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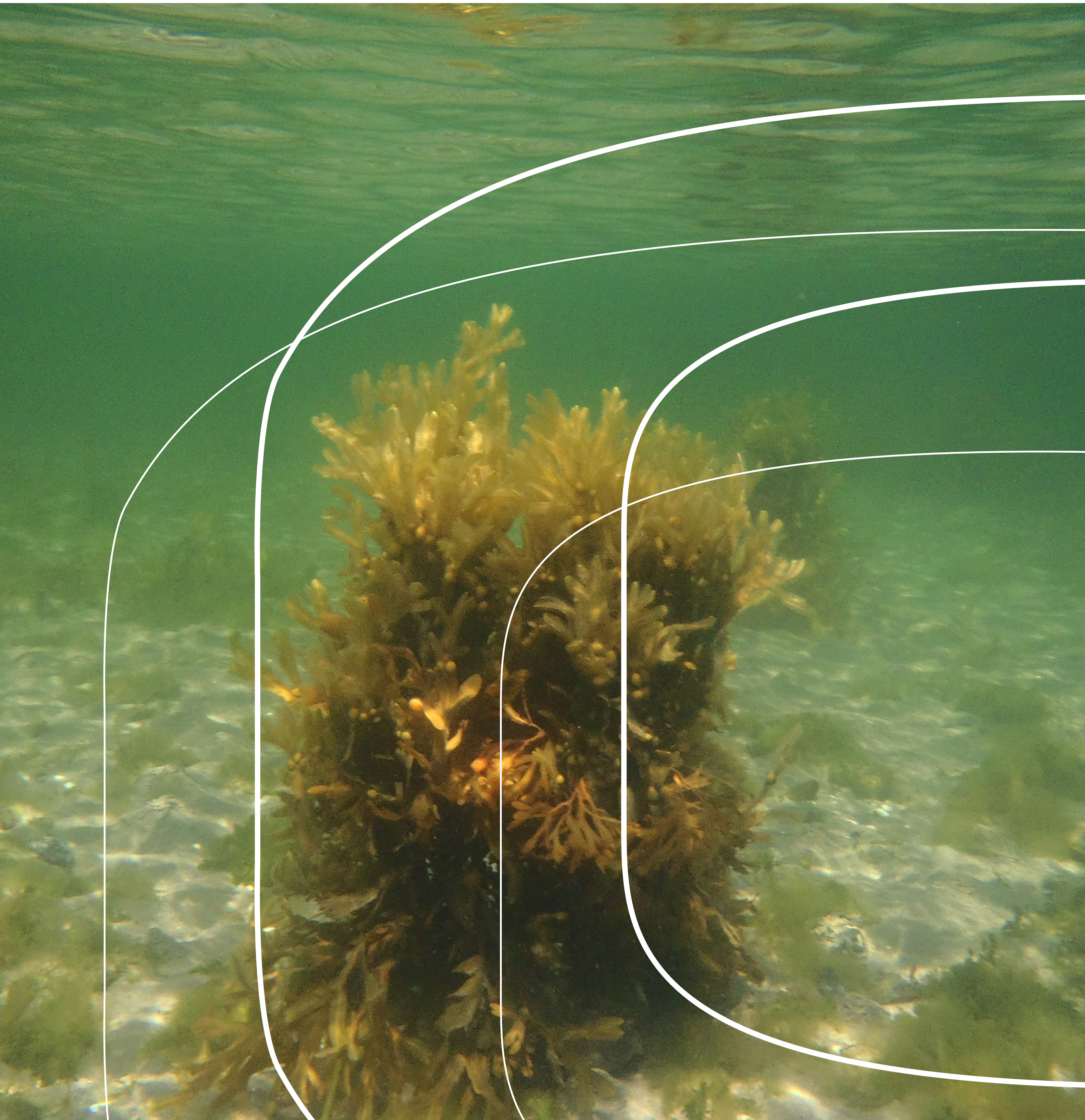

