Epilogue

This is the third and last book in our “Baltic Sea trilogy”. The first book focused on tools and criteria for sustainable coastal ecosystem management for smaller coastal areas in the Baltic Sea than those discussed in this book. The second book dealt with the eutrophication in the Baltic Sea and remedial measures to mitigate eutrophication. That book studied the same five major sub-basins in the Baltic Sea as this book, the Baltic Proper, the Bothnian Sea, the Bothnian Bay, the Gulf of Finland and the Gulf of Riga. This book has a focus on methods to determine the fish production potential of the entire Baltic Sea system. We also present a new approach to determine fish quota based on holistic ecosystem modeling. This book motivates and presents a management plan for the Baltic Sea including a cost-benefit analysis.

To develop scientifically warranted programs of conservation, management and remediation is a great challenge. In this situation, quantitative models are essential to predict, to guide assessment and to direct intervention. We would like to regard the CoastWeb-model presented in this book as a new complimentary and general tool to set fish quota based on the fish production potential of a given system such as the Baltic Sea. It is also an approach to handle “trade-offs” and test working hypotheses concerning aquatic foodweb processes and interactions. The fact that the CoastWeb-model, in spite of its breadth and complexity , may be driven by relatively few readily accessible variables, and that it is based on a general production unit which may be repeated for different groups of functional organisms, gives, as we see it, a certain robustness and attractiveness to the model and provides a framework for its practical usefulness and predictive power, which are essential components in models for aquatic management. The minimalistic approach has been essential to us, and it is interesting to note that so much information about complicated ecosystem interactions can be obtained from a model based on this structure.

In ecosystem sciences, there is a need to optimize the model size, i.e., to create a balance between simplification and complication. The predictive power of any model depends on the number of driving variables, the uncertainty of the values used for the driving variables and uncertainties related to the model structure. The practical use of any model depends on the accessibility of the driving variables. Without equations there are few or no possibilities to gain the scientific insights that go with predictive power, and small or no possibilities to make, e.g., meaningful simulations of consequences of remedial measures. Without equations there is, we would

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argue contrary to many persons' opinions, very little understanding and knowledge on interactions in aquatic ecosystems, since such systems at most scales are very complex, where "everything depends on everything else". So, mathematical models are fundamental tools to gain understanding about ecosystem interactions. But the CoastWeb-model presented in this book has not been, and no models of this kind could be, deduced only from logical reasoning, like models of physical phenomena. "Logics" in ecology is in the eye of the beholder and explanations at one scale generally focus on processes at the next lower scale, and so on down to the level of the atom. Evidently, ecosystems are much more complex than the physical, chemical or geological parts making up the whole. There may be different approaches to handle, e.g., algorithms for biouptake, consumption rates and distribution coefficients in natural ecosystems. The biggest challenge is to find the best of these alternatives, i.e., the alternatives that are mechanistically most reasonable, the ones which provide the best predictive power in the widest possible domain from the fewest and most readily available driving variables when tested against empirical data. Reliable empirical data are needed at many steps in the derivation of ecosystem models. The ultimate limitation does not, we would argue, lie in the mathematics of modeling but in the access to empirical data and in the knowledge of ecosystem processes that only empirical data can provide.

Chapter 2 gave basic information on the conditions in the Baltic Sea, e.g., on the morphometry including the criteria to define the limit for the surface-water layer from the theoretical wave base using sedimentological criteria. That chapter also presented the water fluxes among and within the sub-basins and between the vertical water layers. These water fluxes are important for the quantification of all fluxes of salt, nutrients and SPM regulating all monthly concentrations in all twelve water layers in the Baltic Sea and also for the transport of planktonic organisms among the sub-basins. We have presented the dynamic mass-balance model (CoastMab) for suspended particulate matter for the entire Baltic Sea. Chapter 2 also gave approaches to predict chlorophyll-a concentrations and Secchi depths from dynamically modeled values of phosphorus, SPM and salinity and monthly light conditions. These approaches are of fundamental importance in the CoastWeb-modeling because the foodweb model is driven by chlorophyll-a concentrations and the Secchi depth regulates the depth of the photic layer. The water fluxes determined from the CoastMab-model for salinity are used throughout the CoastWeb-model. We have demonstrated that the CoastMab-model for phosphorus, which prior to this work has been validated for many independent aquatic systems and been demonstrated to predict very well, also predicts TP-concentrations in the Baltic Sea very well. When modeled values are compared to empirical annual data the coefficient of determination is 0.98 and the slope is close to 1 (0.96), and this is better than when the empirical data from the sub-basins in the Baltic Sea are split into two files and regressed against one another. We have shown how the model predicts TP-concentrations in water and sediments, and also the target bioindicators. In fact, the inherent uncertainties in the available empirical data used to run and test the model set the limit to the predictive power of the model. Chapter 2 also gave comprehensive compilations of how the conditions in the Baltic Sea have changed during the last 50 years. These trend analyses provide a framework to understand the present situation and future developments. Chapter 2 also gave results from extensive literature surveys related to the key fish species and groups of functional organisms and what the organisms eat. This information is important not just to test predictions using the CoastWeb-model but this literature review also disclosed where important knowledge and systematically collected data are missing.

The basic structure of the foodweb model (CoastWeb) was given in Chap. 3, which also gave a short comparison between this modeling approach and the Ecopath/Ecosim approach. This was done to highlight the specific features of the CoastWeb-approach and to stress that it actually provides a new dimension to understand and quantitatively simulate the factors regulating the fish production potential of coastal systems. CoastWeb is based on general principles and processes that apply for most aquatic systems. Simulations in Chap. 3 demonstrate that zoobenthos is an important food for prey fish in the Baltic Sea and that threats to the production of zoobenthos (e.g., low oxygen conditions) would be serious to the fish production in the system.

Chapter 4 gave all sub-models for all functional groups in detail and comparisons between dynamically modeled values and empirically-based values (norm-values) for all functional groups in three scenarios. It should be stressed that there is generally good correspondence between dynamically modeled biomasses or production values and the norm-values. We have also compared modeled biomasses for prey and predatory fish to empirical data compiled from our literature review. Given the fact that our modeled values apply for entire defined basins and provide monthly mean values and that most of the existing data emanate from individual sites, the correspondence is good and within order-of-magnitude ranges. In Chap. 4, we gave three scenarios, which were meant to provide gradients to illustrate the range of the model and how modeled values correspond the norm-values in such wider domains. (1) The TP-inflow to the Baltic Proper was reduced in steps from present-day conditions to very oligotrophic conditions. (2) The salt-water inflow from Kattegat was changed in steps to study how salinity variations would likely influence the system. (3). We gave a temperature scenario to illustrate how possible future water temperature increases might influence the system. Those studies demonstrate that reductions in tributary loading of phosphorus and increased salt-water intrusions would create an oligotrophication of the Baltic Sea system. This is easy to understand and state but here we have demonstrated this by quantitative data and explained the underlying processes, which is far more demanding and scientifically valuable than simple qualitative statements. Increased water temperatures will create higher nutrient concentrations, an eutrophication of the entire system, especially in the Bothnian Bay and the Bothnian Sea, with the highest land uplift and the largest ice-cover.

Thousand-year-old sediments influence the Baltic Sea ecosystem today. When the old bottom areas rise after being depressed by the glacial ice, they will be influenced by the waves, which will resuspend the sediments. The land uplift in the Baltic Sea varies from about 9 mm/year in the northern part of the Bothnian Bay to zero in the south-central part of the Baltic Proper. It has been shown that land uplift may contribute with large amounts of, e.g., phosphorus, nitrogen and suspended particulate matter to the Baltic Sea system. Land uplift influences the entire system in many profound ways, and this has been demonstrated in this work.

Chapter 4 also introduced the dynamic model to predict two fundamental functional categories of fish in the Baltic Sea, prey and predatory fish. The fish model is meant to account for all important factors regulating the production of fish in a general way. The basic aim of the model is that it should capture typical functional and structural patterns in all Baltic Sea basins. It accounts in a relatively simple manner for many complicated processes, like fishing (by birds, animals and man) and fish migration to and from basins. Food choices are handled by distribution coefficients regulating how much of the different available food sources a given organism would consume. Beside these distribution coefficients, and the way the food choices are structured (the food choice panel), fundamental concepts in the fish model are: (1) metabolic efficiency ratios, which express how much of the food consumed by the predator that will increase the biomass of the predator and how much that will be lost by respiration and faeces, (2) actual consumption rates, which are defined from the ratio between the actual biomass of the predator and the normal biomass of the predator, and the normal consumption rates, which are related to the turnover time of the predator. We have demonstrated that the CoastWeb-model gives predictions which agree well with the values given by the empirical norms, and also expected and requested divergences from these regression lines when they do not provide sufficient resolution.

In Chap. 4, it was also shown how the modeled proportions of predatory fish to the total fish biomass vary among the basins and seasonally and one can note that this ratio on average varies around 0.05–0.07 for the default period (1997–2006), and this should be compared to the empirically-based mean value of 0.06 (given in Fig. 2.46). The empirically-based biomass of predatory fish in the Baltic Sea around the year 2000 should (see Chap. 2) be about 100 kt ww, and our modeling gives 104 kt ww for the entire Baltic Sea

The total biomass of prey fish has fluctuated very much indeed during the last 4 decades. Typically, the annual biomasses for the dominating species of prey fish should vary around 2,500 and 5,000 kt ww. This is also what this modeling shows (see Chap. 5).

It should be stressed that the model presented in this book (CoastWeb) can provide good predictions in all Baltic Sea basins without basin-specific tuning and without taking nitrogen concentrations into account.

The main aim of the CoastWeb-model is to quantitatively describe typical, characteristic foodweb interactions so that production, biomasses and predation can be determined for the functional groups of organisms included in the model. Note that the model predicts functional groups, not species. There are many simplifications in the CoastWeb-model. They are necessary for several reasons, (1) to keep the model as small as possible (it is still quite extensive), (2) to keep the driving variable as few and as accessible as possible (otherwise few people are likely use the model), (3) to be able to critically test the model using empirical data or empirical regressions. The idea has not been to include everything but to focus on the key functional groups of organisms and on key abiotic/biotic relationships.

In Chap. 5, we gave several scenarios to illustrate the practical use of the CoastWeb-approach. In the last section of Chap. 5, we have put the results from these scenarios together and presented an holistic management plan for the Baltic Sea including a cost-benefit analysis. We have shown how the CoastWeb-modeling may be a useful tool in contexts of settling fish quota adjusted to changing environmental conditions, the influences of invasions of jellyfish and the cultivation of mussels and the expected consequences for the fish production potential after reducing the anthropogenic nutrient loading. So, the final compilation in Chap. 5 combines the responces of nutrient reductions, the connected consequences for the fisheries and a cost-benefit analysis related to different remedial strategies. Chapter 5 also includes a scenario where we have accounted for aquaculture and studied the effects of increasing fish farming of rainbow trout in the Baltic Sea and discussed how large fish farms could be recommended in the different basins.

- In the “optimal” scenario we reduce 8,730 t/year of phosphorus and no nitrogen. The annual costs for this would be about 367 million euro if this is done in a cost-effective manner. We argue that most of this would go to the building of sewage treatment plants in the Baltic countries and Poland. The costs to reduce 15,016 t/year of TP and 133,170 t of nitrogen according to the HELCOM strategy would be 3,100 million euro/year. That is 2,733 million euro/year higher than our strategy!
- According to the HELCOM strategy, one would create a situation where the Baltic Sea would be more oligotrophic than knowledgeable Baltic Sea managers should ask for. The total fish production would be much lower than today and the concentrations of organic toxins (such as PCBs, dioxins, etc.) in fish would likely be higher. The value of the fish caught via professional and recreational fishing would be about 1,130 million euro/year, as compared to 1,880 million euro/year today and 1,620 million euro/year in our “optimal” scenario. However, looking at the willingness-to-pay, one should note that this value is about 1,000 million euro/year and this value should be added to the “optimal” scenario because this is the sum that people would be ready to pay to do something about the present conditions in the Baltic Sea.
- The target variable for the “optimal” scenario is that the Secchi depth in the Gulf of Finland could again return to 7 m, which is was 100 years ago. This concrete goal is met in the optimal scenario, but not in the HELCOM scenario, where the Secchi depth would be as high as about 8.5 m, compared to about 4 m today.
- The economic value of the prey and predatory fish is evidently quite uncertain and varies among the Baltic States and with time depending on supply and demand. We have used a general value of 5 euro/kg for predatory fish and 0.62 euro/kg for prey fish and 6 euro/kg for the cultivated rainbow trout from fish cage farming. This gives for the “optimal” scenario a total value of the cultivated fish (30,000 t/year) of 180 million euro/year. The added value related to small-scale coastal and recreational fishing is about 190 million euro/year in the “optimal”

scenario, as compared to about 250 million euro/year today. So, the value of the recreational fishing is substantial.

- It is interesting to note that it would be possible to increase the aquaculture (the fish cage farming of rainbow trout) from about 10,000 t/year today with 30,000 t/year without jeopardizing the environmental goal that the Secchi depth in the Gulf of Finland (GF) should be 7 m. This assumes that the fish cage production is mainly, (1) in the northern part of the Baltic Proper (around Åland, in the Finnish Archipelago Sea and in the Roslagen area in Sweden), 15,000 t/year, (2) in the Bothnian Sea, 10,000 t/year and (3) in the Bothnian Bay, 5,000 t/year. Our strategy for the fish cage production would create more than 7,000 new jobs. Important presuppositions for this scenario are, (1) that a significant fraction (at least 20%) of the food eaten by the cultivated fish should come from wild fish caught in the Baltic Sea, such as sprat, i.e., from commercially less attractive and more abundant prey fish that could be caught without negative consequences for the Baltic Sea foodweb and fisheries and (2) that this fish farming would not jeopardize other natural fish stocks which supply feed (pellets) to the cultivated fish.

In our management plan for the Baltic Proper, we calculate changes in three key bioindicators, Secchi depth (as a measure of water clarity and the depth of the photic zone), chlorophyll-a concentrations (as a measure of phytoplankton production and biomass) and concentration of cyanobacteria (as a measure of harmful algae), and also biomasses of prey and predatory fish.

We have motivated why remedial actions should not focus on nitrogen and there are four main reasons:

1. It is not possible to provide scientifically relevant predictions of how the Baltic Sea system would respond to costly reductions in nitrogen loading since there are several major uncertainties related to the quantification of (a) nitrogen fixation, (b) wet and dry deposition of nitrogen, (c) the algorithm regulating the particulate fraction for nitrogen and hence also (d) sedimentation of particulate nitrogen and (e) denitrification.
2. Nitrogen reductions in the Baltic Sea are likely to favor the blooming of harmful algae (cyanobacteria), and such events should be avoided.
3. There are no validated mass-balance models for nitrogen which have been blind tested for independent coastal systems and been demonstrated to yield good predictive power.
4. In spite of the fact that costly measures have been implemented to reduce nitrogen transport from agriculture, urban areas (e.g., from water purification plants) and industries, the nitrogen concentrations in the surface-water in the main basins in the Baltic Sea, the Baltic Proper, have remain almost constant for 30 years.

The general phosphorus model presented in this book can provide good predictions of chlorophyll-a concentrations in all Baltic Sea basins without basin-specific tuning and without taking nitrogen concentrations into account. These findings fundamentally contradict the popular "vicious circle theory" which asserts that phosphorus diffusion from deep sediments is driven by nitrogen limited diatoms. Phosphorus rather than nitrogen seems to limit the long-term (growing season period) primary production in the Baltic Sea.

We have also discussed why oxygenation of the deep-water layer in the Baltic Proper, and chemical treatment of the sediments to reduce the diffusion of phosphorus from the sediments below the halocline at 75 m should be largely useless. This is because the sediment concentrations of TP in the deep-water layer in the Baltic Proper are low and close to the TP-concentration in older clay, e.g., of glacial origin. The main reason for the low sediment concentration of TP is that it is well documented that more than 90% of the phosphorus in the deep-water layer appears in dissolved forms, so the sedimentation of phosphorus is by necessity limited.

For the future, we believe that research in the following areas would help to reduce the uncertainties addressed in this book.

- The limited empirical knowledge regarding most biomasses for most functional groups of organisms and dominating species in the Baltic Sea basins is a problem which can only be handled by collecting more and better data from the system in a systematic manner.
- Today, there are uncertainties concerning the values used for the distribution coefficients on the food choice panels, e.g., regulating the consumption by prey fish of herbivorous zooplankton relative to predatory zooplankton. It would be valuable to get more information on that issue.
- Better information is also needed on consumption rates and metabolic efficiency ratios for the functional groups in the Baltic Sea system. How much of a given prey biomass is actually consumed by the predator per time unit? Are there other more relevant approaches to estimate consumption rates quantifying the fraction of the prey in the system being lost per time unit from grazing by the given predator?
- There are also uncertainties regarding structural foodweb changes at trophic boundaries. What is actually happening to foodweb structures, species composition and biomasses at trophic boundaries? Sudden changes may take place in the production and abundance of key functional organisms when there are changes in abiotic state variables, such as phosphorus, salinity and water temperature.
- The CoastWeb-model is based on many new structures and approaches, and it would be interesting to try to expand this type of modeling, e.g., to larger water bodies, such the Great Lakes of America, the Caspian Sea, the Black Sea, Norwegian fjords and Lake Ladoga. It would be a great challenge, with many possibilities for the management of such large water bodies, to try to adopt the modeling principles presented in this work, e.g., to set quota for fisheries also in such important systems. Evidently, large water bodies may have to be differentiated into functional parts, just like we have done for the Baltic Sea, and such divisions may not be related to geographical or national boundaries. So, to paraphrase Winston Churchill, “This is not the end, not even the beginning of the end, but it is the end of the beginning”.

Thus, the CoastWeb-model should be regarded as a tool for sustainable Baltic Sea management and science. The scenarios in Chap. 5 have been included to stress and illustrate this point.

What makes a free thinker is not his beliefs, but the way in which he holds them. If he holds them because his elders told him they were true when he was young, or if he holds them because if he did not he would be unhappy, his thought is not free; but if he holds them because, after careful thought, he finds a balance in their favour, then his thought is free, however odd his conclusions may seem – Bertrand Russell.

A

Appendices

Table A.1 A compilation of the differential equations for the dynamic SPM-model (CoastMab) using data for the Gulf of Riga (GR) to exemplify the calculation routines. Abbreviations and dimensions are given in Table 2.11

Surface water (SW)

$M_{SPMSWGR}(t) = M_{SPMSWGR}(t - dt) + (F_{SWSPMBPGR} + F_{xSPMDWSWGR} + F_{SPMETSWGR} + F_{SPMtribGR} - F_{SPMSWGRBP} - F_{SPMSWDWGR} - F_{SPMSWETGR} - F_{xSPMSWDWGR} - F_{SPMminSWGR})dt$

$M_{SPMSWGR}(t)$ = Mass (amount of SPM) in the SW-compartment at time t (g)
$F_{SWSPMBPGR}$ = Flow into the SW-compartment from the Baltic Proper (BP; g/month); see below
$F_{xSPMDWSWGR}$ = Flow from deep water to surface water (upward mixing; g/month)
$F_{SPMETSWGR}$ = Flow (resuspension) from ET-areas to the SW-compartment (g/month)
$F_{SPMtribGR}$ = Flow into the SW-compartment from tributaries (g/month)
$F_{SPMSWGRBP}$ = Flow from the SW-compartment and out to the Baltic Proper (g/month)
$F_{SPMSWDWGR}$ = Flow (sedimentation) from the SW-compartment to deep-water (DW) compartment (g/month)
$F_{SPMSWETGR}$ = Flow (sedimentation) from the SW-compartment to ET-areas (g/month)
$F_{xSPMSWDWGR}$ = Flow from surface water to deep water (downward mixing; g/month)
$F_{SPMminSWGR}$ = Flow (mineralization) from the SW-compartment (g/month)

ET-areas (ET)

$M_{SPMETGR}(t) = M_{SPMETGR}(t - dt) + (F_{SPMSWETGR} + F_{SPMLUGR} - F_{SPMETDWGR} - F_{SPMETSWGR} - F_{SPMminETGR})\cdot dt$

$M_{SPMETGR}(t)$ = Mass (amount of SPM) in the ET-compartment at time t (g)
$F_{SPMLUGR}$ = Flow into the SW-compartment from land uplift (g/month)
$F_{SPMETDWGR}$ = Flow (resuspension) from ET-areas to the DW-compartment (g/month)
$F_{SPMminETGR}$ = Flow (mineralization) from the ET-areas (g/month)

Deep water (DW)

$M_{SPMDWGR}(t) = M_{SPMDWGR}(t - dt) + (F_{SPMSWDWGR} + F_{SPMETDWSWGR} + F_{xSPMSWDWGR} + F_{SPMDWBPGR} - F_{xSPMDWSWGR} - F_{SPMDWADWGR} - F_{SPMDWGRBP} - F_{SPMminDWGR})dt$

$M_{SPMDWGR}(t)$ = Mass (amount of SPM) in the DW-compartment at time t (g)
$F_{SPMDWBPGR}$ = Flow into the DW-compartment from the Baltic Proper (g/month)
$F_{SPMDWADWGR}$ = Flow (sedimentation) from the DW-compartment to A-areas (ADW; g/month)
$F_{SPMDWGRBP}$ = Flow from the DW-compartment and out to the Baltic Proper (g/month)
$F_{SPMminDWGR}$ = Flow (mineralization) from the DW-compartment (g/month)

