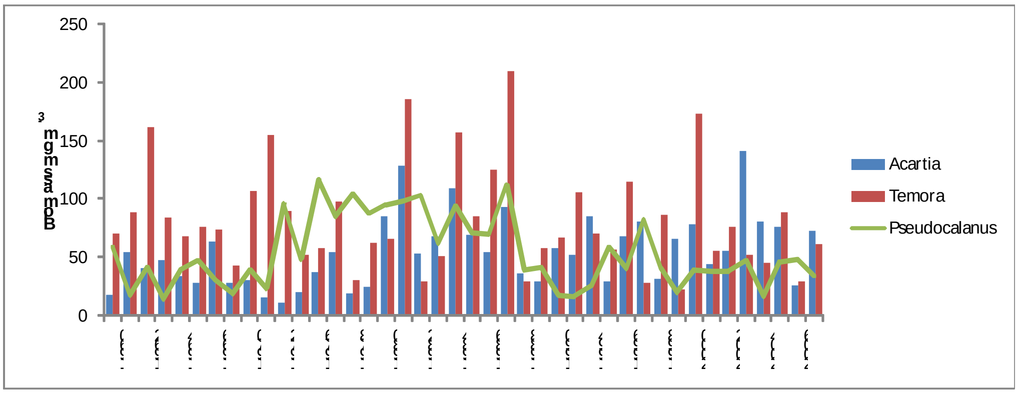

Figure 7: Biomass of the main copepod species in the Eastern Gotland Basin in August.

1.2 Bornholm Basin

Hydrography

In the Bornholm basin, the 2003 inflow had improved bottom-water oxygen conditions, but already in 2004 bottom-water oxygen concentrations were below the long-term average, dropping to anoxic conditions in summer 2005, which again improved in 2006 (Figure 8). In summer 2007, bottom-water oxygen concentrations were low (0.5 ml/l), but positive. Unlike in the Eastern Gotland Basin, in the shallower Bornholm basin bottom-water oxygen concentrations also carry a seasonal signal. Therefore oxygen concentrations in summer tend to be lower than during winter. Winter oxygen conditions have slightly improved in 2006–2008, which is also reflected in a higher cod reproduction volume in 2006, but it is difficult to predict, whether this trend will also be visible in the cod reproduction volume in 2008.

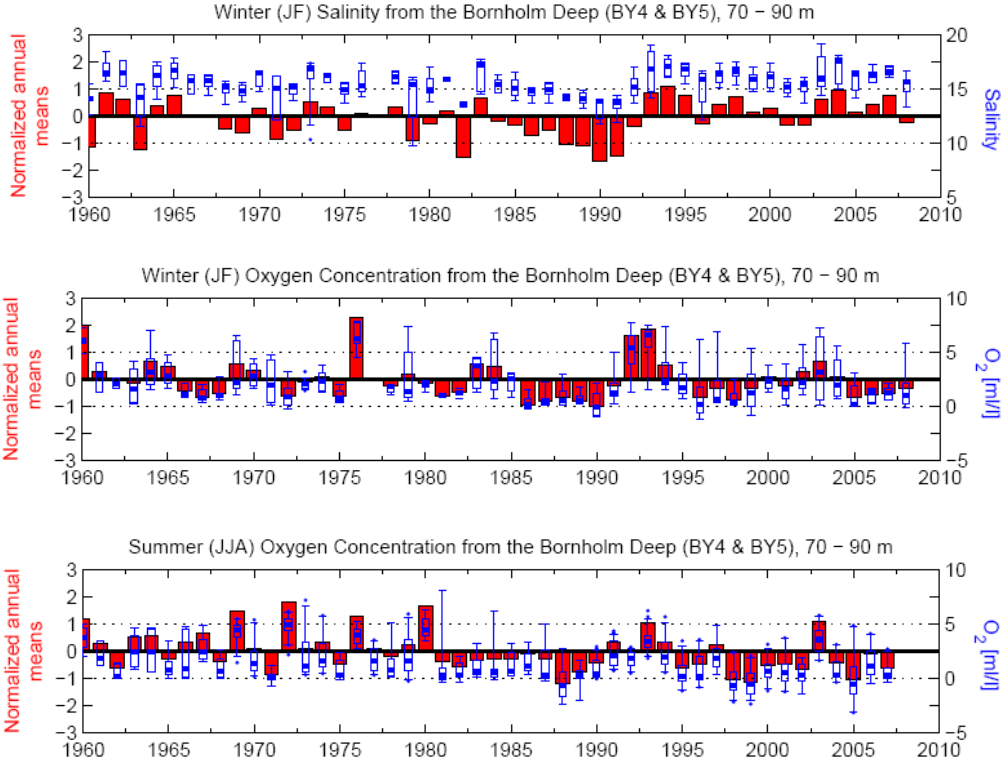

Figure 8: Salinity and oxygen conditions in the bottom layer (70 – 90 m) of the Bornholm basin.

In the surface layer of the Bornholm basin, the typical long-term freshening and warming of the Baltic Sea is evident (Figure 9). Similar to the Eastern Gotland basin, winter temperature in 2007 was exceptional high. 2008 winter temperatures were lower, but also above the long-term average.

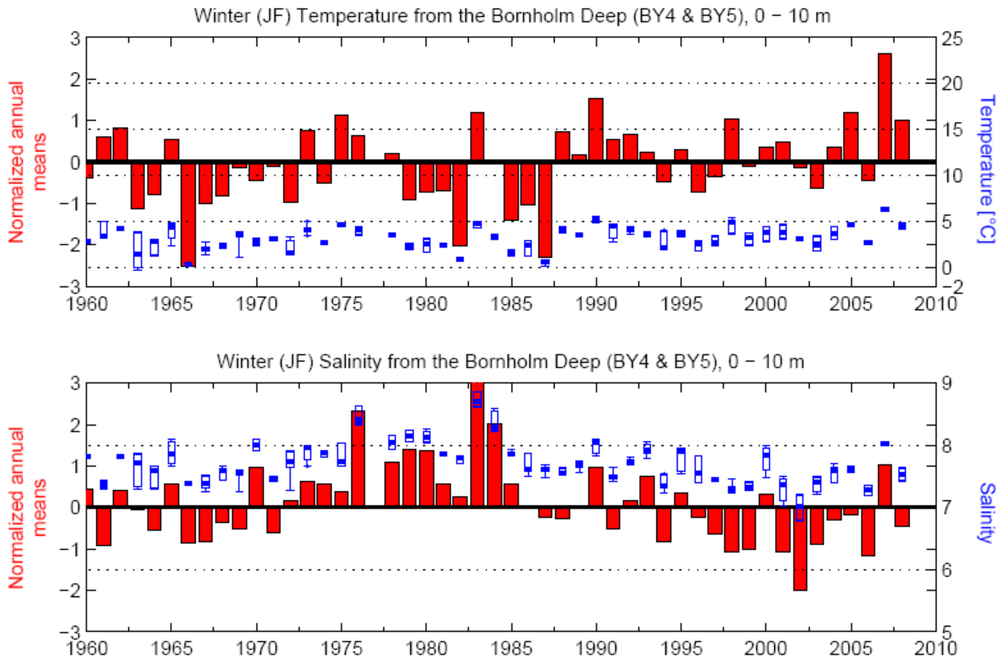

Figure 9: Winter temperature and salinity in the surface layer (0 – 10 m) of the Bornholm basin.

Nutrients

Surface layer nutrient concentrations in winter (Figure 10) were similar to the Eastern Gotland basin and indicate high surface water exchange between both sub-basins. The period 2004–2008 is characterized by high surplus DIP and therefore sensitive to cyanobacteria blooms.

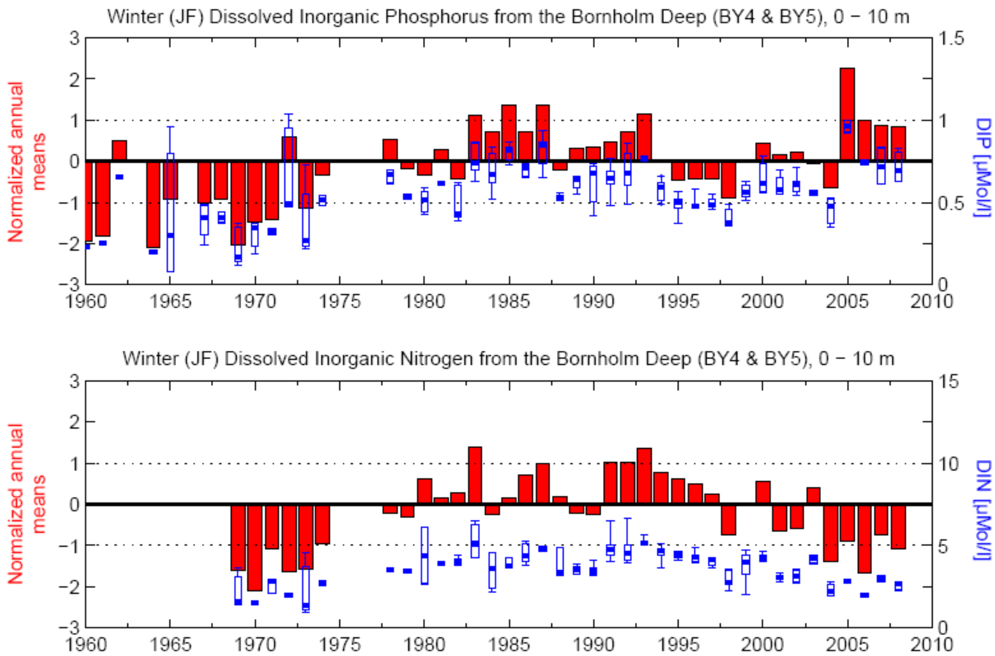

Figure 10: Winter DIP and DIN concentrations in the surface layer (0 – 10 m) of the Bornholm basin.

Phytoplankton

Phytoplankton biomass data for 2007 were not available for the Bornholm Basin yet. In 2006, biomass counts reported a low spring bloom (Figure 11), which is most likely an artefact caused by delayed sampling. Alg@line observations in 2007 in the Southern Baltic found a steep, relatively early chlorophyll *a* spring peak and average summer dynamics (see 1.4).

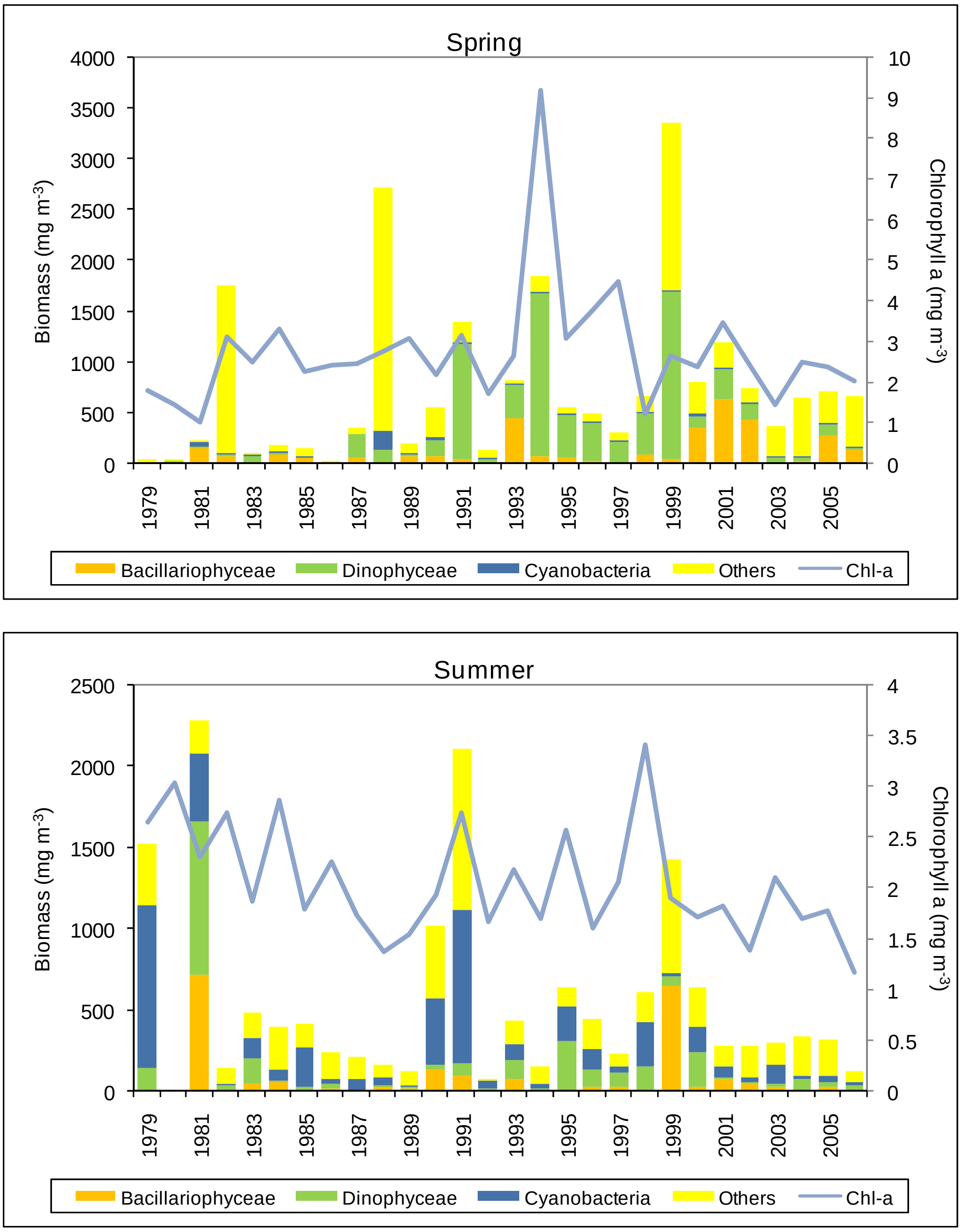

Figure 11: Phytoplankton biomass and chlorophyll a in the Bornholm Basin in spring (left) and summer (right) (IO-Warmenmünde, marine monitoring data, ICES oceanographic database)

1.3 Cod reproduction volume

Baltic cod eggs require saline water (> 11 PSU) with suitable oxygen concentrations (> 2 ml/l) and temperature conditions (> 2 ºC) for survival. Cod recruitment success strongly depends on the "reproduction volume", i.e. the volume of water masses with suitable salinity and oxygen conditions.

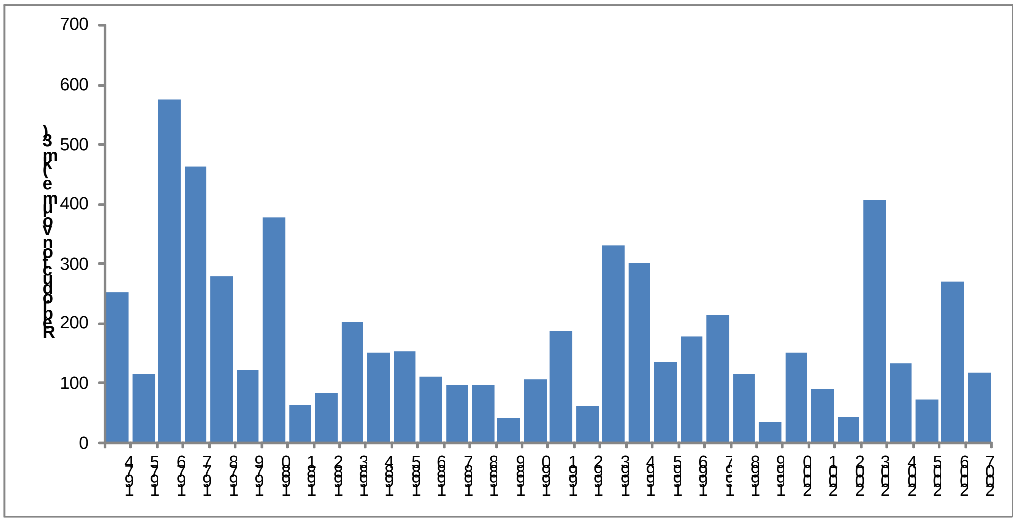

Figure 12: Cod reproduction volume in the Baltic.

Since the mid-1960s, cod reproduction volume has steadily declined (Figure 14). Starting from the mid-1980s, cod reproduction was mainly restricted to the Bornholm basin, while in the Gdańsk and Gotland deep suitable reproduction conditions occurred only occasionally.

After the 2003 saline water inflow, cod reproduction conditions improved only briefly. Even though the Eastern Gotland basin was replenished with saline water and salinity in the 80–100 m layer maintained approx. 10.5 PSU from summer 2004 until present (winter 2008), oxygen concentrations were insufficient for successful cod reproduction (see Figure 13, bottom right).

In contrast to the Gotland basin, cod reproduction conditions in the Bornholm basin have a strong seasonal signal. Oxygen content at 11 PSU is generally highest in March/April, before thermal stratification is established, and lowest in October/November, before winter mixing replenishes the deeper water layers with oxygen (Figure 13, bottom left).

Because of the low oxygen concentrations in the Eastern Gotland Basin, cod reproduction volume was low.

