Document title	Discussion paper on initial ideas on pelagic habitats and food webs including comments
Code	3-2
Category	INF
Agenda Item	3 – Setting the scene: assessing food webs
Submission date	14.4.2021
Submitted by	Secretariat
Reference	

Background

This document was shared by the Secretariat with identified HELCOM Expert and Working Groups members on 10 September 2021 to initiate discussion on the topics of pelagic habitats and food webs/ecosystems. Comments received to this document have been compiled in the text, shown in red text below. Comments so far received from Sweden, Denmark, Finland and Germany have been included.

At the First HELCOM Indicator Workshop the topics of pelagic habitats and food webs were raised as issues that should be addressed at the 2nd HELCOM Indicator Workshop (16-18 October 2019) – see information provided within the document below. Since there is currently no designated HELCOM Expert Group that covers these topics directly the Secretariat has drafted a discussion paper on the two topics, see below, that is now shared with existing HELCOM Expert and Working Groups that may address the topics (in part or in full). The document is provided now in preparation for the Second HELCOM Indicator Workshop, simply as a way of initiating discussion on the topics. This document could form a document that is submitted to the Second HELCOM Indicator Workshop, if needed, but comments directly to it or alternative and more appropriate approaches for shorter-term and longer-term development of suitable HELCOM indicators on these topics would also be most welcomed.

Is 'pelagic habitats' not covered by PEG?

The document represents a prior steps taken under the *Future work on HELCOM indicators* process, as summarised under document 4-20 to HOD 57-2019. The information was used to support discussion at the Second HELCOM Indicator Workshop on the topic of foodwebs.

Action requested

The Meeting is invited to take note of the information.

Preparation for the HELCOM indicator workshop 2-2019

The following topics (pelagic habitats and ecosystems/food webs) were addressed in the first HELCOM indicator workshop in May 2019. These form important components contributing to HELCOM Baltic Sea Action Plan aims and objectives, e.g. Favourable status of Baltic Sea biodiversity, natural marine and coastal landscapes, thriving and balanced communities of plants and animals, viable populations of species. Below in this document are some initial ideas put on paper to initiate discussion. The ideas are loosely formed and the main aim is to address issues raised at the first workshop so that concepts can be developed and progress be made towards a better third holistic assessment (short term), and beyond. Some of the ideas here should be considered in a longer-term perspective (i.e. post-HOLAS III) as the plan here is devise an ideal conceptual approach and then identify what can be realistically achieved in the shorter-term perspective also (e.g. by HOLAS III).

Please adjust, correct, or proposal better alternatives to all aspects below as these are initial ideas only by way of starting the discussion.

Foodwebs

FROM 1st HELCOM INDICATOR WORKSHOP 2019: HIGH priority areas/indicators identified for adjustment/development– for HOLAS III: Food webs, particularly the diversity and balance of trophic guilds to initiate discussion related to the development of a viable assessment approach (MSFD D4C1 and D4C2). The immediate focus will consider how the topic can be tackled in HOLAS III and the longer-term aims for improved assessments post-HOLAS III. Clarify a framework for the assessment, a suitable constellation of indicators, and a clear rationale for the assessment system.

Thank you for this first draft overwiev of what could be done in regards to the food web indicators, some general comments to the document:

- As a HELCOM CP that are also member of EU, it is important that the indicators developed in HELCOM can also be used to support CP's in ther national obligations under MSFD.

- Since the the work with indepentend food web indicators are still in the initial phase, we are of the wiev that we should try to keep it as simple as possiple. Eg. By focusing on one of the proposed ecosystem (pelagic/coastal/benthic) and limit ouer focus to few areas as eg. diversity within trophic guilds and balance of abundance between guilds.

- Maybe it would be an idea to cooperate with OSPAR, since they are having the same discussions on how to assess food web.

- It would also be helpful to discuss the establishment of an official regional list of trophic guilds that will be assessed.

