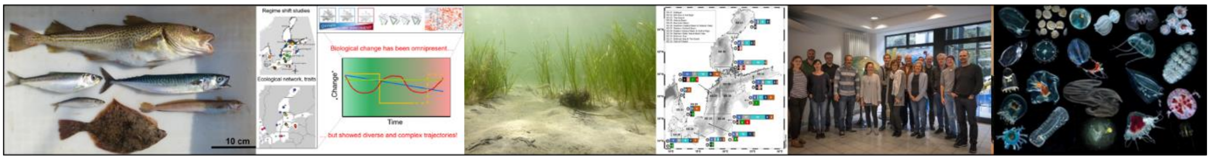
BONUS XWEBS policy brief no. 4[1]



Use and usefulness of food web knowledge in resource management and marine environmental conservation

Highlights

Synthesis work in BONUS XWEBS revealed that food web processes play a central role in the mediation of anthropogenic pressures in the Baltic Sea region. At the same time, the application of food web knowledge in management has varied strongly, from formalized integration in decision making, to supporting the selection of indicators and their relevant biologically meaningful threshold values, to the informal use to explain biological changes and ecosystem dynamics. Barriers to the more formal integration of food web knowledge include the complexity of the involved ecological processes, but also that management frameworks are not designed to incorporate such information in systematic fashion. This policy brief provides a categorization of the multi-faceted uses of food web knowledge and summarizes the status quo of its application in the management of four central environmental concerns in the Baltic Sea. We then highlight the potential future benefits of a more systematic incorporation of food web knowledge, and its fundamental importance for the move towards ecosystem-based management enshrined in present marine policies and directives.

The problem

EU policies, directives and strategies including the Marine Strategy Framework Directive (MSFD), Common Fisheries Policy (CFP), Baltic Sea Action Plan (BSAP) and Water Framework Directive (WFP) require an enhanced ability to hind-, now- and forecast food web dynamics to support management actions under an ecosystem approach. The required knowledge increases proportionally with the speed and amplitude of ecosystem change, and the time-span and spatial scale that management measures aim to address. This is a particular challenge in the spatio-temporally variable Baltic Sea, which is experiencing particularly pronounced changes in environmental conditions and anthropogenic pressures. At the same time, the actual use of food web knowledge in environmental and resource management has not been systematically assessed in the Baltic Sea, hampering recommendations on data, science and governance needs to implement an ecosystem approach. BONUS XWEBS now provided this much needed assessment of the use and usefulness of food web knowledge in the management of four key environmental concerns in the Baltic Sea, eutrophication, chemical contamination, exploitation of living resources and impacts of non-indigenous species (NIS).

[1]*Our policy briefs are summaries of scientific knowledge produced in the BONUS XWEBS project, connected to current management and policy needs concerning the Baltic Sea.*

Key results and conclusions

The mediation of initial pressures to ecosystem-level consequences by food web processes played an essential role in all four assessed concerns. Encouragingly, in line with this importance, food web knowledge was indeed used in resource management and environmental conservation concerning all four areas. At the same time, the specific type of application varied, from informal food web knowledge use to formalized integration in decision making. The schematic summary of one assessment is shown in Figure 1 for the issue of chemical contaminants, whereas Table 1 provides an overarching categorization of the uses of food web knowledge identified from all four reviews

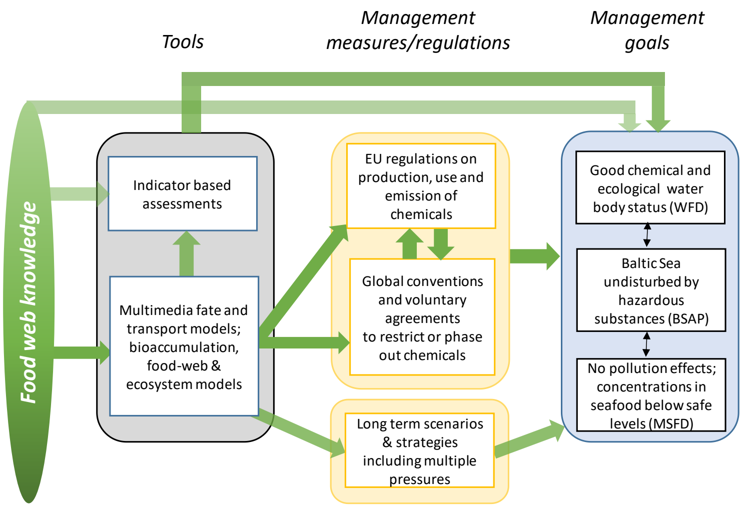


Figure 1. Schematic illustration of the use of food web knowledge in the management of chemical contaminants, exemplifying the assessment carried out for all four environmental concerns. Overarching management goals (blue), associated management measures & regulations (yellow) and relevant tools (grey) channeling food web information. The arrows depict the flow of food web knowledge, with color intensity indicating how well-defined pathway are.

Table 1. Summary of the categories of the use of food web knowledge in a management context identified from the review of the four central environmental concerns in the Baltic Sea, and examples of how knowledge is applied.