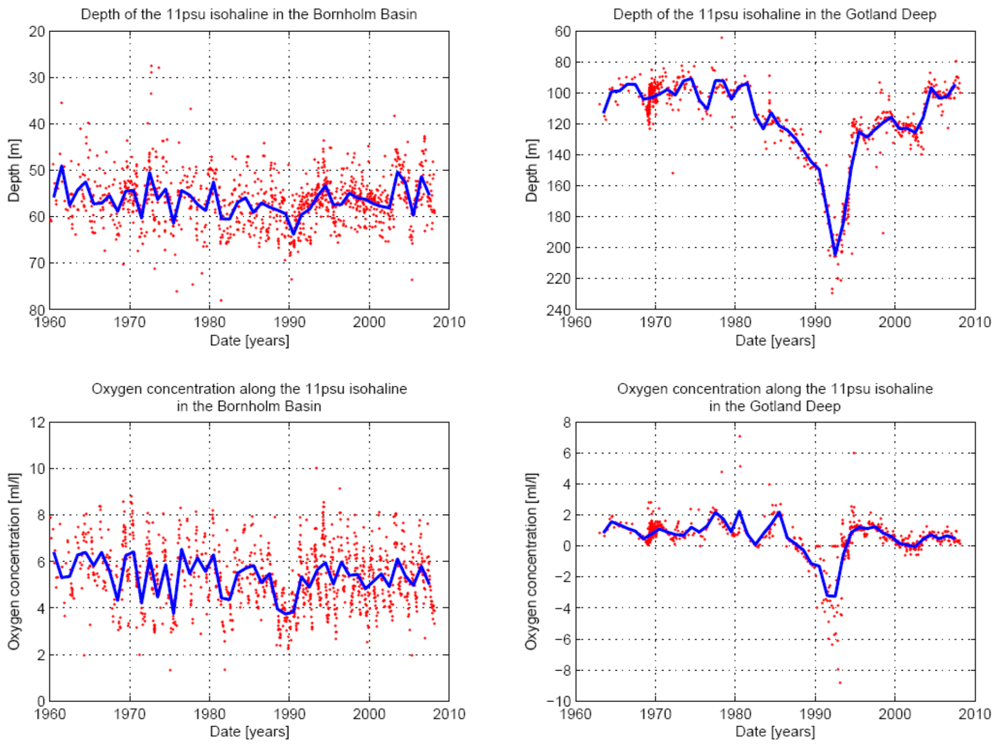

Figure 13: Depth of the 11 PSU isohaline and oxygen content at 11 PSU in the Bornholm (left) and Eastern Gotland Basin (right).

1.3 Alg@line phytoplankton observations

The Algaline-project has collected monitoring data on board commercial vessels since 1992. 12 or 24 weekly water samples have been taken during the phytoplankton growth season along the route between Travemünde and Helsinki. The water flow-through system includes an automatic refrigerated sequential water sampler, taking samples for supplemental analysis, such as inorganic nutrients, phytoplankton species composition and chlorophyll-*a* with extraction method in the laboratory. The approximate sampling points are show in Figure 14.

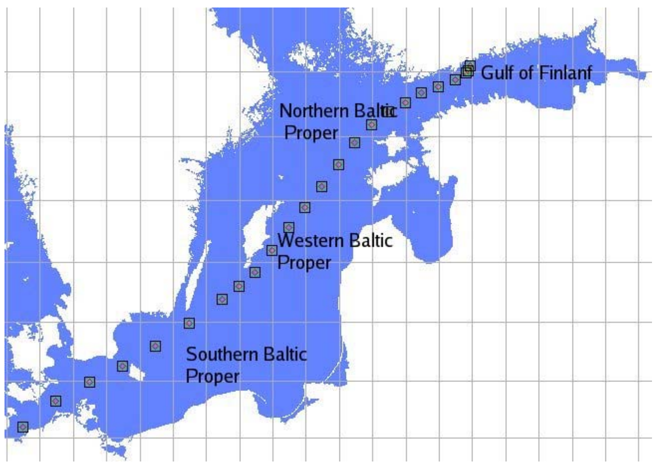

Figure 14: Water sampling points for chlorophyll-a analysis

In the Gulf of Finland the 2007 spring bloom formed about a week earlier in March, and the peak reached the average level in the beginning of April, but it declined almost two weeks earlier than usual in the end of April. The following summer peak, according to the measurements of chlorophyll-a concentrations in water, was reached in the beginning of July and it was twice as high as the long-term average in the Gulf of Finland and the Northern Baltic Proper (Figure 15, top).

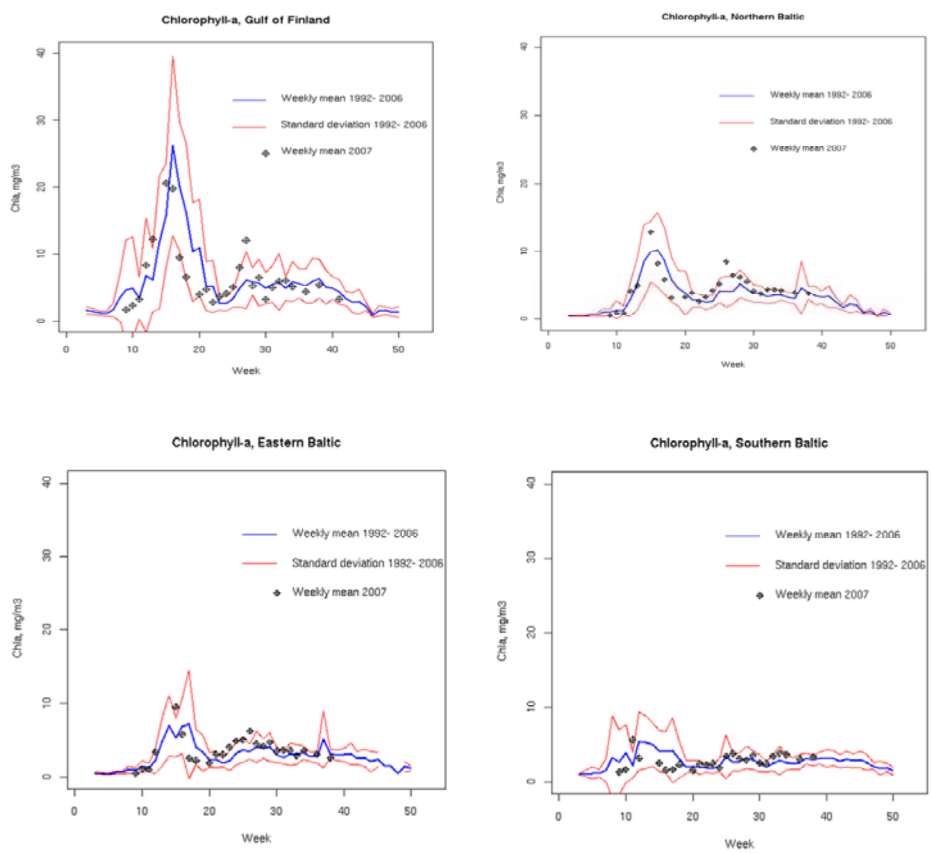

Figure 15: Annual variation of chlorophyll *a* (mg m^{-3}) in the Western Gulf of Finland (upper left), the Northern Baltic Proper (upper right), the Eastern Baltic Proper (lower left) and the Southern Baltic Proper (lower right). The blue curve represents the average for the years 1992–2006 and red lines mark standard deviations, the black stars the measurements made in 2007.

Towards the end of July, algal blooms at the surface have been rare in the Gulf of Finland, the Archipelago Sea and the sea areas south of the Åland Islands. However, the phytoplankton concentrations remained as high as during the previous week, though mixed in the water column. Although bloom-forming filamentous cyanobacteria constituted in August a significant portion (1/3), diverse small motile flagellated algae (mainly chryso- and haptophytes) were dominating the biomass (2/3). The autotrophic ciliate *Mesodinium rubrum* was also visible in phytoplankton biomass.

1.5 Cyanobacteria blooms

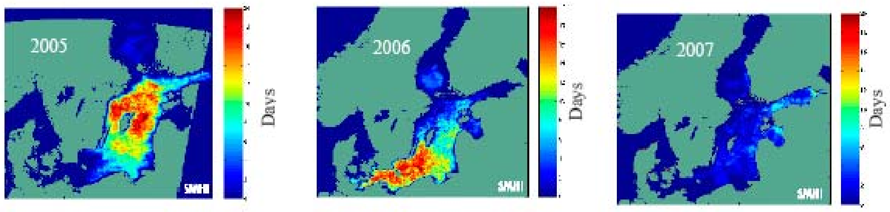

Figure 16: Surface accumulations of algae in summer (SMHI indicator report, http://www.helcom.fi/environment2/ifs/ifs2007/en_GB/Cyanobacterial_blooms/).

Cloud cover was high during summer 2007. Satellite observations reported only very low surface accumulations of algae.

2 Gulf of Riga

Runoff

Runoff from the Daugava (Figure 17), the largest river draining into the Gulf of Riga, provides a proxy for the nutrient load to the Gulf, especially with respect to nitrogen inputs (Yurkovskis *et al.* 2004). Runoff in 2007 was 1.6 times its long-term average, caused by a run-off peak in January. However, the summer season was dry and fresh-water inputs during the productive season from March to October were only half their long-term average.

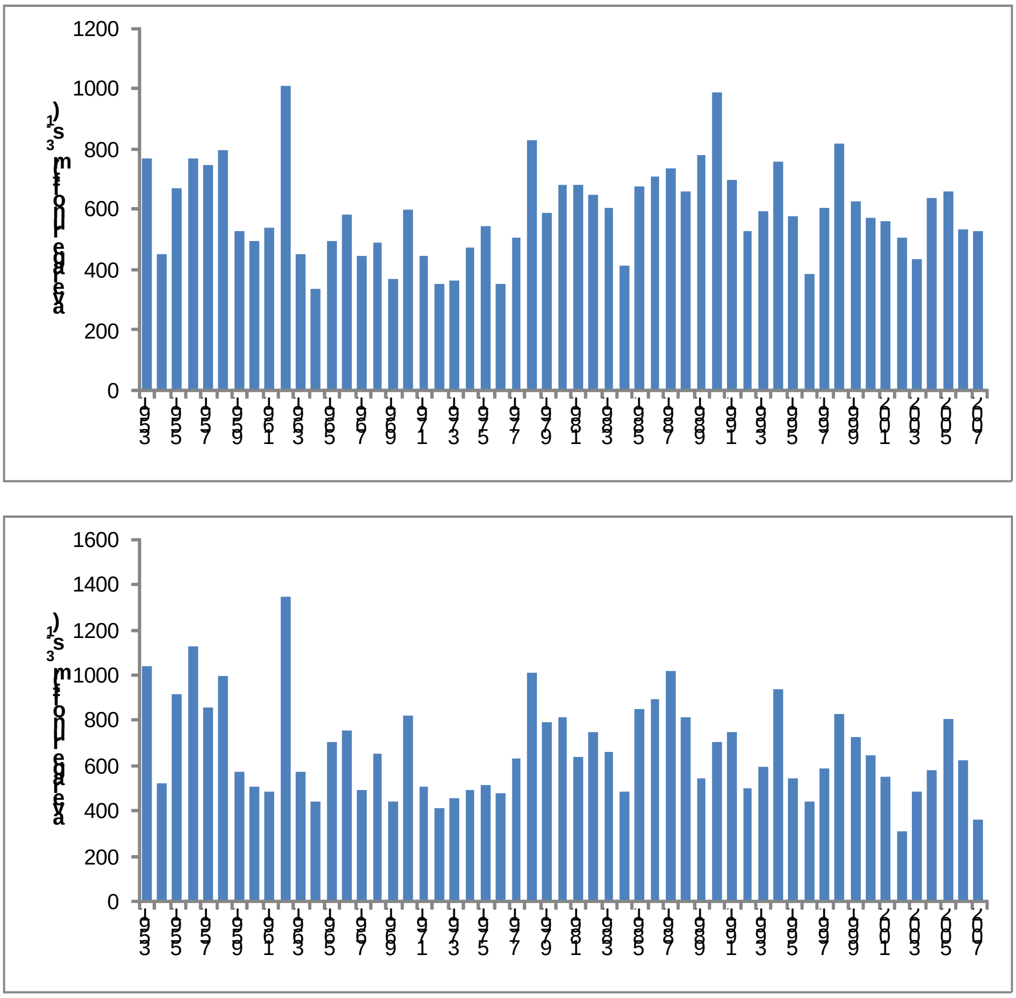

Figure 17: Runoff to the Gulf of Riga from the Daugauva River annually (top) and during the productive season (March – October, bottom).

Hydrography

The relatively high salinities observed in the bottom layer of the Gulf during 2006, which contributed to prolonged stratification and low bottom-water oxygen conditions, were mixed into the entire water column and bottom-water salinities were only slightly larger than their long-term average. Compared to the relatively fresh state of the water column with average salinities as low as 5.2 PSU around the year 2000, average salinity has increased again to approximately 5.6 PSU. The latter is about 0.5 units lower than the maximum average salinity observed in the Gulf (6.1 PSU).

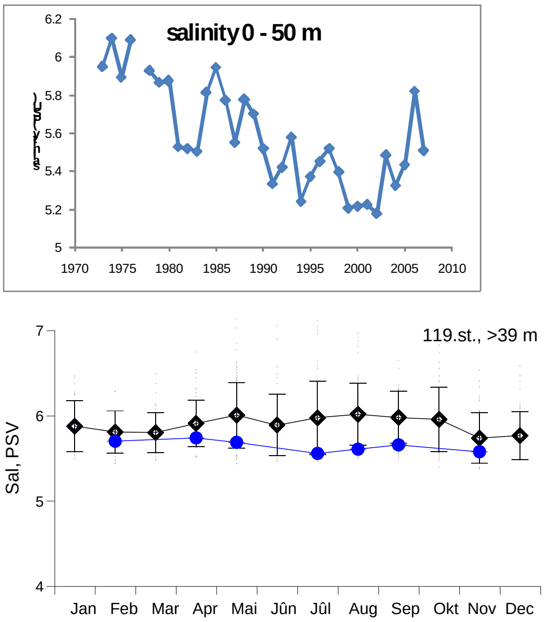

Figure 18: Salinity in the Gulf of Riga: Average water column salinity in August (top panel) and seasonal dynamics in the bottom water (bottom panel) in 2007 compared to long-term data (filled blue dots: 2007 observations, black rhombs: 1973–2007 average with standard deviations).

Also during summer 2007 oxygen concentrations in the bottom layer of the Gulf (Figure 19) dropped to low levels beneath their long-term average. In August, the minimum oxygen concentration observed was 3.0 ml/l. Values in October, before the breakup of thermal stratification were most likely slightly lower, but observations are not available.

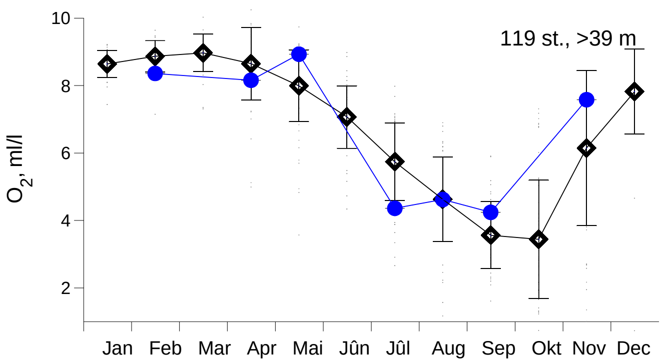

Figure 19: Seasonal dynamics of oxygen in the bottom water in 2007 compared to long-term data (filled blue dots: 2007 observations, black rhombs: 1973–2007 average with standard deviations).

Temperature conditions in the Gulf were determined by a relatively cold and late spring, which followed the warm winter. Therefore compared to their long-term dynamics, upper layer temperatures in May were relatively low and the warming of the euphotic layer was delayed. Summer sea surface temperature was high (Figure 20).

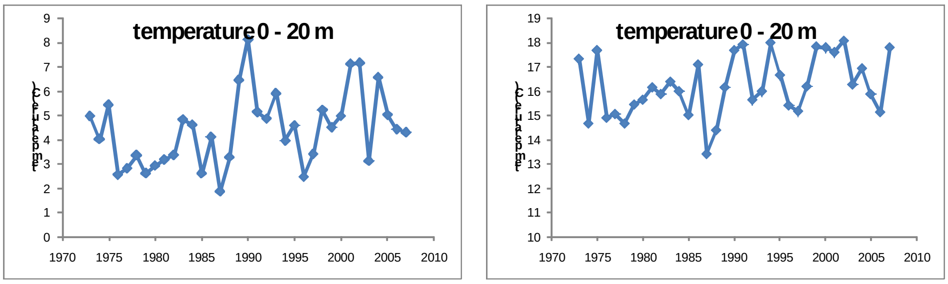

Figure 20: Surface layer temperature in the Gulf of Riga in May (left) and August (right) in the Gulf of Riga.

