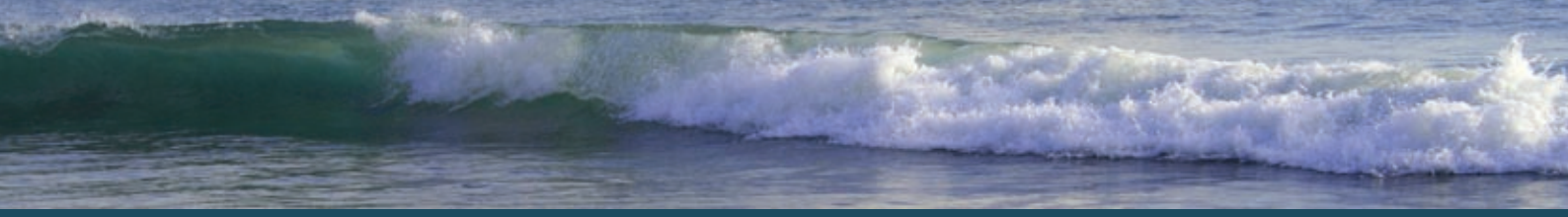


Evaluating the Baltic Sea food web responses to environmental change

Background

Marine ecosystems are constantly under the influence of both a variable and changing environment and a range of human impacts. The latter, including eutrophication, climate change, fisheries and the release of harmful substances, can lead to the deterioration of marine ecosystem goods and services. The Baltic Sea is an example of such a heavily exploited waterbody in which the ecosystem faces a diverse array of anthropogenic pressures.

Why ecosystem modelling?

Modelling offers the possibility to forecast marine ecosystem responses to environmental change and human impacts, based on the understanding of ecological processes collected over many years. Models also offer the opportunity to evaluate potential outcomes of different management policy options prior to their implementation. The Ecopath with Ecosim (EwE) modelling approach employed here gives valuable information on the basic structure and functioning of marine ecosystems and can be used in a wide range of studies.

Modelling the food web response

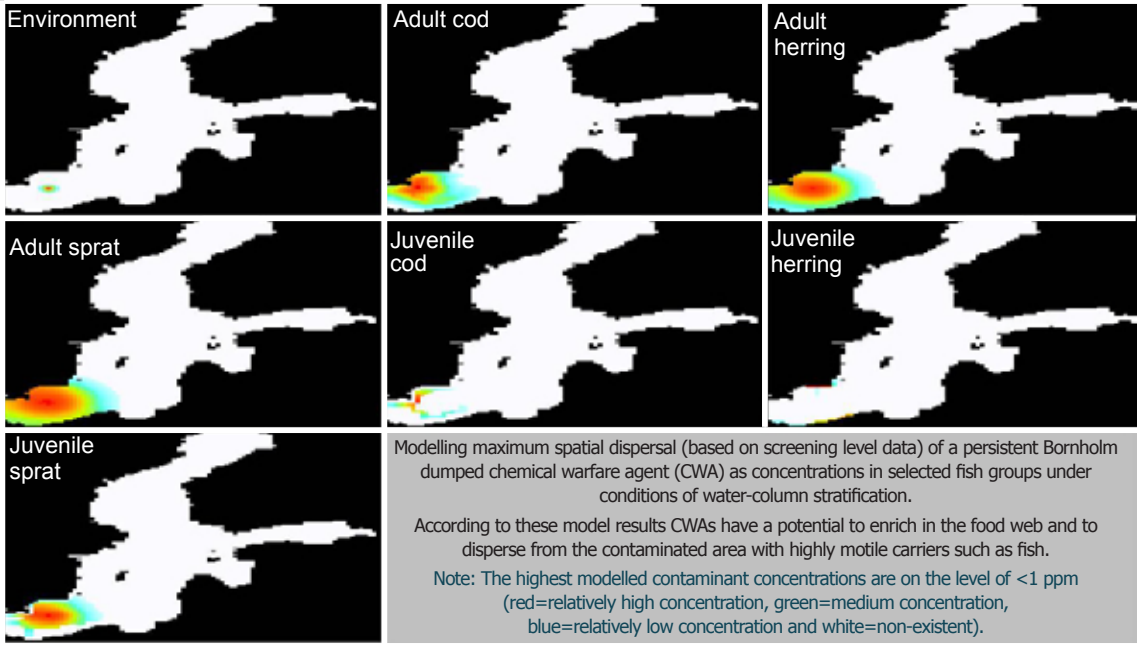
In a relatively simple ecosystem such as the Baltic Sea, ecosystem models are capable of capturing the main ecological processes in the ecosystem, thus providing tools for understanding the responses of the Baltic Sea's food web to environmental change. The Ecopath with Ecosim (www.ecopath.org) platform was used for creating mass-balance food web models that build on two simple equations:

1. **Production = predation + fishery + other mortality + biomass accumulation + migration**
2. **Consumption = production + unassimilated food + respiration**

These mass-balance models provide ecosystem snapshots that reflect the food web structure, pathways of energy flow and species interactions at a given time. Temporal as well as spatial simulations are built on the snapshot models to track changes in the ecosystem at different spatial and temporal scales.