- Ecosystems, including food webs (taking an MSFD perspective) need to consider/develop a list of trophic guilds via regional/sub-regional cooperation (where species or lowest appropriate taxonomic level is considered).
- Must include minimum of 3 trophic guilds, 2 must not be fish, 1 must be a primary producer – ideally primary, secondary and top included.
- ICES list of tropic guilds as advice/guidance: primary (phytoplankton), secondary (zooplankton), benthos (filter-feeders, deposit-feeders, planktivores, benthic feeding fish, benthic-feeding birds, demersal predatory birds), pelagic fish (planktivores, sub-apex and apex), birds (planktovores, sub.-apex and apex), mammals (apex).

Apex could also include certain piscivorous fish.

- Other aspects raised in ICES Special Request Advice (published 20 March 2015): trophic and functional groups, potentially includes all living organisms and non-living organic components, network of feeding interactions between consumers and their food (Rogers et al., 2010), reproductive capacity maintains fertility and avoidance of reduction in population genetic diversity
- Possible aspects to consider when assessing ecosystems/foodwebs (for each taxonomic component): diversity, species composition, relative abundance, balance of total abundance between trophic guilds, size distribution of individuals, productivity (last two being secondary MSFD criteria).
- Identified HELCOM indicators of potential relevance include: phytoplankton (seasonal succession, diatom-dinoflagellate index, cyanobacterial bloom index, chlorophyll-a), zooplankton, fish (migratory, commercial (?), coastal and aspects such as length under development), birds (wintering birds, breeding birds and eagle), and mammals (three seal spp. and harbour porpoise).
- Identified HELCOM expert areas: Phytoplankton Expert Group (PEG) and Intersessional Network on Eutrophication (IN EUTRO), Benthic Habitats Expert Group (EN BENTHIC), Zooplankton (ZEN-ZIIM), FISH PROIII, EG MAMA, and JWG BIRD.
- Identified HELCOM working group of relevance: State and Conservation and FISH.

- Habitat types to be assessed? Should different assessments be made for different habitat types? If needed could this be done based on HELCOM HUB and existing HELCOM assessment units (e.g. scale 3 and coastal areas)? Same division as pelagic habitats in MSFD needed, i.e. variable salinity, coastal, shelf, oceanic (beyond shelf), other types defined by regional or sub-regional cooperation?

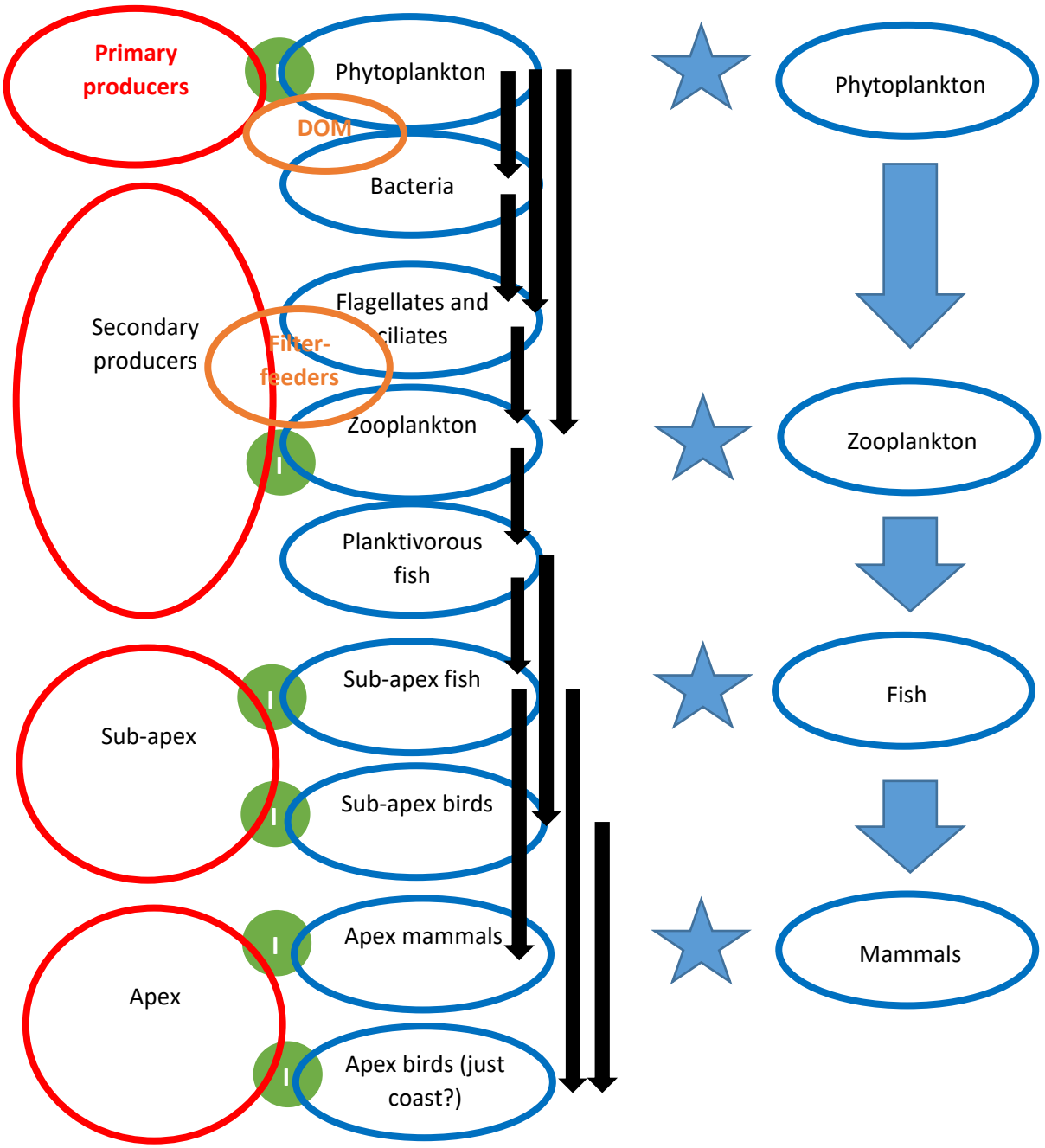
Is data for all suggested guilds represented at this scale? Perhaps scale 2 is better if mammals, birds and plankton should be included?