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Preface

Many coastal and offshore fish species in the Baltic Sea are strongly dependent on shallow and sheltered near-shore habitats for their spawning, nursery, feeding and migration. Still, the role of these essential fish habitats, EFH, for the development and support of fish stocks and communities has received relatively little attention. As EFH in the Baltic often are found in the same parts of the coastal zone that are highly utilized and valued by humans, they are subjected to many threats and therefore management needs are urgent. In addition, EFH provide and support important ecosystem services and are included in national and international agreements and legislative acts as the Baltic Sea Action Plan, Habitats Directive and Marine Strategy Framework Directive. Despite this, the conservation status of EFH is generally poor in the region.

As a result of these shortcomings and needs, the Nordic Council of Ministers financed a project including a workshop with Baltic Sea experts with the aim to review the importance of, protection of and threats to coastal EFH in the Baltic Sea. This report describes the results of the project, primarily focusing on the outcome of the workshop.

Figure 0: Group photo of the workshop participants

Summary

Many fish species in the Baltic Sea are highly dependent on shallow and sheltered coastal habitats that they use for spawning, nursery, feeding and migration. Still, the role of these essential fish habitats (EFH) for the development and support of fish stocks and communities has received relatively little attention, even though there is general consensus among scientists about their critical importance. Little is also known about the major threats to EFH, and their conservation status in different countries has previously not been reviewed. As EFH often are found in the same parts of the coastal zone that are also highly valued by humans, this gap in knowledge needs to be addressed. Hence, there is an urgent need to focus more thoroughly on the importance, mapping, monitoring and protection of EFH and also the driving factors and mechanisms behind the changes we observe in their status. Only this way, we will be able to predict and mitigate future effects of environmental change in these valuable habitats and to create adaptive management plans.

The main objectives of this project were to 1) organize a workshop for experts around the Baltic Sea on the importance, protection of and threats to coastal EFH (including an overview of the methods used for the mapping and monitoring of these habitats), and 2) based on the outcome of the workshop, produce a review paper in an international scientific journal about the state of the art of the subject for the Baltic Sea, including knowledge gaps and future research needs. Here, we report the results of the project, focusing on the outcome of the workshop.

From the workshop (organised during 2nd–4th June 2015 in Öregrund, Sweden) we conclude that there are only few quantitative studies available concerning the importance of EFH for fish stocks. This evidence is in turn quite complex and do not necessarily provide straightforward answers. Nevertheless, for some coastal species, indirect evidence exists and sufficient data are also available to carry out further quantitative analyses. More evidence on the role of EFH for fish production could potentially also be achieved using spatial and temporal data analyses, stage-structured modelling and otolith chemistry techniques. Based on qualitative results/analyses, it can be reasoned that EFH are very important and valuable for the provisioning of rich fish communities and for

fish production. This conclusion is reached, despite the still quite low degree of targeted studies that are focusing explicitly on the role of the habitats and that are providing straight quantitative relationships. Most likely the importance of these habitats has been underestimated in the past and more studies could contribute to pinpoint their ecological importance.

For the monitoring and mapping aspects of EFH in Baltic Sea countries, a lot of data seems to be available. Different sampling methods are used for a wide range of both coastal and offshore species and life stages (from eggs, larvae, YOY (young of the year) to adult fish). The use of these data in producing habitat maps has for long been poor, but the situation is now improving rapidly in many countries as a result of national and regional underwater mapping and inventory programs. In this sense, not only habitat mapping and mapping of fish distribution (fish in different life stages) are of importance. Also the mapping of major threats, pressures and environmental background conditions should be performed. This would ensure maximum availability and optimized use of information necessary for efficient management and for the improvement of marine spatial planning.