Nutrients

2008 winter nutrient concentrations are on a low level, especially for DIP (Figure 21). The DIN/DIP ratio in the winter nutrient pool (DIN/DIP = 14.1) is close to the Redfield ratio. Based on the winter nutrient pool, productivity in 2008 can be expected to be relatively low. Supplemented by fresh-water inputs with high N/P ratio, the DIN//DIP ratio in the winter nutrient pool is most likely sufficiently large to suppress blooms of N-fixing phytoplankton.

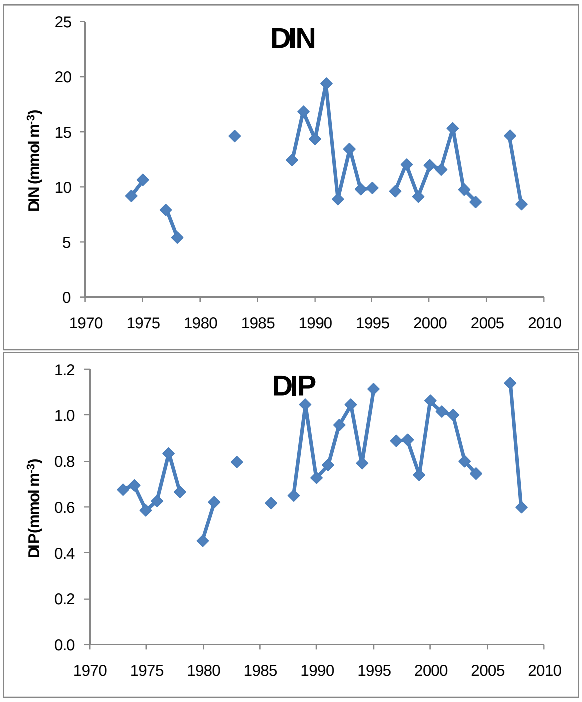

Figure 21: Winter nutrient concentrations in the Gulf of Riga.

Phytoplankton

Spring chlorophyll *a* observation captured a strong 2007 spring bloom in the open parts of the Gulf. In summer, the long-term increasing trend in chlorophyll *a* concentrations continued (Figure 22). Even though chlorophyll *a* concentrations were large, no exceptional summer blooms were observed and cyanobacteria made up at maximum 50 % of the observed phytoplankton biomass.

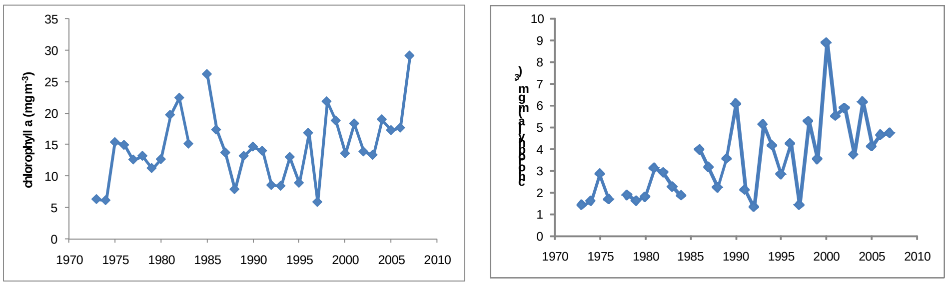

Figure 22: Spring (left) and summer (right) concentrations of chlorophyll *a* in the Gulf of Riga.

Zooplankton

Spring (May) zooplankton biomass in 2007 (Figure 23) exceeded the long-term average, despite the delayed warming of the water column. *Acartia* and *Eurytemora* were the dominant species. *Limnocalanus macrurus* biomasses continued to increase, but compared to the 1970s, its abundance still remains on a very low level.

While spring biomasses of *Acartia* and *Eurytemora* in 2007 reached 3–4 times their long-term average, their biomasses in summer (Figure 24) were still slightly lower than the long-term average. *Limnocalanus* made up a significant part (30 %) of the summer copepod community. During the August 2007 sampling, also mass development of cladocerans, mainly *Bosmina* spp. was observed (Figure 25).

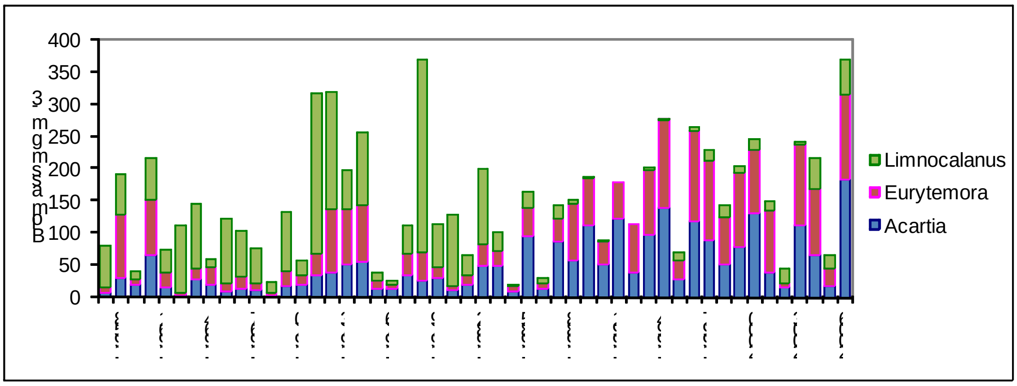

Figure 23: Biomass of the main copepod species in the Gulf of Riga in May.

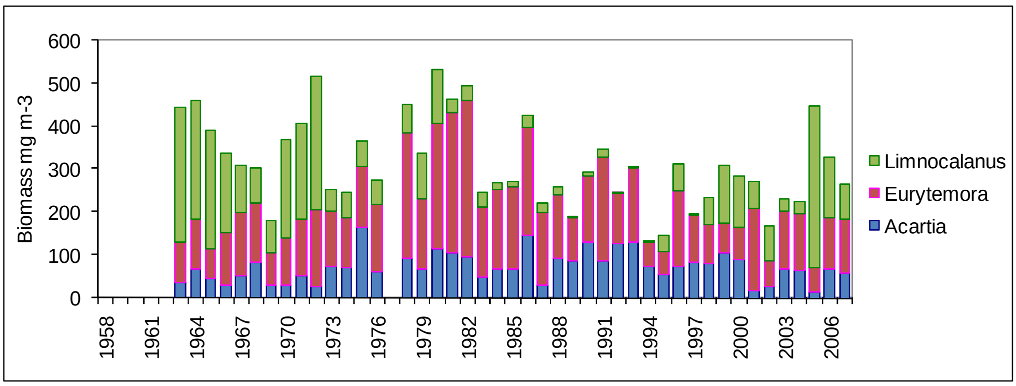

Figure 24: Biomass of the main copepod species in the Gulf of Riga in August.

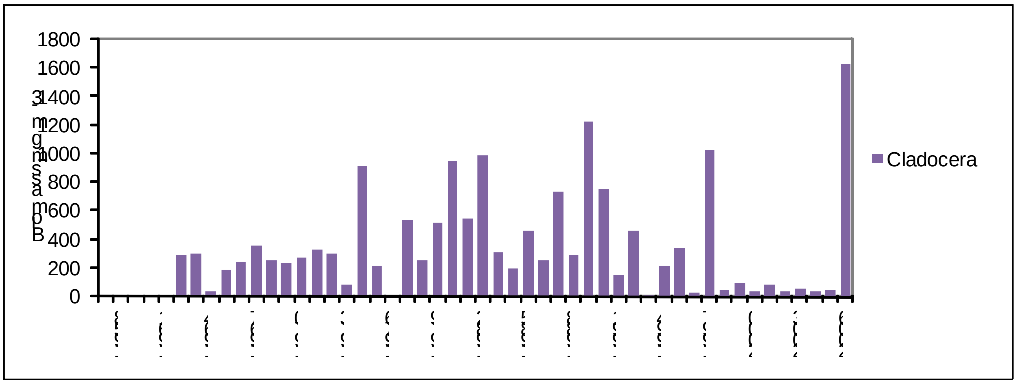

Figure 25: Biomass of cladocera in the Gulf of Riga in August.

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Annex 7: Spreading of *Mnemiopsis leidyi*

Info on Spreading of *Mnemiopsis leidyi* from 2006 to 2008 in the Baltic Sea

Lutz Postel (ZEN)

In autumn 2006 the West Atlantic comb jelly *Mnemiopsis leidyi* was observed for the first time at several locations in Northern Europe. It was almost synchronously found in the North Sea (Faasse and Bayha 2006, Boersma *et al.*,2007), at the Swedish west coast (Hansson 2006), in Oslofjorden (Oliveira 2007) and in the western Baltic Sea (Javidpour *et al.* 2006, Kube *et al.* 2007).

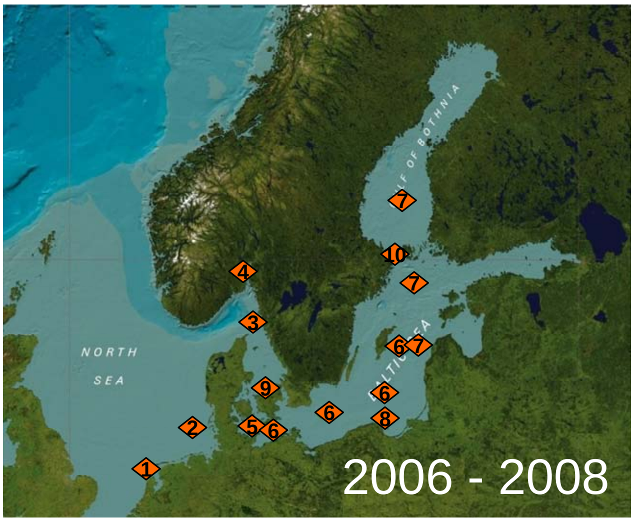

Figure 1: Spreading of *M. leidyi* in Northern European waters according reports in the literature between 2006 and 2008 (from Postel and Kube in: ICES Insights 45, 2008).

1) Faasse and Bayha (2006): August – November, 2006), 2001?

2) Boersma *et al.*,(2007): November - December, 2006) 0,1 Ind./m³,

3) Hansson (2006): late August, 2006: "Thousands per catch"

4) Oliveira (2007): Oslofjord

5) Javidpour *et al.* (2006): First record – October 17, 2006, 109 ind/m³ in November, decline to 0.2 Ind./m³ in March 2007

6) Kube *et al.* (2007): First records from summer 2006, in October identification as *M. leidyi*, overwintering in deep water of the central Baltic Sea and in shallow areas of the western Baltic Sea

7) Lehtiniemi *et al.* (2007) – in late summer 2007 (halocline)

8) Janas und Zgrundo (2007) – Gdańsk Bight

9) Tendal *et al.* (2007) – Danish waters

10) Lehtiniemi *et al.*, (2008) – overwintering in deep waters of Åland Sea (3800 ind./m² = app. 13 ind./m³)

During autumn/winter 2006 and spring 2007, *M. leidyi* spread up from the south western Baltic Sea to the southeastern Gotland Basin (Kube *et al.*, 2007). While it was found in the entire water column in Kiel Bight (up to 90 ind. /m³ in autumn 2006), it occurred exceptionally below the halocline in the deep stratified central Baltic basins in abundances of <1 ind. m^{-3} through the entire winter /spring period at temperatures of 9 -10°C, salinities of 10 to 14 PSU and oxygen contents between 1 to 3 ml l^{-1}. In late summer 2007, *M. leidyi* was detected at the entrance of the Gulf of Finland and in the central Bothnian Sea in quantities of less than 10 ind. m^{-3}. The highest densities including juveniles were found in the water layers around the halocline (Lehtiniemi *et al.*, 2007). Further reports came up from Gdańsk Bay (Janas and Zgrundo, 2007) and from all Danish waters (Tendal *et al.*, 2007).

M. leidyi also survived in winter 2007/2008 in the Baltic Sea with low concentrations in the southern parts but up to 13 ind. m^{-3} in January the Åland Sea (Lehtiniemi *et al.*, 2008). Figure 1 includes spreading of *M. leidyi* in Northern European waters according reports in the literature.

For more details, please refer Postel and Kube in the current ICES Insight 45 (2008).

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Annex 8: Zooplankton indicators

"Not to be cited without prior reference to the author"

International Council for the Exploration of the Sea

ICES CM 2007/C:03

ZOOPLANKTON INDICATORS OF EUTROPHICATION AND PRODUCTIVITY FOR THE BALTIC SEA

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Extended abstract

Zooplankton plays a key role in the pelagic foodweb by controlling phytoplankton production and shaping pelagic ecosystems. In addition, because of their critical role as a food source for larval and juvenile fish, the dynamics of zooplankton populations, their reproductive cycles, growth, reproduction, and survival rates are all important factors influencing recruitment to fish stocks (Harris *et al*., 2000).

The identification of zooplankton indicators is difficult and demanding as is confirmed in the ICES Working Group on Zooplankton Ecology report (ICES 2004): 'WGZE realises that it is tasked with the development of indices that are relevant and useful for fisheries management. Also, WGZE realises that generating indices requires exploring multiple factors and associations, so requires multivariate techniques or multi-parameter models to produce simple, repeatable indices. It is very possible however, that such results may be wrongly interpreted or applied, when all the known and unknown variability is reduced to single figure indices'.

The Baltic Sea provides a unique opportunity to test zooplankton indicators because one of the longest dataseries is available here. Monitoring of varying intensity has been performed since 1959 by the Latvian Fish Resources Agency (LatFRA) in the Gotland Basin and the Gulf of Riga. The goal is to understand the effect of zooplankton on local commercial fish populations.

There are many examples from the Baltic Sea that zooplankton organisms, and especially copepods, may have a strong impact on fish growth, survival, and condition and therefore might be useful productivity indicators. Zooplankton data, in general, also provide fundamental information on the dynamics and functioning of the Baltic Sea ecosystem. In this respect, the Baltic Sea Regional Project provided a heretofore absent platform for cooperation between monitoring and fish and fisheries specialists.

This extended abstract provides selected up-to-date information regarding the results of our analyses that contributes to the identification of reliable zooplankton indicators of eutrophication and productivity in the Baltic Sea.

Three study areas of the Baltic Sea were selected: the eastern Gotland Basin, the Gulf of Finland, and the Gulf of Riga (Figure 1).

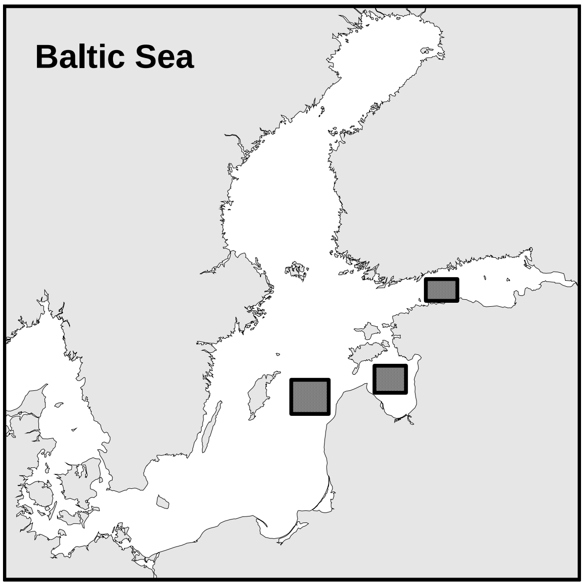

Figure 1. Location of study areas in the Baltic Sea.

The time-series of the **Gulf of Riga** data were collected from different sources. Long-term time-series of mesozooplankton and hydrography (1963–2004) were obtained from the Latvian Fish Resources Agency (LatFRA) database. Zooplankton sampling was performed in May (spring) and August (summer) at 10–13 stations at two depth layers (0-20m, 20m-bottom) or from the surface to the bottom. For each station the total abundance ($n*m^{-3}$) of each zooplankton taxa/stage was computed for the whole water column (0-bottom) and then the average value was calculated for all the stations. Biomass ($mg*m^{-3}$) was estimated from individual standard wet weights (Hernroth, 1985).

Hydrographic data on temperature, salinity, Secchi depth, and chlorophyll *a* concentrations (1963–2004) were provided by the Latvian Institute of Aquatic Ecology, LatFRA, and the Latvian Hydrometeorological Agency. Average values were calculated for the Gulf of Riga open water stations.

Winter DIN and DIP (January–February, 1973–2004) were provided by the Latvian Institute of Aquatic Ecology.

Herring recruitment and abundance data were obtained from an Extended Survivor Analysis (XSA) conducted by the ICES Baltic Fisheries Assessment Working Group (WGBFAS) for the period of 1969–2004. Length and weight-at-age 1 herring data from late summer/autumn trawl catches (1980-2006) were provided by LatFRA.

In the **Gulf of Finland** long-term zooplankton samples have been collected since the 1960s from three transects with three to five sampling stations per transect. However, zooplankton data from before 1974 are scarce and many auxiliary data are not available for the zooplankton sampling period; thus, useful dataseries for analyses start with those of 1974. Samples were taken from up to four separate layers, depending on station depth and sampling period: fixed depths (0-10 m, 10-25 m, 25-50 m, 50-bottom) were sampled previously, but the location of the thermocline has determined depth since 1993. For each station the total abundance ($n*m^{-3}$) of each zooplankton taxa/stage was computed for the whole water column (0-bottom). Biomasses ($mg*m^{-3}$) were estimated from individual standard wet weights (Hernroth, 1985). For the current analyses, the average zooplankton biomasses were calculated for each transect, and then transects were used in analyses as independent samples.