Table A.1 (continued)

A-areas (ADW)
$M_{SPMADWGR}(t) = M_{SPMAGR}(t - dt) + (F_{SPMDWADWGR} - F_{BurSPMGR} - F_{SPMminADWGR})dt$

$M_{SPMADWGR}(t)$ = Mass (amount of SPM) in the ADW-compartment at time t (g)
$F_{BurSPMGR\ P}$ = Flow (burial) from the ADW-compartment (g/month)
$F_{SPMminADWGR}$ = Flow (mineralization) from the ADW-compartment (g/month)

Algorithms for fluxes

Inflow:
$F_{SPMtribGR} = F_{TPtribGR} \cdot Y_{TribGR}$
$F_{SWSPMBPGR} = Q_{SWBPGR} \cdot SPM_{SWBP}$
$F_{SPMDWBPGR} = Q_{MWBPGR} \cdot SPM_{MWBP}$

Outflow
$F_{SPMSWGRBP} = Q_{SWGRBP} \cdot SPM_{SWGR}$
$F_{SPMDWGRBP} = Q_{DWGRBP} \cdot SPM_{DWGR}$

Production (mass of SPM from primary production from the CoastWeb-model)
$M_{SPMprodGR} = (M_{BPGR} + M_{PHGR} + M_{ZHGR}) \cdot 1{,}000$

Sedimentation
$F_{SPMSWETGR} =$
$M_{SPMSWGR} \cdot (v_{SWGR}/D_{SWGR}) \cdot ET_{GR} \cdot (1 - DC_{ResSPMSWGR}) + Y_{ResGR} \cdot DC_{ResSPMSWGR})$
$F_{SPMSWDWGR} =$
$M_{SPMSWGR} \cdot (v_{SWGR}/D_{SWGR}) \cdot (1 - ET_{GR}) \cdot (1 \cdot (1 - DC_{ResSPMSWGR}) + Y_{ResGR} \cdot DC_{ResSPMSWGR})$
$F_{SPMDWADWGR} =$
$M_{SPMDWGR} \cdot Y_{TGR} \cdot (v_{DWGR}/D_{DWGR}) \cdot ((1 - DC_{ResSPMDWGR}) + Y_{ResGR} \cdot DC_{ResSPMDWGR})$

Burial
$F_{BurSPMGR} = M_{SPMAGR} \cdot (1/(Age_{ADWGR})) \cdot Y_{LU}$

Resuspension
$F_{SPMETSWGR} = M_{SPMETGR} \cdot R_{ResGR} \cdot (1 - Vd_{GR}/3)$
$F_{SPMETDWGR} = M_{SPMETGR} \cdot R_{ResGR} \cdot (Vd_{GR}/3) \cdot Y_{LU}$
$F_{SPMLUGR} = F_{TPLUGR} \cdot Y_{TribGR}$

Mixing
$F_{xSPMSWDWGR} = M_{SPMSWGR} \cdot R_{MixSWDWGR}$
$F_{xSPMDWSWGR} = M_{SPMDWGR} \cdot R_{MixSWDWGR} \cdot V_{SWGR}/V_{DWGR}$

Mineralization
$F_{SPMminSWGR} = M_{SPMSWGR} \cdot R_{MinSWGR}$
$F_{SPMminDWGR} = M_{SPMDWGR} \cdot R_{MinDWGR}$
$F_{SPMminETGR} = M_{SPMETGR} \cdot R_{Minsed}$

Other model variables and algorithms
$Area_{GR} = 16{,}700 \cdot 10^{6}$ (km^{2})
$Area_{EGR} = 7{,}810 \cdot 10^{6}/(Area_{GR} - Area_{belowDwbGR})$ (km^{2})
$A_{areasGR} = Area_{GR} \cdot (1 - ET_{GR})$ (dim. less)
$Area_{AboveDwbGR} = Area_{GR} - Area_{BelowDwbGR}$ (km^{2})
$Area_{BelowDwbGR} = 3{,}500 \cdot 10^{6}$ (km^{2})
$Area_{UpfilftedperyrGR} = (Area_{GR} - Area_{BelowDwbGR}) \cdot 0.001 \cdot LR_{mm/monthGR} \cdot 12/D_{wbGR}$ (km^{2})
$Age_{ETGR} = (12/Strat_{GR})$ (months)
$Age_{ADWGR} = 12 \cdot 10/(Sed_{cm/ryrGR})$ (months)

Table A.1 (continued)

$\mathrm{Amp_{Rmig}} = 0.2$ (dim. less)
$\mathrm{Amp_{Trib}} = 0.5$ (dim. less)
$\mathrm{C_{BPGR}} = 1{,}000 \cdot \mathrm{M_{BPGR}/V_{SWGR}}$ (conc. bacterioplankton; t/m^3)
$\mathrm{Chl_{GR}} = \mathrm{Y_{DayLGR} \cdot TP_{SWGR} \cdot (DF_{SWGR}/1) \cdot Y_{4GR} \cdot Y_{TempChl}}$ [µg/l]
$\mathrm{DC_{ResSPMDWGR}} = \mathrm{F_{SPMETDWSWGR}/(F_{SPMDWBPGR}+F_{SPMETDWSWGR}+F_{SPMSWDWGR}+F_{xSPMSWDWGR})}$ (dim. less)
$\mathrm{DC_{ResSPMSWGR}} = \mathrm{(F_{SPMETSWGR})/(F_{SPMETSWGR}+F_{SPMPPGR}+F_{SWSPMBPGR}+F_{SPMtribGR}+F_{xSPMDWSWGR})}$ (dim. less)
$\mathrm{D_{DWGR}} = \mathrm{(D_{MaxGR} - D_{wbGR})/2}$ (m)
$\mathrm{DF_{SWGR}} = 1 - \mathrm{PF_{SWGR}}$ (dim. less)
$\mathrm{D_{MaxGR}} = 56$ (m)
$\mathrm{D_{wbGR}} = (45.7 \cdot (\mathrm{Area_{GR}} \cdot 10^{-6})^{0.5}/(21.4+(\mathrm{Area_{GR}} \cdot 10^{-6})^{0.5}))$ (m)
$\mathrm{D_{SWGR}} = \mathrm{D_{wbGR}}/2$ (m)
$\mathrm{d_{GR}} = 100 \cdot 2.6/(100+(\mathrm{W_{GR}}+\mathrm{IG_{GR}} \cdot (1-\mathrm{W_{GR}}/100)) \cdot (2.6-1))$ (g/cm^3)
$\mathrm{DWT_{GR}}$ = (1.00, 4.29), (2.00, 3.50), (3.00, 3.32), (4.00, 3.26), (5.00, 3.41), (6.00, 3.68), (7.00, 3.76), (8.00, 3.83), (9.00, 3.91), (10.0, 4.02), (11.0, 4.73), (12.0, 5.39) (°C)
$\mathrm{ET_{GR}} = \mathrm{(Area_{GR} - Area_{BelowDwbGR})/Area_{GR}}$ (dim. less)
$\mathrm{F_{TPLUGR}} = (10^6) \cdot \mathrm{LU_{GR}}/12$ (g TP/month)
$\mathrm{F_{TPtribGR}} = (((202+582+335))/12) \cdot 10^6 \cdot \mathrm{Y_{QGR}}$ (g/month)
Ice limit = 0.9 (°C)
$\mathrm{Lat_{GR}} = 57.7$ (°N)
$\mathrm{LR_{mm/monthGR}} = 0.625/12$ (mm/month)
$\mathrm{LU_{GR}} = 12 \cdot (\mathrm{Area_{AboveDwbGR}+Area_{UpfilftedperyrGR}}) \cdot 0.001 \cdot \mathrm{LR_{mm/monthGR}} \cdot ((1-(\mathrm{W_{GR}}-15)/100)) \cdot (\mathrm{d_{GR}}+0.2) \cdot ((\mathrm{TP_{Clay} \cdot Area_{EGR}}+(1-\mathrm{Area_{EGR}}) \cdot \mathrm{TP_{AsedGR}})) \cdot 1{,}000 \cdot 10^{-6}$ (µg TP/year)
$\mathrm{NBM_{BPGR}} = \mathrm{Y_{SPMGR}} \cdot 0.001 \cdot \mathrm{V_{SWGR}} \cdot 10^{(0.973 \cdot (0.27 \cdot \log(\mathrm{ChlGR})+0.19)-0.438)}$ (kg ww)
$\mathrm{PF_{SWGR}} = \mathrm{(Y_{PFGR}+(M_{TPBioSGR}/(M_{TPSWGR}+M_{TPBioSGR}))}$ (dim. less)
$\mathrm{Q_{DWGRBP}} = \mathrm{Q_{GRBP} - Q_{SWGRBP}}$ (m^3/month)
$\mathrm{Q_{MWBPGR}} = \mathrm{QB_{PGR}} . (1-\mathrm{DC_{SWDWGR}})$ (m^3/month)
$\mathrm{Q_{SWBPGR}} = \mathrm{Q_{BPGR} \cdot DC_{SWDWGR}}$ (m^3/month)
$\mathrm{Q_{SWGRBP}} = \mathrm{Q_{SWBPGR}+Q_{TribGR}+(Q_{PrecGR}-Q_{EvaGR})}$ (m^3/month)
$\mathrm{Ref_{Temp}} = 9$ (°C)
$\mathrm{R_{MinDWGR}} = \mathrm{R_{minGR}} \cdot (\mathrm{DWT_{GR}/Ref_{Temp}})^{1.2}$ (1/month)
$\mathrm{R_{MinGR}} = (\mathrm{M_{BPGR}/NBM_{BPGR}}) \cdot 0.01 \cdot (0.99/\mathrm{ET_{GR}})$ (1/month)
$\mathrm{R_{Minsed}} = 0.01 \cdot (30/\mathrm{Y_{LU}})$
$\mathrm{R_{MinSWGR}} = \mathrm{R_{minGR}} \cdot (\mathrm{SWT_{GR}/Ref_{Temp}})^{1.2}$ (1/month)
$\mathrm{R_{MixSWDWGR}} =$ (if $\mathrm{Sal_{DWGR}} > \mathrm{Sal_{SWGR}}$ then $\mathrm{R_{mixdefGR}} \cdot (1/(1+\mathrm{Sal_{DWGR}}-\mathrm{Sal_{SWGR}}))^2$ else $\mathrm{R_{MixdefGR}}$) (1/month)
$\mathrm{R_{MixdefGR}} = \mathrm{Strat_{GR} \cdot ET_{GR}}/12$ (1/month)
$\mathrm{R_{ResGR}} =$ if $\mathrm{SWT_{GR}} <$ Ice limit then $(\mathrm{SWT_{GR}}+ 0.2) \cdot 1/\mathrm{Age_{ETGR}}$ else $1/\mathrm{Age_{ETGR}}$ (1/month)
$\mathrm{Seasnorm_{Latma}}$ = −1.000, −1.000, −1.000, −1.000, 2.170, 2.510, 0.630, 0.240, 0.050, −0.030, −0.660, −0.920 (dim. Less)
$\mathrm{Seasnorm_{Latmin}}$ = 1.040, 1.370, 0.560, 0.380, −0.290, −0.230, −0.620, −0.710, −0.790, −0.740, −0.280, 0.320 (dim. less)
$\mathrm{Seasnorm_{Qmax}}$ = −0.710, −0.480, −0.170, −0.170, 0.620, 1.740, 0.520, 0.090, −0.160, −0.200, −0.630, −0.440 (dim. less)
$\mathrm{Seasnorm_{Qmin}}$ = 0.580, 0.810, 0.840, 1.580, −0.100, −1.000, −1.000, −1.000, −0.820, −0.560, 0.110, 0.540 (dim. less)
$\mathrm{Strat_{GR}} =$ if $\mathrm{ABS(SWT_{GR}-DWT_{GR})} < 4$ then $1+1/1/(1+\mathrm{ABS(SWT_{GR}-DWT_{GR})})$ else $1/\mathrm{ABS(SWT_{GR}-DWT_{GR})}$ (dim. less)

Table A.1 (continued)

$Sec_{GR} = Y_{QSec} \cdot GR \cdot (10^{(-(zGR+0.5) \cdot (\log(SPMSWGR)/1+0.3)/2+zGR)})$ (m)

$Sed_{DWGR} = 10^2 \cdot F_{SPMDWAGR}/(A_{AreasGR} \cdot 30)$ (μg/cm^2·d)

SWT_{GR} = (1.00, 2.00), (2.00, 1.13), (3.00, 0.755), (4.00, 1.76), (5.00, 3.27), (6.00, 4.16), (7.00, 5.11), (8.00, 6.10), (9.00, 12.6), (10.0, 11.1), (11.0, 7.02), (12.0, 7.02) (°C)

$SPM_{DWGR} = M_{SPMDWGR}/V_{DWGR}$ (mg/l)

$SPM_{SWGR} = (M_{SPMSWGR} + M_{SPMprodGR})/V_{SWGR}$ (mg/l)

$Temp_{CritGR}$ = if $SWT_{GR} <$ Ice_limit then Ice_limit/(Ice_limit+SWT_{GR}) else Y_{DRGR}

$TP_{Clay} = 0.36$ (mg/g dw)

$TP_{AsedGR} = M_{TPADWGR}/((10^3) \cdot V_{AsedGR} \cdot d_{GR} \cdot (1-W_{GR}/100))$ (mg/g dw)

$TP_{SWGR} = 1{,}000 \cdot (M_{TPSWGR}+M_{TPBioSGR})/V_{SWGR}$ (μg/l)

$TP_{Nat}/TP_{TotGR} = 0.18 = 202/(202+582+335)$ (dim. less)

$V_{AsedGR} = Area_{belowDwbGR} \cdot 10 \cdot 0.01 \cdot (Vd_{DWGR})/3$ (m^3)

$Vd_{DWGR} = 3 \cdot D_{MVDWGR}/(D_{MaxGR}-D_{wbGR})$ (dim. less)

$Vd_{GR} = 3 \cdot D_{MVGR}/D_{MaxGR}$ (dim. less)

$v_{DWGR} = v_{Def} \cdot Y_{SalDWGR} \cdot Y_{SPMDWGR} \cdot Y_{LU} \cdot Temp_{CritGR}$ (m/month)

$v_{SWGR} = v_{def} \cdot Y_{SPMSWGR} \cdot Y_{SalSWGR} \cdot Temp_{critGR}$ (m/month)

$v_{Def} = 6$ m/month

Y_{DRGR} = if $DR_{GR} < 0.26$ then $DR_{GR}/0.26$ else $0.26/DR_{GR}$

$V_{DWGR} = 18 \cdot 10^9$ (m^3)

$V_{SWGR} = 392 \cdot 10^9$ (m^3)

$W_{GR} = 75$ (% ww)

$Y_{DayLGR} = HDL/12$ (dim. less)

Y_{DR} = If DR < 0.26 then 1 else 0.26/DR (calculates how changes in DR and turbulence influence sedimentation) (dim. less)

Y_{DW} = If $T_{DW} < 7$ (days) then $Y_{DW} = 1$ else $Y_{DW} = (T_{DW}/7)^{0.5}$ (calculates how changes in T and turbulence influence deep-water sedimentation)

Y_{LU} = if $((F_{TotTPinGR}+F_{TPLUGR})/F_{TotTPinGR}) \cdot (0.76/Vd_{GR}) < 1$ then 1 else $((F_{TotTPinGR}+F_{TPLUGR})/F_{TotTPinGR}) \cdot (0.76/Vd_{GR})$ (dim. less)

$Y_{QGR} = 1+0.526 \cdot ((Lat_{GR}-35)^{2.18}/35^{2.18} \cdot Seasnorm_{Latmax}+(1-(Lat_{GR}35)^{2.18}/35^{2.18}) \cdot Seasnorm_{Latmin})+ 0.265 \cdot ((Q_{empGR}/(60 \cdot 60 \cdot 24 \cdot 365))^{0.22}/ 5{,}000^{0.22} \cdot Seasnorm_{Qmax}+(1-(Q_{empGR}/(60 \cdot 60 \cdot 24 \cdot 365))^{0.22}/5{,}000^{0.22}) \cdot Seasnorm_{Qmin})$ (dim. Less)

$Y_{QSec} = (Q_{MWBPGR}+Q_{SWBPGR})/(Q_{TribGR}+Q_{MWBPGR}+Q_{SWBPGR})$ (dim. less)

$Y_{PFGR} = F_{TPETSWGR}/(F_{TPprecGR}+F_{TPETSWGR}+F_{TPSWBPGR}+F_{TPtribGR}+F_{dTPDWSWGR}+F_{xTPDWSWGR})$ (dim. less)

$Y_{ResGR} = (Age_{ETGR}+1)^{0.5} \cdot Y_{LU}$ (calculates how much faster resuspended sediments settle out) (dim. less)

$Y_{SalSW} = (1 + 1 \cdot (Sal_{SWGR}/1-1) = 1 \cdot Sal/1$ (calculates how changes in salinities > 1 psu influence sedimentation) (dim. less)

$Y_{SalDWGR} = (1+1 \cdot (Sal_{SWGR}/1-1))$ (dim. less)

$Y_{SPMDWGR} = 1+0.75 \cdot (SPM_{DWGR}/50-1)$ (dim. less)

$Y_{SPMSWGR} = 1+0.75 \cdot (SPM_{SWGR}/50-1)$ (dim. less)

Y_{TGR} = if $T_{DWGR}/30 < 7$ then 1 else $((T_{DWGR}/30)/7)^{0.5}$ (dim. less)

$Y_{TribGR} = (1{,}000/2) \cdot (1-0.5 \cdot (TP_{nat}/TP_{totGR}/0.5-1))$ (dim. less)

Y_{4GR} = if $Y_{3GR} < 0.012$ then 0.012 else Y_{3GR} (dim. less)

Y_{3GR} = if $Sal_{SWGR} > 40$ then $(0.06-0.1 \cdot (Sal_{SWGR}/40-1))$ else Y_{2GR} (dim. less)

Y_{2GR} = if $Sal_{SWGR} < 12.5$ then Y_{1GR} else $(0.28-0.1 \cdot (Sal_{SWGR}/12.5-1))$ (dim. less)

Y_{1GR} = if $Sal_{SWGR} < 2.5$ then $(0.20-0.2 \cdot (Sal_{SWGR}/12.5-1))$ else $(0.20+0.02 \cdot (Sal_{SWGR}/2.5-1))$ (dim. less)

$Y_{TempChl}$ = if $SWT_{GR} > 4$ then 1 else $(SWT_{GR}+0.1)/4$ (dim. less)

$z_{GR} = (10^{\wedge(0.15 \cdot \log(1+SalSWGR)+0.3)-1})$ (dim. less)

Table A.2 Compilation of monthly SPM-fluxes in the Baltic Sea based on the mean monthly values. Values in kt SPM (= 10^9 g) per month. Abbreviations and dimensions are given in Table 2.11

Month	1	2	3	4	5	6	7	8	9	10	11	12	MV
burADWBP	1,647	1,864	2,041	2,257	2,528	2,509	2,135	1,798	1,571	1,321	1,182	1,382	1,853
burADWGF	13	38	26	6	6	6	6	6	5	5	4	5	11
burAMWBP	1,460	1,470	1,619	1,570	1,138	745	683	692	735	877	1,344	1,452	1,149
burAMWGF	38	99	74	20	16	16	16	17	19	18	17	17	31
burBB	557	606	769	797	914	907	818	740	651	476	466	543	687
burBS	880	952	1,209	1,256	1,446	1,438	1,301	1,181	1,042	762	744	863	1,090
burGR	7	11	9	6	6	6	6	7	7	6	7	7	7
DWABB	2,006	1,000	526	570	421	657	383	299	386	911	1,185	1,101	787
DWABS	1,104	1,171	1,455	1,430	1,552	1,577	1,467	1,331	1,173	878	892	1,069	1,258
DWADWBP	1,646	1,841	1,954	2,243	2,707	2,636	2,101	1,733	1,492	1,243	1,125	1,370	1,841
DWADWGF	22	64	42	10	10	10	10	9	9	8	7	8	17
DWAGR	13	21	16	12	11	11	11	13	12	11	12	13	13
DWBBBS	41	16	6	5	15	25	24	21	20	29	40	47	24
DWBPBS	4	5	5	5	5	3	3	3	2	2	3	4	4
DWBPGF	15	16	18	18	17	14	12	10	9	8	10	12	13
DWBPGR	5	6	6	6	5	4	4	4	3	3	4	5	5
DWBSBB	4	4	4	4	3	0	0	0	0	3	7	5	3
DWGFBP	15	14	13	15	15	16	17	16	15	14	13	14	15
DWGRBP	18	19	20	19	18	19	21	20	16	13	16	18	18
DWKABP	40	40	40	40	40	40	40	40	40	40	40	40	40
ETDWBB	753	252	330	518	1,166	145	101	138	788	1,272	1,185	1,139	649
ETDWBS	1,107	1,068	1,060	1,269	823	120	92	100	147	1,014	1,947	1,192	828
ETDWGR	23	23	25	27	29	24	23	8	3	12	27	25	21
ETMWBP	2,493	2,331	2,601	2,079	993	192	157	169	251	1,096	2,790	2,836	1,499
ETMWGF	29	12	30	51	56	49	50	33	5	25	41	34	35
ETSWBB	428	140	180	266	566	72	51	70	402	665	643	639	344
ETSWBP	3,446	3,187	3,443	2,842	1,455	279	214	225	328	1,419	3,663	3,878	2,032
ETSWBS	944	893	869	980	603	90	71	77	113	802	1,591	1,007	670