The threats to and conservation status of EFH suggest urgent and diverse management solutions. Eutrophication, climate change, coastal construction and development, invasive species and fishery seem to constitute the major threats to the habitats. Among these threats, the physical pressures, including for example marine shipping/boat traffic and its associated infrastructure (like dredging), physical exploitation of shore areas and trawl fishery, tend to be more easily manageable. These activities disturb fish habitats both directly and indirectly, and are typically more serious to fish reproduction and juvenile stages. The conservation status of EFH is generally poor, mainly due to that fisheries management and nature conservation in the Baltic Sea region historically have been separated. Internationally, however, many marine ecological studies have shown how mutual benefits may be reached through an integrated management of fisheries and habitats. This gives EFH a central role in management, merging the interests of fisheries management and habitat protection, and simultaneously attracting a lot of scientific interest to associated research questions.

The results of the current project hence suggest that there are data for quantitative analyses to support the role of EFH for fish production, a potential to initiate, develop and synchronize future monitoring and mapping of the habitats, and that there is an increasing awareness for the protection and increased concern for the sustainability of these shallow coastal systems. The outcome of this project could serve as a basis for improving cooperation between Baltic Sea countries in this field, which in the long run could result in both harmonized monitoring and mapping methods of the EFH in the Baltic Sea and a strengthened management. The work also provides important input for developing indicators to assess the status of EFH and for the implementation of international agreements and legislative acts as the Baltic Sea Action Plan (BSAP), the Habitats Directive (HD) and the Marine Strategy Framework Directive (MSFD).

1. General background

The Baltic Sea is relatively shallow in relation to its size, and the coastal zone constitutes a large and ecologically important part of the system. The environmental status of many coastal areas of the Baltic Sea has declined during recent decades, partly as a result of increased eutrophication, but also due to climate change, coastal development and the introduction of non-indigenous species. Many studies report that evident changes in species composition of coastal fish and benthic communities have taken place during the past 30–40 years (e.g. Olsson *et al.* 2012, 2013a, Rousi *et al.* 2013, Snickars *et al.* 2015, Weigel *et al.* 2015). The habitat quality of shallow coastal ecosystems is also affected by non-indigenous species especially in inner coastal areas, since most of these species are originally spread by vessels (Katsenevakis *et al.* 2014, Ojaveer and Kotta 2014). In addition, evidence is accumulating for the occurrence of trophic cascades in the coastal system. In areas where populations of coastal predatory fish such as perch (*Perca fluviatilis*) and pike (*Esox lucius*) are weak, mesopredatory fish, such as the three-spined stickleback (*Gasterosteus aculeatus*), are present in high numbers (Eriksson *et al.* 2009, 2011, Bergström *et al.* 2015, Byström *et al.* 2015). These mesopredators can have substantial impacts on the community of invertebrate grazers, reducing their numbers and hence the grazing pressure on algae, ultimately leading to eutrophication symptoms and habitat changes with blooms of ephemeral filamentous algae (Korpinen and Jormalainen 2007, Baden *et al.* 2010, Sieben *et al.* 2011, Östman *et al.* 2016). Sticklebacks may also affect the egg and larval stages of many species of predatory fish negatively, further emphasizing this problem (Bergström *et al.* 2015; Byström *et al.* 2015).

An integrated management strategy which both includes fish and their preferred environments hence appears to be of key importance for combating eutrophication symptoms in coastal areas. Given the importance and vulnerability of coastal areas, a central focus on these parts of the Baltic Sea ecosystem in management would be pivotal for the future potential of the sea area to provide ecosystem goods and services (Ahtiainen and Öhman 2014, Sundblad and Bergström 2014, Sundblad *et al.* 2014, Bryhn *et al.* 2015). In order to halt the ongoing negative development and reverse the current unfavourable ecosystem status of the Baltic Sea, additional effective management actions are needed along with the current methods concentrating on reduction of nutrient loads. To support similar management measures, we need to build knowledge of the causal factors for ecosystem change and how these factors interact, and to monitor and assess the status of key ecosystem components such as for instance the availability and conditions of essential coastal habitats for fish, EFH.