Finally, the central transect was chosen for further analyses, as it was best covered with zooplankton and environmental data and due its central position in the gulf. Environmental factors for years prior to 1993 were obtained from the HELCOM monitoring database (ICES Data Centre), and data collected during the same month and within 1.5 degrees longitude from the transect were used to calculate monthly averages, and then these were related to the available zooplankton data. Since 1993, ambient data have been collected simultaneously with zooplankton sampling. Most of the fish-related parameters used in conjunction with Gulf of Finland analyses were from the central Baltic Sea, but data for sprat and herring landings and average weight-at-age for the Gulf of Finland were also included. Data series regarding herring are short for the Gulf of Finland and are strongly correlated with those of the central Baltic. This also applies to the sprat weight-at-age data. Only the trends of sprat landings in the Gulf of Finland differ remarkably from those of the central Baltic. All zooplankton data and several other parameters were transformed prior to analyses to improve normality. In addition to common or dominating zooplankton species, the following indices or aggregated zooplankton values were calculated for testing: total zooplankton biomass; copepod, cladoceran, and rotifer biomasses; crustacean-rotifer biomass ratio; mean zooplankton weight; number of species; and diversity and uniformity indices.

Zooplankton data from the **eastern Gotland Basin** were collected within the monitoring programme of the Latvian Fish Resources Agency along three meridional transects in the south, center, and north of the Latvian Economic Zone. Data were collected in May, August, and October, but only summer data were used for the current analysis. Temperature, salinity, oxygen, as well as nutrient and chlorophyll *a* data were taken from the ICES Oceanographic database. Stations in the centre of the eastern Gotland Basin were used to represent ambient conditions.

Several examples of the analyses carried out are presented in the following paragraphs.

First, **long-term trends** were described. Figure 2 presents the performance of selected dataseries from the Gulf of Riga.

There were apparently no trends in temperature in May and August; however, much higher amplitude in year-to-year differences has been noted in May temperatures since the late 1980s. Winter salinity increased until the mid 1970s, and then it began to decrease again. However, a salinity decrease from 6 to 5.2^{o}C should not drastically change conditions for zooplankters. Summer Secchi depth presented a significant decreasing tendency throughout the period, while the opposite trend was observed in the average summer chlorophyll *a* concentration. These two parameters indicated increasing eutrophication in the Gulf of Riga. Both winter DIN and DIP concentrations increased until the end of the 1980s, then DIN levels dropped, while DIP concentrations remained high. A pronounced change in climatic conditions was documented based on the Winter Baltic Climate Index (WIBIX, Hagen and Feistel 2005). Since the late 1980s, a much higher frequency of positive values has been recorded indicating relatively warm winter periods. *Limnocalanus* has nearly disappeared from May samples since the mid 1980s, and in spring an apparent shift in *Eurytemora* biomass has been observed since the late 1980s. A similar shift was also recorded in herring recruitment and abundance. Numerous dataseries confirm that there has been a regime shift in the state of the ecosystem after 1988; this is also well documented by the findings of the ICES/BSRP/HELCOM Workshop on Developing a Framework for an Integrated Assessment for the Baltic Sea (ICES 2006).

Patterns in the datasets, (i.e. similarities and differences), were identified with **Principal Components Analyses** (PCA). The results for the Gulf of Finland case study with the spring zooplankton data are presented in Figure 3.

Small zooplankton and fish components have the highest loadings in Factor 1. *Limnocalanus macrurus* had the highest loading of all the crustaceans. In Factor 2, climatic-driven components prevailed: the Baltic Sea Index had the highest loading in Factor 2 together with salinity, temperature in the upper layer, and maximum ice cover.

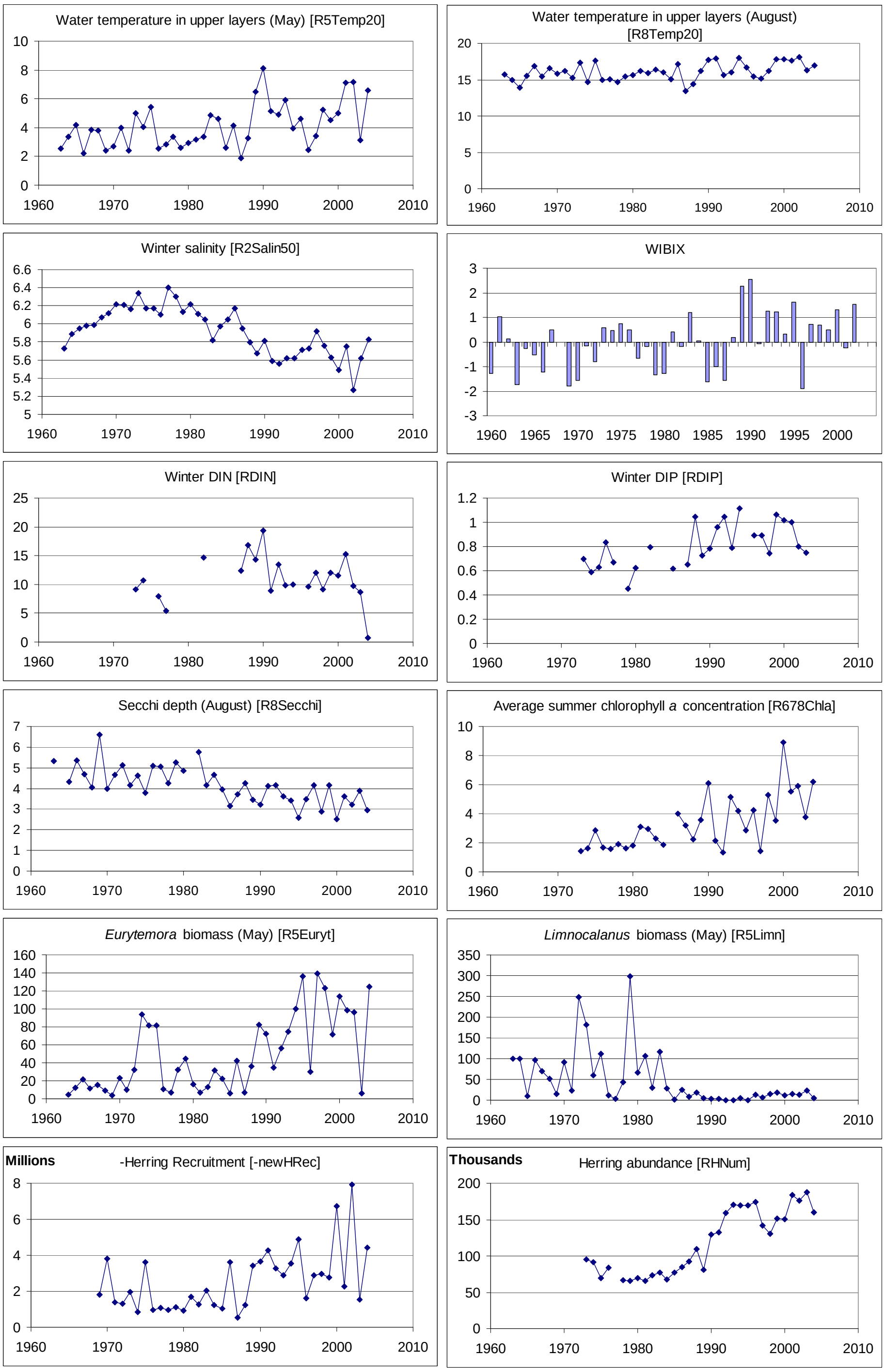

Figure 2. Long-term changes of selected Gulf of Riga factors (data for herring recruitment were shifted one year so as to be comparable with the previous year's conditions).

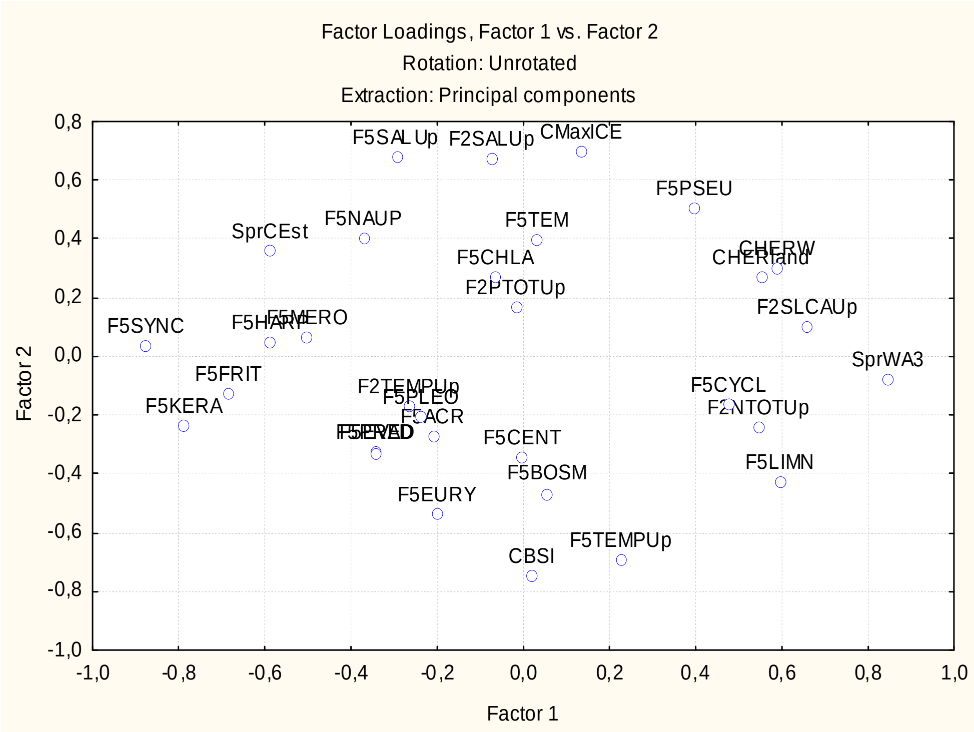

Figure 3. XY-plot of factor-variable correlations, computed for the spring zooplankton community.

No clear bottom-up effect was identified for the zooplankton community in the Gulf of Finland using the analyses presented. Relationships between fish (herring and sprat) and zooplankton are more evident, but it is not clear whether they indicate the top-down effect of fish on zooplankton or the bottom-up effect of zooplankton on fish. The link between small-sized zooplankton and fish suggests some indirect influence since these zooplankton taxa are not the preferred food items of sprat and herring.

To determine whether the zooplankton biomass of particular groups/taxa is correlated with any of the available independent variables, multiple correlations were used. In the eastern Gotland Basin case study area different tools were applied: **generalized additive models** (GAM) and **general linear models** (GLM). Results for the *Pseudocalanus acuspes* biomass are presented in figures 4 and 5. The number of hydrographic factors analyzed was restricted to temperature, salinity, and oxygen conditions in the halocline region of the eastern Gotland Basin (both at a fixed depth, which is the habitat layer for adult *Pseudocalanus*). Additionally, the only nutrient/phytoplankton indicators selected were those that could have potentially influenced their food supply, i.e. chlorophyll *a* during spring as an indicator of the amount of phytoplankton material potentially sedimenting to the halocline, as well as particulate nitrogen concentrations in the halocline region. Among the fish time-series, only the SSB of herring and sprat, and a number of sprat recruits were included. Focusing on a restricted parameter set avoids diluting statistically significant relationships among many intercorrelated time-series.

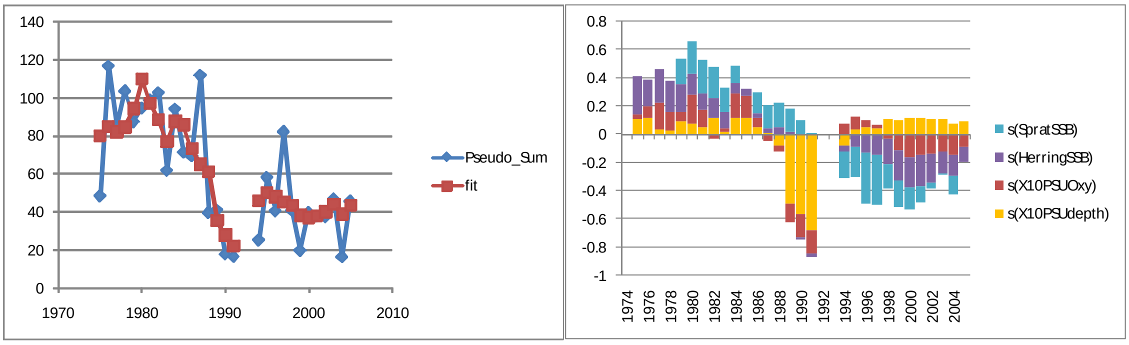

Figure 4. Modelled and measured *Pseudocalanus acuspes* biomass (mg m^{-3}, left panel) and predictors contributing to model fit (right panel).

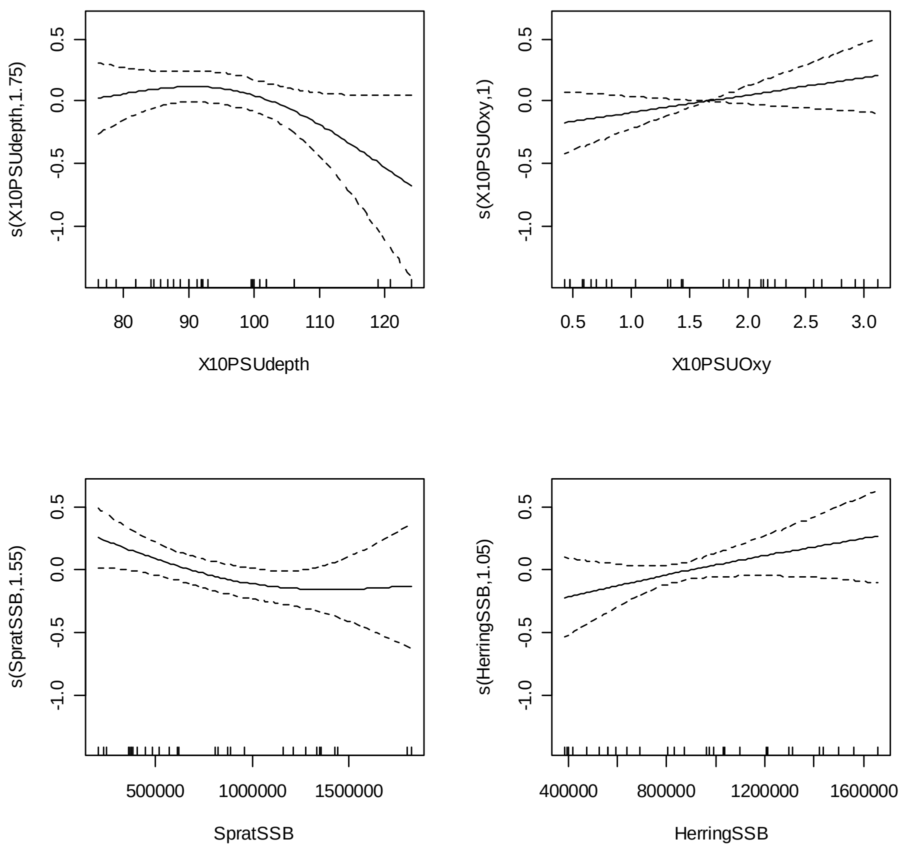

Figure 5: *Pseudocalanus acuspes* GAM smoothing functions for depth at the 10 PSU isohaline (top left), oxygen content at 10 PSU (top right), sprat SSB (bottom left), and herring SSB (bottom right).

Physical factors at the 10 PSU isohaline performed slightly better than those at a fixed depth (80 m), and *Pseudocalanus acuspes* dynamics were described by the depth of the 10 PSU isohaline, oxygen content at 10 PSU, sprat SSB and herring SSB (*Pseudocalanus* ~ s(10 PSU depth)+s(10 PSU oxygen)+s(herring SSB)+s(sprat SSB), link=log). The model fit the data well (R^2adj=.60, Figure 4 left), but significance levels for all independent parameters were low except for sprat SSB, which was significant at p<0.1. The model attributed the decline in the *Pseudocalanus* biomass mainly to the deepening of the 10 PSU isohaline at the end of the 1980s. Low oxygen levels at the 10 PSU isohaline contributed to the decline but were only of secondary importance. A plausible explanation for the strong adverse effect of low 10 PSU depths on *Pseudocalanus* could be declining food quality with increasing distance to the productive layer, but it could also be attributed to the undersampling of *Pseudocalanus* in this depth range. Inflows of more saline waters allow *Pseudocalanus* to distribute over a wider depth range what potentially creates more favourable reproductive conditions (Schmidt *et al.*, 2003). Based on lipid biomarkers, *Pseudocalanus* in the Baltic was characterized as an opportunistic feeder that consumes sinking phytoplankton, detritus, and microzooplankton (Peters *et al.*, 2006). At least for sinking phytoplankton and detritus, a decline in food quality is to be expected. The smoothing functions (Figure 5) showed an interesting relationship between *Pseudocalanus* and planktivorous fish. While sprat was depicted as a predator, herring SSB was positively related to *Pseudocalanus* biomass. This implies that herring was not able to control *Pseudocalanus* biomass; to the contrary, *Pseudocalanus* had a notable bottom-up effect on the herring stock. The dependence of herring condition on *Pseudocalanus* as a food source was demonstrated previously by Möllmann *et al.* (2005).