Table A.2 (continued)

Month	1	2	3	4	5	6	7	8	9	10	11	12	MV
ETSWGF	56	23	56	98	107	92	95	63	10	47	78	64	66
ETSWGR	27	26	28	32	35	28	25	9	3	13	30	28	24
LUBB	1,032	1,030	1,029	1,031	1,033	1,030	1,024	1,020	1,019	1,023	1,026	1,029	1,027
LUBP	4,507	4,532	4,549	4,559	4,547	4,485	4,423	4,364	4,306	4,263	4,362	4,455	4,446
LUBS	1,879	1,880	1,881	1,883	1,884	1,883	1,881	1,879	1,875	1,873	1,875	1,876	1,879
LUGF	294	294	293	293	294	294	294	294	294	294	294	294	294
LUGR	119	119	119	119	119	119	119	119	119	119	119	119	119
minADWBB	82	42	22	28	24	36	17	12	15	33	44	44	33
minADWBP	106	118	121	144	187	179	133	108	91	75	69	88	118
minADWBS	73	76	92	86	88	91	87	79	70	53	56	70	77
minADWGF	7	19	13	3	3	3	3	3	3	2	2	2	5
minADWGR	4	6	4	3	3	3	3	3	3	3	3	4	3
minAMWBP	108	106	109	114	95	60	48	47	49	57	89	104	82
minAMWGF	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.1	0.1
minDWBB	1	0.004	0.001	0.000	0.113	1	1	1	2	7	10	2	2
minDWBP	42	42	52	78	114	63	61	58	35	23	33	34	53
minDWBS	14	13	12	10	29	30	15	18	8	6	22	15	16
minDWGF	0.1	0.03	0.03	0.1	0.3	0.3	0.2	0.4	0.4	0.3	0.3	0.2	0.2
minDWGR	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.1	0.2
minETBB	240	286	314	375	419	376	342	343	340	287	253	242	318
minETBP	1,986	1,846	1,689	1,653	1,791	1,926	1,998	2,136	2,266	2,362	2,268	2,142	2,005
minETBS	717	674	640	590	530	606	705	780	846	899	820	751	713
minETGF	277	347	411	383	333	299	278	268	280	292	283	275	311
minETGR	119	117	121	118	114	106	101	103	113	120	121	121	114
minMWBP	19	15	18	26	36	20	21	22	14	10	21	18	20
minMWGF	1.5	0.3	0.3	0.8	2.2	2	2	4	5	5	5	2	3
minSWBB	0.8	0.000	0.000	0.001	0.8	10	16	19	12	13	18	2	8
minSWBP	63	47	69	165	445	459	714	744	364	151	142	64	286
minSWBS	3	2	2	3	51	78	53	61	22	8	15	3	25

Table A.2 (continued)

Month	1	2	3	4	5	6	7	8	9	10	11	12	MV
minSWGF	1.20	0.02	0.09	1.44	8	11	10	30	52	41	25	3	15
minSWGR	0.64	0.23	0.33	1.32	3	4	5	14	25	15	9	1	7
MWAMWBP	1,665	1,657	1,766	1,773	1,383	891	764	758	794	937	1,453	1,634	1,290
MWAMWGF	72	190	141	38	31	31	31	33	35	34	32	33	59
MWBPBS	4	5	5	5	5	3	3	3	2	2	3	4	4
MWBPGF	8	8	9	9	7	6	5	5	4	4	6	7	7
MWBPGR	5	6	6	6	5	4	4	4	3	3	4	5	5
MWDWBP	2,406	2,396	2,553	2,563	1,999	1,287	1,104	1,096	1,147	1,354	2,100	2,362	1,864
MWDWGF	20	54	40	11	9	9	9	9	10	10	9	9	17
MWGFBP	24	24	23	22	21	22	24	26	25	25	25	24	24
MWGRBP	18	19	20	19	18	19	21	20	16	13	16	18	18
MWKABP	70	70	70	70	70	70	70	70	70	70	70	70	70
prodBB	111	53	40	56	68	486	420	259	375	287	326	288	231
prodBP	4,287	3,834	3,915	4,808	8,105	9,425	3,783	8,453	8,099	7,639	4,510	4,053	5,909
prodBS	376	467	516	540	1,175	3,480	1,130	1,921	2,049	1,827	913	721	1,260
prodGF	467	226	133	520	1,440	1,479	650	927	833	690	557	503	702
prodGR	240	203	173	340	643	653	313	410	398	405	261	223	355
SWBBBS	41	16	6	5	15	25	24	21	20	29	40	47	24
SWBPBS	147	156	165	150	121	131	147	141	127	115	123	136	138
SWBPGF	153	163	172	173	166	167	164	152	135	120	126	140	153
SWBPGR	16	17	19	19	17	18	19	18	16	14	14	15	17
SWBPKA	156	167	166	215	286	252	177	144	122	103	107	135	169
SWBSBB	21	22	23	16	7	10	15	14	12	11	17	21	16
SWBSBP	112	118	120	116	127	117	96	80	65	58	85	106	100
SWDWBB	535	365	150	113	52	69	91	102	89	109	145	157	165
SWDWBS	506	535	715	534	572	520	446	394	358	290	357	483	476
SWDWGR	9	17	12	9	9	9	10	10	10	11	11	10	11
SWETBB	920	629	258	195	90	119	156	175	154	188	249	271	284
SWETBP	1,180	1,258	1,325	1,346	1,115	891	942	943	976	994	1,002	1,079	1,088

Table A.2 (continued)

Month	1	2	3	4	5	6	7	8	9	10	11	12	MV
SWETBS	353	373	499	372	399	362	311	275	250	202	249	337	332
SWETGF	161	400	256	59	57	64	70	72	66	68	68	66	117
SWETGR	35	64	47	34	33	35	38	38	37	40	41	37	40
SWGFBP	258	225	190	202	244	278	286	289	285	275	266	262	255
SWGRBP	32	32	31	33	37	38	36	35	35	34	33	33	34
SWKABP	319	319	319	319	319	319	319	319	319	319	319	319	319
SWMWBP	1,663	1,773	1,868	1,897	1,572	1,256	1,328	1,330	1,377	1,402	1,412	1,522	1,533
SWMWGF	94	233	149	35	33	38	41	42	38	40	40	38	68
tribBB	69	71	67	119	192	164	103	84	76	65	57	63	94
tribBP	696	695	619	808	1,136	988	634	519	474	445	480	642	678
tribBS	73	74	69	107	164	141	89	73	66	58	56	67	86
tribGF	216	217	196	280	412	356	227	186	169	153	155	199	230
tribGR	51	51	46	56	72	61	39	33	31	31	35	47	46
xDWMWBP	42	45	57	53	27	4	2	2	2	7	24	36	25
xDWMWGF	2	1	1	2	3	3	3	2	0	1	2	2	2
xDWSWBB	164	53	19	25	75	11	4	3	29	113	166	206	72
xDWSWBS	86	93	99	122	82	9	5	4	4	26	84	77	58
xDWSWGR	17	19	21	27	40	37	32	10	1	4	13	15	20
xMWDWBP	22	23	28	26	12	2	1	1	1	4	14	21	13
xMWDWGF	3	3	3	3	4	4	4	3	0	2	3	3	3
xMWSWBP	60	63	78	71	34	4	3	2	2	10	37	55	35
xMWSWGF	69	67	64	70	89	86	100	73	11	45	80	69	68.5
xSWDWBB	121	46	17	18	33	6	4	4	20	57	90	127	45
xSWDWBS	44	47	48	55	38	4	2	2	2	11	42	40	28
xSWDWGR	13	14	15	19	28	28	25	8	1	5	11	12	15
xSWMWBP	112	120	146	134	70	11	7	6	7	24	73	102	68
xSWMWGF	63	54	48	55	78	82	98	70	10	42	73	63	61

Table A.3 Basic equations for the CoastWeb-model for a system with two vertical compartments (here the Bothnian Bay, BB). Abbreviations and dimensions are given in Table 2.11

Bacterioplankton

$BM_{BPBB}(t) = BM_{BPBB}(t - dt) + (IPR_{BPBB} + MIG_{InBPBB} - CON_{BPZHBB} - EL_{BPBB} - MIG_{OutBPBB})dt$

$IPR_{BPBB} = R_{PRBP} \cdot (SPM_{SWBB}/1{,}000) \cdot V_{SWBB} \cdot Y_{SWTBB}{}^{1}$
$MIG_{InBPBB} = R_{MigPHBB} \cdot NBM_{BPBS}$
$CON_{BPZHBB} = BM_{BPBB} \cdot CR_{ZHBB}$
$EL_{BPBB} = BM_{BPBB}/T_{BP}$
$MIG_{OutBPBB} = R_{MigPHBB} \cdot BM_{BPBB}$

Benthic algae

$BM_{BABB}(t) = BM_{BABB}(t - dt) + (IPR_{BABB} - EL_{BABB} - CON_{BAZBBB} - ER_{BABB})dt$

$IPR_{BABB} = R_{IPRBABB} \cdot Area_{SecBB} \cdot (2 \cdot Sec_{BB}) \cdot Y_{TPBB} \cdot (HDL/12) \cdot Y_{SWTBB}{}^{1}$
$EL_{BABB} = BM_{BABB}/T_{BA}$
$CON_{BAZBBB} = BM_{BABB} \cdot CR_{BAZBBB}$
$ER_{BABB} = BM_{BABB} \cdot R_{ErBB}$

Jellyfish

$BM_{JEBB}(t) = BM_{JEBB}(t - dt) + (IPR_{ZHJEBB} + IPR_{ZPJEBB} + MIG_{InJEBB} - EL_{JEBB} - MIG_{OutJEBB})dt$

$IPR_{ZHJEBB} = Y_{SalJEBB} \cdot DC_{ZPtoPHBP} \cdot (1 - DC_{ZPZHJE}) \cdot CON_{ZHJEBB} \cdot MER_{ZP} \cdot Y_{SWTBB}{}^{0.5}$
$IPR_{ZPJEBB} = Y_{SalJEBB} \cdot (DC_{ZPtoPHBP}) \cdot DC_{ZPZHJE} \cdot CON_{ZPJEBB} \cdot MER_{ZP}$
$MIG_{InJEBB} = R_{MigPYBB} \cdot NBM_{JEBB} \cdot Y_{SalJEBB}$
$EL_{JEBB} = BM_{JEBB}/T_{JE}$
$MIG_{OutJEBB} = R_{MigPYBB} \cdot BM_{JEBB}$

Macrophytes

$BM_{MABB}(t) = BM_{MABB}(t - dt) + (IPR_{MABB} - CON_{MAZBBB} - EL_{MABB} - Er_{MABB})dt$

$IPR_{MABB} = R_{PRMA} \cdot Area_{BB} \cdot MA_{CovBB} \cdot 0.01 \cdot (HDL/12) \cdot Y_{SWTBB}{}^{1}$
$CON_{MAZBBB} = BM_{MABB} \cdot CB_{ZBvsMABB} \cdot 0.001$
$EL_{MABB} = BM_{MABB}/T_{MA}$
$Er_{MABB} = BM_{MABB} \cdot R_{erBB}$

Predatory fish

$BM_{PDBB}(t) = BM_{PDBB}(t - dt) + (IPR_{PDBB} + MIG_{InPDBB} - FISH_{PDBB} - EL_{PDBB} - MIG_{OutPDBB})dt$

$IPR_{PDBB} = BM_{ERPD} \cdot F_{PYPDBB} \cdot Y_{SWTBB}{}^{0.25}$
$MIG_{InPDBB} = R_{MigPDBB} \cdot NBM_{PDBB}$
$FISH_{PDBB} = 2 \cdot BM_{PDBB} \cdot R_{FishBB}$
$EL_{PDBB} = BM_{PDBB} \cdot 1/T_{PD}$
$MIG_{OutPDBB} = \text{if } BM_{PDBB}/NBM_{PDBB} > 1 \text{ then } (R_{migPDBB}) \cdot (BM_{PDBB}) \text{ else } 0.5 \cdot (R_{MigPDBB}) \cdot (BM_{PDBB})$

Phytoplankton

$BM_{PHBB}(t) = BM_{PHBB}(t - dt) + (IPR_{PHBB} + MIG_{InPHBB} - ELP_{HBB} - CON_{PHZHBB} - MIG_{OutPHBB}) \cdot dt$

$IPR_{PHBB} = PrimP_{BB}$
$MIG_{InPHBB} = R_{MigPHBB} \cdot NBM_{PHBS}$

Table A.3 (continued)

$EL_{PHBB} = BM_{PHBB}\cdot 1/T_{PH}$
$CON_{PHZHBB} = BM_{PHBB}\cdot CR_{ZHBB}$
$MIG_{OutPHBB} = R_{MigPHBB}\cdot BM_{PHBB}$

Prey fish
$BM_{PYBB}(t) = BM_{PYBB}(t - dt) + (IPR_{ZHPYBB} + IPR_{ZPPYBB} + IPR_{ZBPYBB} + MIG_{InPYBB} - CON_{PYPDBB} - EL_{PYBB} - FISH_{PYBB} - MIG_{OutPYBB})dt$

$IPR_{ZHPYBB} = DC_{ZPZBBB}\cdot(1-DC_{ZPZH})\cdot MER_{PY}\cdot CON_{ZHPYBB}\cdot Y_{SWTBB}{}^{0.25}$
$IPR_{ZPPYBB} = DC_{ZPZBBB}\cdot DC_{ZPZH}\cdot CON_{ZPPYBB}\cdot MER_{PY}\cdot Y_{SWTBB}{}^{0.25}$
$IPR_{ZBPYBB} = F_{ZBPYBB}\cdot MER_{PY}\cdot(1-DC_{ZPZBBB})\cdot Y_{SWTBB}{}^{0.25}$
$MIG_{InPYBB} = \text{if } BM_{PYBB}/NBM_{PYBB} > 1 \text{ then } 0.5\cdot R_{MigPYBB}\cdot NBM_{PYBS} \text{ else } R_{MigPYBB}\cdot NBM_{PYBS}$
$CON_{PYPDBB} = BM_{PYBB}\cdot CR_{PYBB}$
$EL_{PYBB} = BM_{PYBB}\cdot 1/T_{PY}$
$FISH_{PYBB} = BM_{PYBB}\cdot R_{FishBB}$
$MIG_{OutPYBB} = \text{if } BM_{PYBB}/N_{BMPYBB} > 1 \text{ then } R_{migPYBB}\cdot BM_{PYBB} \text{ else } 0.5\cdot R_{MigPYBB}\cdot BM_{PYBB}$

Zoobenthos
$BM_{ZBBB}(t) = BM_{ZBBB}(t - dt) + (IPR_{MAZBBB} + IPR_{BAZBBB} + IPR_{SedZBBB} - CON_{ZBPYBB} - EL_{ZBBB})dt$

$IPR_{MAZBBB} = (1-DC_{BAMA})\cdot CON_{MAZBBB}\cdot MER_{MA}\cdot Y_{SWTBB}{}^{0.25}$
$IPR_{BAZBBB} = DC_{BAMA}\cdot MER_{BA}\cdot CON_{BAZBGBB}\cdot Y_{SWTBB}{}^{0.25}$
$IPR_{SedZBBB} = M_{SedBB}\cdot DC_{SedBA}\cdot NCR_{ZBBB}\cdot(MER_{SedBB}\cdot(ET_{BB}+(1-ET_{BB})\cdot Y_{Eh1BB}\cdot Y_{EhBB}))\cdot Y_{SWTBB}{}^{0.25}$
$CON_{ZBPYBB} = BM_{ZBBB}\cdot CR_{PYBB}$
$EL_{ZBBB} = BM_{ZBBB}\cdot 1/T_{ZB}$

Herbivorous zooplankton
$BM_{ZHBB}(t) = BM_{ZHBB}(t - dt) + (IPR_{PHZHBB} + IPR_{BPZHBB} + MIG_{InZHBB} - EL_{ZHBB} - CON_{ZHPYBB} - CON_{ZHZPBB} - CON_{ZHJEBB} - MIG_{OutZHBB})dt$

$IPR_{PHZHBB} = DC_{PHBPBP}\cdot CON_{PHZHBB}\cdot MER_{PHZH}\cdot Y_{SWTBB}{}^{0.5}$
$IPR_{BPZHBB} = (1-DC_{PHBPBP})\cdot CON_{BPZHBB}\cdot MER_{BPZH}\cdot Y_{SWTBB}{}^{0.5}$
$MIG_{InZHBB} = R_{MigZPBB}\cdot NBM_{ZHBS}$
$EL_{ZHBB} = BM_{ZHBB}\cdot 1/T_{ZH}$
$CON_{ZHPYBB} = BM_{ZHBB}\cdot CR_{PYBB}$
$CON_{ZHZPBB} = BM_{ZHBB}\cdot CR_{ZPBB}$
$CON_{ZHJEBB} = \text{if } BM_{JEBB} > 1 \text{ then } BM_{ZHBB}\cdot CR_{JEBB}\cdot R_{ProdJE} \text{ else } 0$
$MIG_{OutZHBB} = R_{MigZPBB}\cdot BM_{ZHBB}$

Predatory zooplankton
$BM_{ZPBB}(t) = BM_{ZPBB}(t - dt) + (IPR_{ZPBB} + MIG_{InZPBB} - CON_{ZPPYBB} - EL_{ZPBB} - CON_{ZPJEBB} - MIG_{OutZPBB})dt$

$IPR_{ZPBB} = CON_{ZHZPBB}\cdot MER_{ZP}\cdot Y_{SWTBB}{}^{0.25}$
$MIG_{InZPBB} = R_{MigZPBB}\cdot NBM_{ZPBS}$
$CON_{ZPPYBB} = BM_{ZPBB}\cdot CR_{PYBB}$
$EL_{ZPBB} = BM_{ZPBB}\cdot 1/T_{ZP}$
$CON_{ZPJEBB} = BM_{ZPBB}\cdot C_{RJEBB}\cdot R_{ProdJE}$
$MIG_{OutZPBB} = R_{MigZPBB}\cdot BM_{ZPBB}$
Model variables
$Area_{BB} = 36{,}260\cdot 10^{6}$

Table A.3 (continued)

$\mathrm{Area_{2SecBB} = Area_{BB} - Area_{2SecBB} \cdot 10^{9}}$ (=littoral fraction above 2 Secchi depths)

$\mathrm{C_{BABB} = 1{,}000 \cdot BM_{BABB}/Area_{BB}}$

$\mathrm{C_{BPBB} = 1{,}000 \cdot BM_{BPBB}/V_{SWBB}}$

$\mathrm{Chl_{ModBB}}$ = Modeled concentration of chlorophyll-a in BB (μg/L)

$\mathrm{C_{MABB} = 1{,}000 \cdot BM_{MABB}/Area_{BB}}$

$\mathrm{C_{PDBB} = 1{,}000 \cdot BM_{PDBB}/V_{SWBB}}$

$\mathrm{C_{PHBB} = 1{,}000 \cdot BM_{PHBB}/V_{SWBB}}$

$\mathrm{C_{PYSWBB} = 1{,}000 \cdot BM_{PYBB}/V_{SWBB}}$

$\mathrm{CR_{BAZBBB} = (NCR_{ZBBB} + NCR_{ZBBB} \cdot (BM_{ZBBB}/NBM_{ZBBB} - 1))}$

$\mathrm{CR_{ZBMABB} = (NCR_{ZBBB} + NCR_{ZBBB} \cdot (BM_{ZBBB}/NBM_{ZBBB} - 1))}$

$\mathrm{CR_{JEBB} = (NCR_{JEBB} + NCR_{JEBB} \cdot (BM_{JEBB}/NBM_{JEBB} - 1))}$

$\mathrm{CR_{PDBB} = Y_{Fish} \cdot (NCR_{PDBB} + NCR_{PDBB} \cdot (BM_{PDBB}/NBM_{PDBB} - 1))}$

$\mathrm{CR_{PYBB} = (NCR_{PYBB} + NCR_{PYBB} \cdot (BM_{PYBB}/(NBM_{PYBB}) - 1))}$

$\mathrm{CR_{ZHBB} = (NCR_{ZHBB} + NCR_{ZHBB} \cdot (BM_{ZHBB}/NBM_{ZHRBB} - 1))}$

$\mathrm{CR_{ZPBB} = (NCR_{ZPBB} + NCR_{ZPBB} \cdot (BM_{ZPBB}/NBM_{ZPBB} - 1))}$

$\mathrm{C_{ZBBB} = 1{,}000 \cdot BM_{ZBBB}/Area_{BB}}$

$\mathrm{C_{ZHBB} = 1{,}000 \cdot BM_{ZHBB}/V_{SWBB}}$

$\mathrm{C_{ZPBB} = 1{,}000 \cdot BM_{ZPBB}/V_{SWBB}}$

$\mathrm{DC_{BAMA} = (1 - DC_{SedBA}) \cdot 0.75}$

$\mathrm{DC_{SedBA} = 0.75}$

$\mathrm{DC_{PDBBBS} = Q_{SWBSBB}/(Q_{SWBSBB} + Q_{SWBSBP})}$

$\mathrm{DC_{PHBP} = 0.5}$

$\mathrm{DC_{PYPDBB}} =$ if $\mathrm{(TP_{SWBB}/(TP_{SWBB}+22))^{0.4} < 0.9}$ then 0.9 else $\mathrm{(TP_{SWBB}/(TP_{SWBB}+22))^{0.4}}$