EFH may be defined as environments necessary for any life-stage of a fish species and their importance can be assessed as the effects of changes in the quantity and/or quality of these habitats on populations or stocks in time or space (see e.g. Hansen and Snickars 2014, Sundblad *et al.* 2014). EFH thus includes nursery areas, feeding areas, spawning areas and migratory routes. The latter three habitats may be important for fisheries because of high catches or value per fishing effort. Therefore some habitats are important both for fish stocks and for fisheries, which creates challenges for their sustainable management. Despite the evident role of EFH for development of fish stocks, they have still in northern Europe received relatively little attention (but see Sundblad *et al.* 2014).

Many coastal fish species are highly dependent on shallow and sheltered coastal habitats, such as coastal wetlands, flads/lagoons/bays/estuaries, seagrass beds, macroalgal beds, mussel beds, rocky bottoms (also artificial substrates), and unvegetated bottom habitats, for their reproduction (Airoldi and Beck 2007, Sundblad *et al.* 2011, Seitz *et al.* 2014). Coastal habitats are in addition also utilized as spawning and nursery areas of migratory marine species, such as herring and flatfishes. Sundblad *et al.* (2014) were among the first in the Baltic Sea to quantitatively demonstrate that the amount of suitable nursery habitat had a substantial impact on population densities of adult fish. In their study, the amount of essential coastal habitats explained about half of the variation in the adult population size. Despite the importance of EFH, their current status of protection is generally poor (Sundblad *et al.* 2011). Given that EFH are commonly found in parts of the coastal zone that are simultaneously subjected to many human activities, the exploitation rate of these spawning and nursery areas for coastal fish is high (Sundblad and Bergström 2014). Hence, there is an urgent need to focus on the role and protection of EFH, and on the driving factors and mechanisms behind the changes occurring in them. Apparently, there are also urgent needs for cross-sectoral management when it comes to EFH, i.e. fisheries management should consider environmental and habitat management and *vice versa*.

Despite that increased attention during recent years has been paid to characterizing, mapping and monitoring EFH around the Baltic Sea (HELCOM 2012), adequate information is still lacking for most species in order to assess to which degree these coastal habitats limit population growth and production of fish. What we today also lack is a review of the work accomplished so far, including experiences of good practices and methods used. This gap in knowledge prevents quantitative comparisons of the results, and makes it difficult to draw general conclusions on the role of EFH in order to define the most urgent research needs to bring the work forward.

2. Project objectives

The main objectives of this project were to

- organize a workshop for experts around the Baltic Sea on the role and protection of EFH and for reviewing the methods used for mapping and monitoring these habitats
- based on the outcome of the workshop produce a review paper, about the state of the art of the subject in the Baltic Sea including knowledge gaps and future research needs, to be published in an international scientific journal
- initiate discussions and cooperation between Baltic Sea experts towards a common understanding for mapping, monitoring, protection and evaluation of EFH.

3. Venue, participants and outline of the workshop

The workshop was arranged in Öregrund in Sweden during 2nd–4th June 2015 and it gathered 30 participants from eight countries around the Baltic Sea: Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden. Of the Baltic Sea countries, participants were lacking only from Russia: (see Appendix 1. Participants list).

The workshop was structured around three central themes (Appendix 2. Agenda of the workshop):

- Theme 1 – The role of essential coastal habitats for fish – availability of quantitative evidence showing the importance of coastal habitats for fish stocks.
- Theme 2 – How are essential coastal habitats for fish mapped and monitored? Methods, available maps, are there data for maps?
- Theme 3 – Conservation of and threats to essential coastal habitats for fish.

4. Outcome of the workshop

In this section the primary outcomes of the workshop are presented and summarised per theme (see Appendix 3, Abstracts for presentations).

4.1 General evidence for relationships between habitat and population size

Theme 1 – The role of essential coastal habitats for fish – availability of quantitative evidence showing the importance of coastal habitats for fish stocks.