Very simplified food webs

Below are some simplified food web/ecosystem ideas for pelagic, coastal and benthic ecosystems. Outlined under that are some ideas on possible short- and longer-term indicator approaches.

Regarding the diagram below some changes and alteration should be considered, for example: are planktivorous fish seen as secondary consumers? No fish species in the BS are feeding on phytoplankton in the way that flagellates, ciliates and zooplankton do. Where are piscivorus fish? Is it the same as sub-apex fish? I think one should split fish that feed on benthos, planktivores and piscivores.

Pelagic ecosystems

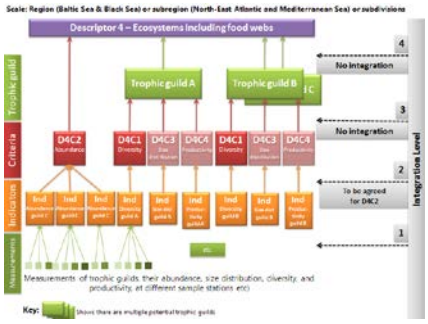


The above figure is a very crude food web for pelagic ecosystems (food webs). It tries to put together some of the taxa but also to divide them up into guilds, including based on functional aspects. The terms added try to take into consideration terms set out in the MSFD and in the ICES guidance from 2015. The black arrows are simplistic links between the compartments in the food web and the green circles suggest where there are HELCOM indicators (operational, or down to candidate) that may be relevant for the approach. Where the stars are indicates what could represent a simple but valid food web/ecosystem indicator (i.e. bringing the assessment of these four components together). Ideas on possible indicator/assessment approaches below.

The black arrows are more indicative of a food chain. Shouldnt there be links going the top-down path as well? This is very bottom-up focused in the current form.

Clarification – the stars indicate 'areas' where there are existing or under development HELCOM indicators that could, in theory, be used for a simple assessment.

When it comes to the structure and what indicators to develop, I do not have a fixed solution, but we could be inspired by draft MSFD art 8 guidance, that shows some thoughts on how it could be done.