What has been studied?

The EwE -approach has been used to address basic ecological questions and to investigate environmental change-impact scenarios. A particular characteristic of the Baltic sea ecosystem is its capacity to shift states or regimes, by changing its dominant species as a result of environmental or man-made actions. The past and present ecological status of the Baltic ecosystem has been assessed and the models have proved to be capable of characterizing ecosystem regime shifts and identifying the role of human action (e.g. eutrophication and fishery impacts) behind these. In coastal food webs studies have further identified differences and commonalities in trophic cascades (a process that occurs when changes in abundance of particular species release/increase pressure on their prey, cascading its effect across the whole ecosystem) between different regions in the Baltic Sea. Scenario studies have given indications of the possible ecosystem effects of different management decisions. For example, the sensitivity of the Baltic Sea food web to reductions in nutrient inputs has been described and the impacts of fishing on the ecosystem have been studied. Furthermore, the effect of chemical munitions dumped after WWII in the Bornholm basin on biota including fish species (e.g. cod) has been modelled.



Modelling maximum spatial dispersal (based on screening level data) of a persistent Bornholm dumped chemical warfare agent (CWA) as concentrations in selected fish groups under conditions of water-column stratification.

According to these model results CWAs have a potential to enrich in the food web and to disperse from the contaminated area with highly motile carriers such as fish.

Note: The highest modelled contaminant concentrations are on the level of <1 ppm (red=relatively high concentration, green=medium concentration, blue=relatively low concentration and white=non-existent).

Ecosystem modelling – a tool for Baltic policy-making?

BSAP created a need to assess new policies

In November 2007 the Baltic Sea countries signed the ambitious Baltic Sea Action Plan (BSAP). The plan includes a number of actions targeted at preserving biodiversity and reducing the negative impacts of toxic substances. The major focus of the action plan is on reducing eutrophication. Using the best available knowledge (see below) targets for nutrient reductions as well as country specific allocation schemes were agreed on. However, we do not yet know what effects specific reductions on nutrient loads will have on the ecosystem as a whole. Hence, the Baltic Sea food web model could be used to describe these impacts on primary productivity, and develop scenarios on potential cascading effects impacting, for example, commercially important cod and sprat stocks.

Blue-green algae blooms in the Baltic Sea. Photograph: Riku Lumiaro, FIMR.

Baltic Nest- an example of model based decision-making

The Baltic Nest decision support system is an example of successful interaction between an ecosystem model and policy advice. The Nest-model is primarily aimed at describing the flow of nutrients from land to sea, as well as the effects of nutrients in the marine environment. In policy-making this model has been used by the Baltic Marine Environment Protection Commission (HELCOM) to define "critical loads" of nutrient discharge (as determined by the BSAP goals) and to define the corresponding nutrient allocation scheme. Currently, the possibility of incorporating food web modelling as part of the Baltic Nest is being explored.

A traditional Baltic Sea fishing village. Photograph: Fredrik Wulff, BNI.

Evaluating multiple interactions

Food webs are not only influenced by nutrients, but also by changes in oceanographic conditions. Climate driven variation in processes such as rainfall, and parameters such as water temperature, will affect some species and thus their interactions with the ecosystem. For example, inflows of saline, oxygen-rich waters from the North Sea affect deep-water spawning conditions for Baltic cod, as well as pelagic zooplankton. The introduction of invasive species or an intensification of a fishery can alter the ecosystem structure. With ecosystem models these interactions can be studied together and the total impact on the ecosystem can be assessed, hence making these models highly useful in a management context.

Action Points

1. The effectiveness of various marine policy options (e.g. nutrient reductions and fisheries policy) should be explored using ecosystem-wide considerations prior to decision-making.
2. Recent studies have indicated that the size of Baltic fish stocks can influence phytoplankton production. These potential top-down effects should be evaluated with a food web model.
3. Fisheries have a significant impact on the Baltic environment. Hence, ecosystem models should be used as integrated tools to evaluate fisheries management in ecosystem and multispecies contexts as well as to assess the effect of the environment on fisheries.
4. Modelling the enrichment of harmful chemicals in marine food webs should be an integrated part of their risk assessment, especially in cases where validated chemical analytical methods do not exist.

This Fact Sheet was jointly composed by scientists from Finnish Institute of Marine Research, Baltic Nest Insitute and DTU-Aqua. For further information please contact Susa Niiranen (Susa.Niiranen@fimr.fi), Maciej T. Tomczak (mtt@aqua.dtu.dk), Tapani Stipa (tapani.stipa@fimr.fi) and Henrik Österblom (hst@mbox.su.se) or go to www.balticnest.org, www.fimr.fi and www.mercw.org. Download related papers from the Fact Sheet pages at www.EUR-OCEANS.org/KTU.

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