Day 1 was largely devoted to *Theme 1* and oral presentations were given by:

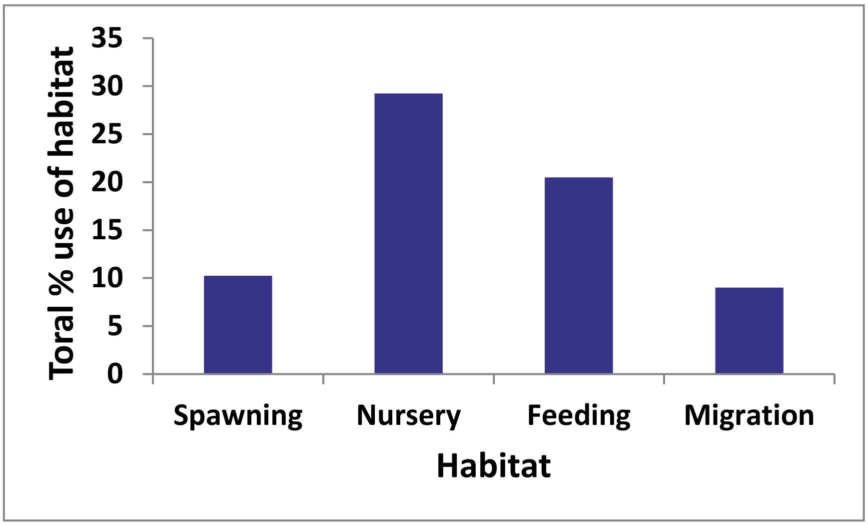
- Göran Sundblad, Sweden.
- Josianne Støttrup, Denmark.
- Henri Jokinen, Finland.
- Didzis Ustups, Latvia.
- Mehis Rohtla, Estonia.
- Timo Arula, Estonia.

In the following, the main background information and some case study examples as well as summaries and conclusions from the presentations within this theme are given.

A recent review by Seitz *et al.* (2014) has shown that 44% of all ICES species, i.e. the ones for which the International Council for Exploration of the Seas (ICES) do stock assessment (or give advice), utilize coastal habitats as spawning, feeding, nursery or migration areas and that these stocks contribute to 77% of the commercial landings of these species (Fig. 1). A limited habitat supply must therefore by some means control the size and dynamics of fish populations, but how can we find ways to quantify this? Species distribution modelling has emerged as a tool to map specific habitat requirements for different life stages of species with ontogenetic habitat shifts.

Basically, studies of fish populations appear to have evolved along two distinct paths, where one has centred on the dynamics of populations in relation to their exploitation and another has focused on the static relationships between fish and their habitats. As quantitative evidence for habitat limitation is accumulating, from different areas and species through the use of different methods for quantification, there is now an unprecedented possibility, as well as a need, to integrate habitat in fisheries management and nature conservation. This is especially important in the light of efforts towards an ecosystem based approach to (fisheries) management (Appendix 3. Göran Sundblad's abstract).

Figure 1: Percentage (%) of ICES-advice fish species using coastal habitats for spawning, as nursery grounds, for feeding, and for migration

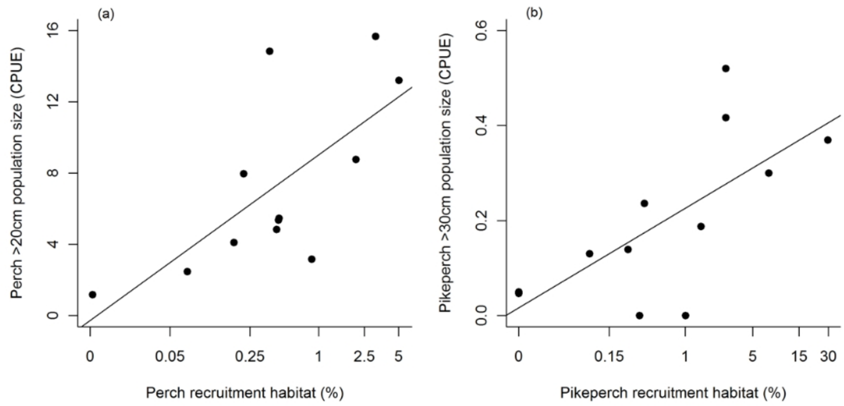


Source: Redrawn from data in Seitz *et al*. 2014.