Multiple correlations were used (General Regression Model, Multiple Regression, Forward Stepwise method) to identify which independent variables influenced 'fish and fisheries factors'. Different transformations were used for dependent variables when it was necessary.

As an example, the model of Gulf of Riga herring recruitment vs. hydrological, 'eutrophication' and zooplankton factors (all temperature and salinity dataseries, WIBIX, winter DIN and DIP, summer Secchi depth, summer average chlorophyll *a* concentration, spring and summer copepod and cladoceran biomass, and spring total zooplankton biomass) is presented:

LN_-New HRec = 0.3323*<u>WIBIX</u> + 0.2299*<u>resR8Temp20(WIBIX)</u> – 0.9632*<u>resR2Salin50(WIBIX)</u> + 0.0039*<u>R5Euryt</u> + 14.1474

(F=42.7, p=.0000, $AdjR^2$=.89)

As the WIBIX index was significantly correlated with most of hydrological data, residuals of particular temperature and salinity vs. WIBIX correlations were used in the final model.

A 'complete model' explains 89% of the total variance.

Herring recruitment is positively related to changes of WIBIX, summer surface temperature, and spring *Eurytemora* biomass and negatively to changes of winter salinity.

Summary

Essentially, the current results indicate that there was only limited correlation between zooplankton time-series and potential 'eutrophication' factors like winter nutrient concentrations, Secchi depth, or chlorophyll *a* concentrations. On the other hand, zooplankton might be a very useful indicator of fish productivity as it is significantly related to the recruitment of numerous fish stocks.

According to many publications, zooplankton organisms, and especially copepods, may have a strong impact on fish growth, survival, and condition. Copepods of the genus *Pseudocalanus* are a major food organism for larval fish, determining their growth and survival (Hinrichsen *et al*. 2002, Möllmann *et al*. 2003), but also for adult pelagic planktivorous fish such as sprat and herring (Möllmann and Köster 1999 and 2002). Flinkman *et al.* (1998) also reported that changes in herring weight-at-age in the northern Baltic are related to the mesozooplankton species composition. The analyses of the feeding habits of Baltic sprat demonstrated that copepod species form an important link between phytoplankton production and fish recruitment in the foodweb of the Baltic Sea (Voss *et al.* 2003).

The current results are also very much in line with various recent activities focused on including environmental factors into fisheries assessments, e.g. the EU funded project 'Incorporating extrinsic drivers into fisheries management' (In Ex Fish) or the ICES/BSRP Workshop on Recruitment Processes of Baltic Sea herring stocks (WKHRPB).

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Annex 9: Zooplankton net intercomparison

Second HELCOM MONAS Zooplankton Monitoring Expert Workshop R/V Aranda 14.-19.08.2006

NET INTERCOMPARISON REPORT

by

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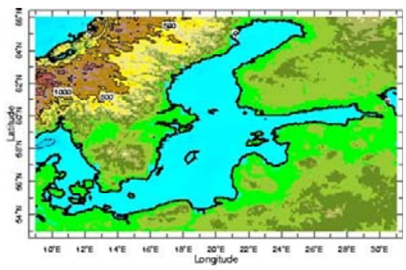

Photo Janne Bruun

Sampling with WP-2 net with different mash sizes (60, 100, and 200 µm) and Juday-net (90 µm) was carried out on August 17, 2006 at BY-38 station during RV "Aranda" cruise. Three hauls with each net from 20-0m were taken. All the nets were equipped with TSK flowmeter. Samples were taken by the same person and subsequently all of them were analysed by one zooplankton expert.

TSK flowmeter

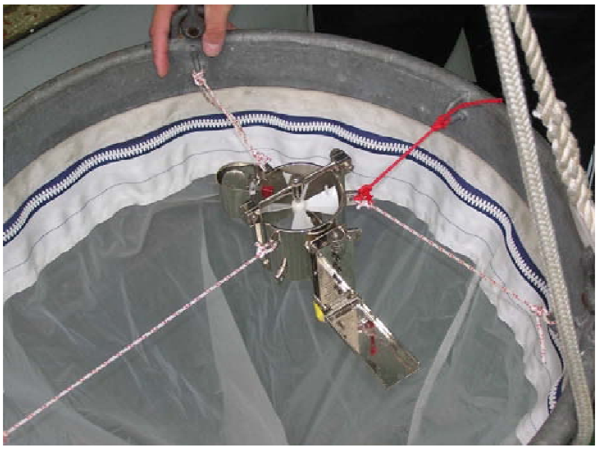

Table 1. Flowmeter counts (distance in red).

net	WP-2 100 µm	WP-2 200 µm	WP-2 60 µm	Juday 90 µm
haul 1	125	110	125	115
haul 2	130	110	125	120
haul 3	130	110	115	110

Table 2. Volume of water filtered (m^3).

net	WP-2 100 µm	WP-2 200 µm	WP-2 60 µm	Juday 90 µm
haul 1	4.938	4.345	4.938	1.817
haul 2	5.135	4.345	4.938	1.896
haul 3	5.135	4.345	4.543	1.738

Those results are slightly surprising as all the WP-2 measurements of filtered water should be close to 5m3. The highest clogging was presented by the 200 µm net. On the other hand, the 100 µm net flowmeter counts showed volume larger than 5 m3 in two cases. Juday net was expected to filter about 2m3 and it was presenting a limited degree of clogging.

Abundance of each taxon is presented in tables 3 and 4.

When we assume the average total abundance of 100 µm net as 100%, the average total number of organisms collected by 60 µm net is approximately 10% lower, and those of 200 µm net and Juday net are close to 50% and 25%, respectively. In the case of 100 µm net 85% of all organisms are *Bosmina* spp. whereas they constitute only 65% in 60 µm net. In contrary the share of *Evadne* spp. increased from about 5% to more than 15% for the same nets.

Table 3. Abundance in each haul (n*m³)

	WP-2 60 µm			WP-2 100 µm			WP-2 200 µm			Juday 90 µm		
	1	2	3	1	2	3	1	2	3	1	2	3
Acartia bifilosa F	1270	1063	1099	1024	810	748	655	817	633	845	473	976
Acartia bifilosa M	531	765	704	506	548	748	670	891	633	511	456	608
Acartia longiremis M			14							4		
Acartia tonsa F	1348	1296	1212	415	573	424	147	221	243	154	177	235
Acartia tonsa M	480	467	409	71	84	93	125	199	169	114	127	115
Acartia spp.C I-III	149	169	148	16	34	37	37	81	110	79	76	92
Acartia spp.C IV-V	194	201	197	149	125	206	155	265	184	136	173	175
Acartia spp.N	194	169	141	19	25	25		4		62	84	97
Centropages hamatus F	117	104	106	97	69	37	74	63	48	31	59	41
Centropages hamatus M	162	136	155	23	22	50	55	48	26	31	57	67
Centropages hamatus C IV-V	6			3	6	3	4			4	2	
Centropages hamatus N	19	19	7	3							4	
Centropages hamatus eggs	1089	1037	1296	13	16	12	4			22	30	51
Eurytemora affinis F	201	181	211	156	181	168	70	96	96	44	114	74
Eurytemora affinis M	175	246	211	240	156	162	92	118	133	84	101	115
Eurytemora affinis C I-III	97	84	77	32	44	37	7	11	29	35	34	37
Eurytemora affinis C IV-V	207	272	254	130	324	231	155	88	236	114	165	97
Eurytemora affinis N	52	39	49	6	50	6				9	25	14
Pseudocalanus spp. F	78											
Pseudocalanus spp.C I-III				6								
Pseudocalanus spp.C IV-V				10			7					
Temora longicornis F						3						
Temora longicornis M			14	3							8	
Temora longicornis C IV-V					3							
Balanus (cipris)			7				4	4			4	
Bosmina spp.	29553	31109	31334	45626	41877	41678	25453	20032	16497	7538	5198	12152
Evadne spp.	6844	9540	8453	2696	2842	2592	619	1370	2401	1039	1232	2191
Pleopsis polyphemoides	136	214	218	311	361	374	92	96	177	11	44	37
Podon intermedius	363	415	451	350	287	349	155	177	188	64	68	237
Podon juv.	123	97	113	130	174	137	41	48	66	24	42	69
Keratella qudrata	6		7					4				
Keratella cruciformis		6										
Bivalvia larvae	382	292	359	518	511	536	538	574	295	110	101	106
Gastropoda larvae		6	7	13	3	9	4					5
total	43 779	47 927	47 255	52 567	49 125	48 667	29 161	25 206	22 164	11 067	8 854	17 588

Table 4. Abundance in each haul – main, max, and average values (n*m³)

	WP-2 60 µm			WP-2 100 µm			WP-2 200 µm			Juday 90 µm		
	min	max	average	min	max	average	min	max	average	min	max	average
Acartia bifilosa F	1063	1270	1144	748	1024	861	633	817	702	473	976	765
Acartia bifilosa M	531	765	667	506	748	601	633	891	732	456	608	525
Acartia longiremis M		14	5								4	1
Acartia tonsa F	1212	1348	1285	415	573	471	147	243	204	154	235	189
Acartia tonsa M	409	480	452	71	93	83	125	199	164	114	127	119
Acartia spp.C I-III	148	169	155	16	37	29	37	110	76	76	92	82
Acartia spp.C IV-V	194	201	198	125	206	160	155	265	201	136	175	161
Acartia spp.N	141	194	168	19	25	23		4	1	62	97	81
Centropages hamatus F	104	117	109	37	97	68	48	74	61	31	59	44
Centropages hamatus M	136	162	151	22	50	31	26	55	43	31	67	52
Centropages hamatus C IV-V		6	2	3	6	4		4	1		4	2
Centropages hamatus N	7	19	15		3	1					4	1
Centropages hamatus eggs	1037	1296	1141	12	16	14		4	1	22	51	34
Eurytemora affinis F	181	211	198	156	181	168	70	96	87	44	114	77
Eurytemora affinis M	175	246	211	156	240	186	92	133	114	84	115	100
Eurytemora affinis C I-III	77	97	86	32	44	38	7	29	16	34	37	35
Eurytemora affinis C IV-V	207	272	244	130	324	228	88	236	160	97	165	125
Eurytemora affinis N	39	52	47	6	50	21				9	25	16
Pseudocalanus spp. F		78	26									
Pseudocalanus spp.C I-III					6	2						
Pseudocalanus spp.C IV-V					10	3		7	2			
Temora longicornis F					3	1						
Temora longicornis M		14	5		3	1					8	3
Temora longicornis C IV-V					3	1						
Balanus (cipris)		7	2					4	2		4	1
Bosmina spp.	29553	31334	30666	41678	45626	43061	16497	25453	20661	5198	12152	8296
Evadne spp.	6844	9540	8279	2592	2842	2710	619	2401	1463	1039	2191	1487
Pleopsis polyphemoides	136	218	189	311	374	349	92	177	122	11	44	31
Podon intermedius	363	451	410	287	350	329	155	188	173	64	237	123
Podon juv.	97	123	111	130	174	147	41	66	52	24	69	45
Keratella qudrata		7	5					4	1			
Keratella cruciformis		6	2									
Bivalvia larvae	292	382	344	511	536	522	295	574	469	101	110	106
Gastropoda larvae		7	5	3	13	8		4	1		5	2

All the samples were dominated by cladocerans of genera *Bosmina* and *Evadne* and copepods representing genera *Acartia*, *Centropages*, and *Eurytemora* with a different share in particular nets. Comparison of individuals counted in each net is indicating a different level of variance between particular hauls of the same gear.

Cluster analyses (Figure 1) are showing a different level of similarity depending if dominating or rare species are playing the main role. The first figure (values/no transformation) is presenting grouping dominated by the most abundant species: the most different results were achieved by Juday net (similarity 40%). At similarity level equalled 60% nets are divided again into two groups 200 µm and 100 µm and 60 µm. The last ones are differentiated at the similarity level of ~70%. The only 'accident' is grouping of the third Juday net haul with WP-2 200 µm.

A completely different picture was received when the role of rare species increased (%/4root transformation): nets are divided into two groups with bigger and smaller mesh sizes (200 µm and 100 µm and 60 µm and Juday) at 83% of similarity.

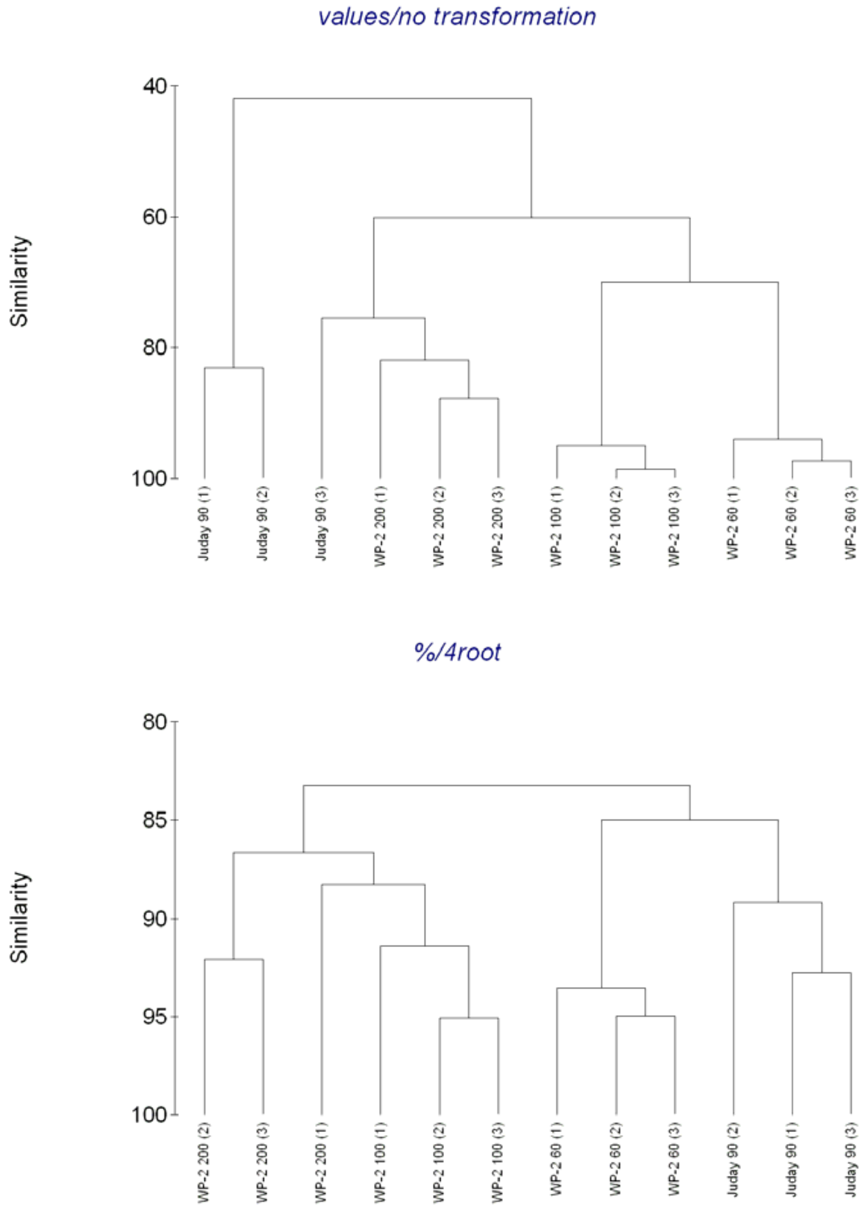

Figure 1. Cluster analyses.

For more abundant taxons and developmental stages a detailed figures were prepared.