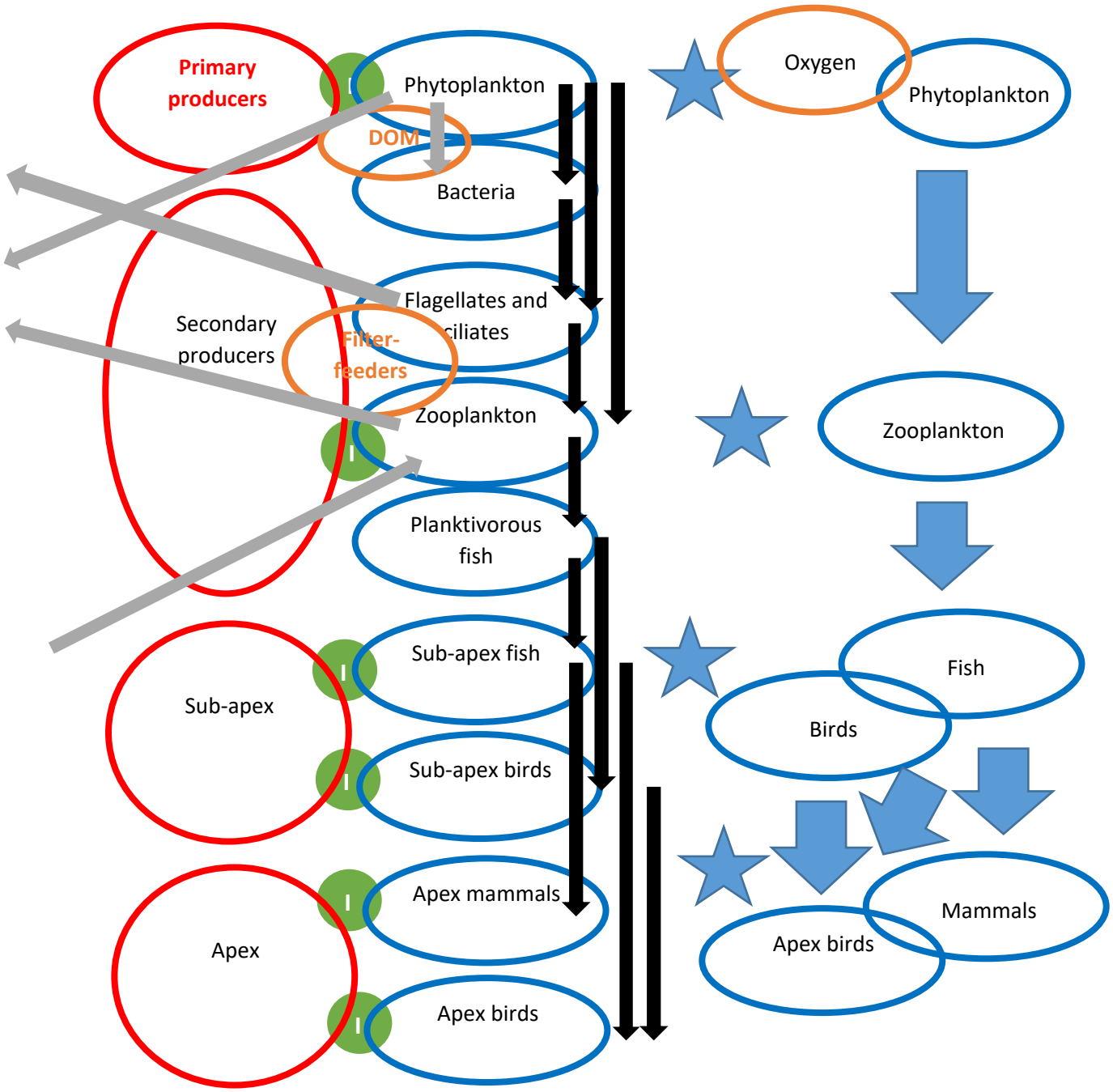
Here is a brief idea for developing indicators for food web.

The top layer (purple in the figure) could be an "umbrella like" indicator giving an final description of the entire food web for the chosen ecosystem (pelagic/coastal/benthic). This owerarching indicator will include results from the assessment of abundance between throphic guilds in the current ecosystem and diversity within single trophic level in the same ecosystem. GES is not defined at this level.

One indicator is developed for abundance between throphic guilds in the the current ecosystem. GES is defined at this level. This assessment will go directely to the "umbreala" indicator to be used in the joined description of the state of the current ecosystem.