4.1.1 Case studies on the importance of EFH

In Sweden and Finland, Sundblad *et al.* (2014) used species distribution modelling to relate distribution of nursery habitats for perch and pikeperch to the size of the adult populations in twelve archipelago areas. In this specific study, habitat availability explained almost half of the variation in population size, indicating a crucial role in limiting adult stock sizes. The relationships were, however, non-linear, suggesting that the effect of habitat loss or restoration would be largest in areas with little available habitat (Fig. 2). Especially important in this sense is that a map-based spatial approach yields quantitative links, which allows for map-based estimates of the regional distribution of large fish, scenario analyses, etc. (e.g. Bergström *et al.* 2013) (Appendix 3. Göran Sundblad's abstract).

Figure 2: Relationship between recruitment habitat in % and CPUE of a) perch and b) pikeperch



Source: Redrawn from data in Sundblad *et al*. 2014.

In Öresund, Denmark, multiple uses, such as commercial gillnet fishing, angling and sports diving as well as shipping, wind energy production and extraction of marine aggregates, may lead to conflicts between the fishing sector and between sectors impacting the sea floor and its habitats. Therefore, ecologically important habitats of selected fish species of commercial value were mapped during 2014–2015 based on descriptive information and fishermen interviews to visualize hot-spot fishery/fish habitat areas. Quantitative information from fishing surveys was, however, lacking and no attempt was made to relate the habitats to fish production (Appendix 3. Josianne Støttrup's abstract).

In Finland, the high diversity of habitats along the coast causes spatial overlap and mixing between different EFH, and makes it difficult to distinguish between specific effects of different EFH and to establish their relative roles for fish stocks. This may be exemplified by the flounder (*Platichthys flesus*) that is facing multiple pressures due to on-going large-scale ecosystem changes linked to e.g. eutrophication and climate change. Using available fishery-independent data on adult flounder as well as historical and present-state data on juvenile flatfish in nursery areas, a negative change over time may be demonstrated for both adults and juveniles, concurrent with increased coverage of filamentous algae in shallow areas (Jokinen *et al.* 2015, 2016). It is, however, difficult to find quantitative evidence on the role of the juvenile EFH for the adult flounder stock on the Finnish coast (Appendix 3. Henri Jokinen's abstract).

In Latvia, central Baltic Sea, pelagic and demersal spawning flounder (*P. flesus*) differ in their spawning habitat. In a recent study, it was examined whether the hydrological regime can explain fluctuations in early life stages of pelagic spawning flounder (eggs, larvae, juveniles) over the past 30 years (Ustups *et al.* 2013). The hypothesis that the available reproductive volume (habitat), defined as the water column with dissolved oxygen larger than 1 ml/l and salinity between 10.6 and 12 PSU, affects the survival of flounder ichthyoplankton and determines recruitment success was evaluated. Both reproductive habitat volume and spawning stock biomass were significant factors determining flounder ichthyoplankton abundance. However, recruitment did not correlate with the supply of larvae, which could indicate that important bottlenecks are present in the shallow nearshore nursery grounds, utilized by both pelagic and demersal spawning flounder in the central Baltic Sea (Appendix 3. Didzis Ustups' abstract).

In Estonia, in the Väinameri Sea area, spawning habitat preference (i.e. fresh or brackish water) was investigated in brackish water populations of pike (*Esox lucius*), ide (*Leuciscus idus*) and burbot (*Lota lota*). Otolith Sr:Ca profiles were used to determine the hatching biome. Regarding adult pike, 90% hatched in freshwater and only 10% in brackish water (Rohtla *et al.* 2012), which may be compared with results from the Swedish waters, where 45% hatched in freshwater and 55% in brackish water (Engstedt *et al.* 2010). In another study from southern Sweden, no pike hatched in brackish water (Olsson *et al.* 2013b). These results suggest that brackish water spawning pike is becoming rarer, which could be due to deterioration of spawning grounds due to negative effects of eutrophication or overfishing. Regarding ide, 72% hatched in seasonal freshwater bays and only 28% in rivers (Rohtla *et al.* 2015). Regarding burbot, 96% hatched in fresh water and 4% showed signs of hatching in an environment with Sr:Ca slightly higher than the freshwater threshold, possibly in river mouths (Rohtla *et al.* 2014). In summary, also freshwater tributaries are of importance for coastal fish, but no analysis of the relationship between the rates of degradation of freshwater habitats and adult fish stocks has been undertaken (Appendix 3. Mehis Rohtla's abstract).