$\mathrm{DC_{PYPDBB2}} =$ if $\mathrm{DC_{PYPDBB} > 0.99}$ then 0.99 else $\mathrm{DC_{PYPDBB}}$

$\mathrm{DC_{PHBPBP} = 0.5}$

$\mathrm{DC_{ZHZP} = 0.8}$

$\mathrm{DC_{ZPPHBP} = 0.75}$

$\mathrm{DC_{ZPZB} = 0.65}$

$\mathrm{DC_{ZPZBBB}} =$ if $\mathrm{DC_{ZPZB} > 0.9}$ then 0.9 else $\mathrm{DC_{ZPZB}}$

$\mathrm{DC_{ZPZH} = 0.2}$

$\mathrm{DC_{ZPZHJE} = 0.5}$

$\mathrm{ET_{BB}}$ = ET-areas in BB from the CoastMab-model

$\mathrm{F_{FishPDBB} = BM_{PDBB} \cdot R_{fishBB}}$

$\mathrm{Y_{SalSec} = (Sal_{SWBB}/12)}$

$\mathrm{IG = 12}$

$\mathrm{Lat_{BB} = 64}$

$\mathrm{MA_{percentage} = 0.01}$

$\mathrm{MA_{CovBB} = Litfrac_{BB} \cdot MA_{Percentage}}$

$\mathrm{MER_{BA} = 0.15}$

$\mathrm{MER_{BPZH} = 0.24}$

$\mathrm{MER_{SedBB} = MER_{BA} \cdot 0.25}$

$\mathrm{MER_{MA} = 0.15}$

$\mathrm{MER_{PD} = 0.25}$

$\mathrm{MER_{PHZH} = 0.24}$

$\mathrm{MER_{PY} = 0.16}$

$\mathrm{MER_{ZP} = 0.32 \cdot 1}$

$\mathrm{M_{SedBB} = ((12-5)/12) \cdot (IG/100) \cdot (1/(1-W/100)) \cdot (M_{SPMABB} + M_{SPMETBB})}$

$\mathrm{NBM_{MABB} = NPR_{MABB} \cdot T_{MA}}$

$\mathrm{NBM_{BABB} = NPR_{BABB} \cdot T_{BA}}$

$\mathrm{NBM_{BPBB} = 0.001 \cdot V_{SWBB} \cdot 10^{(0.973 \cdot (0.27 \cdot log(ChlModBB) + 0.19) - 0.438)}}$

Table A.3 (continued)

$NBM_{FishBB} = Y_{ChlBB} \cdot 10^{-6} \cdot ((Area_{BB} \cdot 590 \cdot TP_{SWBB}{}^{0.71}))$
$NBM_{JEBB} = NBM_{ZPBB} \cdot 4 \cdot Y_{SalJEBB}$
$NBM_{PDBB} = (1-DC_{PYPDGR2}) \cdot SMTH(NBM_{FishBB}, T_{PD}, NBM_{FishBB})$
$NBM_{PHBB} = Y_{ChlBB} \cdot (10^{-6}) \cdot (1{,}500-V_{SecBB}) \cdot (10^{9}) \cdot (30 \cdot TP_{SWBB}{}^{1.4})$
$NBM_{PYBB} = (DC_{PYPDBB}) \cdot SMTH(NBM_{FishBB}, T_{PY}, NBM_{FishBB})$
$NBM_{ZBBB} = Y_{ChlBB} \cdot (10^{-6}) \cdot 810 \cdot (TP_{SWBB}{}^{0.71}) \cdot Area_{BB}$
$NBM_{ZHRBB} = Y_{ChlBB} \cdot (DC_{ZHZP}) \cdot 10^{-6} \cdot (V_{SWBB}) \cdot 38 \cdot TP_{SWBB}{}^{0.64}$
$NBM_{ZPBB} = Y_{ChlBB} \cdot (1-DC_{ZHZP}) \cdot 10^{-6} \cdot V_{SWBB} \cdot 38 \cdot TP_{SWBB}{}^{0.64}$
$NCR_{JEBB} = N_{JE}/T_{JE}$
$NCR_{PDBB} = 1/T_{PD}$
$NCR_{PYBB} = N_{PY} \cdot (NCR_{ZPBB} \cdot 0.15 + NCR_{PDBB} \cdot 0.85)$
$NCR_{ZBBB} = N_{ZB}/T_{ZB}$
$NCR_{ZHBB} = N_{ZH}/T_{ZH}$
$NCR_{ZPBB} = 1/T_{ZP}$
$N_{JE} = 2$
$NPR_{BABB} = 0.63 \cdot (A_{2Sec}/A) \cdot PR_{PHBB}$
$NPR_{MABB} = 0.001 \cdot Area_{BB} \cdot 1/52 \cdot 10^{(2.472+1.028 \cdot \log(MACovBB)-0.516 \cdot 90/(90-LatBB))}$
$NPR_{ZHBB} = 0.148 \cdot F_{IPRPHBB}{}^{0.86}$
$NPR_{ZPBB} = 0.0759 \cdot F_{IPRPHBB}{}^{0.84}$
$N_{PY} = 2$
$N_{ZB} = 2$
$N_{ZH} = 2$
$MIG_{OutPDBS} = \text{if } BM_{PDBS}/NBM_{PDBS} > 1 \text{ then } (R_{MigPDBS}) \cdot (BM_{PDBS}) \text{ else}$
$\quad 0.5 \cdot (R_{MigPDBS}) \cdot (BM_{PDBS})$
$MIG_{OutPYBS} = \text{if } BM_{PYBS}/NBM_{PYBS} > 1 \text{ then } (R_{MigPYBS}) \cdot (BM_{PYBS}) \text{ else}$
$\quad 0.5 \cdot (R_{MigPYBS}) \cdot (BM_{PYBS})$
$PR_{BABB} = BM_{BABB}/T_{BA}$
$PR_{BPBB} = BM_{BPBB}/T_{BP}$
$PrimP_{BB} = \text{if } Sec_{BB} > 1 \text{ then}$
$\quad ((10^{-6}) \cdot ((2.13 \cdot Chl_{modBB}{}^{0.25+0.25})^{4}) \cdot (1/0.45) \cdot (1/0.2) \cdot 30.42 \cdot (1{,}500-V_{SecBB}) \cdot 10^{9}) \text{ else}$
$\quad ((10^{-6}) \cdot ((2.13 \cdot Chl_{modBB}{}^{0.25+0.25})^{4}) \cdot (1/0.45) \cdot (1/0.2) \cdot 30.42 \cdot Area_{BB} \cdot (2 \cdot Sec_{BB})^{2}))$
$PR_{JEBB} = BM_{JEBB}/T_{JE}$
$PR_{MABB} = BM_{MABB}/T_{MA}$
$R_{ProdJE} = 8.5$
$PR_{PDBB} = BM_{PDBB}/T_{PD}$
$PR_{PHBB} = BM_{PHBB}/T_{PH}$
$PR_{PYBB} = BM_{PYBB}/T_{PY}$
$PR_{ZBBB} = BM_{ZBBB}/T_{ZB}$
$PR_{ZHBB} = BM_{ZHBB}/T_{ZH}$
$PR_{ZPBB} = BM_{ZPBB}/T_{ZP}$
$Q_{SWBSBB} = (Q_{evaBB} + Q_{SWBBB}S) - (Q_{tribBB} + Q_{precBB} + Q_{DWBSBB})$
$Q_{SWBSBP} = (1{,}055 \cdot 10^{9})/12$
$R_{ErBB} = \text{if } (0.1186 - 0.1338 \cdot \log(MA_{covBB}) + 0.0769 \cdot Vd_{BB}) < 0.1 \text{ then } 0.1 \text{ else}$
$\quad (0.1186 - 0.1338 \cdot \log(MA_{covBB}) + 0.0769 \cdot Vd_{BB})$
$R_{FishBB} = (BM_{PDBB}/NBM_{PDBB}) \cdot Y_{Arearef/BB} \cdot R_{fish/12}$
$R_{Fish} = 0.5$
$R_{IPRBABB} = 0.01$
$R_{Migconst} = 0.1$
$R_{MigPDBB} = R_{Migconst} \cdot Y_{SeasonBB}/T_{SWBB}$
$R_{MigPHBB} = 1/T_{SWBB}$
$R_{MigPYBB} = R_{MigPDBB}$

Table A.3 (continued)

$R_{MigZPBB} = 1/T_{SWBB}$
$R_{PRBP} = 12$
$RP_{RMA} = 0.025\cdot(30.42/7)$
Sal_{SWBB} = Modeled salinity in SW-layer in BB
SecBB = Modeled Secchi depth in BB
Sec_{LakeBB} = if ($10^{(-(1+0.5)\cdot(\log(SPMSWBB)+0.3)/2+1)}$) > Sec_{BB} then Sec_{BB} else ($10^{(-(1+0.5)\cdot(\log(SPMSWBB)+0.3)/2+1)}$)
$Sed_{ABBcmyr}$ = Modeled salinity in sedimentation in A-areas in BB in cm/year
$smth_{BB}$ = if $Lat_{BB} > 63$ then 1 else ($63-Lat_{BB}$)
SPM_{SWBB} = Modeled SPM-concentration in SW-layer in BB
$T_{BA} = 4/30.42$
$T_{BP} = 2.8/30.42$
$Thres_{SalJE} = 10$
$T_{JE} = 120/30.42$
$T_{MA} = 300/30.42$
TP_{SWBB} = Modeled TP-concentration in SW-layer in BB
$T_{PY} = 2\cdot450/30.42$
$T_{PY} = 300/30.42$
$T_{ZB} = 128/30.42$
$T_{ZP} = 11/30.42$
Vd_{BB} = Form factor in BB
$V_{SWBB} = 1{,}067\cdot10^{9}$
$W = 75$
$Y_{Arearef/BB} = (10^{12}/Area_{BB})^{0.5}$
$Y_{AreasecBP} = (Area_{2SeclakeBP}/Area_{2SecBP})$
$Y_{ChlBB} = Chl_{modBB}/Chl_{modlakeBB}$
$Y_{ChlZBBB} = 1/Y_{area2SecBP}$
Y_{Eh1BB} = if $Sed_{ABBcmyr} > 0.75$ (cm/year) then $Y_{Eh1BB} = 0$ else $Y_{Eh1BB} = 1$
Y_{EhBB} = if $Sed_{ABBcmyr} < 0.075$ (cm/year) then Y_{EhBB} = (1−1·(SedADWGR_cm/year/0.075−1)) else $Y_{EhBB} = 1$
Y_{FishBB} = if $Y_{fish1BS} < 0.2$ then 0.2 else $Y_{fish1BS}$
$Y_{Fish1BS}$ = if $TP_{SWBS} < 30$ then $(1-2.5)\cdot(NBM_{PYTPBB}/NBM_{refPYBB}-1)$ else $(1-0.4)\cdot(NBM_{PYTPBB}/NBM_{refPYBB}-1)$
$Y_{SWTBB} = SWT/9$
$NBM_{PYTPBB} = 10^{-6}\cdot(Area_{BB}\cdot590\cdot {TP_{SWBB}}^{0.71})$
$NBM_{refPYBB} = 10^{-6}\cdot(Area_{BB}\cdot590\cdot30^{0.71})$
Y_{LU} = Modeled "clay factor" from CoastMab
$Y_{SalJEBB}$ = if $Sal_{SWBB} < Thres_{SalJE}$ then 0 else 1
$Y_{SalSWBB} = (1+1\cdot(Sal_{SWBB}/1-1))$
$Y_{SalSecBB} = Sal_{SW}/12$
$Y_{SeasonBB}$ = if $(Y_{SeasonBB}-Y_{Season1BB}) \geq 0$ then $((Y_{SeasonBB}+Y_{Season1BB})/2)\cdot(Lat_{BB}/63)$ else $((Y_{Season1BB}+Y_{SeasonBB})/2)\cdot(63/Lat_{BB})$
If Lat > 63°N then AV = 1 else AV = (63-Lat); AV is an averaging function used in the smoothing function $Y_{Season1BB} = SMTH(Y_{SeasonBB}, AV, 1)$
$Y_{SecZPBB}$ = if $Sec_{BB} < 2$ then $(1+1\cdot(Sec_{BB}/2-1))$ else 1
$Y_{TPBB} = (1+0.75\cdot(TP_{SWBB}/10-1))$

References

Abrahamsson, O. and Håkanson, L., 1998. Modelling seasonal flow variability of European rivers. Ecol. Modell., 114:49–58.

Ackefors, H. and Olburs, C., 1996. Swedish Aquaculture Policy – a nightmare for the industry? Aquacult. Eur., 21:6–13.

Aertbjerg, G. (ed.), 2001. Eutrophication in Europe's coastal waters. European Environment Agency, Topic Report 7/2002, Copenhagen, 86p.

Aho, T., Ask, L., Axenrot, T., Bergström, L., Degerman, E., Edsman, L., Engwall, Y., Florin, A.-B., Gustavsson, T., Hemmingsson, M., Jonsson, A., Königsson, S., Lunneryd, S.-G., Nordwall, F., Nyberg, P., Paulrud, A., Persson, P., Sandström, A., Sjöstrand, B., Sköld, M., Sundelöf, A., Svedäng, H., Ulmestrand, M., Westerberg, H., Öresland, V. and Andersson, L., 2008. Fiskbestånd och miljö i hav och sötvatten. Fiskeriverket, Göteborg.

Aizaki, M., Otsuki, A., Fukushima, T., Hosomi, M. and Muraoka, K., 1981. Application of Carlson's trophic state index and other parameters. Verh. Int. Verein. Limnol., 21:675–681.

Alanärä, A., 2000. Optimizing feeding in fish farm,in (in Swedish, Optimering av utfodring vid kommersiell fisskodling). Vattenbruksinstitutionen, SLU, Rapport 21, Umeå, 32p.

Al-Hamdani, Z. and Reker, J. (eds.), 2007. Towards marine landscapes in the Baltic Sea. BALANCE interim report #10. Accessible at http://balance-eu.org/. ISBN: 978-87-7871-203-5.

Alimov, A.F., 1982. Productivity of invertebrate community of macrobenthos in continental water bodies of the Soviet Union (Review). Hydrobiol. J., 18:7–18 (in Russian).

Alimov, A.F., 1989. Introduction to production hydrobiology. Nauka, Leningrad (in Russian).

Ambio, 1990. Marine eutrophication, Ambio, 19:101–176, Special issue.

Ambio, 2000. Eutrophication and contaminants in the aquatic environment. Ambio, 4–5:183–290.

Anderson, G.C. and Zeutschel, R.P., 1970. Release of dissolved organic matter by marine phytoplankton in coastal and offshore areas of the Northeast Pacific Ocean. Limnol. Oceanogr., 15:402–407.

Andersson, M.H., Gullström, M., Asplund, M.E. and Öhman, M.C., 2007. Importance of using multiple sampling methodologies for estimating of fish community composition in offshore wind power construction areas of the Baltic Sea. Ambio, 36:634–636.

Anonymous, 2000. The state of the world fisheries and aquaculture 2000. FAO, Fisheries Department, Rome. ISBN 92-5-104492-9.

Anonymous, 2002. Report of the Workshop Course on Fish Assessment Techniques. ICES CM 2002/D:02.

Appelgren, K. and Mattila, J., 2005. Variation in vegetation communities in shallow bays of the northern Baltic Sea. Aquat. Bot., 83:1–13.

Arifin, Z. and Bendell-Young, L.I., 2001. Cost of selective feeding by the blue mussel (Mytilus trossulus) as measured by respiration and ammonia excretion rates. J. Exp. Mar. Biol. Ecol., 260:259–269.

Aro, E., 1989. A review of fish migration patterns in the Baltic. Rapp. P.-v. Réun. Cons. Int. Explor. Mer., 190:72–96.

Aro, E., 2000. The spatial and temporal distribution patterns of cod (*Gadus morhua callarias* L.) in the Baltic Sea and their dependence on environmental variability – implications for fishery management. Thesis. Finnish Game and Fisheries Research Institute.

Arrhenius, F. and Hansson, S., 1993. Food consumption of larval, young and adult herring and sprat in the Baltic Sea. Mar. Ecol. Prog. Ser., 96:125–137.

Axenrot, T. and Hansson, S., 2004. Seasonal dynamics in pelagic fish abundance in a Baltic Sea coastal area. Estuar. Coastal Shelf Sci., 60:541–547.

Azevedo, P.A., Cho, C.Y., Leeson, S. and Bureau, D.P., 1998. Effects of feeding level and water temperature on growth, nutrient and energy utilization and waste outputs of rainbow trout (Oncorhynchus mykiss). Aquat. Living Resour., 11:227–238.

BACC, 2008. Assessment of climate change for the Baltic Sea Basin. Springer, Heidelberg, 474p.

Baines, S.B. and Pace, M.L., 1991. The production of dissolved organic matter by phytoplankton and its importance to bacteria: patterns across marine and freshwater systems. Limnol. Oceanogr., 36:1078–1090.

Balistrieri, L.S. and Murray, J.W, 1983. Metal-solid interactions in the marine environments: estimating apparent equilibrium binding constants. Geochim. Cosmochim. Acta, 47:1091–1098.

Balistrieri, L.S., Murray, J.W. and Paul, B., 1992. The biogeochemical cycling of trace metals in the water column of Lake Sammamish, Washington: response to seasonally anoxic conditions. Limnol. Oceanogr., 37:510–528.

Balls, P.W., 1988. The control of trace metal concentrations in coastal seawater through partition onto particulate matter. Neth. J. Sea Res., 22:213–218.

Balls, P.W., 1989. The partition of trace metals between dissolved and particulate phases in European coastal waters: a compilation of field data and comparison with laboratory studies. Neth. J. Sea Res., 23:7–14.

BALTEX, 2006. Baltex Phase II 2003–2012. Science framework and implementation strategy. International BALTEX Secr., Publication, No. 34, pp.92, GKSS, Geestacht, Germany.

Beach Erosion Board, 1972. Waves in inland reservoirs. Tech. Mem. 132, Beach Erosion Corps of Engineers, Washington, DC.

Beeton, A.M. and Edmondson, W.T., 1972. The eutrophication problem. J. Fish. Res. Can., 29:673–682.

Benoit, G., 1995. Evidence of the particle concentration effect for lead and other metals in fresh waters based on ultraclean technique analyses. Geochim. Cosmochim. Acta, 59:2677–2687.

Benoit, G., Oktaymarshall, S.D., Cantu, A., Hood, E.M., Coleman, C.H., Corapcioglu, M.O. and Santschi, P.H., 1994. Partitioning of Cu, Pb, Ag, Zn, Fe, Al and Mn between filter-retained particles, colloids, and solution in 6 Texas estuaries. Mar. Chem., 45:307–336.

Bergström, S. and Carlsson, B., 1993. Hydrology of the Baltic basin. Swedish Meteorological and Hydrological Institute, Reports Hydrology No. 7, 32p.

Bergström, S. and Carlsson, B., 1994. River runoff to the Baltic Sea: 1950–1990. Ambio, 23: 280–287.

Bergström, L., Djodjic, F., Kirchmann, H., Nilsson, I. and Ulén, B., 2007. Phosphorus from farmland to water – status, flows and preventive measures in a Nordic perspective. Report Food 21 no. 4/2007. Swedish Agricultural University, Uppsala, 65p.

Bernardi Aubry, F., Acri, F., Bastianini, M., Pugnetti, A. and Socal, 2006. Picophytoplankton contribution to phytoplankton community structure in the Gulf of Venice (NW Adriatic Sea). Int. Rev. Hydrobiol., 91:51–70.

Bird, D.F. and Kalff, J., 1984. Empirical relationships between bacterial abundance and chlorophyll concentration in fresh and marine waters. Can. J. Fish. Aquat. Sci., 41:1015–1023.

Blanc, M., Banarescu, P., Gaudet, J.-L. and Hureau, J.C., 1971. European inland water fish: a multilingual catalouge. Fishing News (Books), London, 170p.

Blaxter, J.H.S. and Hunter, J.R., 1982. The biology of the clupeoid fishes. Adv. Mar. Biol., 20: 1–223.

Blazhchishin, A.I., 1984. Balance of settling matter in the Gdansk Basin of the Baltic Sea. Litologiya i Poleznye Iskopayemye, 5:67–76 (in Russian).

Blazhchishin, A.I. and Shuyskiy, Y.D., 1973. Inflow of terrigenic matter to the Baltic Sea. Litologiya i Poleznye Iskopayemye, 3:141–145 (in Russian).

Blazka, P., Backiel, T. and Taub, F.B., 1980. Ratio of primary and fish productions. The functioning of the freshwater ecosystems. Cambridge University Press, Cambridge, pp. 398–401.

Blindow, I., 2000. Distribution of charophytes along the Swedish coast in relation to salinity and eutrophication. Int. Rev. Hydrobiol. 85:707–717.

Bloesch, J. and Burns, N.M., 1980. A critical review of sedimentation trap technique. Schweiz. Z. Hydrol., 42:15–55.

Bloesch, J. and Uehlinger, U., 1986. Horizontal sedimentation differences in a eutrophic Swiss lake. Limnol. Oceanogr., 31:1094–1109.