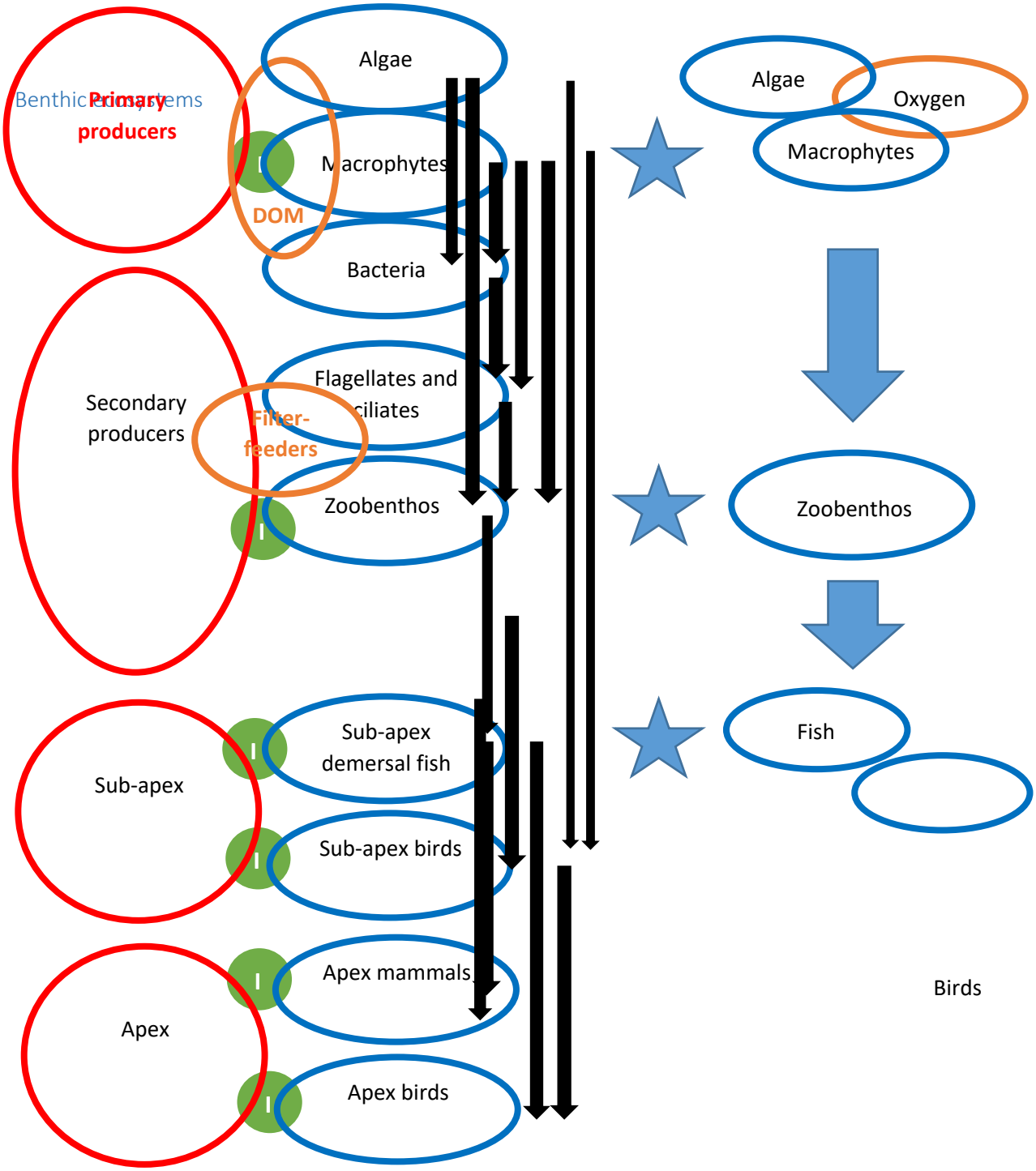
Several indicators (one per throphic guild - eg. Primary producers, sec. Producers, sub-apex and apex) are develop to assess diversity within single trophic level in the same ecosystem (pelagic/coastal/benthic). GES is defined at this level for each throphic gulid. All assessments of diversity will hereafter go to the "umbrella" indicator to be used in the joined description of the state of the current ecosystem.