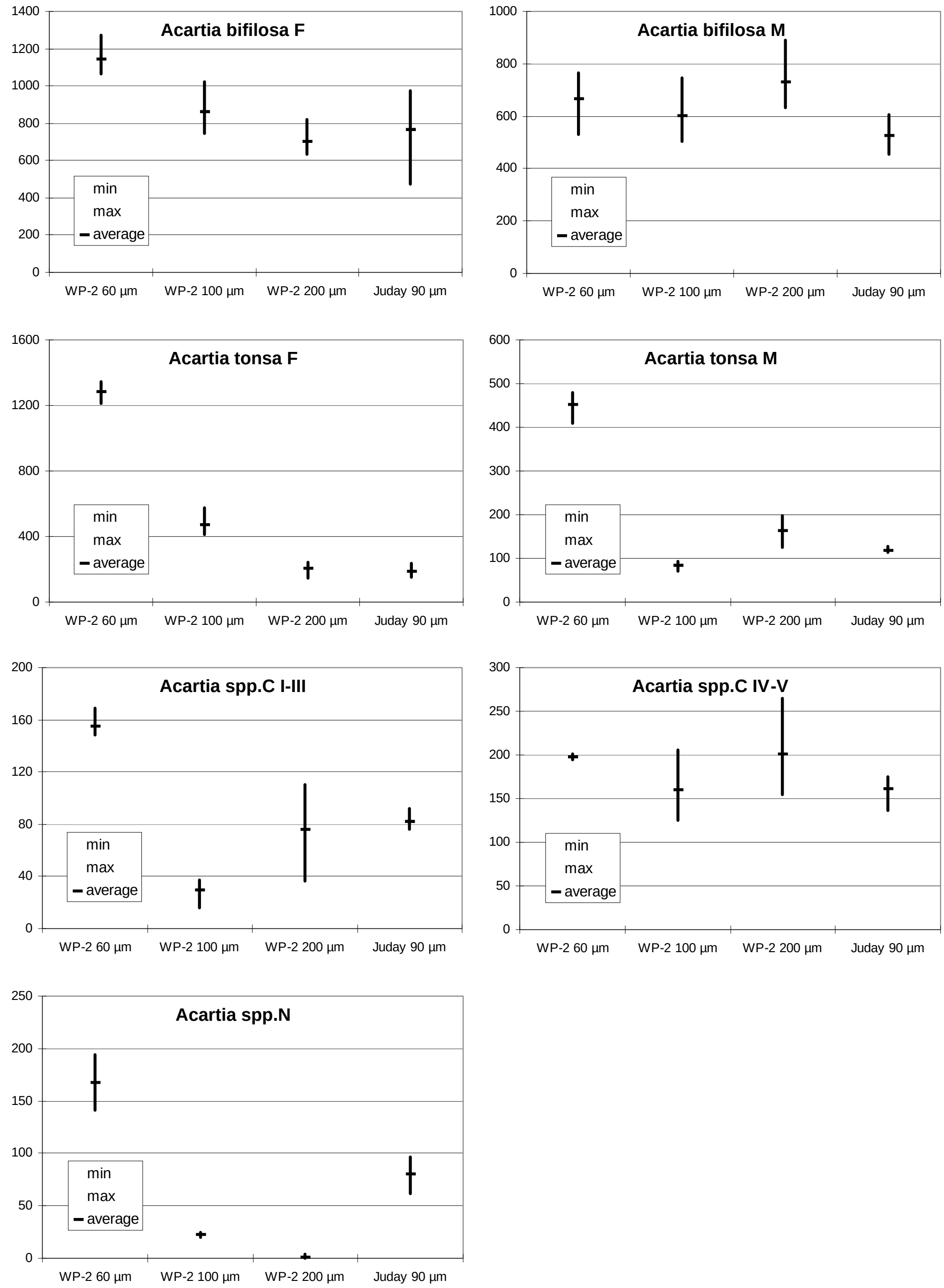

Figure 2A. Comparison of Acartia abundance.

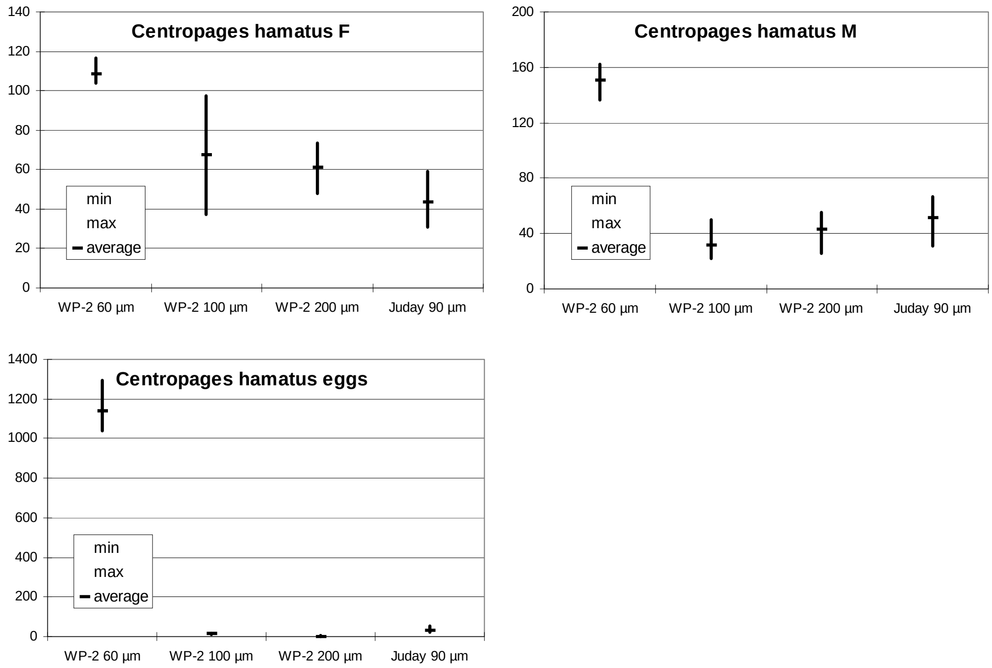

Figure 2B. Comparison of Centropages abundance.

In the case of *Acartia bifilosa* males and females it might be said that differences in abundance are probably cased by natural variability (Figure 2A). Completely different pattern is presented by *Acartia tonsa* adult stages: the highest abundance was recorded by WP-2 60 µm net what is difficult to justify as we would rather expect a similar pattern to that observed for *A. bifilosa*. For the organisms of that length the mesh size should not influence calculated abundance. Copepodites IV and V were presenting a similar pattern to *A. bifilosa* adults. Obviously the highest abundance of *Acartia* nauplii was calculated on the basis of WP-2 60 µm hauls. They were actually filtered out through the larger mesh sizes (Figure 2A).

Using the smallest mesh size is the best solution to calculate *Centropages hamatus* egg abundance (Figure 2B) but the same net was also the most efficient at catching relatively large males of the same copepod species. Female pattern looks 'better' but also in this case estimated abundance is decreasing with mesh size increase. The lowest values were calculated using Juday net. It might be caused by higher avoidance of the smaller gear.

For *Eurytemora affinis* adults the highest estimates of abundance were achieved using WP-2 net 60 and 100 microns (Figure 2C). In this case performance of Juday net was similar to that of WP-2 200 µm. Abundances of older copepodites were generally characterized by larger inter-haul variance but it was also decreasing with mesh size increase. The lowest values were calculated for Juday net. The best gear to assess abundance of nauplii and eggs was WP-2 60 µm. *Eurytemora affinis* eggs are carried in egg-sacs and single eggs are not observed in natural conditions. Sacs were probably damaged during sampling and eggs were released. They remained in the samples taken by the smallest mesh size net only.

For cladocerans results might be divided into two groups: the largest taxons (*Evadne spp*. and *Podon intermedius*) were sampled in largest abundances by the smallest mesh size net (Figure 2D) what is rather difficult to justify; for *Bosmina spp*., *Pleopsis plyphemoides*, and juveniles of *Podon* the best results were performed by WP-2 100 µm.

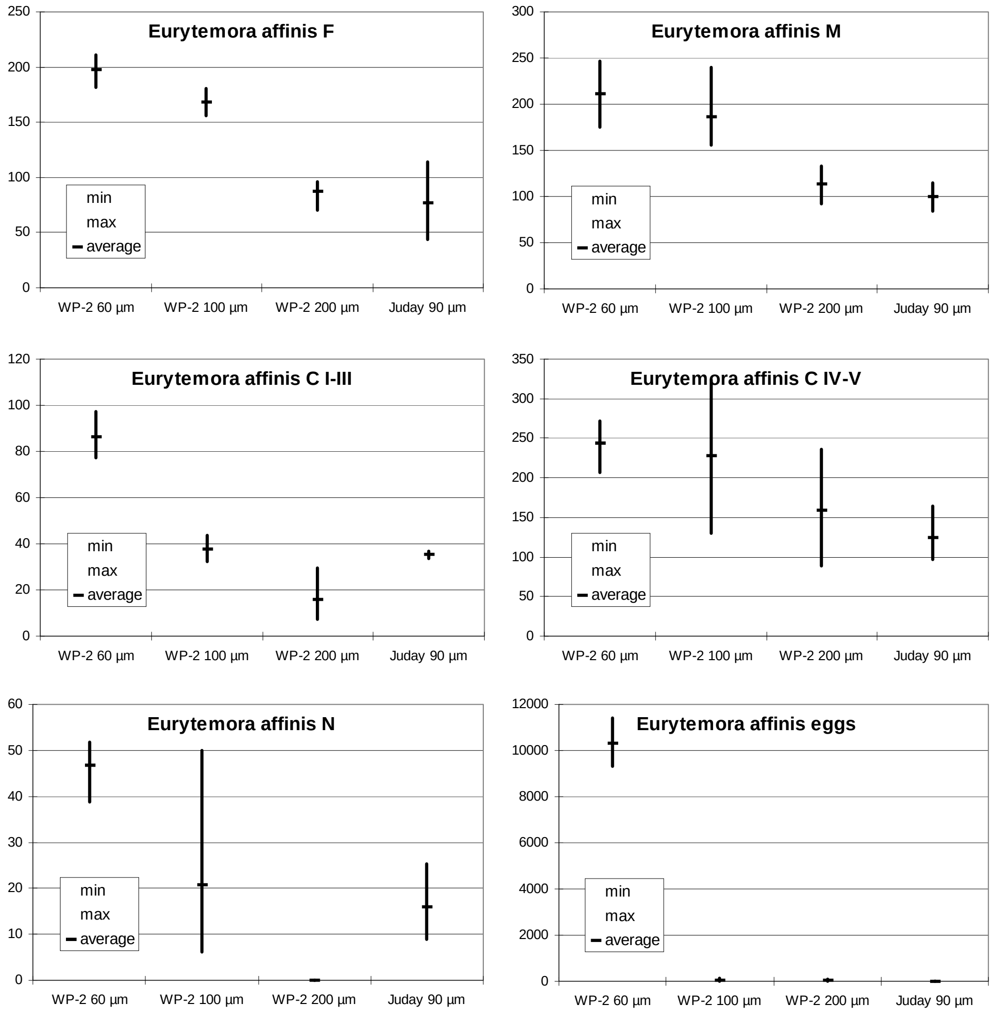

Figure 2C. Comparison of *Eurytemora affinis* abundance

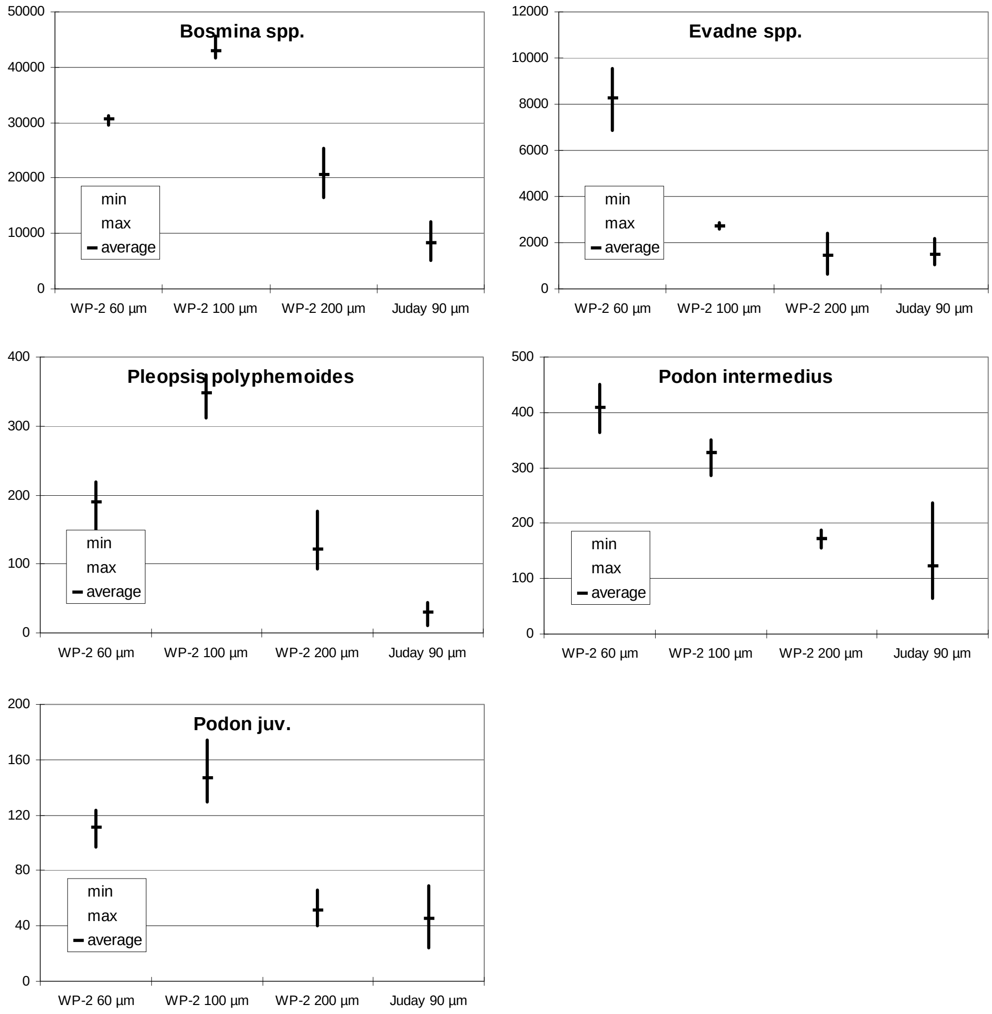

Figure 2D. Comparison of *cladocerans* abundance.

Summary

1) First of all we need to say that such intercomparisons carried out in the 'natural conditions' are characterized by internal variance. Experiment lasted for few hours and it is hard to assume that we were sampling exactly the same zooplankton community all the time. This fact might explain some of the 'strange' results.

2) It seems that WP-2 net with 60 µm mesh size was the best gear in the experienced conditions, presenting the highest abundances in most of the taxonomic groups and characterized by the lowest inter-haul variability (in most of the cases).

3) In many cases Juday net 90 µm performance was closest to that of WP-2 200 µm, which means to the net with two times larger mesh size (and 5 times larger mesh opening). One of the possible explanations is that the smaller entrance of Juday net would increase the rate of avoidance especially by adult copepods. Additionally, installing of relatively large TSK flowmeter in the opening of nets will seriously affect the performance of the smallest gear (Juday net).

Annex 10: CPR and WP-2 net intercomparison

WP-2 NET vs. CPR INTERCOMPARISON REPORT

by

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Baltic Sea Regional Project

RV "Baltica" HELCOM COMBINE cruise took place 29–31 January 2007. During this cruise CPR samples were collected (Table 1). To enable the intercomparison between CPR and the regular monitoring gear, the WP-2 net, samples were taken at both ends of CPR profiles (Table 2). Continuous Plankton Recorder is operating in the upper 10m layer and according to guidelines the standard depth of the WP-2 net near-surface sample is 0m to thermocline (or 0-25m). Therefore two kinds of WP-2 net samples were collected in January: 0-10m and 0-25m. Dr. Juha Flinkman from the Finnish Institute of Marine Research kindly agreed to participate in the cruise supervising samples collection and providing the on-board training.

Table 1. CPR tows taken in January 2007.

CPR Tow 1, launched at P1 (vessel speed appox 8 kn, set to advance once an hour)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)
1-1	29/01/2007	11:10:59	01:00:00	5385	5385	8	14816	2.39
1-2	29/01/2007	12:10:59	01:00:00	8970	3585	5.3	9864	1.59
1-3	29/01/2007	13:10:59	01:00:00	12555	3585	5.3	9864	1.59

CPR Tow 2, launched at P2 (vessel speed 7.3 kn initially, set to advance once per 30 minutes)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)	To be compared with WP-2 net sample taken at
2-1	30/01/2007	10:14:26	00:44:26	425413	425413	7.3	10027	1.62	~P2
2-2	30/01/2007	10:44:26	00:30:00	727111	301698	7.7	7111	1.15	
2-3	30/01/2007	11:14:26	00:30:00	1071171	344060	8.8	8110	1.31	
2-4	30/01/2007	11:44:26	00:30:00	1446631	375460	9.6	8850	1.43	
2-5	30/01/2007	12:14:26	00:30:00	1867395	420764	10.7	9917	1.60	
2-6	30/01/2007	12:44:26	00:30:00	2291838	424443	10.8	10004	1.61	
2-7	30/01/2007	13:14:26	00:30:00	2730996	439158	11.2	10351	1.67	
2-8	30/01/2007	13:44:26	00:30:00	3075681	344685	8.8	8124	1.31	~P3

CPR Tow 3, launched at P3 (vessel speed 8 kn, programmed for 30 min silk advances)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)	To be compared with WP-2 net sample taken at
3-1	30/01/2007	16:11:18	00:16:18	228737	228737	8	4025	0.65	~P3
3-2	30/01/2007	16:41:18	00:30:00	694622	465885	8.9	8198	1.32	
3-3	30/01/2007	17:11:18	00:30:00	1162397	467775	8.9	8231	1.33	
3-4	30/01/2007	17:41:18	00:30:00	1627930	465533	8.8	8192	1.32	
3-5	30/01/2007	18:11:18	00:30:00	2102667	474737	9.0	8354	1.35	
3-6	30/01/2007	18:41:18	00:30:00	2569095	466428	8.9	8208	1.32	
3-7	30/01/2007	19:11:18	00:30:00	3037740	468645	8.9	8247	1.33	~P5

Table 2. WP-2 net samples taken in January 2007 (red colour indicates flowmeter counts far form sampled layer thickness.