Blomqvist, S., Gunnars, A. and Elmgren, R., 2004. Why the limiting nutrient differs between temperate coastal seas and freshwater lakes: a matter of salt. Limnol. Oceanogr., 49:2236–2241.

Blomqvist, S. and Larsson, U., 1994. Detrimental elements as tracers of settling resuspended particulate matter in a coastal area of the Baltic Sea. Limnol. Oceanogr., 49:880–896.

Blomqvist, S. and Rydin, E., 2009. How phosphorus sequestration in Baltic Sea bottom sediments can be improved. Swedish EPA Report 5914, Stockholm, 111p (in Swedish).

Boesch et al., 2008. Eutrophication of the seas along Sweden's west coast. Naturvårdsverket, Report 5898, Stockholm, 78p.

Bonsdorff, E., 2006. Zoobenthic diversity-gradients in the Baltic Sea: continuous post-glacial succession in a stressed ecosystem. J. Exp. Mar. Biol. Ecol., 330:383–391.

Boyle, J.F. and Birks, H.J.B., 1999. Predicting heavy metal concentrations in the surface sediments of Norwegian headwater lakes from atmospheric deposition: an application of a simple sediment-water partitioning model. Water Air Soil Pollut., 114:27–51.

Boulion, V.V., 1997. Regularities of the plankton primary production and their importance for the control and prediction of a trophic condition in water ecosystems. Biol. Inner Waters, 1:13–22 (in Russian).

Boulion, V.V. and Håkanson, L., 2003. A new general model to predict biomass and production of bacterioplankton in lakes. Ecol. Modell., 160:91–114.

Boulion, V.V. and Paveljeva, E.B., 1998. Relationship between bacterial abundance and chlorophyll concentration in plankton of freshwaters. Microbiology, 67:261–266 (in Russian).

Boulion, V.V. and Winberg G.G., 1981. A ratio between the primary production and fish productivity in water bodies. Bases of Study of Freshwater Ecosystems. Leningrad, pp. 5–10 (in Russian).

Brinkhurst, R.O., 1974. The benthos of lakes. Macmillan, London, 189p.

Brittain, J.E., 1998. European fish species of radioecological importance. ENEA, Rome, RT/AMB/98/4, pp. 19–21.

Brittain, J.E. and Brabrand, Å., 2001. Fish movement in rivers, lakes and estuaries in relation to contamination by radionuclides. Freshwater Ecology & Inland Fisheries Laboratory (LFI), Natural History Museums, University of Oslo, Oslo, Norway.

Brodeur, R.D., Sugisaki, H. and Hunt, G.L. Jr., 2002. Increases in jellyfish biomass in the Bering Sea: implications for the ecosystem. Mar. Ecol. Prog. Ser., 233:89–103.

Bryhn, A., Håkanson, L. and Eklund, J., 2008a. Variabilities and uncertainties in key coastal water variables as a basis for understanding changes and obtaining predictive power in modelling. Vatten 64:259–272.

BSAP, 2007. HELCOM Baltic Sea Action Plan – HELCOM Ministerial Meeting, Krakow, Poland, 15 November, 2007, 101p. (see HELCOM website).

Burban, P.-Y., Lick, W. and Lick, J., 1989. The flocculation of fine-grained sediments in estuarine waters. J. Geophys. Res., 94:8223–8330.

Burban, P.-Y., Xu, Y.-J., McNeiel, J. and Lick, W., 1990. Settling speeds of flocs in fresh water and seawater. J. Geophys. Res., 95:18213–18220.

Burbridge, P., Hendrick, V., Roth, E. and Rosenthal, H., 2001. Social and economic policy issues relevant to marine aquaculture. J. Appl. Ichthyol., 17:194–206.

Busch, W.-D.N. and Sly, P.G., 1992. The development of an aquatic habitat classification system for lakes. CRC Press, Boca Raton, FL.

Carlson, R.E., 1977. A trophic state index for lakes. Limnol. Oceanogr., 22:361–369.

Carroll, J. and Harms, I.H., 1999. Uncertainty analysis of partition coefficients in a radionuclide transport model. Water Res., 33:2617–2626.

Carstensen, J., Conley, J., Andersen, J.H. and Aertebjerg, G., 2006. Coastal eutrophication and trend reversal: a Danish case study. Limnol. Oceanogr., 51:398–408.

Casini, M., Cardinale, M. and Arrhenius, F., 2004. Feeding preferences of herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) in the southern Baltic Sea. ICES J. Mar. Sci., 61:1267–1277.

Casini, M., Cadinale, M. and Hjelm, J., 2006. Inter-annual variation in herring, *Clupea harengus*, and sprat, *Sprattus sprattus*, condition in the central Baltic Sea: what gives the tune? Oikos 112:638–650.

Cato, I., 1977. Recent sedimentological and geochemical conditions and pollution problems in two marine areas in south-western Sweden. Striae Vol. 6, Societas Upsaliensis pro Geologia Quaternaria, Uppsala, 158p.

Chabot, D., Dutil, J.-D. and Couturier, C., 2001. Impact of chronic hypoxia on food ingestion, growth and condition of Atlantic cod, Gadus morhua. ICES CM 2001/V:05.

Chow-Fraser, P. and Trew, D.O., 1994. A test of hypothesis to explain the sigmoidal relationship between total phosphorus and chlorophyll a concentrations in Canadian lakes. Can. J. Fish. Aquat. Sci., 51:2052–2065.

Christiansen, C., Gertz, F., Laima, M.J.C., Lund-Hansen, L.C., Vang, T. and Jürgensen, C., 1997. Nutrient (P, N) dynamics in the southwestern Kattegat, Scandinavia: sedimentation and resuspension effects. Environ. Geol., 29:66–77.

Christensen, V., Walters, C.J. and Pauly, D., 2000. Ecopath with ecosim: a user's guide. Fisheries Centre, University of British Columbia, Vancouver, 130p.

Cole, J.J., Likens, G.E. and Strayer, D.L., 1982. Photosynethetically produced dissolved organic carbon: an important carbon source for planktonic bacteria. Limnol. Oceanogr., 27: 1080–1090.

Conan, P., Turley, C., Stutt, E., Pujo-Pay, M. and Van Wambeke, F., 1999. Relationship between phytoplankton efficiency and proportion of bacterial production to primary production in the Mediterranean Sea. Aquat. Microbial. Ecol., 17:131–144.

Corten, A., 1996. The widening gap between fisheries biology and fisheries management in the European Union. Fish. Res., 27:1–15.

Cowan, J.H. Jr., Houde, E.D. and Rose, K.A., 1996. Size-dependent vulnerability of marine fish larvae to predation: an individual-based numerical experiment. ICES J. Mar. Sci., 53:23–37.

Cummings, K.W., 1973. Trophic relations in aquatic insects. Ann. Rev. Entomol., 18:183–206.

Currie, D.J., 1990. Large-scale variability and interactions among phytoplankton, bacterioplankton, and phosphorus. Limnol. Oceanogr., 35:1437–1455.

Davenport, J., Smith, R.J.J.W., Packer, M., 2000. Mussels *Mytilus edulis*: significant consumers and destroyers of mesozooplankton. Mar. Ecol. Prog. Ser., 198:131–137.

Derenbach, J.B., Williams, P.J. and Le, B., 1974. Autotrophic and bacterial production: fractionation of plankton populations by differential filtration of samples from the English Cannel. Mar. Biol., 25:263–269.

De Robertis, A., et al., 2003. Differential effects of turbidity on prey consumption of piscivorous and planktivorous fish. Can. J. Fish. Aquat. Sci., 60:1517–1526.

Dillon, P.J. and Rigler, F.H., 1974. The phosphorus-chlorophyll relationship in lakes. Limnol. Oceanogr., 19:767–773.

Dippner, J.W., Hänninen, J., Kuosa, H. and Vourinen, I., 2001. The influence of climate variability on zooplankton abundance in the Northern Baltic Archipelago Sea (SW Finland). ICES J. Mar. Sci., 58:569–578.

Duarte, C.M., Conley, D., Carstensen, J. and Sánchez-Camacho, M., 2009. Return to Neverland: shifting baselines affect eutrophication restoration targets. Estuar. Coast., 32:29–36.

Eckhéll, J., Jonsson, P., Meili, M. and Carman, R., 2000. Storm influence on the accumulation and lamination of sediments in deep areas of the northwestern Baltic proper. Ambio, 29: 238–245.

Edler, L., 1979. Phytoplankton succession in the Baltic Sea. Acta Bot. Fenn. 110:75–78.

Ehrenberg, S.Z., Hansson, S. and Elmgren, R., 2005. Sublittoral abundance and food consumption of Baltic gobies. J. Fish. Biol., 67:1083–1093.

Eilola, K., Meier, H.E.M. and Almroth, E., 2009. On the dynamics of oxygen, phosphorus and cyanobacteria in the Baltic Sea; a model study. J. Mar. Syst., 75:163–184.

Elmgren, R., 1984. Trophic dynamics in the enclosed, brackish Baltic Sea. Rapp. P.-v. Cons. Int. Explor. Mer., 183:152–169.

Elmgren, R., 1989a. Trophic dynamics in the enclosed brackish Baltic Sea. Rapp. P.-v. Cons. Int. Explor. Mer., 183:152–169.

Elmgren, R., 1989b. Man's impact on the ecosystem of the Baltic Sea: energy flows today and at the turn of the century. Ambio, 18:326–332.

Emelyanov, E.M., 1986. Geochemistry of particulate matter and sediments in the Gdansk Basin and sedimentation processes. In: Emelyanov, E.M. and Lukashin, V.N. (eds.), Geochemistry of the sedimentation process in the Baltic Sea. Nauka, Moscow, pp. 57–115 (in Russian).

Emelyanov, E.M., 1988. Biogenic sedimentation in the Baltic Sea and its consequences. In: Winterhalter, B. (ed.), The Baltic Sea, Geological Survey of Finland, Special Paper 6: 127–135.

Emelyanov, E.M., 2001. Biogenic components and elements in sediments of the Central Baltic and their sedimentation. Mar. Geol., 172:23–41.

Enell, M., 1994. Environmental impact of nutrients from Nordic fish farming. Water Sci. Tech., 31:61–71.

Enin, U.I., Gröger, J. and Hammer, C., 2004. Species and length composition of fish in the southwestern Baltic Sea. J. Appl. Ichthyol., 20:369–375.

EPA, 1994. Eutrophication of soil, fresh water and the sea. National Swedish Environmental Protection Agency, Report 4244, 207p.

Erel, Y. and Stolper, E.M., 1993. Modeling of rare-earth element partitioning between particles and solution in aquatic environments. Geochim. Cosmochim. Acta, 57:513–518.

European Communities, 2006. Facts and figures on the CFP. Office for Official Publications of the European Communities, Luxembourg, 43p.

Evans, M.S., Arts, M.T. and Robarts, R.D., 1996. Algal productivity, algal biomass, and zooplankton biomass in a phosphorus-rich, saline lake: deviations from regression model predictions. Can. J. Fish. Aquat. Sci., 53:1048–1060.

FAO, 2000. The state of the world fisheries and aquaculture 2000. Food and Agriculture Organisation. Fisheries Department, Rome. ISBN 92-5-104492-9.

FAO, 2001. FAO Yearbook. Fishery statistics. Capture production 2001, Vol. 92/1. FAO, Quebec.

Finni, T., Kononen, K., Olsonen, R. and Wallström, K., 2001. The history of cyanobacterial blooms in the Baltic Sea. Ambio, 30:172–178.

Fischer, H. and Matthäus, W., 1996. The importance of the Drogden Sill in the sound for major Baltic inflows. J. Mar. Syst. 9:137–157.

Fiskeriverket, 2008. See: http://www.fiskeriverket.se/

Fiskeriverket, 2009. See: http://www.fiskeriverket.se/vanstermeny/statistikochdatabaser/provfiskeisotkustvatten/provfiskevidkusten/kustdatabas

Flinkman, J., Vuorinen, I. and Aro, E., 1992. Planktivorous Baltic herring (*Clupea harengus*) prey selectively on reproducing copepods and cladocerans. Can. J. Fish. Aquat. Sci., 49:73–77.

Fogg, G.E., 1966. The extracellular products of algae. Oceanogr. Mar. Biol., 4:195–212.

Froese, R. and Pauly, D., 2008. Accessible at http://FishBase.org

FRP, 1978. The sea; natural conditions and use (in Swedish, Havet; naturförhållanden och utnyttjande). Fysisk riksplanering (FRP), Bostadsdepartementet, Nr 7, 303p.

Fursenko, M.V. and Kuzmitskaja, N.K., 1975. Microbiological researches. Biological productivity of north lakes, 1. Proc. Zool. Inst. Acad. Sci. USSR, 57:53–76 (in Russian).

Gallego, E., Brittain, J.E., Håkanson, L., Heling, R., Hofman, D. and Monte, L., 2004. MOIRA: a computerised decision support system for the management of radionuclide contaminated freshwater ecosystems. Radioprotection, 98:83–102 (ISSN-0874-7016).

Goecker, M.E. and Kåll, S.E., 2003. Grazing preferences of marine isopods and amphipods on three prominent algal species of the Baltic Sea. J. Sea Res. 50:309–314.

Gorokhova, E., Aladin, N. and Dumont, H., 2000. Further expansion of the genus Cercopagis (*Crustacea, Branchiopoda, Onychopoda*) in the Baltic Sea, with notes on the taxa present and their ecology. Hydrobiologia, 429:207–218.

Gorokhova, E., Lehtiniemi, M., Viitasalo-Frösen, S. and Haddock, S.H.D., 2009. Molecular evidence for the occurrence of ctenophore *Mertensia ovum* in the northern Baltic Sea and implications for the status of the *Mnemiopsis leidyi* invasion. Limnol. Ocenogr., 54:2025–2033.

Gren, I.-M., 2001. International versus national actions against nitrogen pollution of the Baltic Sea. Environ. Resour. Econ., 20:41–59.

Gren, I.-M., Elofsson, K., 2008. Costs and benefits from nutrient reductions to the Baltic Sea. Report 5877. Swedish EPA, Stockholm, 67p.

Gustafsson, Ö. and Gschwend, P.M., 1997. Aquatic colloids: concepts, definitions and current challenges. Limnol. Oceanogr., 42:519–528.

Gustafsson, B.G. and Stigebrandt, A., 2007. Dynamics of nutrients and oxygen/hydrogen sulfide in the Baltic Sea deep water. J. Geophys. Res., 112(G02023), 12p.

Gutelmakher, B.L., 1986. Metabolism of plankton as a single whole. Nauka, Leningrad (in Russian).

Gyllenhammar, A. and Håkanson, L., 2005. Environmental consequence analyses of fish farms emissions related to different scales and exemplified by data from the Baltic – a review. Mar. Environ. Res. 60:211–243.

Gyllenhammar, A., Håkanson, L. and Lehtinen, K.-J., 2008. A mesocosm fish farming experiment and its implications for reducing environmental effects on a regional scale. Aquacult. Eng., 38:117–126.

Hairston, N.G. and Hairston, N.G., 1993. Cause-effect relationships in energy flow, trophic structure, and interspecific interactions. Am. Nat., 142:379–411.

Hajdu, S., Larsson, U., Andersson, A. and Huseby, S., 2007. Sommarens växtplanktonsamhälle har förändras. Havet, Naturvårdsverket, Stockholm, pp. 47–50.

Håkanson, L., 1977. The influence of wind, fetch, and water depth on the distribution of sediments in Lake Vänern, Sweden. Can. J. Earth Sci., 14:397–412.

Håkanson, L., 1982. Lake bottom dynamics and morphometry – the dynamic ratio. Water Resour. Res., 18:1444–1450.

Håkanson, L., 1984. Sediment sampling in different aquatic environments: statistical aspects. Water Resour. Res., 20:41–46.

Håkanson, L., 1991. Physical geography of the Baltic. The Baltic University. Session 1. Uppsala University, Uppsala, ISBN 91-506-0876-2.

Håkanson, L., 1995. Fish farming and environmental effects in lakes – new results motivate new criteria for evaluations (in Swedish, Fiskodling och miljöeffekter i sjöar – nya resultat motiverar nya bedömningsunderlag). Vatten 51, Bloms Boktryckeri, Lund, 103p.

Håkanson, L., 1999. Water pollution – methods and criteria to rank, model and remediate chemical threats to aquatic ecosystems. Backhuys Publishers, Leiden, 299p.

Håkanson, L., 2000. Modelling radiocesium in lakes and coastal areas – new approaches for ecosystem modellers. A textbook with Internet support. Kluwer Academic Publishers, Dordrecht, 215p.

Håkanson, L., 2002. The Baltic – present status, what it should be and how to get there. Accessible at http://www.sedimentology.geo.uu.se/BALTWEB_OH.pdf

Håkanson, L., 2003a. Consequences and correctives related to acidification, liming and mercury in lake fish – a case study for Lake Huljesjön, Sweden, using the LakeWeb-model. Environ. Modell. Assess., 8:275–283.

Håkanson, L., 2003b. Quantifying burial, the transport of matter from the lake biosphere to the geosphere. Int. Rev. Hydrobiol., 88:539–560.

Håkanson, L., 2004. Lakes – form and function. The Blackburn Press, Caldwell, NJ, 201p.

Håkanson, L., 2006. Suspended particulate matter in lakes, rivers and marine systems. The Blackburn Press, Caldwell, NJ, 331p.

Håkanson, L., 2008. Factors and criteria to quantify coastal area sensitivity/vulnerability to eutrophication. Presentation of a sensitivity index based on morphometrical parameters. Int. Rev. Hydrobiol., 3:372–388.

Håkanson, L., 2009. Modeling nutrient fluxes to, within and from the Kattegat to find an optimal cost-efficient Swedish remedial strategy. Uppsala University, Geotryckeriet, Uppsala, 122p, ISBN 978-91-633-4819-8.

Håkanson, L., Blenckner, T. and Malmaeus, J.M., 2004. New, general methods to define the depth separating surface water from deep water, outflow and internal loading for mass-balance models for lakes. Ecol. Modell., 175:339–352.

Håkanson, L. and Boulion, V.V., 2001a. Regularities in primary production, Secchi depth and fish yield and a new system to define trophic and humic state indices for aquatic ecosystems. Int. Rev. Hydrobiol., 86:23–62.

Håkanson, L. and Boulion, V.V., 2001b. A practical approach to predict the duration of the growing season for European lakes. Ecol. Modell., 140:235–245.

Håkanson, L. and Boulion, V., 2002a. The Lake Foodweb – modelling predation and abiotic/biotic interactions. Backhuys Publishers, Leiden, 344p.

Håkanson, L. and Boulion, V.V., 2002b. Empirical and dynamical models to predict the cover, biomass and production of macrophytes in lakes. Ecol. Modell., 151:213–243.

Håkanson, L. and Boulion, V.V., 2003a. Modelling production and biomasses of herbivorous and predatory zooplankton in lakes. Ecol. Modell., 161:1–33.

Håkanson, L. and Boulion, V.V., 2003b. A model to predict how individual factors influence Secchi depth variations among and within lakes. Int. Rev. Hydrobiol., 88:212–232.

Håkanson, L. and Boulion, V.V., 2003c. A general dynamic model to predict biomass and production of phytoplankton in lakes. Ecol. Modell., 165:285–301.

Håkanson, L. and Boulion, V.V., 2003d. Modelling production and biomasses of zoobenthos in lakes. Aqua. Ecol., 37:277–306.

Håkanson, L. and Boulion, V., 2004a. Modelling production and biomasses of prey and predatory fish in lakes. Hydrobiologia, 511:125–150.

Håkanson, L. and Boulion, V., 2004b. Empirical and dynamical models of production and biomasses of benthic algae in lakes. Hydrobiologia, 522:75–97.

Håkanson, L. and Bryhn, A.C., 2008a. Tools and criteria for sustainable coastal ecosystem management – with examples from the Baltic Sea and other aquatic systems. Springer, Heidelberg, 300p.

Håkanson, L. and Bryhn, A.C., 2008b. Eutrophication in the Baltic Sea – present situation, nutrient transport processes, remedial strategies. Springer, Berlin/Heidelberg, 261p.

Håkanson, L. and Bryhn, A.C., 2008c. Goals and remedial strategies for water quality and wildlife management in a coastal lagoon – a case-study of Ringkobing Fjord, Denmark. J. Environ. Manag., 86:498–519.

Håkanson, L. and Bryhn, A.C., 2008d. A dynamic mass-balance model for phosphorus in lakes with a focus on criteria for applicability and boundary conditions. Water Air Soil Pollut., 187:119–147.

Håkanson, L. and Bryhn, A.C., 2008e. Modeling the foodweb in coastal areas – a case study of Ringkobing Fjord, Denmark. Ecol. Res., 23:421–444.

Håkanson, L., Bryhn, A.C. and Hytteborn, J.K., 2007. On the issue of limiting nutrient and predictions of cyanobacteria in aquatic systems. Sci. Total Environ., 379:89–108.

Håkanson, L., Bryhn, A.C. and Hytteborn, J.A., 2009. A new general approach to quantify nitrogen fixation exemplified for the Baltic Proper. Open Mar. Biol. J., 3:36–48.

Håkanson, L. and Eckhéll, J., 2005. Suspended particulate matter (SPM) in the Baltic – new empirical data and models. Ecol. Modell., 189:130–150.