Coastal ecosystems (aquatic part)



As with pelagic habitats, above, but grey arrows indicate potential interaction with the benthic environment is coastal (especially shallow) areas. Could an assessment cover all or various routes in the above flow (right hand side) – i.e. using the productivity aspect for the eagle indicator, or using the haul out component in the seal indicators. Adding the abiotic oxygen factor could also be a strong factor as any poorly oxygenated coastal zone is unlikely to be of good status. It could also rely on selected aspects from the bird indicators, for example selecting the component related to waders.

Same comments as on above diagram.

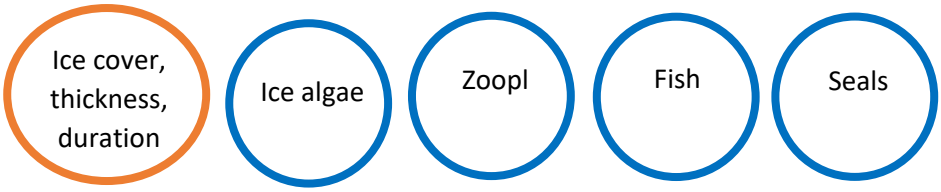


For benthic habitats could fish consider just demersal ones (e.g. could cod be used or could some flat fish be considered only), or could migratory fish also be relevant, possibly also juvenile stages of fish that use the coastal area for breeding? Birds could again be selected to only look at the benthic feeding group from the indicators. Mammals are excluded here, as is the eagle, since separating them specifically to only benthic appears difficult. Grey arrows from coastal above also relevant here. See more discussion below on benthic-pelagic coupling.

Same comments as on above diagram.

Ice ecosystems

Should ice-cover be considered here as part of the Baltic ecosystem assessment? It has critical importance for some things, e.g. ice algal and microbial communities, timing of spring blooms, and also for breeding of ringed seals.



While the middle three may be problematic or costly for monitoring then possibly number 1 and 5 (ice cover aspects and could act as an indicator of ice ecosystems for now.

From an MSFD perspective: a little bit strange to include the physical habitat here I think as there is no criteria for habitat within D4 in the MSFD. The algal and bacterial communities in the ice might very well be assessed, but not the ice cover itself.

Possible options could include:

1. Developing a specific food web indicator that summarises these aspects using a specifically designed method (e.g. some multi-dimensional scaling approach). Possibly a similar approach to those above for pelagic habitats but taking into account more trophic guilds. Could future developments in BEAT provide the integrated assessment for such ecosystems?

With this it is meant that a multivariate index based on several indicators of the food web are used to describe the ecosystem state?

2. Applying a one-out-all-out (OOAO) approach, or alternative to this aggregation approach to existing HELCOM indicators could provide an assessment in the short term (or longer). There are many assumptions involved here such as that all threshold vales are somehow in correspondence with one another.

It might be relevant to look at draft MSFD art 8 guidance that shows a possible way forward for the integratione of food-web indicators. And how to use the different componants for one assessment per throphic guild.

For example (as above some scaling/averaging approach could also be applied):

Should there be tresholds for status for food webs? Arent there just different states that we are observing?

3. As above with the OOAO approach, but set so that the approach only covers each issue/component separately (e.g. diversity, species composition, relative abundance, balance of total abundance between trophic guilds, size distribution of individuals, or productivity). This would mean that any integration/aggregation of indicators to assess a food web/ecosystem would only focus on a single parameter, i.e. comparison between trophic guild is only carried out with one of these components, for example abundance is used for all trophic guilds. This would require thresholds per tropic guild for each component to be in place so that a OOAO or some scaling approach could be applied.

Should there be thresholds at all? D4 might serve as a surveillance indicator wothout thresholds?

4. Using the above and subsequently combining multiple components so that ecosystem is assessed with greater overview/certainty, for example combining abundance, size and diversity components.