Used to...	**Delivery**	**Eutrophication**	**Contamination**	**Exploitation of fish stocks**	**NIS**
IDENTIFY	State indicators & reference values	Water clarity/algal blooms	Potential for bioaccumulation	Sustainable fishing mortality e.g. F_{MSY}	
ASSESS	Status of ecosystems & its components relative to reference levels	Climate/oceanographic/biogeo-chemical models	Bioaccumulation models	Multispecies stock assessment models	Bio-pollution assessments
DEFINE	Specific management measures to reach/ approach targets, avoid limit reference points	Maximum allowable nutrient input	Acceptable pollutant thresholds	Total allowable catches	
PREDICT	System dynamics in response to management under multiple human pressures/climate change	Effects of Baltic Sea Action Plan	Bioaccumulation of specific chemicals	Effects of Multiannual Fisheries Plan	
EVALUATE	Performance of existing & alternative medium/long-term management strategies & plans	Evaluation of country allocated reduction targets		Evaluation of harvest control rules	
EXPLAIN	Changes in ecosystem, progress towards achieving management goals; conceptual & process understanding to develop long-term management strategies	Environmental impact of nutrient loading	Environmental impact of contaminants	Impact of technical management measures on status of fish stocks	Environmental impacts of NIS

This framework provides a foundation on which to base future assessments of food web knowledge application in the management of (other) anthropogenic pressures in the Baltic Sea and beyond.

A highly **adaptive short-term management** can in principal be designed without process-based understanding relying on up-to-date monitoring system covering relevant ecosystem components in adequate spatial and temporal scales.

In contrast, **long-term, strategic management** plans and targets require advanced process-based information and models related to key ecosystem components including drivers and pressures through human activities.

Representation of entire ecosystems and multiple drivers in model systems is required as the projection period expands and several drivers need to be considered.

Application of food web knowledge implies not only gathering qualitative food-web evidence to be able to **interpret dynamics observed** ("explain"), but incorporating quantitative process knowledge at relevant spatio-temporal scales in **defining and testing indicators and setting reference values** ("identify") as well as **describing quantitatively ecosystem states** ("assess").

Adequate representation of food web processes in ecosystem models is a prerequisite to **define effective management actions** ("define"), and develop **predictive tools and management strategy evaluation tools** ("predict" and "evaluate").

Finally, a key overarching question resulting from the above considerations is why food web knowledge is not in all cases used in formalized fashion, given the clear theoretical benefits from doing so. The reasons are case-dependent, but there are two commonalities: first, the involved ecological processes are in all cases complex and therefore at present difficult to capture in simple, intuitive, repeatable measures or indicators that can routinely feed into assessments and management. Secondly, given this complexity, even if the data foundation is good and process understanding advanced, management frameworks are at present often not designed to handle such information.

In combination, these results lead to a set of applied recommendations:

Recommendations

- Environmental and resource managers should explicitly acknowledge the multi-faceted potential benefits of food web knowledge, and its integral role when moving towards ecosystem-based management.
- Scientific advice providers should utilize the framework in Table 1 to categorize food web knowledge use in the management of specific environmental pressures. This will help identify shortcomings in the application of knowledge, and help define a plan towards more systematic incorporation.
- The research-, funding- and resource management communities need to tackle the current barriers hampering food web knowledge incorporation. This includes the need for…
    - … better quantitative understanding of the consequences of **simultaneous top-down and bottom-up effects** (e.g. fisheries vs. eutrophication and climate change).
    - … enhanced **process models** to be integrated into ecosystem models to predict/simulate ecosystem dynamics across trophic levels.

- ○ … **integrated models** encompassing key trophic levels, physical forcing, physical-biological interactions and biogeochemical processes to simulate cumulative impact of drivers.
- ○ … iterative assessments ensuring that what we deliver the necessary data, update process models, factor them into integrated models and improve their capabilities to evaluate management measures and strategies before and after implementation.

- Priorities in this context should be:
  - The **modification of monitoring programs** to deliver information on several trophic levels and associated external pressures simultaneously on relevant temporal/spatial scales.
  - **Improving currently limited process understanding,** e.g. regarding trophic interactions, prey selection and migration/distribution changes of ecologically important species incl. NIS.
  - **Enhancing model configurations** to be able to capture complex interactions acting on individual, population, community and ecosystem level.

- Finally, there is a clear need not only for the integration of monitoring programs, existing primary data and models, but also their alignment with management goals and needs; vice versa, management frameworks need to be designed to be able to account for the available, often complex scientific information.

This policy brief is based on synthesis work and thoughts developed in XWEBS WP4 “Knowledge to management”, and the corresponding WP4 manuscript:

Margit Eero, Jan Dierking, Christoph Humborg, Emma Undeman, Brian MacKenzie, Henn Ojaveer, Tiina Salo, Fritz Köster. Use and usefulness of food web knowledge in resource management and marine environmental conservation. In review at ICES Journal of Maine Sciences.

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BONUS XWEBS - For more overarching information on Baltic food webs and other project output and policy briefs, visit our XWEBS website.

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