Håkanson, L. and Eklund, J.M., 2007. A dynamic mass-balance model for phosphorus fluxes and concentrations in coastal areas. Ecol Res., 22:296–320.

Håkanson, L., Ervik, A., Mäkinen, T. and Möller, B., 1988. Basic concepts concerning assessments of environmental effects of marine fish farms. Nordic Council of Ministers, NORD88:90, Copenhagen, 103p.

Håkanson, L. and Gyllenhammar, A., 2005. Setting fish quotas based on holistic ecosystem modelling including environmental factors and foodweb interactions – a new approach. Aquat. Ecol., 39:325–351.

Håkanson, L., Gyllenhammar, A. and Karlsson, M., 2002. The Baltic – present status, what it should be and how to get there (in Swedish, Östersjön – hur läget är, hur det borde vara och hur man kommer dit!). LUVA 02-01, Geotryckeriet, Uppsala, 110p.

Håkanson, L. and Jansson, M., 1983. Principles of lake Sedimentology. Springer, Berlin, 316p.

Håkanson, L., Kvarnäs, H. and Karlsson, B., 1986. Coastal morphometry as regulator of water exchange – a Swedish example. Estuar. Coast. Shelf Sci., 23:1–15.

Håkanson, L. and Lindgren, D., 2008a. A protocol (computer codes, equations and motivations) for a general operational foodweb model for coastal areas which can be run by readily accessible driving variables from maps and monitoring programs incorporating the eutrophication model discussed in WP5. Thresholds Project, 6th Framework Programme, EU, 89p.

Håkanson, L. and Lindgren, D., 2008b. On regime shifts and budgets for nutrients in the open Baltic Proper – evaluations based on extensive data between 1974 and 2005. J. Coast. Res., 24:246–260.

Håkanson, L. and Lindgren, D., 2009. Test and application of a general process-based dynamic coastal mass-balance for contaminants using data for radionuclides in the Dnieper-Bug estuary. Sci. Total Environ. 407:899–916.

Håkanson, L., Ostapenia, A. and Boulion, V.V., 2003a. A mass-balance model for phosphorus accounting for biouptake and retention in biota. Freshw. Biol., 48:928–950.

Håkanson, L., Ostapenia, A., Parparov, A., Hambright, K.D. and Boulion, V.V., 2003b. Management criteria for lake ecosystems applied to case studies of changes in nutrient loading and climate change. Lakes Reserv. Res. Manag., 8:141–155.

Håkanson, L. and Peters, R.H., 1995. Predictive limnology. Methods for predictive modelling. SPB Academic Publishing, Amsterdam, 464p.

Håkanson, L. and Rosenberg, R., 1985. Practical coastal ecology (Praktisk kustekologi). SNV PM 1987, Solna, 110p. (in Swedish).

Hansson, M., 2006. Cyanobakterieblomningar i Östersjön, resultat från satellitövervakning 1997–2005 (Blooms of cyanobacteria in the Baltic Sea, results from satellite monitoring 1997–2005). SMHI Reports Oceanography No 82, Norrköping (in Swedish).

Hansson, S. and Rudstam, L.G., 1990. Eutrophication and the Baltic fish communities. Ambio, 19:123–125.

Hårding, K.C. and Härkönen, T.J., 1999. Development in the Baltic grey seal (*Halichoerus grypus*) and ringed seal (*Phoca hispida*) populations during the 20th century. Ambio, 28: 619–627.

Harrison, W.G., Azam, F., Renger, E.H. and Eppley, R.W., 1977. Some experiments of phosphate assimilation by coastal marine plankton. Mar. Biol., 40:9–18.

Harden-Jones, F.R., 1968. Fish migration. Edward Arnold Publishers, London, 325 pp.

Harvey, C.J., Cox, S.P., Essington, T.E., Hansson, S. and Kitchell, J.F., 2003. An ecosystem model of food web and fisheries interactions in the Baltic Sea. ICES J. Mar. Sci., 60: 939–950.

Hatcher, A., 2000. Subsidies for European fishing fleets: the European Community's structural policy for fisheries 1971–1999. Mar. Policy, 24:129–140.

Hawley, N., Robbins, J.A. and Eadie, B.J., 1986. The partition of beryllium in fresh water. Geochim. Cosmochim. Acta, 50:1127–1131.

Heibo, E. and Karås, P., 2005. The coastal fish community in the Forsmark area SW Bothnian Sea. Svensk kärnbränslehantering AB, P-05-148.

Heikinheimo, O., 2008. Average salinity as an index for environmental forcing on cod recruitment in the Baltic Sea. Boreal Environ. Res., 13:457–464.

HELCOM, 1986. Water balance of the Baltic Sea. Baltic Sea Environment Proceedings 16, HELCOM, Helsinki, Finland.

HELCOM, 1987. First Baltic Sea pollution load compilation. Baltic Sea Environment Proceedings 20, HELCOM, Helsinki, 57p.

HELCOM, 1990. Second periodic assessment of the state of the marine environment of the Baltic Sea, 1984–1988; Background Document. Baltic Sea Environment Proceedings, 35B, 432p.

HELCOM, 1993. Second Baltic Sea pollution load compilation. Baltic Sea Environment Proceedings 45, HELCOM, Helsinki, 162p.

HELCOM, 1998. Third Baltic Sea pollution load compilation. Baltic Sea Environment Proceedings 70, HELCOM, Helsinki, 134p.

HELCOM, 2000. Baltic Sea Environment Proceedings 100.

HELCOM, 2002. Environment of the Baltic Sea area 1994–1998. Baltic Sea Environment Proceedings 82 B., 215p. Helsinki Commission, Helsinki, Finland. Accessible at www.helcom.fi

HELCOM, 2003. The Baltic Marine Environment 1999–2002. Baltic Sea Environment Proceedings 87, Helsinki Commission, Helsinki, Finland. Accessible at www.helcom.fi

HELCOM, 2005. Nutrient pollution to the Baltic Sea in 2000. Baltic Sea Environment Proceedings 100, HELCOM, Helsinki, 24p.

HELCOM, 2007a. Waterborne inputs of nitrogen and phosphorus. Indicator Fact Sheets 2007. Accessible at http://www.helcom.fi/environment2/ifs/ifs2007/en_GB/nutrient_load/ (accessed 27 February, 2009).

HELCOM, 2007b. Towards a Baltic Sea unaffected by eutrophication. HELCOM, Helsinki, 35p.

HELCOM, 2007c. HELCOM Baltic Sea Action Plan – HELCOM Ministerial Meeting, Krakow, Poland, 15 November, 2007, 101p. (see HELCOM website).

HELCOM, 2008a. Total and regional runoff to the Baltic Sea. Indicator Fact Sheets 2008. Accessible at http://www.helcom.fi/environment2/ifs/ifs2008/en_GB/Runoff/ (accessed 27 February, 2009).

HELCOM, 2008b. Phytoplankton biomass and species succession in the Gulf of Finland, Northern Baltic Proper and Southern Baltic Sea in 2008. Indicator Fact Sheets 2008. Accessible at http://www.helcom.fi/environment2/ifs/ifs2008/en_GB/Phyto_biomass/ (accessed 2 November, 2009)

HELCOM, 2008c. Eutrophication in the Baltic Sea. Baltic Sea Environment Proceedings No. 115B.

HELCOM and NEFCO, 2007. Economic analysis of the BSAP with focus on eutrophication. HELCOM, Helsinki, 112p.

Hinrichsen, H.-H., Möllmann, C., Voss, R., Köster, F.W. and Kornilovs, G., 2002. Biophysical modelling of larval Baltic cod (*Gadus morhua* L.) growth and survival. Can. J. Fish. Aquat. Sci., 59:1858–1873.

Hinrichsen, H.-H., St. John, M., Aro, E., Groenkjaer, P., Voss, R., 2001. Testing the larval drift hypothesis in the Baltic Sea: retention vs. dispersion due to influence of wind driven circulation. ICES J. Mar. Sci., 58:973–984.

Hjerne, O. and Hansson, S., 2002. The role of fish and fisheries in Baltic Sea nutrient dynamics. Limnol. Oceanogr., 47:1023–1032.

Holby, O. and Hall, O.L., 1991. Chemical fluxes and mass balances in a marine fish cage farm. II. Phosphorus. Mar. Ecol. Prog. Ser., 70:263–272.

Holmer, M., Black, K., Duarte, C.M., Marbà, N., Karakassis, I., (eds.), 2008. Aquaculture in the ecosyste. Springer, Berlin, 326p.

Holmlund, C.M. and Hammer, M., 1999. Ecosystem services generated by fish populations. Ecol. Econ., 29:253–268.

Honeyman, B.D. and Santschi, P.H., 1988. Metals in aquatic systems. Environ. Sci. Technol., 22:862–871.

Howarth, R.W., Marino, R. and Cole, J.J., 1988a. Nitrogen fixation in freshwater, estuarine, and marine ecosystems. 2. Biogeochemical controls. Limnol. Oceanogr., 33:688–701.

Howarth, R.W., Marino, R., Lane, J. and Cole, J.J., 1988b. Nitrogen fixation in freshwater, estuarine, and marine ecosystems. 1. Rates and importance. Limnol. Oceanogr., 33: 669–687.

Hüssy, K., St. John, M.A. and Böttcher, U., 1997. Food resource utilization by juvenile Baltic cod *Gadus morhua*: a mechanism potentially influencing recruitment success at the demersal stage? Mar. Ecol. Prog. Ser., 155:199–208.

Hutchings, J., 1996. Spatial and temporal variations in the density of northern cod and a review of hypotheses for the stock's collapse. Can. J. Fish. Aquat. Sci., 53:943–962.

Hutchinson, P. (ed.), 1997. Interactions between salmon culture and wild stocks of Atlantic solmon: the scientific and management issues. ICES J. Mar. Sci., 54:963–1227.

ICES, 2006a. HELCOM data. http://www.ices.dk/ocean/asp/helcom/helcom.asp?Mode=1

ICES, 2006b. ICES CM 2006/F. What plankton are fish really eating? Species and diets, availability and dependency. Accessible at http://www.ices.dk

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

ICES, 2008a. ICES CM 2008/BCC:02. Accessible at http://www.ices.dk/products/CMdocs/CM-2008/BCC/sgprod08.pdf

ICES, 2008b. Report of the ICES Advisory Committee, 2008. ICES Advice, 2008. Book 8, 133 pp.

ICES, 2008c. Accessible at http://www.ices.dk/products/CMdocs/CM-2008/BCC/sgprod08.pdf

ICES Fisheries Statistics 1973–2000, Nominal Catch Statistics, STATLANT Programme, ICES, Copenhagen, Denmark, 2002. Accessible at http://www.ices.dk/fish/statlant.asp

IBSFC, 2003. Total allowable catches (TACs) established by the IBSFC for the respective years in thousand tonnes. Accessible at http://www.ibsfc.org

Ivanova, M.B., 1985. Production of planktonic crustaceans in fresh water. Nauka, Leningrad (in Russian).

Ivlev, V.S., 1961. Experimental ecology of the feeding of fishes. Translated from Russian by D. Scott. Yale University Press, New Haven, CT.

Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J. and Warner, R.R., 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science, 293:629–638.

Jacobsen, T.S., 1980. The Belt Project. Sea water exchange of the Baltic-measurements and methods. Report from the National Agency of Environmental Protection, Denmark. ISBN 87-503-3532-4, 106 pp.

Jarre-Teichmann, A., Wieland, K., MacKenzie, B., Hinrichsen, H.-H., Plikshs, M. and Aro, E., 2000. Stock-recruitment relationships for cod (*Gadus morhua callarias L.)* in the central Baltic Sea incorporating environmental variability. Arch. Fish. Mar. Res., 48:97–123.

Järvi, T. (coord.), 2002. Performance and ecological impacts of introduced and escaped fish: physiological and behavioural mechanisms – AQUAWILD. Final Report to: European Commission EC Contract No. FAIR CT 97-1957. National Board of Fisheries, Institute of Freshwater Research, Drottningholm, Sweden.

Javidpour, J., Sommer, U. and Shiganova, T., 2006. First record of *Menemiopsis leidyi* A. Agazziz 1985 in the Baltic Sea. Aquat. Invasions, 1: 299:302.

Jeppesen, E., Jensen, J.P., Kristinsen, P., Sondergaard, M., Mortensen, E., Sortkjaer, O. and Olrik, K., 1990. Fish manipulation as a lake restoration tool in shallow, eutrophic, temperate lakes: threshold levels, long-term stability and conclusions. Hydrobiologia, 200/201: 219–227.

Johansson, T., Håkanson, L., Borum, K. and Persson, J., 1998. Direct flows of phosphorus and suspended matter from a fish farm to the wild fish in Lake Southern Bullaren, Sweden. Aquacult. Eng., 17:111–137.

Jones, J.R. and Bachmann, R.W., 1975. Algal response to nutrient inputs in some Iowa lakes. Verh. Int. Ver. Limnol., 19:904–910.

Jonsson, P., 1992. Large-scale changes of contaminants in Baltic Sea sediments during the twentieth century. Thesis, Uppsala University, Sweden.

Jonsson, P, Carman, R. and Wulff, F., 1990. Laminated sediments in the Baltic – a tool for evaluating nutrient mass balances. Ambio, 19:152–158.

Jonsson, P., Persson, J. and Holmberg, P., 2003. Skärgårdens bottnar (The bottom areas of the archipelago). Swedish EPA, Report 5212, 112p.

Jönsson, A., 2005. Model studies of surface waves and sediment resuspension in the Baltic Sea. Dr thesis No 332, Linköping University, Linköping, 49p.

Jørgensen, S.E., 1998. An improved parameter estimation procedure in lake modelling. Lake Reserv. Res. Manag., 3:139–1432.

Jurvelius, J., Leinikki, J., Mamylov, V. and Pushkin, S., 1996. Stock assessment of pelagic three-spined stickleback (*Gasterosteus aculeatust*): a simultaneous up- and down-looking echo-sounding study. Fish. Res., 27:227–241.

Karås, P., 1999. Rekryteringsmiljöer för kustbeståndet av abborre, gädda och gös. Fiskeriverket Rapport 6:31–65.

Karagiannikos, A., 1996. Total Allowable Catch (TAC) and quota management system in the European Union.

Karjalainen, M., Engström-Öst, J., Korpinen, S., Peltonen, H., Pääkkönen, J-P., Rönkkönen, S., Suikkanen, S. and Viitasalo, M., 2007. Ecosystem consequences of cyanobacteria in the Northern Baltic Sea. Ambio, 36:195–202.

Karlson, A.M.L., Almqvist, G., Skora, K.E. and Appelberg, M., 2007. Indications of competition between non-indigenous round goby and native flounder in the Baltic Sea. ICES J. Mar. Sci., 64:479–486.

Karlson, K., Rosenberg, R. and Bonsdorff, E., 2002. Temporal and spatial large-scale effects of eutrophication and oxygen deficiency on benthic fauna in Scandinavian and Baltic waters – a review. Oceanogr. Mar. Biol. Annu. Rev., 40:427–489.

Karlsson, O.M., Jonsson, P.O., Lindgrejn, D., Lännergren, C., Mamaeus, J.M. and Stehn, A., 2009. Indications of recovery from hypoxia in the inner Stockholm archipelago (submitted).

Kasumyan, A.O. and Doving, K.B., 2003. Taste preferences in fishes. Fish Fish., 4:289–347.

Kautsky, L., 1991. Life in the Baltic Sea. The Baltic University, Uppsala University, Uppsala, 37p.

Kautsky, L. and Kautsky, H., 1989. Algal species diversity and dominance along gradients of stress and disturbance in marine environments. Vegetatio, 83:259–267.

Kautsky, L. and Kautsky, N., 2000. The Baltic Sea, including Bothnian Sea and Bothnian Bay. In: Sheppard, C. (ed.), Seas at the millennium: an environmental evaluation. Elsevier, Amsterdam, pp. 121–133.

Kitaev, S.P., 1984. Ecological principles of productivity of the lake of different natural zones. Nauka, Moscow (in Russian).

Kiirikki, M., Rantanen, P., Varjopuro, R. et al., 2003. Cost effective water protection in the Gulf of Finland. Focus on St. Petersburg. Finnish Environment Institute, Helsinki, 57p.

Knoechel, R. and Holtby, L.B., 1986. Cladoceran filtering rate: body length relationships for bacterial and large algal particles. Limnol. Oceanogr., 3:195–200.

Koelmans, A.A. and Lijklema, L., 1992. Sorption of 1,2,3,4-tetrachlorobenzene and cadmium to sediments and suspended solids in Lake Volkerak/Zoom. Water Res., 26:327–337.

Koelmans, A.A. and Radovanovic, H., 1998. Prediction of trace metal distribution coefficient (KD) for aerobic sediments. Water Sci. Technol., 37:71–78.

Köhler, J., 2006. Detergent phosphates: an EU policy assessment. J. Bus. Chem., 3:15–30.

Konopka, A. and Brock, T.D., 1978. Effect of temperature on blue-green algae (Cyanobacteria) in Lake Mendota. Appl. Environ. Microbiol., 36:572–576.

Kornilovs, G., Sidrevics, L. and Dippner, J.W., 2001. Fish and zooplankton interaction in the Central Baltic Sea. ICES J. Mar. Sci., 58:579–588.

Köster, F.W. and Möllmann, C., 2000a. Egg cannibalism in Baltic sprat (*Sprattus sprattus L.).* Mar. Ecol. Prog. Ser., 196:269–277.

Köster, F.W. and Möllmann, C., 2000b. Trophodynamic control by clupeid predators on recruitment success in Baltic cod? ICES J. Mar. Sci., 57:310–323.

Köster, F.W., Möllmann, C., Hinrichsen, H.-H., Wieland, K., Tomkiewicz, J., Kraus, G. Voss, R., Makarchouk, A., MacKenzie, B.R., St. John, M.A., Schnack, D., Rohlf, N., Linkowski, T. and Beyer, J.E., 2005. Baltic cod recruitment – the impact of climate variability on key processes. ICES J. Mar. Sci., 62:1408–1425.

Köster, F.W., Möllmann, C., Neuenfeldt, S., Vinther, M., St. John, M.A., Tomkiewicz, J., Voss, R., Hinrichsen, H.-H., MacKenzie, B., Kraus, G. and Schnack, D., 2003a. Fish stock development in the central Baltic Sea (1974–1999) in relation to variability in the environment. ICES Mar. Sci. Symp., 219:294–306.

Köster, F.W., Hinrichsen, H.-H., Schnack, D., St. John, M.A., MacKenzie, B.R., Tomkiewicz, J., Möllmann, C., Kraus, G., Plikhs, M., Makarchouk, A. and Aro. E., 2003b. Recruitment of Baltic cod and sprat stocks: identification of critical life stages and incorporation of environmental variability into stock-recruitment relationships. Sci. Mar., 67(Suppl. 1):129–154.

Kotilainen, A.T., Hämäläinen, J.M.S. and Winterhalter, B., 2002. Reconstructing a continuous Holocene composite sedimentary record for the eastern Gotland Deep, Baltic Sea. Boreal Environ. Res. 7:1–12.

Kranck, K., 1973. Flocculation of suspended sediment in the sea. Nature, 246:348–350.

Kranck, K., 1979. Particle matter grain-size characteristics and flocculation in a partially mixed estuary. Sedimentology, 28:107–114.

Kuznetsov, S.I., 1970. Microflora of lakes and its geochemical activity. Nauka, Leningrad (in Russian).

Laine, A.O., 2003. Distribution of soft-bottom macrofauna in the deep open Baltic Sea in relation to environmental variability. Estuar. Coast. Shelf Sci., 57:87–97.

Lalonde, S. and Downing, A., 1991. Epiphyton biomass is related to lake trophic status, depth, and macrophyte architecture. Can. J. Fish. Aquat. Sci. 48:2285–2291.

Lappalainen, A., Shurukhin, A., Alekseev, G. and Rinne, J., 2000. Coastal-Fish Communities along the Northern Coast of the Gulf of Finland, Baltic Sea: responses to salinity and eutrophication. Int. Rev. Hydrobiol., 85:687–696.

Lappalainen, A., Westerbom, M. and Vesala, S., 2004. Blue mussels (*Mytilus edulis*) in the diet of roach (*Rutilus rutilus*) in outer archipelago areas of the western Gulf of Finland, Baltic Sea. Hydrobiologia, 514:87–92.

Larson, R.J., 1987. Daily ration and predation by medusae and ctenophores in Saanich inlet, B.C., Canada. Neth. J. Sea Res., 21:35–44.

Larson, U. and Hagström, A., 1979. Phytoplankton exudate release as an energy source for the growth of pelagic bacteria. Mar. Biol., 52:199–206.

Larsson, S. and Berglund, I., 2005. The effect of temperature on the energetic growth efficiency of Arctic charr (*Salvelinus alpinus* L.) from four Swedish populations. J. Therm. Biology, 30: 29–36.

Larsson, U., Elmgren, R. and Wulff, F., 1985. Eutrophication and the Baltic Sea: causes and consequences. Ambio, 14:9–14.

Larsson, U., Hajdu, S., Walve, J. and Elmgren, R., 2001. Baltic Sea nitrogen fixation estimated from the summer increase in upper mixed layer total nitrogen. Limnol. Oceanogr., 46:811–820.

Laznik, M., Stålnacke, P., Grimvall, A. and Wittgren, H.B., 1998. Riverine input of nutrients to the Gulf of Riga – temporal and spatial variation. J. Mar. Syst., 23:11–25.