5. Baltic Sea ATLANTIS model (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0199168). Could this model be used to evaluate an ecosystem or food web in the Baltic Sea? The model itself contains many of the tropic guilds and functional aspects covered above. Could the model be re-adapted by feeding in data from agreed reference periods (e.g. those used in established HELCOM indicators – for practical reasons currently the model uses data from 2005 as main input to structure the model)? Could the model be run using data inputted to the model for components where there are known data trends for an assessment period – and would forcing the model via the data inserted indicate if a functional food web/ecosystem was achieved (i.e. the model would be inhibited by data that was 'out of balance' – e.g. if oxygen was too low or if zooplankton biomass was too low then the model would fail to run beyond a certain stage and compute an error – result being a failure to achieve balance food web and red status)? Could applying the data for indicators on important sections of the food web (e.g. phytoplankton, zooplankton, fish and mammals) test if the model provided a balanced result – thus indicating of the ecosystem/food web is functional/in good status? Could this model be used to also evaluate if the good status threshold values for different assessment components are compatible (e.g. could it indicate if good status threshold for nutrients equates with good status in bird or zooplankton)? Could threshold values agreed in HELCOM be applied to the model output (e.g. all the trend figures per trophic group) also to determine which factors may be the 'break points' in the ecosystem (e.g. by adding in the status of zooplankton as a fixed value and running the model could it infer if fish or phytoplankton were the potential causative factor)? Could running the model driven by multiple different scenarios (including based on fixed values from known data or threshold values) inform on ecosystem/food web functionality and status?

Can we define a reference state for food webs? Arent they just in different states? Defining 'functionality' in this concept would need to be examined as all food webs can be considered as functional just in different ways.

Additional details provided by some of the the ATLANTIS model autors: It should be possible to cover most of the options you mention with Atlantis in point 5.

Concerning abundances and biomasses of different functional groups in the food web in the Baltic Sea ecosystem (see below) the Atlantis model can in context of HOLAS III be calibrated to other certain baseline year(s). Also, the Atlantis can be calibrated to a given year concerning physical and hydrographical forcing by the RCO-SCOBI climate and bio-geo-chemical models.

Atlantis estimates the biomass pool (and production) for each of the 29 functional groups in the Baltic Sea ecosystem and foodweb for the different areas (Atlantis polygons) on a seasonal and yearly basis (for any period). Accordingly, this can also used for evaluating species composition, relative abundance (or biomass), and to evaluate balance of/between total abundance/biomass in trophic guilds, and to define robust guilds on a regional basis according to ecosystem and forcing dynamics. Also, size distributions for the vertebrates can be evaluated for the vertebrates, which by the way are separated into age groups and the juvenile and mature part of the population. Furthermore, Atlantis estimate abundance, biomass, mean weight, mean length, size distributions and frequencies, weight distributions and frequencies, and age distributions and frequencies for the vertebrate functional groups. This among other covers bacteria (benthic and pelagic), phytoplankton, ciliates/flagellates, makro-algae, makrophytes, micro- and meso-zooplankton (two groups in the foodweb, but combined so far in biomass), mysids, gelatinous zooplankton, fish (cod, sprat, herring, whiting, flatfish, small demersals, small pelagics, carps and perch), Nephrops, marine

mammals (seals, harbor porpoise), and pursuit diving seabirds. With respect to the benthic community the Atlantis also cover a long row of benthic invertebrate functional groups such as mussels, polychaetes, etc.

The model include carefully informed and data driven food web and biological interactions as well as food web interactions with the physical environment and habitats. Reproductive capacity is not evaluated in detail.

Furthermore, Chl.a is estimated as model output as well. Concerning biodiversity (species richness – see further below). Concerning non-living organic components Atlantis cover carrion, fractional and labile detritus, and groups of dissolved and particulate organic matter.

According to the above qualities, the Atlantis can contribute to evaluate the robustness, sensitivity, and possible reversibility of different food web indicators as described in the discussion paper.

We consider it in this context to be relevant and a good idea to make comparative evaluation of ensemble modelling outputs and approaches considering both estimates from and evaluations by the Baltic Atlantis model (Bossier et al. 2017) and the Baltic Ecopath w. Ecosim w. Ecospace model (Bauer et al. 2018). The Atlantis model may be more robust in evaluating gradual changes over time according to climate and eutrophication forcing also considering gradual changes in carrying capacity, while the latter model may be more robust in evaluating spatial changes in habitat distribution and quality for example in relation to oxygen depletion areas. Given assumptions in the EwE model on depletion of certain species in high resolution spatial areas this model may also be more robust in predicting changes in biodiversity. However, it demands very strong assumptions in biological models to estimate actual extinction of a species, so we would be careful with letting such models evaluate changes in biodiversity (species richness).