Station	Date	Time	Layer	Flowmeter counts	Distance (m)	Volume filtered (m3)
P104	2007-01-29	09:00	0-25	84	25.2	6.3
P104	2007-01-29	09:00	0-10	28	8.4	2.1
P1	2007-01-29	13:10	0-25	77	23.1	5.8
P1	2007-01-29	13:10	0-10	35	10.5	2.6
P-2	2007-01-30	10:00	0-25	***226***	***67.8***	***17.0***
P-2	2007-01-30	10:00	0-10	***65***	***19.5***	***4.9***
P-3	2007-01-30	15:00	0-25	102	30.6	7.7
P-3	2007-01-30	15:00	0-10	37	11.1	2.8
P-5	2007-01-30	20:40	0-25	57	17.1	4.3
P-5	2007-01-30	20:40	0-10	26	7.8	2.0

Next CPR samples were collected during regular monitoring cruise (March/April 2007). There were 3 tows (Table 3) and unfortunately only one WP-2 net sample taken at station P-2 (Table 4).

Table 3. CPR tows taken in March/April 2007.

CPR Tow 1, launched at P63 (vessel speed 8 kn, programmed for 60 min silk advances)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)	To be compared with WP-2 net sample taken at
1-1	30/03/2007	10:35:41	01:00:00	924165	924165	8	14816	2.39	
1-2	30/03/2007	11:35:41	01:00:00	1872940	948775	8.2	15211	2.45	

CPR Tow 2, launched at P5 (vessel speed 8 kn, programmed for 60 min silk advances)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)	To be compared with WP-2 net sample taken at
2-1	04/04/2007	09:11:41	01:00:00	811327	811327	8	14816	2.39	
2-2	04/04/2007	10:11:41	01:00:00	1665742	854415	8.4	15603	2.52	
2-3	04/04/2007	11:11:41	01:00:00	2518059	852317	8.4	15565	2.51	

CPR Tow 3, launched at P3 (vessel speed 8 kn, programmed for 60 min silk advances)

Tow	Date	Time	Duration	Flowmeter	Flowmeter counts	Vessel speed	Distance (m)	Volume filtered (m3)	To be compared with WP-2 net sample taken at
3-1	04/04/2007	14:02:49	01:00:00	819589	819589	8	14816	2.39	
3-2	04/04/2007	15:02:49	01:00:00	1636712	817123	8.0	14771	2.38	
3-3	04/04/2007	16:02:49	01:00:00	2475794	839082	8.2	15168	2.45	~P2

Table 4. WP-2 net sample taken in March/April 2007.

Station	Date	Time	Layer	Flowmeter counts	Distance (m)	Volume filtered (m3)
P-2	2007-04-04		0-20	41	12.3	3.1

CPR logger recorded three separate samples for January tow 1. Unfortunately, only one zooplankton sample was actually collected. As we are not sure if it is merged sample or single one of three expected, we decided to not include it in our intercomparison exercise.

Both gears were equipped with nylon mesh (100 μm).

CPR has an external flowmeter not presenting the volume of water passing through the sampling mechanism. It creates a fundamental problem regarding the precise calculation of filtered water volume. This problem is still not solved. On the basis of time between silk advances, vessel speed and flowmeter counts we are able to estimate roughly the distance covered during sampling and subsequently the filtered volume. Luckily, we do not expect any clogging in January and perhaps only a limited one at the beginning of April. WP-2 net was equipped with Hydro-Bios flowmeters for vertical operation with back-run stop. Apparently, using of those flowmeters created a different kind of problem: in some cases the calculated distance covered was very far from expected (Table 2 and 4). It seems that this is another source of bias and therefore we decided to recalculate the abundance in both ways: using flowmeter counts and filtered water layer thickness.

Zooplankton abundance (n/m^3) is presented in the following tables.

Table 5. Zooplankton abundance (n/m³) in January collected using WP-2 net and recalculated on the basis of flowmeter counts.

WP-2 100 µm	Station	P-104	P-104	P-1	P-1	P-2	P-2	P-3	P-3	P-5	P-5
	Date	29.01.2007	29.01.2007	29.01.2007	29.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007
Taxon	Layer	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m
Acartia bifilosa	F	8	6	67	44	7	2	9	2	16	11
Acartia bifilosa	M	3	4	18	39	3	2	12	2	4	4
Acartia longiremis	F	133	198	573	432	315	283	317	485	558	397
Acartia longiremis	M	7	71	165	55	25	9	23	27	103	26
Acartia spp.	C I-III	282	193	146	172	62	57	69	61	53	37
Acartia spp.	C IV-V	213	198	311	360	92	87	121	109	238	105
Acartia spp.	N	1173	579	1146	1130	788	536	623	895	656	689
Centropages hamatus	F	2	6	15	19	9	26	12	17	25	37
Centropages hamatus	M	7	5	43	28	25	17	46	27	57	26
Centropages hamatus	C I-III	6	25	30	11			23	13	21	22
Centropages hamatus	C IV-V	152	198	183	305	43	62	161	155	353	247
Centropages hamatus	N		3								
Centropages hamatus	eggs	8		18	33	10	11	14	15	8	4
Pseudocalanus spp.	F	2	5	18	11	1	25	150	50	123	101
Pseudocalanus spp.	M	1	5		3	7			2		
Pseudocalanus spp.	C I-III	57	43	18	39	18	26	92	63	164	67
Pseudocalanus spp.	C IV-V	91	112	201	272	118	529	1418	1238	2658	1931
Pseudocalanus spp.	N	213	117	226	249	51	30	127	343	673	749
Pseudocalanus spp.	eggs			12			11	63	29	33	37
Temora longicornis	F	36	32	152	211	51	94	144	276	131	157
Temora longicornis	M	42	25	189	283	39	64	110	226	111	187
Temora longicornis	C I-III	57	79	30	83	2		14	13	8	
Temora longicornis	C IV-V	137	152	152	294	25	51	69	88	205	180
Temora longicornis	N	95	107	219	255	223	125	173	100	164	187
Cyclopoida spp	C IV-V	4									
Balanus	npl		1								
Bosmina spp.				6					2		
Evadne spp.						3	9			8	
Synchaeta spp.		40	5	122	216	92	70	118	209	377	412
Synchaeta monopus					6		2				
Fritillaria borealis		5	15	110	133	197	151	167	259	172	94
Bivalvia larvae		18	61	171	477	414	464	588	820	1411	1497
Gastropoda larvae						2					
Polychaeta larvae		1	11	6		1		6	4	4	7
Trochophora		2	1						2		
Polychaeta	eggs	1	1								
Ctenophora	juv.	7	22	15	42	4	11	20	10	213	292
Ctenophora	eggs	7	3	3	3						
Bryozoa	larvae									4	
Harpacticoida		1	1								

Table 6. Zooplankton abundance (n/m³) in January collected using WP-2 net and recalculated on the basis of filtered water layer thickness.

WP-2 100 µm	Station	P-104	P-104	P-1	P-1	P-2	P-2	P-3	P-3	P-5	P-5
	Date	29.01.2007	29.01.2007	29.01.2007	29.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007	30.01.2007
Taxon	Layer	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m	0-10 m	0-25 m
Acartia bifilosa	F	6	6	70	41	13	5	10	3	13	8
Acartia bifilosa	M	2	4	19	36	6	5	13	3	3	3
Acartia longiremis	F	112	200	602	399	614	768	352	594	435	271
Acartia longiremis	M	6	72	173	51	48	26	26	33	80	18
Acartia spp.	C I-III	237	195	154	159	122	154	77	74	42	26
Acartia spp.	C IV-V	179	200	326	333	179	236	134	133	186	72
Acartia spp.	N	986	584	1203	1044	1536	1454	691	1096	512	471
Centropages hamatus	F	2	6	16	18	18	72	13	20	19	26
Centropages hamatus	M	6	5	45	26	48	46	51	33	45	18
Centropages hamatus	C I-III	5	26	32	10			26	15	16	15
Centropages hamatus	C IV-V	128	200	192	282	83	169	179	189	275	169
Centropages hamatus	N		3								
Centropages hamatus	eggs	6		19	31	19	31	16	18	6	3
Pseudocalanus spp.	F	2	5	19	10	2	67	166	61	96	69
Pseudocalanus spp.	M	1	5		3	14			3		
Pseudocalanus spp.	C I-III	48	44	19	36	35	72	102	77	128	46
Pseudocalanus spp.	C IV-V	77	113	211	251	230	1434	1574	1516	2074	1321
Pseudocalanus spp.	N	179	118	237	230	99	82	141	420	525	512
Pseudocalanus spp.	eggs			13			31	70	36	26	26
Temora longicornis	F	30	32	160	195	99	256	160	338	102	108
Temora longicornis	M	35	26	198	261	77	174	122	276	86	128
Temora longicornis	C I-III	48	79	32	77	3		16	15	6	
Temora longicornis	C IV-V	115	154	160	271	48	138	77	108	160	123
Temora longicornis	N	80	108	230	236	435	338	192	123	128	128
Cyclopoida spp	C IV-V	3									
Balanus	npl		1								
Bosmina spp.				6					3		
Evadne spp.						6	26			6	
Synchaeta spp.		34	5	128	200	179	189	131	256	294	282
Synchaeta monopus					5		5				
Fritillaria borealis		4	15	115	123	384	410	186	317	134	64
Bivalvia larvae		15	61	179	440	806	1260	653	1004	1101	1024
Gastropoda larvae						5					
Polychaeta larvae		1	12	6		2		6	5	3	5
Trochophora		2	1						3		
Polychaeta	eggs	1	1								
Ctenophora	juv.	6	22	16	38	8	31	22	13	166	200
Ctenophora	eggs	6	3	3	3						
Bryozoa	larvae									3	
Harpacticoida		1	1								

Table 7. Zooplankton abundance (n/m³) in January collected using CPR.

Taxon		P2-P3 TOW 2-1	P2-P3 TOW 2-2	P2-P3 TOW 2-3	P2-P3 TOW 2-4	P2-P3 TOW 2-5	P2-P3 TOW 2-6	P2-P3 TOW 2-7	P2-P3 TOW 2-8	P3-P5 TOW 3-1	P3-P5 TOW 3-2	P3-P5 TOW 3-3	P3-P5 TOW 3-4	P3-P5 TOW 3-5	P3-P5 TOW 3-6	P3-P5 TOW 3-7
Acartia bifilosa	F			1		1		1	2		2		2	3	2	4
Acartia bifilosa	M								1							2
Acartia longiremis	F	2	15	11	6	8	6	3	116	22	41	17	33	62	32	78
Acartia longiremis	M		1	4				3	11	5	3	2	8	7	4	11
Acartia spp.	C I-III	4	52	30	18	4	5	8	13	65	14	9	9	13	11	7
Acartia spp.	C IV-V	6	56	57	28	22	23	29	110	96	91	48	68	157	94	126
Acartia spp.	N	109	398	269	132	94	84	58	150	394	269	205	297	425	317	277
Centropages hamatus	F				1				2		1	2			2	4
Centropages hamatus	M			2	1	1		1	4			1		1		5
Centropages hamatus	C I-III			2												
Centropages hamatus	C IV-V		1	2	1	3	2	1	24	2	3	2	3	3	3	14
Centropages hamatus	N		1	1		1	1			3	4	1	2	1	1	1
Centropages hamatus	eggs	3				1			2		2			1	1	2
Eurytemora affinis	M				1											
Eurytemora affinis	N					1										
Pseudocalanus spp.	F			1	1	1		1	32		1	1	8	7	4	41
Pseudocalanus spp.	M								2							
Pseudocalanus spp.	C I-III	1	3	1	4		2	2	8	3	4	2	4	4	4	9
Pseudocalanus spp.	C IV-V	1	5	6	29	11	9	13	287	77	74	36	54	74	50	229
Pseudocalanus spp.	N	2	4	5	6	9	4	7	8	26	103	87	97	95	97	60
Pseudocalanus spp.	eggs								3							1
Temora longicornis	F		3	6	15	8	6	7	64	15	12	13	10	21	12	39
Temora longicornis	M	1	4	6	13	9	11	6	58	9	11	11	14	14	10	30
Temora longicornis	C I-III		3		1				2	2		3	1	2	4	7
Temora longicornis	C IV-V	1	8	6	14	8	9	8	67	23	12	9	25	62	32	72
Temora longicornis	N	3	14	8	5	4	7	5	4	22	67	11	16	65	30	8
Bosmina spp.		1				1						2	2	1		2
Evadne spp.												1	2	1		2
Synchaeta spp.			3	7	1	7		1	11		2	6	13	6	8	6
Fritillaria borealis		84	91	44	81	56	124	35	95	86	115	93	142	140	112	141
Bivalvia larvae		2	17	44	87		9	2	76	15	2	7	16	33	14	7
Gastropoda larvae											1					
Ctenophora	juv.			1												

Table 8. Zooplankton abundance (n/m³) in April collected using WP-2 net and recalculated on the basis of filtered water layer thickness (wlt) and flowmeter counts (fm).

WP-2 100 µm	Station	P-2 (fm)	P-2 (wlt)
	Date	04.04.07	04.04.07
Taxon	Depth	0-20 m	0-20 m
Acartia bifilosa	F	3	2
Acartia bifilosa	M	6	4
Acartia longiremis	F	87	54
Acartia longiremis	M	18	11
Acartia spp.	C I-III	255	157
Acartia spp.	C IV-V	112	69
Acartia spp.	N	2113	1299
Centropages hamatus	F	23	14
Centropages hamatus	M	6	4
Centropages hamatus	C I-III		
Centropages hamatus	C IV-V	1	1
Centropages hamatus	N	86	53
Centropages hamatus	eggs	151	93
Pseudocalanus spp.	F	16	10
Pseudocalanus spp.	M	1	0
Pseudocalanus spp.	C I-III	96	59
Pseudocalanus spp.	C IV-V	18	11
Pseudocalanus spp.	N	1207	742
Pseudocalanus spp.	eggs	250	154
Temora longicornis	F	7	4
Temora longicornis	M	1	1
Temora longicornis	C I-III	18	11
Temora longicornis	C IV-V	4	2
Temora longicornis	N	739	454
Copepoda	eggs	10	6
Bosmina spp.			
Evadne spp.		3	2
Pleopsis polyphemoides		1	0
Keratella quadrata			
Keratella cruciformis			
Synchaeta spp.		312	192
Synchaeta monopus			
Synchaeta	eggs	312	192
Fritillaria borealis		1540	947
Bivalvia larvae		1218	749
Polychaeta larvae		1009	621
Trochophora		17	10
Ctenophora	juv.	3	2
Fish larvae		1	0
Tintinnids		3	2

Table 9. Zooplankton abundance (n/m³) in April collected using CPR.

Taxon		P63-P1 TOW 1-1	P63-P1 TOW 1-2	P5-P3 TOW 2-1	P5-P3 TOW 2-2	P5-P3 TOW 2-3	P3-P2 TOW 3-1	P3-P2 TOW 3-2	P3-P2 TOW 3-3
Acartia bifilosa	F	10	5	8	8	7	6	3	11
Acartia bifilosa	M	10	11	13	17	9	13	3	7
Acartia longiremis	F	261	548	26	33	48	69	42	45
Acartia longiremis	M	37	88	10	14	19	18	9	13
Acartia spp.	C I-III	348	391	89	140	255	348	148	147
Acartia spp.	C IV-V	208	313	84	111	178	429	94	121
Acartia spp.	N	3455	4435	412	839	854	1071	665	693
Centropages hamatus	F	97	157	7	2	1	1	3	3
Centropages hamatus	M	84	137	5	12	4	3	5	4
Centropages hamatus	C IV-V	33	29				0	0	
Centropages hamatus	N	174	157	45	32	29	57	17	56
Centropages hamatus	eggs	911	861	308	629	880	1245	1101	2040
Pseudocalanus spp.	F	5	7		2			1	2
Pseudocalanus spp.	M					0			
Pseudocalanus spp.	C I-III	50	104	9	9	6	3	10	20
Pseudocalanus spp.	C IV-V		3					1	1
Pseudocalanus spp.	N	4098	6600	527	699	650	870	792	811
Temora longicornis	F	55	72	1	0	1	0	3	2
Temora longicornis	M	52	127		4	2		3	2
Temora longicornis	C I-III	17	78	7	2	1	17	5	16
Temora longicornis	C IV-V		6	0	2	0	1	1	
Temora longicornis	N	1473	2009	226	420	351	629	171	353
Copepoda	eggs	50	522	100	292	242	429	242	235
Bosmina spp.					0				
Evadne spp.					1				
Keratella qudrata			1						
Synchaeta spp.		482	235	5	4	8	5	2	8
Fritillaria borealis		2759	2478	787	1494	1402	1875	1142	1386
Bivalvia larvae		67	1670	3	4	23	38	3	7
Polychaeta larvae		683	887	1		0		1	11
Fish larvae			2				0		
Tintinnids		33	20	3	4	10	8	3	36

Intercomparison analyses

Results useful for gear intercomparison analyses are presented in Tables 10 and 11.