Leclerc, M.J., Secretan, Y. and Boudreau, P., 2000. Integrated two-dimensional macrophyte-hydrodynamic modeling. J. Hydraulic Res. 38:163–172.

Lehtimäki, J. Moisander, P. Sivonen, K. and Kononen, K., 1997. Growth, nitrogen Fixation, and Nodularin production by two Baltic Sea Cyanbacteria. Appl. Environ. Microbiol., 63:1647–1656.

Lehtimäki, J., Sivonen, K., Luukainen, R. and Niemelä, S.I., 1994. The effects of incubation time, temperature, light, salinity, and phosphorus on growth and hepatotoxin production by *Nodularia* strains. Arch. Hydrobiol., 130:269–282.

Lehtiniemi, M. and Lindén, E., 2006 *Cercopagis pengoi* and *Mysis* spp. Alter their feeding rate and prey selection under predation risk of herring (*Clupea harengus membras*). Mar. Biol., 149:845–854.

Legović, T., 1987. A recent increase in Jellyfish populations: a predator-prey model and its implications. Ecol. Modell., 38:243–256.

Lehane, C. and Davenport, J., 2002. Ingestion of mesozooplankton by three species of bivalve: *Mytilus edulis*, *Cerastoderma edule* and *Aequipecten opercularis*. J. Mar. Biol. Assoc. UK, 82:3999/1–6.

Lemmin, U. and Imboden, D.M., 1987. Dynamics of bottom currents in a small lake. Limnol. Oceanogr., 32:62–75.

Leppäkoski, E., Gollasch, S., Gruszka, P. et al., 2002. The Baltic – a sea of invaders. Can. J. Fish. Aquat. Sci. 59:1175–1188.

Levinton, J.S., 2001. Marine biology: function, biodiversity, ecology, 2nd ed. Oxford University Press, New York, 515 pp.

Li, Y.-H., Burkhardt, L., Buchholtz, M.B., O'Hara, P. and Santschi, P.H., 1984. Partition of radiotracers between suspended particles and seawater. Geochim. Cosmochim. Acta, 48:2011–2019.

Lick, W., Lick, J. and Ziegler, C.K., 1992. Flocculation and its effect on the vertical transport of fine-grained sediments. Hydrobiologia, 235/236:1–16.

Lindahl, O., 2008. Musseloding för miljön – nu även i Östersjön. Havsutsikt, 3:4–5.

Lindquist, A., 2001. Catches of some "non-ICES" fish species in the Baltic. Fiskeriverket informerar 2001.

Lövdin, I., 2007. Tyst hav, Ordfront.

Lozán, J.L., Lampe, R., Mattäus, W., Rachor, E., Rumohr. H. and von Westernhagen, H. (eds.), 1996. Warnsignale aus der Ostsee. Pary, Buchverlag, Berlin, 385p.

Lucas, C.H. 2001. Reproduction and life history strategies of the common jellyfish, *Aurelia aurita*, in relation to its ambient environment. Hydrobiologia, 451:229–246.

Lucas, M.C. and Baras, E., 2001. Migration of freshwater fishes. Blackwell Science Ltd., Oxford.

Lučić, D., Njire, J., Morović, M., Precali, R., Fuks, D. and Bolotin, J., 2003. Microzooplankton in the open waters of the northern Adriatic Sea from 1990 to 1993: the importance of copepod nauplii densities. Helgol. Mar. Res., 57:73–81.

Lundström, K., et al. 2007. Estimation of grey seal (*Halichoerus grypus*) diet composition in the Baltic Sea. NAMMCO Sci. Pub., 6:177–196.

Mace, P.M, 2001. A new role for MSY in single-species and ecosystem approaches to fisheries stock assessment and management. Fish Fish., 2:2–32.

MacKenzie, B.R., Alheit, J., Conley, D.J., Holm, P. and Kinze, C.C., 2002. Ecological hypothesis for a historical reconstruction of upper trophic level biomass in the Baltic Sea and Skagerrak. Can. J. Fish. Aquat. Sci., 59:173–190.

MacKenzie, B.R., Hinrichsen, H-H., Plikshs, M., Wieland, K. and Zezera, A.S., 2000. Quantifying environmental heterogeneity: habitat size necessary for successful development of cod *Gadus morhua* eggs in the Baltic Sea. Mar. Ecol. Prog. Ser., 193:143–156.

MacKenzie, B.R. and Köster, F.W., 2004. Fish production and climate: sprat in the Baltic Sea. Ecology, 85:784–794.

Maitland, P.S., 1977. Freshwater fishes of Britain and Europe. Hamlyn, London, 256p.

Maitland, P.S., 1978. Biology of fresh waters. Blackie, Glasgow, 244p.

Mäkinen, T., 1991 (ed.), Marine aquaculture and environment, Vol. 22. Nordic Council of Minister, Nord, 126p.

Marino, R., Chan, F., Howarth, R.W., Pace, M.L. and Likens, G.E., 2006. Ecological constraints on planktonic nitrogen fixation in saline estuaries. I. Nitrogen and trophical controls. Mar. Ecol. Prog. Ser., 309:25–39.

Marker, A.F.H., 1965. Extracellular carbohydrate liberation in the flagellates *Isochrysis galbana* and *Prymnesium parvum*. J. Mar. Biol. Assoc. UK, 45:755–772.

Martinussen, M.B. and Båmstedt, U., 1999. Nutritional ecology of gelatinous planktonic predators. Digestion rate in relation to type and amount of prey. J. Exp. Mar. Biol. Ecol., 232:61–84.

Marumo, R. and Asaoka, O., 1974. Distribution of pelagic blue-green algae in the Northen Pacific Ocean. J. Oceanogr. Soc. Jpn, 30:77–85.

Matthiesen, H., Emeis, K.-C. and Jensen, B.T., 1998. Evidence for phosphate release from sediment in the Gotland Deep during oxic bottom water conditions. Meyniana, 50:175–190.

Mattila, J., Kankaanpää, H. and Ilus, E., 2006. Estimation of recent sediment accumulation rates in the Baltic Sea using artificial radionuclides 137Cs and 239,240Pb as time markers. Boreal Environ. Res., 11:95–107.

McDowall, R.M., 1988. Diadromy in fishes. Timber Press, Portland, OR, 308 pp.

Meier, H.E.M., Döscher, R. and Halkka, A., 2004. Simulated distributions of Baltic Sea-ice in warming climate and consequences for the winter habitat of the Baltic ringed seal. Ambio, 33:249–256.

Meijer, M.L., Dehaan, M.W., Breukelaar, A.W. and Buiteveld, H., 1990. Is reduction of benthivorous fish an important cause of high transparency following biomanipulation in shallow lakes? Hydrobiologia, 200/201:303–315.

Menshutkin, V.V., 1971. Mathematical modelling of populations and communities of aquatic animals. Leningrad Branch of Nauka Press, Leningrad (in Russian).

Mills, C.E., 1995. Medusae, siphonophores, and ctenophores as planktivorous predators in changing global ecosystems. ICES J. Mar. Sci., 52:575–581.

Moen, F.E. and Svensen, E., 2004. Marine fish and invertebrates. AquaPress, Essex, 608p.

Möller, P., Pihl, L. and Rosenberg, R., 1985. Fisk och bottendjur i grundområden i Bohuslän och Halland – en biologisk värdering. SNV PM 1911:7–95.

Möllmann, C., Kornilovs, G., Fetter, M. and Köster, F.W., 2004. Feeding ecology of central Baltic Sea herring and sprat. J. Fish Biol., 65:1563–1581.

Möllmann, C., Kornilovs, G. and Sidrevics. L., 2000. Long-term dynamics of main mesozooplankton species in the central Baltic Sea. J. Plankton Res., 22:2015–2038.

Möllmann, C. and Köster, F.W., 1999. Food consumption by clupeids in the Central Baltic: evidence for top-down control? ICES J. Mar. Sci. 56(Suppl.):100–113.

Möllmann, C. and Köster F.W., 2002. Population dynamics of calanoid copepods and the implications of their predation by clupeid fish in the Central Baltic Sea. J. Plankton Res. 24:959–977.

Monitor, 1988. Sweden's marine environment – ecosystem under pressure. Swedish Environmental Protection Agency, Stockholm, 207p.

Monakov, A.V., 1998. Feeding of freshwater invertebrates. Russian Academy of Sciences, Moscow (in Russian).

Monte, L. 1995. A simple formula to predict approximate initial contamination of lake water following a pulse deposition of radionuclide. Health Phys., 68(3):397–400.

Monte, L. 1996. Collective models in environmental science. Sci. Total Environ., 192:41–47.

Monte, L., Brittain, J.E., Håkanson, L. and Gallego, E. 1999. MOIRA models and methodologies for assessing the effectiveness of countermeasures in complex aquatic systems contaminated by radionuclides. ENEA, RT/AMP. 150 pp.

Monte, L., Håkanson, L. and Brittain, J., 1997. Prototype models for the MOIRA computerised system. ENEA, ISSN/1120-5555, Roma, 90p.

Monte, L., Van der Steen, J., Bergström, U., Gallego Diaz, E., Håkanson, L. and Brittain, J., 2000. The Project MOIRA A model-based computerised system for management support to identify optimal remedial straegies for restoring radionuclide contaminated aquatic ecosystens and drainage areas. Final Report. ENEA. ISSN/1120-5555, Rome, 89p.

Morgan, N.C., 1980. Transfer efficiency. The functioning of freshwater ecosystems. Cambridge University Press, Cambridge, pp. 329–334.

Muller, F.L.L., Tranter, M. and Balls, P.W., 1994. Distribution and transport of chemical constituents in the Clyde estuary. Estuar. Coast. Shelf Sci., 39:105–126.

Münsterhjelm, R., 1987. Flads and gloes in the archipelago. Geol. Surv. Finl. Spec. Pap., 2:55–61.

Myers, R.A. and Worm, B., 2005. Extinction, survival or recovery of large predatory fishes. Phil. Trans. R. Soc. B., 360:13–20.

Myrberg, K., 1998. Analysing and modelling the physical processes of the Gulf of Finland in the Baltic Sea. Monogr. Boreal Environ. Res. 10:50p.

NEFCO, 2007. Economic analysis of the BSAP with focus on eutrophication. HELCOM, Helsinki, 112p.

Neuenfeldt, S., Hinrichsen, H.-H., Nielsen, A. and Andersen, K.H., 2007. Reconstructing migrations of individual cod (*Gadus morhua L.*) in the Baltic Sea by using electronic data storage tags. Fish. Oceanogr., 16:526–535.

Nikolskiy, G.V., 1974. Fish ecology. Vysshaya Shkola, Moscow (in Russian).

Nilsson, J. Andersson, J., Karås, P. and Sandström, A., 2004. Recruitment failure and decreasing catches of perch (*Perca fluviatilis L.*) and pike (*Esox lucius L.)* in the coastal waters of southeast Sweden. Boreal Environ. Res., 9:295–306.

Nissling, A., Johansson, U., Jacobsson, M., 2006. Effects of salinity and temperature conditions on the reproductive success of turbot (Scophthalmus maximus) in the Baltic Sea. Fish. Res., 80:230–238.

Northcote, T.G., 1978. Migratory strategies and production in freshwater fishes. In: Gerking, S.D. (ed.), Ecology of freshwater fish production. Blackwell Scientific Publications, Oxford, pp. 326–359.

Odum, E., 1986. Ecology. Mir, Moscow (in Russian).

OECD, 1982. Eutrophication of waters. Monitoring, assessment and control. OECD, Paris, 154p.

Oglesby, R.T., 1977. Relationships of fish yield to lake phytoplankton standing crop, production, and morphoedaphic factors. J. Fish. Res. Board Can. 34:2271–2279.

Ojaveer, E., 2003. Fishes of Estonia. Estonian Academy Publishers, Tallinn.

Ojaveer, E. and Lehtonen, H., 2001. Fish stocks in the Baltic Sea: finite or infinite resource? Ambio, 30:217–221.

Olsen, Y., Jensen, A., Reinertsen, H., Borsheim, K.Y., Heldal, M. and Langeland, A., 1986. Dependence of the rate of release of phosphorus by zooplankton on P:C ratio in the food supply, as calculated by a recycling model. Limnol. Oceanogr., 31:34–44.

Omstedt, A. and Axell, L.B., 2003. Modeling the variations of sainity and temperature in the large Gulfs of the Baltic Sea. Cont. Shelf Res., 23:265–294.

Omstedt, A. and Chen, D., 2001. Influence of atmospheric circulation on the maximum ice extent in the Baltic Sea. J. Geophys. Res., 106:4493–4500.

Omstedt, A., Elken, J., Lehmann, A. and Piechura, J., 2004. Knowledge of the Baltic Sea Physics gained during the BALTEX and related programmes. Prog. Oceanogr., 63:1–28.

Omstedt, A. and Rutgersson, A., 2000. Closing the water and heat cycles of the Baltic Sea. Meteorol. Z., 9:57–64.

Ostapenia, A.P., 1989. Seston and detritus as structural and functional components of water ecosystems. Thesis for a Doctor's degree, Kiev (in Russian).

Ostmann, M., Suursaar, Ü. and Kullas, T., 2001. The oscillatory nature of the flows in the system of straits and small semienclosed basins of the Baltic Sea. Cont. Shelf Res., 21:1577–1603.

Ottosson, F. and Abrahamsson, O., 1998. Presentation and analysis of a model simulating epilimnetic and hypolimnetic temperatures in lakes. Ecol. Modell. 110:223–253.

Overbeck, J., 1972. Distribution pattern of phytoplankton and bacteria, microbial decomposition of organic matter and bacterial production in eutrophic, stratified lake. Productivity problems of freshwater. Warszawa-Krakow, 227–237.

Pace, M.L., 1993. Heterotrophic microbial processes. The trophic cascade in lakes. Cambridge University Press, Cambridge, pp. 252–277.

Pace, M.L., McManus, G.B. and Findlay, S.E.G., 1990. Plankton community structure determines the fate of bacterial production in a temperate lake. Limnol. Oceanogr., 35:795–808.

Paoli, A., Celussi, M., Valeri, A., Larato, C., Bussani, A., Fonda Umani, S., Vadrucci, M.R., Mazziotti, C. and Del Negro, P., 2007. Picocyanobacteria in Adriatic transitional environments. Estuar. Coast. Shelf Sci., 75:13–20.

Pearson, T.H. and Rosenberg, R., 1976. A comparative study on the effects on the marine environment of wastes from cellulose industries in Scotland and Sweden. Ambio, 5:77–79.

Peltonen, H., Vinni, M., Lappalainen, A. and Pönni, J. 2004. Spatial feeding patterns of herring (*Clupea harengus L.*), sprat (*sprattus sprattus L.*), and the three-spined stickleback (*Gasterosteus aculeatus L.*) in the Gulf of Finland, Baltic Sea. ICES J. Mar. Sci. 61:966–971.

Persson, J., 1999. On the role of morphometry in coastal ecosystem modelling and management. Dr. Thesis, Uppsala University, Uppsala.

Persson, J., Håkanson, L., Wallin, M., 1994. A geographical information system for coastal water planning based on chart information (in Swedish). Nordiska ministerrådet. TemaNord, Copenhagen, No. 667, 190p.

Persson, G. and Jansson, M., 1988. Phosphorus in freshwater ecosystems. Hydrobiologia, 170:340p.

Peters, R.H. 1986. The role of prediction in limnology. Limnol. Oceanogr., 31:1143–1159.

Peters, R.H., 1991. A critique for ecology. Cambridge University Press, Cambridge, 366p.

Pihl, L., Svensson, A., Moksnes, P.O. and Wennhage, H., 1999. Distribution of green algal mats throughout shallow soft bottoms of the Swedish archipelago in relation to nutrient loads and wave exposure. J. Sea Res. 41:281–294

Pohl, C. and Hennings, U., 1999. The effect of redox processes on the partitioning of Cd, Pb, Cu, and Mn between dissolved and particulate phases in the Baltic Sea. Mar. Chem., 65:41–53.

Porter, K.G., Paerl, H., Hodson, R., Pace, M., Priscu, J., Riemann, B., Scavia, D. and Stockner, J., 1988. Microbial interactions in lake food webs. Complex interactions in lake communities. Springer, New York, pp. 209–227.

Purcell, J.E. 2003. Predation on zooplankton by large jellyfish, *Aurelia labiata*, *Cyanea capillata* and *Aequorea aequorea*, in Prince William Sound, Alaska. Mar. Ecol. Prog. Ser., 246: 137–152.

Pustelnikov, O.S., 1977. Geochemical features of suspended matter in connection with recent processes in the Baltic Sea. Ambio, 5:157–162.

Quémerais, B., Cossa, D., Rondeau, B., Pham, T.T. and Fortin, B., 1998. Mercury distribution in relation to iron and manganese in the waters of St. Lawrence River. Sci. Total Environ., 213:193–201.

Rahm, L., Jönsson, A. and Wulff, F., 2000. Nitrogen fixation in the Baltic proper: an empirical study. J. Mar. Syst. 25:239–248.

Rai, H., 1978. Chlorophyll pigments in the Central Amazon lake ecosystems. Verh. Int. Verein. Limnol., 20:1192–1197.

Read, P. and Fernandez, T., 2003. Management of environmental impacts of marine aquaculture in Europe. Aquaculture 226:139–163.

Reila, H., 1979. Tursats Pärnu lahes. Abiks kalurile, 1:7–9.

Remane, A., 1934. Die Brackwasserfauna. Verhandlungen der Deutschen Zoologischen Gesellschaft 36:34–74.

Reynolds, C.S., 1987. Cyanobacteria water-blooms. Adv. Bot. Res., 13:67–143.

Reynolds, C.S. and Walsby, A.E., 1975. Water-blooms. Biol. Rev., 50:437–481.

Rodionova, N.V. and Panov, V.E., 2006. Establishment of the Ponto-Caspian predatory cladoceran Evadne anonyx in the eastern Gulf of Finland, Baltic Sea. Aquatic Invasions 1:7–12.

Rönkkönen, S., Ojaveer, E., Raid, T. and Viitasalo, M., 2004. Long-term changes in Baltic herring (Clupea harengus membras) growth in the Gulf of Finland. Can. J. Fish. Aquat. Sci., 61: 219–229.

Rosenberg, R., 1985. Eutrophication – the future marine coastal nuisance? Mar. Pollut. Bull., 16:227–231.

Rubio, V.C., Sánchez-Vázques, F.J., Madrid, J.A., 2005. Effects of salinity on food intake and macronutrient selection in European sea bass. Physiol. Behav., 85:333–339.

Ruohonen, K., Vielma, J. and Grove, D.J., 1998. Effects of feeding frequency on growth and food utilisation of rainbow trout (*Oncorhynchus mykiss*) fed low-fat herring or dry pellets. Aquaculture, 165:111–121.

Rutgersson, A., Omstedt, A. and Räisänen, J., 2002. Net precipitation over the Baltic Sea during present and future climate conditions. Clim. Res., 22:27–39.

Sadchikov, A.P. and Frenkel, O.A., 1990. Release of dissolved organic matter by living phytoplankton (methodical aspects). Hudrobiol. J., 26:84–87 (in Russian).

Sadchikov, A.P. and Makarov, A.A., 1997. Release of dissolved organic matter by living phytoplankton in three water bodies of different trophy. Hydrobiol. J., 33:104–107 (in Russian).

Salazkin, A.A. and Ogorodnikova, V.A.,1984. Methodical recommendations on sampling and treatment of materials at hydrobiological investigations of fresh waters. Nauka, Leningrad (in Russian).

Salomons, W. and Förstner, U., 1984. Metals in the hydrocycle. Springer, Heidelberg, 349p.

Salovius, S. and Kraufvelin, P., 2004. The filamentous green alga *Cladophora glolmerata* as a habitat for littoral macro-fauna in the northern Baltic Sea. Ophelia, 58:65–78.

Samuelsson, M., 1996. Interannual salinity variations in the Baltic Sea during the period 1954–1990. Cont. Shelf Res., 16:1463–1477.

Sandberg, J., Elmgren, R. and Wulff, F., 2000. Carbon flows in Baltic Sea food webs – a re-evaluation using a mass balance approach. J. Mar. Syst., 25:249–260.

Sandström, A., Eriksson, B.K., Karås, P., Isæus, M. and Schreiber, H., 2005. Boating activities influences the recruitment of near-shore fishes in a Baltic Sea archipelago area. Ambio, 34: 125–130.

Sandström, A. and Karås, P., 2002. Effects of eutrophication on young-of-the-year freshwater fish communities in coastal areas of the Baltic. Environ. Biol. Fish., 63:89–101.

Santschi, P.H. and Honeyman, B.D., 1991. Radioisotopes as tracers for the interactions between trace elements, colloids and particles in natural waters. In: Vernet, J.-P. (ed.), Heavy metals in the environment. Elsevier, Amsterdam.

Saulamo, K. and Lappalainen, J., 2007. Effects of abiotic factors on movements of pikeperch during pre-spawning and spawning season in a Baltic archipelago. Hydrobiologia, 579: 271–277.

Saulamo, K. and Neuman, E., 2002. Local management of Baltic fish stocks – significance of migrations. Fiskeriverket informerar, 9:1–18.

Savchuk, O.P., 2000. Studies of the assimilation capacity and effects of nutrient load reductions in the eastern Gulf of Finland with a biogeochemical model. Boreal Environ. Res., 5:147–163.