Please note that the above suggestion related to Baltic ATLANTIS is based purely on initial considerations, and a brief initial discussion with some of the authors. Thus, it is important to consider here that this may be impractical and the details need further discussion to determine if it could be applied. Any work on this would need to consider reviewing what can be done and would likely have resource implications for the experts.

6. Food web efficiency (FWE) approach. This approach would ideally utilize data related to production in terms of carbon and would show how efficiently carbon is transferred through the food web (e.g. Berglund et al., 2007 Limnology and Oceanography 52(1), 121-131).

7. There is also work in the North Sea looking at food web indicators and a national (Germany) project called StoPP that investigated food web interactions in the Wadden Sea by using the "ecological network analysis" (ENA) (see: https://deutsche-kuestenforschung.de/stopp-214.html). There are some publications from this project that can be found here: https://www.nationalpark-wattenmeer.de/sh/misc/publikationsliste/5434.

8. Food web assessment – using biomass and non-dimensional scaling approach to make everything comparable and then be able to estimate the relative balance between the selected partitions from the food web. Can explore providing more details from former colleagues on this idea (based on contacts in Denmark, Sweden and Finland).

9. An approach which considers only selected species or taxa based on knowledge of pathways and interactions – e.g. cod/sprat/herring and zooplankton. See note below‡.

10. Other indicators where their evaluation can be defined as the result of the food web status associated to the measured variable(s) (e.g. seal health, longest fish, etc). For example reviewed in Tam et al., 2017 (https://doi.org/10.1093/icesjms/fsw230): guild level biomass and production, primary production to sustain

a fishery, seabird productivity, zooplankton size biomass index. Other options such as integrated trophic indicators, ecological networks and dietary diversity indexes and condition indicators also discussed. See note below‡.

‡Do the above two meet the requirements of policy (don't directly cover multiple trophic guilds)? Can these approaches be considered to suitably address ecosystems in a holistic or ecosystem-based management approach? Are these valuable since they can miss defining the causal factors underlying the assessment?

11. Could coastal and benthic be combined in an assessment? For example, since benthic and pelagic habitats are logically inseparable, especially in shallow coastal areas (nutrient or biota exchange etc) could all coastal areas of a certain depth (e.g. <60 m or based on photic zone, say 20m) be assessed as a combination of benthic and coastal pelagic (i.e. to account for benthic-pelagic coupling)? It would then allow the combination of the coastal and benthic aspects and give a larger number of food web 'compartments' to construct an indicator from. Could a list of habitat types/ecosystem components be needed as a regional/sub-regional agreement?

12. Could balance of total abundance between trophic guilds be considered also? Is there sufficient information to know how much fish a seal needs to eat to grow well or sustain itself, how much zooplankton a fish needs to eat to grow well or sustain itself, etc. Could this be made as a model structure based on carbon transfer or energy requirements/transfer between trophic guilds? Could threshold values on required abundances for each trophic guild then be set that would relate to the balance between each gild to support a functional ecosystem in good status?

Concluding thoughts

Much of the information above is presented divided into sections for practical reasons (e.g. taxa, habitat type or benthic ecosystems). While this is practical for describing the topic into clear divisions it is likely important to consider how these assemble together. For example, when assessing ecosystems/food webs an ecosystem-based approach may not consider these as independent units that can be assessed alone, thus a broader evaluation may be important. This could be represented by assessing them independently (i.e. for practical and data collection purposes) followed by integrating this together at an end step such as an integrated assessment. Alternatively, an independent and ecosystem encompassing method may be the best development.

In addition, all of the above should be considered within the step-wise development process proposed for the indicators (i.e. short and longer-term developments). Are some of these options suitable for initial and interim developments to provide initial assessments in the shorter-term? Are others more suited to longer-term developments due to the required development involved? Do some provide an overview without delivering a really detailed and substantial assessment, enabling a status to be assigned but insufficiently addressing the Baltic Sea ecosystem? These aspects should be kept in mind so that any assessment system can be adapted and developed to ensure that the Baltic Sea is assessed using the highest level of scientific knowledge and considers the health and status of the ecosystem as its ultimate goal.