Table 10. Zooplankton abundance in January: data used for intercomparison purposes.

	P2fm10	P2wlt10	P2fm25	P2wlt25	TOW 2-1	TOW 2-8	P3fm10	P3fm25	P3wlt10	P3wlt25	TOW 3-1	TOW 3-7	P5fm10	P5fm25	P5wlt10	P5wlt25
Acartia bifilosa F	7	13	2	5		2	9	2	10	3		4	16	11	13	8
Acartia bifilosa M	3	6	2	5		1	12	2	13	3		2	4	4	3	3
Acartia longiremis F	315	614	283	768	2	116	317	485	352	594	22	78	558	397	435	271
Acartia longiremis M	25	48	9	26		11	23	27	26	33	5	11	103	26	80	18
Acartia spp. C I-III	62	122	57	154	4	13	69	61	77	74	65	7	53	37	42	26
Acartia spp. C IV-V	92	179	87	236	6	110	121	109	134	133	96	126	238	105	186	72
Acartia spp. N	788	1536	536	1454	109	150	623	895	691	1096	394	277	656	689	512	471
Centropages hamatus F	9	18	26	72		2	12	17	13	20		4	25	37	19	26
Centropages hamatus M	25	48	17	46		4	46	27	51	33		5	57	26	45	18
Centropages hamatus C I-III							23	13	26	15			21	22	16	15
Centropages hamatus C IV-V	43	83	62	169		24	161	155	179	189	2	14	353	247	275	169
Centropages hamatus N											3	1				
Centropages hamatus eggs	10	19	11	31	3	2	14	15	16	18		2	8	4	6	3
Pseudocalanus spp. F	1	2	25	67		32	150	50	166	61		41	123	101	96	69
Pseudocalanus spp. M	7	14				2		2		3						
Pseudocalanus spp. C I-III	18	35	26	72	1	8	92	63	102	77	3	9	164	67	128	46
Pseudocalanus spp. C IV-V	118	230	529	1434	1	287	1418	1238	1574	1516	77	229	2658	1931	2074	1321
Pseudocalanus spp. N	51	99	30	82	2	8	127	343	141	420	26	60	673	749	525	512
Pseudocalanus spp. eggs			11	31		3	63	29	70	36		1	33	37	26	26
Temora longicornis F	51	99	94	256		64	144	276	160	338	15	39	131	157	102	108
Temora longicornis M	39	77	64	174	1	58	110	226	122	276	9	30	111	187	86	128
Temora longicornis C I-III	2	3				2	14	13	16	15	2	7	8		6	
Temora longicornis C IV-V	25	48	51	138	1	67	69	88	77	108	23	72	205	180	160	123
Temora longicornis N	223	435	125	338	3	4	173	100	192	123	22	8	164	187	128	128
Bosmina spp.					1			2		3		2				
Evadne spp.	3	6	9	26								2	8		6	
Synchaeta spp.	92	179	70	189		11	118	209	131	256		6	377	412	294	282
Synchaeta monopus			2	5												
Fritillaria borealis	197	384	151	410	84	95	167	259	186	317	86	141	172	94	134	64
Bivalvia larvae	414	806	464	1260	2	76	588	820	653	1004	15	7	1411	1497	1101	1024
Gastropoda larvae	2	5														
Polychaeta larvae	1	2					6	4	6	5			4	7	3	5
Trochophora								2		3						
Ctenophora juv.	4	8	11	31			20	10	22	13			213	292	166	200
Bryozoa larvae													4		3	

Table 11. Zooplankton abundance in April: data used for intercomparison purposes.

	TOW 3-3	P2fm20	P2wlt20
Acartia bifilosa F	11	3	2
Acartia bifilosa M	7	6	4
Acartia longiremis F	45	87	54
Acartia longiremis M	13	18	11
Acartia spp. C I-III	147	255	157
Acartia spp. C IV-V	121	112	69
Acartia spp. N	693	2113	1299
Centropages hamatus F	3	23	14
Centropages hamatus M	4	6	4
Centropages hamatus C IV-V		1	1
Centropages hamatus N	56	86	53
Centropages hamatus eggs	2040	151	93
Pseudocalanus spp. F	2	16	10
Pseudocalanus spp. M		1	0
Pseudocalanus spp. C I-III	20	96	59
Pseudocalanus spp. C IV-V	1	18	11
Pseudocalanus spp. N	811	1207	742
Pseudocalanus spp. eggs		250	154
Temora longicornis F	2	7	4
Temora longicornis M	2	1	1
Temora longicornis C I-III	16	18	11
Temora longicornis C IV-V		4	2
Temora longicornis N	353	739	454
Copepoda eggs	235	10	6
Evadne spp.		3	2
Pleopsis polyphemoides		1	0
Synchaeta spp.	8	312	192
Synchaeta eggs		312	192
Fritillaria borealis	1386	1540	947
Bivalvia larvae	7	1218	749
Polychaeta larvae	11	1009	621
Trochophora		17	10
Ctenophora juv.		3	2
Fish larvae		1	0
Tintinnids	36	3	2

At the station P-2 in January, apparently flowmeter was not functioning properly and recorded results were significantly higher than sampled water layer thickness. At the other stations, the filtered water volume calculated using flowmeter counts constituted 90%, 82%, 128%, 146%, and 163% of volume calculated using sampled layer thickness for station P-3 (0-10m), P-3 (0-25m), P-5 (0-10m), P-5 (0-25m) in January, and P-2 (0-20m) in April, respectively.

Therefore, even it is recommended to use flowmeter counts to calculate the volume of filtered water, for the purposes of presented here analyses, we decided to use results achieved on the basis of filtered water layer thickness.

Continuous Plankton Recorder is usually operating in the upper 10m layer. During January cruise CPR was equipped with dive computer and results confirmed a steady flight at 7.5–7.3 meters. In some cases when vessel speed decreased (due to weather conditions) the gear depth fluctuated between 8.8 and 14m. According to guidelines the standard depth of the WP-2 net surface sample is 0m to thermocline (or 0-25m). To enable more precise intercomparison, two kinds of WP-2 net samples were collected in January: 0-10m and 0-25m.

There is no clear picture when the abundance of the same taxon is compared in 0-10m and 0-25m layers. In January, at the stations P-2 and P-3 usually the average abundance in 0-10m layer was lower, but at the station P-5 results were opposite.

Comparison of selected taxa abundance is presented at Figures 1 and 2.

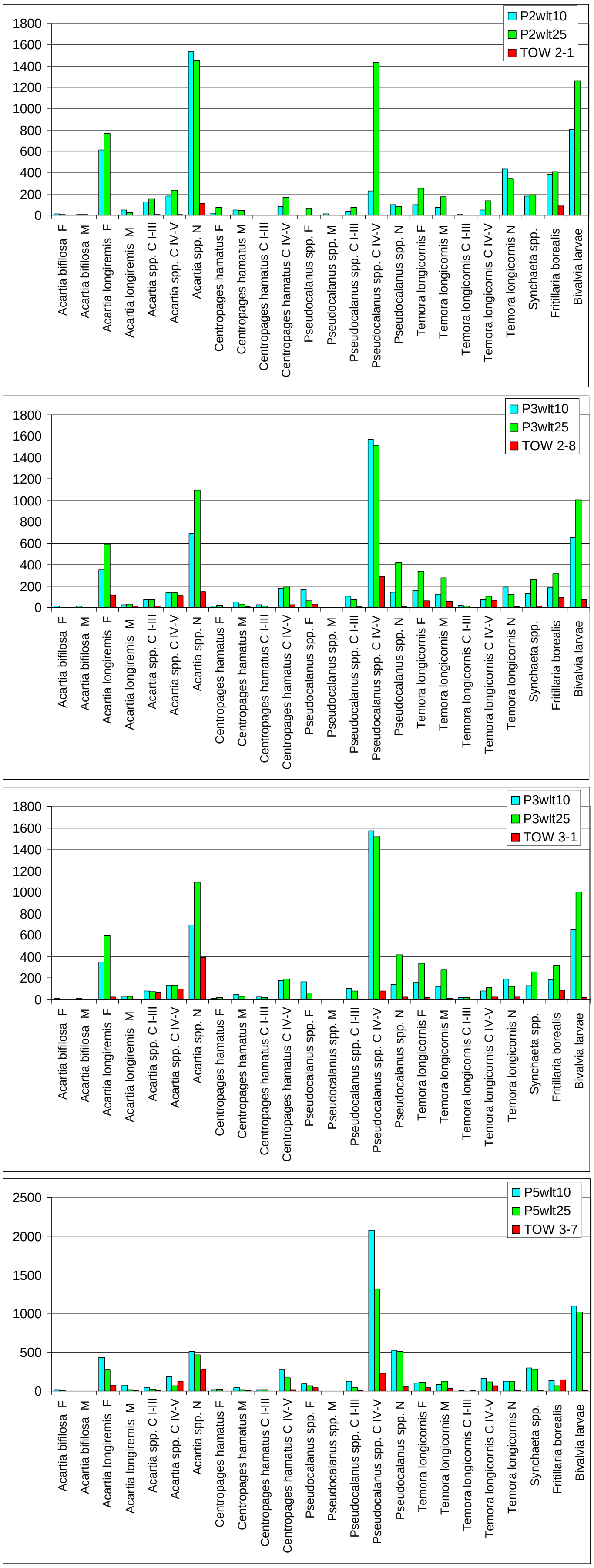

Figure 1. Intercomparison of selected zooplankton taxa abundance during January cruise.

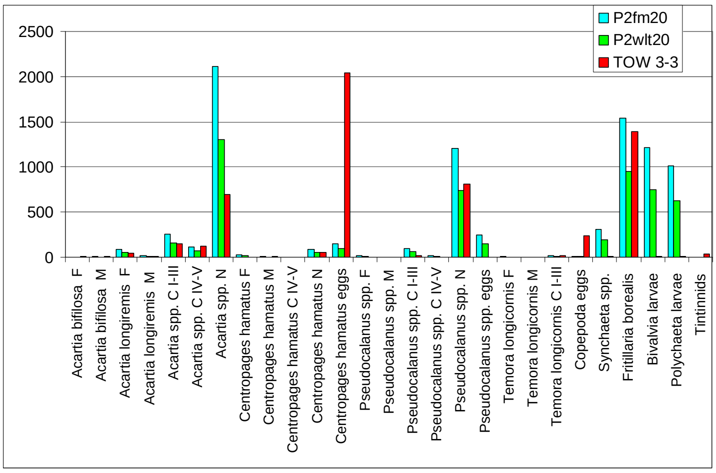

Figure 2. Intercomparison of selected zooplankton taxa abundance during April cruise.

In January, in all the cases when CPR tows were compared with WP-2 net results, abundances calculated from CPR samples were lower or much lower. The only two exceptions were the CPR abundance of *Acartia spp*. c IV-V (177%) and *Fritillaria borealis* (220%) when related to P-5 (0-25m) results.

Performance of CPR was much better in April. There were several taxa with abundance higher in CPR than in WP-2 samples: *Acartia bifilosa* F, *Acartia bifilosa* M, *Acartia longiremis* M, *Acartia spp*. C IV-V, *Centropages hamatus* M, *Centropages hamatus* N, *Pseudocalanus spp*. N, *Temora longicornis* M, *Temora longicornis* c I-III, *Fritillaria borealis.* The abundance of tintinnids and *Centropages hamatus* eggs was 22 times higher and for copepod eggs calculated values were even 37 times higher. Unfortunately, it is very difficult to come to the general conclusion when only one comparison is possible.

Summary

1) The great advantage of CPR sampling is that we are receiving much more information regarding natural high variance in zooplankton organisms' distribution. It might be presented on the basis of abundance of e.g. *Acartia longiremis* females, *Acartia* nauplii, and *Pseudocalanus* copepodite IV-V in January (Table 7), and *Fritillaria borealis* in April (Table 9). Regular procedure with vertical net sampling is the assumption that abundance of organisms collected at 1-3 stations is representative for the whole basin and CPR gives us a clue regarding the scale of distribution variability (especially when programmed for shorter silk advances).

2) Apparently, it is a need to use reliable flowmeters during WP-2 sampling. Unfortunately, we cannot recommend Hydro-Bios ones as they are a significant source of bias. Differences between water volume estimates calculated on the basis of flowmeter counts and filtered water layer thickness were substantial even in the case of relatively good weather conditions and lack of clogging (January!!!). CPR needs to be equipped with flowmeters counting volume of water passing through the sampling mechanism as well.

3) CPR sampling cannot replace a regular WP-2 data collection as CPR operates in the near-surface layers only and no information is provided regarding deeper waters. However, it is a valuable additional source of

data on mesoscale patchiness and long-term changes when used long enough in the same area.

4) It seems that CPR performance in relation to WP-2 net results is presenting a seasonal variability. In the vast majority of samples collected in January, abundances calculated from CPR samples were lower or much lower. April results were different: there were several taxa with abundance higher in CPR than in WP-2 samples. Unfortunately, it is very difficult to come to the general conclusion when only one comparison is possible.

Annex 11: SMHI Primary Production monitoring in the Baltic

Current SMHI Primary Production monitoring in the Baltic

SMHI has measured primary production (PP) at the two stations Kattegat (Anholt E) and Bornholm basin (BY 5) for many years, starting from 1979/1980. Also the Oresund has been monitored in collaboration with a local organization. In the earliest years the measuring frequency was sporadic but later it has become more regular and PP has been measured every month.

From summer 2007 the SMHI monitoring programme is enhanced with three more stations: N14, RefM1V1 and BY 15 (see Figure 2). In the winter SMHI also covers station BY 31 which is otherwise monitored by Stockholm University.

The monitoring frequency is once a month for all stations except Anholt E which is monitored twice a month. Together with PP other oceanographic data are measured (temperature, salinity, pH, alkalinity, Secchi-depth etc).

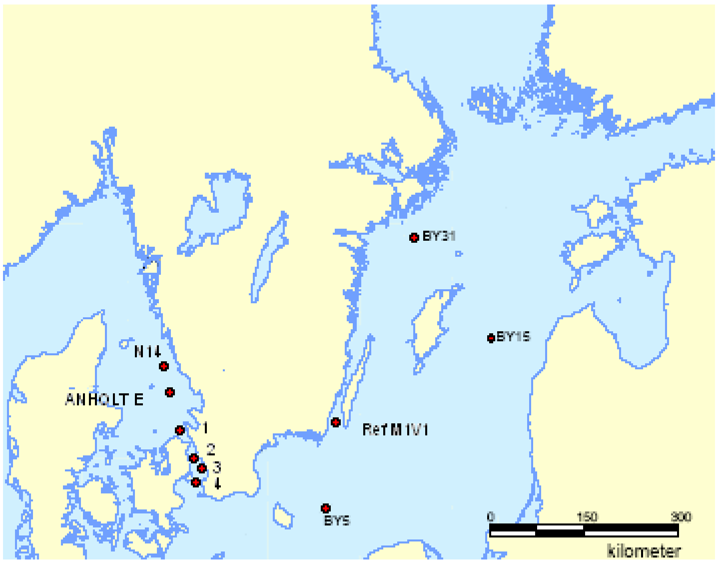

Figure 2: The regularly measured PP stations used by SMHI.

PP measurements are done in an incubator on deck, using the carbon-14 method as described in the HELCOM MONAS manual. From incubations at different light intensities a P/E relationship is created and subsequently the potential PP in the euphotic zone during the day is calculated. Samples are taken with a hose from 0–10 m depth.

The PP data has a high inherent natural variation, so efforts are made to avoid artificial variation. The method is currently under investigation for accreditation by SWEDAC, the Swedish Board for Accreditation and Conformity Assessment.

Primary Production data available at SMHI

PP has been measured in one way or another during quite some time in the coastal areas of Sweden. There are data from Anholt E with occasional measures from 1982 and up until now, with higher frequency during the later years. From BY 5 there is data from 1979 until now also sporadic in the early years and more frequently later. In the Sound PP has been measured since 1998. In our database there are also data from Skagerrak (85-) and the Gulf of Bottnia (89-) both datasets measured by other institutes.

The measurements are however done in various ways. In the data there are both in situ measurements and incubator measurements of various lengths and some of the necessary data are missing to make a real calculation of for example yearly production. The variation in the data is large as stated by Lars Edler the 2007 SGPROD report (ICES 2007), but a re-evaluation of the archived data is currently still in progress.

References:

HELCOM MONAS Combine Manual Annex C-5 Phytoplankton Primary production (Version 22nd, February 1999).

ICES. 2007. Report of the Study Group on Baltic Sea Productivity (SGPROD) 23-26 January 2007, Gdynia, Poland. ICES CM 2007/BCC:02. 70pp.