Savchuk, O.P., 2005. Resolving the Baltic Sea into seven subbasins: N and P budgets for 1991–1999. J. Mar. Syst., 56:1–15.

Savchuk, O.P. and Swaney, D.P., 2000. Water and Nutrient Budget of the Gulf of Riga. Accessible at http://data.ecology.su.se/mnode/Europe/Gulf%20of%20Riga/rigabud.htm (accessed April 19, 2006).

Savchuk, O.S., Wulff, F., Hille, S., Humborg, C. and Pollehne, F., 2008. The Baltic Sea a century ago – a reconstruction from model simulations, verified by observations. J. Mar. Syst., 74: 485–494.

Scheffer, M., 1998. Ecology of shallow lakes. Population and Community Biology Series, Vol. 22. Chapman and Hall, London, 384p.

Schernewski, G. and Neumann, T., 2005. The trophic state of the Baltic Sea a century ago: a model simulation study. J. Mar. Syst., 53:109–124.

Schmölcke, U., 2008. Holocene environmental changes and the seal (Phocidae) fauna of the Baltic Sea: coming, going and staying. Mammal Rev. 38:231–246.

Schneider, G. 1989. Estimation of food demands of *Aurelia Aurita* medusae populations in the Kiel Bight/Western Baltic. Ophelia, 31:17–27.

Schneider, G. and Behrends, G., 1994. Population dynamics and the trophic role of *Aurelia aurita* medusae in the Kiel Bight and western Baltic. J. Mar. Sci., 51:359–367.

Schindler, D.W., 1978. Factors regulating phytoplankton production and standing crop in the world's freshwaters. Limnol. Oceanogr., 23:478–486.

Schindler, D.W., Hecky, R.E., Findlay, D.L., Stainton, M.P., Parker, B.R., Patterson, M.J., Beaty, K.G., Lyng, M. and Kasian, S.E.M., 2008. Eutrophication of lakes cannot be controlled by reducing nitrogen input: results of a 37-year whole ecosystem experiment. PNAS, 105: 11254–11258.

Schou, J.S., Neye, S.T., Lundhede, T. et al., 2006. Modelling cost-efficient reductions of nutrient loads to the Baltic Sea. NERI Technical Report No. 592. NERI, Copenhagen, 69p.

Seifert, T., Tauber, F. and Kayser, B., 2001. A high resolution spherical grid topography of the Baltic Sea, 2nd ed. Baltic Sea Science Congress, Stockholm 25–29. November 2001. Poster #147. Accessible at http//www.io-warnemuende.de/iowtopo/

Seinä, A. and Palusuo, E., 1996. The classification of the maximum annual extent of ice cover in the Baltic Sea 1720–1995. In: MERI, Report 27. FIMR, Helsinki, 93p.

Sellner, K.G., 1997. Physiology, ecology and toxic properties of marine cyanobacteria blooms. Limnol. Oceanogr., 42:1089–1104.

Shafer, M.M., Overdier, J.T., Phillips, H., Webb, D., Sullivan, J.R. and Armstrong, D., 1999. Trace metal levels and partitioning in Wisconsin rivers. Water Air Soil Pollut., 110:273–311.

Skoptsov, V.G., Velichko, G.M. and Koljadin, S.A., 1983. Some questions of feeding and growth of Coregonus in conditions of commodity growing. In: Trophic relationships and their role in productivity of natural waters. Nauka, Leningrad, pp. 141–145 (in Russian).

SMHI, 2003. Djuphavsdata för havsområden 2003. Svenskt vattenarkiv, Nr 73, 69 sid.

SMHI, 2007. Baltic Sea ice climate. Accessible at http://www.smhi.se/cmp/jsp/polopoly.jsp?d=9048&a=25783&l=en (March 24, 2009).

SMHI and FIMR, 1982. Climatological ice atlas for the Baltic Sea, Kattegat, Skagerrak and Lake Vänern (1963–1979). Sjöfartsverkets tryckeri, Norrköping, 220p.

Smith, V.H., 1979. Nutrient dependence of primary productivity in lakes. Limnol. Oceanogr., 24:1051–1064.

Smith, V.H., 1985. Predictive models for the biomass of blue-green algae in lakes. Water Resour. Bull., 21:433–439.

Smith, V.H., 2003. Eutrophication of freshwater and coastal marine ecosystems: a global problem. Environ. Sci. Pollut. Res., 10:126–139.

Snickars, M., Sandström, A., Lappalainen, A., Mattila, J., Rosqvist, K. and Urho, L., 2009. Fish assemblages in coastal lagoons in land-uplift succession: the relative importance of local and regional environmental gradients. Estuar. Coast. Shelf Sci., 81:247–256.

SNV, 1993. Eutrophication of land, freshwater and the Sea (in Swedish, Eutrofiering av mark, sötvatten och hav). Swedish Environmental Protection Agency, Report 4134, Stockholm, 199p.

Söderberg, K. och Gårdmark, A., 2003. Kustfisk och fiske. Bottniska Viken 2003, pp. 19–21, ISSN 1400 2760.

Sogard, S.M. and Able, W., 1991. A comparison of eelgrass, sea lettuce macroalgae, and marsh creeks as habitats for epibenthic fishes and decapods. Estuarine Coastal Shelf Sci. 33:501–519.

Sondergaard, M., Riemann, B. and Jorgensen, N.O.G., 1985. Extracellular organic carbon (EOC) released by phytoplankton and bacterial production. Oikos, 45:323–332.

Sparholt, H., 1996. Causal correlation between recruitment and spawning stock size of central Baltic cod? ICES J. Mar. Sci., 53:771–779.

Sparholt, H., Aro, E. and Modin, J., 1991. The spatial distribution of cod (*Gadus morhua* L.) in the Baltic Sea. Dana, 9:45–56.

Stålnacke, P., Grimvall, A., Sundblad, K. and Tonderski, A., 1999. Estimation of riverine loads of nitrogen and phosphorus to the Baltic Sea, 1970–1993. Environ. Monit. Assess., 58: 173–200.

Stigebrandt, A., 2001. Physical oceanography of the Baltic Sea. In: Wulff, F., Rahm, L. and Larsson, P., (eds.), A systems analysis of the Baltic Sea. Springer, New York, pp. 19–74.

Stigebrandt, A. 2008. Så lindras Östersjöns övergödningssymptom. Webbutskrift från Göteborgs universitet, December 18, 2008.

Stigebrandt, A. and Gustafsson, B.G., 2007. Improvement of Baltic Proper water quality using large-scale ecological engineering. Ambio, 36:280–286.

Stockner, J.G. and Porter, K.G., 1988. Microbial food webs in freshwater planktonic ecosystems. In: Complex interactions in lake ecosystems. Springer, New York, pp. 69–83.

Stockner, J.G. and Shortreed, K.S., 1988. Algal picoplankton production and contribution to food webs in oligotrophic British Columbia lakes. Verh. Int. Ver. Limnol., 23:1–214.

Stone, L. and Weisburd, R.S.J., 1992. Positive feedback in aquatic ecosystems. Trends Ecol. Evol., 7:263–267.

Straskraba, M., 1980. The effect of physical variables on freshwater production: analyses based on models. In: The functioning of freshwater ecosystems. Cambridge University Press, Cambridge, pp. 13–84.

Subasinghe, R., 2004. Aquaculture in the global food supply. FAO, Rome.

Suchman, C.L. and Brodeur, R.D. 2005. Abundance and distribution of large medusae in surface waters of the northern California Current. Deep Sea Res. II, 52:51–72.

Sundblad, G., Härmä, M., Lappalainen, A., Urho, L. and Bergström, U., 2009. Transferability of predictive fish distribution models in two coastal systems. Estuar. Coast. Shelf Sci., in press.

Svensson, C., 2006. Ingenjörsgeologiska Exkursion, Sveriges jordarter. Accessible at http://connywww.tg.lth.se/Sv.jordarterdokument/DeglaciationiSvdokument/Landhjningen.html (September 14, 2006).

SVT, 1997. Ymparisto, 1997: 13. Kalavirrat – tietoa kalan tarjonnasta ja käytöstä, ISBN 951-776-138-4.

Swedish Environmental Advisory Council, 2005. A Strategy for Ending Eutrophication of Seas and Coasts. Swedish Government Official Reports, Environmental Advisory Council, Jo 1968: A, Stockholm, 59p.

Swedish EPA, 2008a. Ingen övergödning (No over-enrichment), revised version. Swedish EPA report 5840, Stockholm, 123p.

Swedish EPA, 2008b. Sweden's Commitment to the Baltic Sea Action Plan. Swedish Environmental Protection Agency, Report 5830. Swedish EPA, Stockholm, 150p (in Swedish).

Swingle, H.S., 1950. Relationships and dynamics of balanced and unbalanced fish populations. Bull. Agric. Exp. State AL, Polytech. Inst., 274:3–73.

Swingle, H.S., 1952. Farm pond investigations in Alabama. J. Wildlife Manag, 16:243–249.

Tessier, A., Carignan, R., Dubreuil, B. and Rapin, F., 1989. Partitioning of zinc between the water column and the oxic sediments in lakes. Geochim. Cosmochim. Acta, 53: 1511–1522.

Thomas, J.F., 1971. Release of dissolved organic matter from natural population of marine phytoplankton. Mar. Biol., 11:311–323.

Thurow, F., 1997. Estimation of the total fish biomass in the Baltic Sea during the 20th century. ICES J. Mar. Sci., 54:444–461.

Toivonen, A.-L., Roth, E., Navrud, S. et al., 2004. The economic value of recreational fisheries in Nordic countries. Fish. Manag. Ecol., 11:1–14.

Tonn, W.M., Magnusson, J.J., Rask, M. and Toivonen, J., 1990. Intercontinental comparison of small-scale fish assembalges. The balance between local and regional processes. Am. Nat., 136:345–375.

Tõnno, I., 2004. The impact of nitrogen and phosphorus concentration and N/P ratio on cyanobacterial dominance and N_2 fixation in some Estonian lakes. Doctoral thesis, Tartu University Press, Tartu.

Törnblom, E. and Rydin, E., 1998. Bacterial and phosphorus dynamics in profundal Lake Erken sediments following the deposition of diatoms: a laboratory study. Hydrobiologia, 364: 55–63.

Totti, C., Cangini, M., Ferrari, C. Kraus, R., Pompei, M., Pugnetti, A., Romagnoli, T., Vanucci, S. and Socal, G., 2005. Phytoplankton size-distribution and community structure in relation to mucilage occurrence in the northern Adriatic Sea. Sci. Total Environ., 353:204–217.

Tucker, J.M., 1999. Marine fish culture. Springer, Berlin, 760p.

Turesson, H., et al. 2002. Prey size selection in piscivorous pikeperch (*Stizostedion lucioperca*) includes active prey choice. Ecol. Freshw. Fish, 11:223–233.

Turner, A., 1996. Trace-metal partitioning in estuaries: importance of salinity and particle concentration. Mar. Chem., 54:27–39.

Turner, R.K., Georgiou, S., Gren, I.-M. et al., 1999. Managing nutrient fluxes and pollution in the Baltic: an interdisciplinary simulation study. Ecol. Econ., 30:333–352.

Turner, A., Millward, G.E., Bale, A.J. and Morris, A.W., 1993. Application of the Kd concept to the study of trace metal removal and desorption during estuarine mixing, Estuar. Coast. Shelf Sci., 36:1–13.

Uzars, D., Baranova, T. and Yula, E., 2000. Variation in environmental conditions, feeding and growth of cod in the Eastern Baltic. ICES CM 2000/Q10.

Uzars, D., Baranova, T., Yula, E., 2001. Interannual variation in gonadal maturation of cod in the Gotland Basin of the Baltic Sea: influence of environment and fish condition. ICES CM 2001/V:29.

Uzars, D. and Plikshs, M., 2000. Cod (*Gadus morhua L.*) cannibalism in the Central Baltic: interannual variability and influence of recruit abundance and distribution. ICES J. Mar. Sci., 57:324–329.

Van Densen, W.L.T. and McCay, B.J. 2007. Improving communication from managers to fishers in Europe and the US. ICES J. Mar. Sci., 64:811–817.

Vahtera, E., Conley, D.J., Gustafsson, B.G., Kuosa, H., Pitkänen, H., Savchuk, O.P., Tamminen, T., Viitasalo, M., Voss, M., Wasmund, N. and Wulff, F., 2007. Internal ecosystem feedbacks enhance nitrogen-fixing cyanobacteria blooms and complicate management in the Baltic Sea. Ambio, 36:186–193.

Vichi, M., Ruardij, P. and Baretta, J.W., 2004. Link or sink: a modelling interpretation of the open Baltic biogeochemistry. Biogeosci. Discuss., 1:79–100.

Viherluoto, M., 2001. Food selection and feeding behaviour of Baltic Sea mysid shrimps. Academic Dissertation. University of Helsinki, Helsinki.

Viherluoto, M. and Viitasalo, M., 2001. Temporal variability in functional responses and prey selectivity of pelagic mysid *Mysis mixta* in natural prey assemblages. Mar. Biol., 138:575–583.

Viitasalo, M., Flinkman, J. and Viherluoto, M., 2001. Zooplanktivory in the Baltic Sea: a comparison of prey selectivity by *Clupea harengus* and *Mysis mixta*, with reference to prey escape reactions. Mar. Ecol. Prog. Ser., 216:191–200.

Viitasalo, M., Vuorinen, I. and Saesmaa, S., 1995. Mesozooplankton dynamics in the northern Baltic Sea: implications of variations in hydrography and climate. J. Plankton Res., 17: 1857–1878.

Voipio, A. (ed.), 1981. The Baltic Sea. Elsevier Oceanographic Series, Elsevier, Amsterdam, 418p.

Vollenweider, R.A., 1968. The scientific basis of lake eutrophication, with particular reference to phosphorus and nitrogen as eutrophication factors. Tech. Rep. DAS/DSI/68.27, OECD, Paris, 159p.

Vollenweider, R.A., 1969. A manual on methods for measuring primary production in aquatic environments. IBP, Oxford, Handbook, 12, 213p.

Vollenweider, R.A., 1976. Advances in defining critical loading levels for phosphorus in lake eutrophication. Mem. Ist. Ital. Idrobiol., 33:53–83.

Vorobev, G.A., 1977. Landscape types of lake overgrowing. Natural Conditions and Resources of North European Part of the Soviet Union, Vologda, pp. 48–60 (in Russian).

Vuorinen, I., Hänninen, J., Viitasalo, M., Helminen, U. and Kuosa, H., 1998. Proportion of copepod biomass declines with decreasing salinity in the Baltic Sea. ICES J. Mar. Sci., 55:767–774.

Wahlström, E., 2000. Effects of nutrient loading on lake foodwebs – a review (in Swedish, Effekter av ökad närsaltsbelastning på födovävar i sjöar – översikt av befintligt kunskapsläge). Vattenbruksinstitutionen, SLU, Rapport 24, Umeå, 34p.

Waller, U. and Boettger, T., 2001. The response of young cod (Gadus morhua) to environmental gradients. ICES CM.

Wallin, M., Håkanson, L. and Persson, J., 1992. Load models for nutrients in coastal areas, especially from fish farms (in Swedish with English summary). Nordiska ministerrådet, 1992:502, Copenhagen, 207p.

Walters, C.J., Christersen, V. and Pauly, D. 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments. Rev. Fish Biol. Fish., 7:139–172.

Walters, C.J., Christersen, V., Pauly, D. and Kitchell, J.F. 2000. Representing density dependent consequences of life history strategies in aquatic ecosystems: Ecosim II. Ecosystems, 3:70–83.

Warren, L.A. and Zimmerman, A.P., 1994. The influence of temperature and NaCl on cadmium, copper and zinc partitioning among suspended particulate and dissolved phases in an urban river. Water Res., 28:1921–1931.

Wasmund, N., 1997. Occurrence of cyanobacterial blooms in the Baltic Sea in relation to environmental conditions. Int. Rev. Gesamten Hydrobiol., 82:169–184.

Wasmund, N. and Uhlig, S., 2003. Phytoplankton trends in the Baltic Sea. ICES J. Mar. Sci., 60:177–186.

Wasmund, N., Voss, M. and Lochte, K., 2001. Evidence of nitrogen fixation by non-heterocystous cyanobacteria in the Baltic Sea and re-calculation of a budget of nitrogen fixation. Mar. Ecol. Prog. Ser., 214:1–14.

Watras, C.J., Back, R.C., Halvorsen, S., Hudson, R.J.M., Morrison, K.A. and Wente, S.P., 1998. Bioaccumulation of mercury in pelagic freshwater food webs. Sci. Total Environ., 219: 183–208.

Watras, C.J., Morrison, K.A. and Bloom, N.S., 1995a. Chemical correlates of Hg and methyl-Hg in northern Wisconsin lake waters under ice-cover. Water Air Soil Pollut., 84:253–267.

Watras, C.J., Morrison, K.A., Host, J.S. and Bloom, N.S., 1995b. Concentration of mercury species in relationship to other site specific factors in the surface waters of northern Wisconsin lakes. Limnol. Oceanogr., 40:556–565.

Watt, W.D., 1966. Release of dissolved organic matter from the cells of phytoplankton populations. Proc. R. Soc., 164:521–551.

Weber, W.J. Jr., McGinley, P.M. and Katz, L.E., 1991. Sorption phenomena in subsurface systems: concepts, models and effects on contaminant fate and transport. Water Res., 25: 499–528.

Westerbom, M., Kilpi, M. and Mustonen, O., 2002. Blue mussels, *Mytilus edulis*, at the edge of the range: population structure, growth and biomass along a salinity gradient in the north-eastern Baltic Sea. Mar. Biol. 140:991–999.

Westin, L. and Nissling, A., 1991. Effects of salinity on spermatozoa motility, percentage of fertilized eggs and egg development of Baltic cod (*Gadus morhua L.)* and its implications for cod stock fluctuations in the Baltic. Mar. Biol., 108:5–9.

Westlake, D.F., 1980. Primary production. The functioning of freshwater ecosystems. Cambridge University Press, pp. 141–246.

Wetzel, R.G., 1964. A comparative study of the primary productivity of higher aquatic plants, periphyton, and phytoplankton in a large, shallow lake. Int. Rev. Gesamten Hydrobiol., 49: 1–61.

Wetzel, R.G., 1983. Limnology. Saunders College Publishing, Philadelphia, 767p.

Weyhenmeyer, G.A., 1996. The significance of lake resuspension in lakes. Uppsala dissertations from the faculty of science and technology 225. Sweden. ISBN 91-554-3820-2.

Wieland, K., Jarre-Teichmann, A. and Horbowa. K., 2000. Changes in the timing of spawning of Baltic cod: possible causes and implications for recruitment. ICES J. Mar. Sci., 57: 452–464.

Winberg, G.G., 1985. Main features of production process in the Naroch lakes. Ecological System of Naroch Lakes, Minsk, pp. 269–284 (in Russian).

Winberg, G.G., Alimov, A.F., Umnov, A.A. and Norenko, D.S., 1986. Productivity and rational use of lakes of Eravno-Kharga system. Investigation of the relationship between food basis and fish productivity. Ackefors, Leningrad, pp. 212–219.

Winsor, P., Rodhe, J. and Omstedt, A., 2001. Baltic Sea ocean climate: an analysis of 100 yr of hydrographic data with focus on the freshwater budget. Clim. Res., 18:5–15.

Wolter, K., 1982. Bacterial incorporation of organic substances released by natural phytoplankton population. Mar. Ecol. Prog. Ser., 17:287–295.

Wotton, R.J., 1990. Ecology of teleost fishes. Chapman and Hall, New York, NY, 404 pp.

Wulff, F., 2006. The Baltic Sea in not like other systems (Östersjön är inte som andra hav). In: Johansson, B., (ed.), The Baltic Sea – threats and hope (Östersjön – hot och hopp), Formas Fokuserar, Stockholm, pp. 51–63.

Wulff, F., Rahm, L. and Larsson, P. (eds.), 2001. A systems analysis of the Baltic Sea. Springer, Berlin, Ecological Studies 148, 455p.

Yan, L., Stallard, R.F., Key, R.M. and Crerar, D.A., 1991. Trace metals and dissolved organic carbon in estuaries and offshore waters of New Jersey, USA. Geochim. Cosmochim. Acta, 55:3647–3656.

You, C.-F., Lee, T. and Li, Y.-H., 1989. The partition of be between soil and water. Chem. Geol., 77:105–118.

Youngson, A.F., Dosdat, A., Saroglia, M. and Jordan, W.C., 2001. Genetic interactions between marine finfish species in European aquaculture and wild conspecifics. J. Appl. Ichthyol., 17:153–162.

Zaitsev, Y. and Mamaev, V., 1997. Marine biological diversity in the Black Sea. A study of change and decline. United Nations Publications, New York, 208p.

Zehr, J.P., Jenkins, B.D., Short, S.M. and Steward, G.F., 2003. Nitrogenase gene diversity and microbial community structure: a cross-system comparison. Environ. Microbiol., 5:539–554.

Zhou, J.L., Fileman, T.W., Evans, S., Donkin, P., Readman, J.W., Mantoura, R.F.C. and Rowland, S., 1999. The partition of fluoranthene and pyrene between suspended particles and dissolved phase in the Humber Estuary: a study of the controlling factors. Sci. Total Environ., 244: 305–321.

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