In another Estonian study from the NE part of Gulf of Riga (GoR), which has been the most important spawning and nursery ground for spring and autumn spawning herring populations and where larval herrings and the related environment has been studied regularly since 1947, larval herring individuals have been counted weekly. A new bottleneck may have been identified for spring spawning herring in form of temperatures exceeding the physiological thermal optimum for the survival of postflexion herring larvae in shallow estuarine habitats (Ojaveer *et al.* 2011, Arula *et al.* 2012a). Future climate warming indicates a risk for decreased survival of spring spawning larval herring, which may lead to reduced stocks of herring relying in recruitment in shallow coastal areas. With regard to Baltic autumn spawning herring, these landings constituted up to 47% in total herring landings in GoR, but have dropped drastically to <1% in the most recent decades (Arula *et al.* 2012b). In 2009–2012, historically important spawning and nursery grounds for herring were visited and distribution and abundance of larvae were compared with historical data. It appeared that the same nursery grounds were in use and the number of larvae was comparable with the levels in the the1960s and 1970s before the herring stock collapsed. In conclusion, this nursery habitat does not seem to be limiting autumn spawning herring in the NE GoR (Appendix 3. Timo Arula's abstract).

4.1.2 Summary and conclusions of Theme 1

There are only few quantitative studies concerning the importance of EFH for fish stocks available in the Baltic Sea, and these do not provide straightforward answers. For most species, too little seems to be known in order to judge whether the coastal habitats are actually essential and limiting the production for fisheries (Seitz *et al.* 2014). Nevertheless, for some coastal species in some regions, indirect evidence exists, for example for flounder in the Gulf of Riga and Gulf of Finland. Curiously, there seems to be better evidence for non-migrating coastal species compared to migrating species. This could potentially be due to the conservative nature in habitat choice of non-migratory fish, or simply that it is easier to detect fish-habitat relationships in studies where many geographically restricted populations may be included. At some occasions, however, the necessary data for quantitative examination of the importance of EFH for fish stocks may already exist, but no analyses have yet been undertaken.

More evidence on the role of EFH could potentially be achieved using:

- Spatial approaches (e.g. assessing relationships between habitats of juveniles and adult fish to detect bottlenecks in early life stage).
- Temporal data analyses (e.g. assessing variability between years in success of different life stages).
- Stage-structured modelling (assessing habitat specific survival in stage-structured models) or
- Otolith chemistry techniques (comparing contribution of different habitats through "fingerprinting" the origin of fish).

On a general basis, it can be qualitatively reasoned that EFH are central for the provisioning of rich fish communities and for fish production, despite the so far low number of targeted studies focusing explicitly on the role of the habitats in the Baltic Sea. There may also be a great deal of indirect and qualitative evidence of the importance of EFH, and the role of freshwater habitats for coastal fish stocks should also be examined more closely. Most likely the importance of EFH has been underestimated in the past and more studies could contribute to pinpoint their ecological importance. A fruitful step forward could be to

- determine the current state of the art by forming country-wise roadmaps
- start-up investigations in countries where studies have yet not been conducted
- carefully looking into the methodologies and the needs and potentials for integration in a Baltic Sea-wide perspective.

Figure 3: The evening of Day 1 was closed with dinner and a boat trip in the Öregrund-Gräsö archipelago

4.2 Mapping and monitoring of EFH

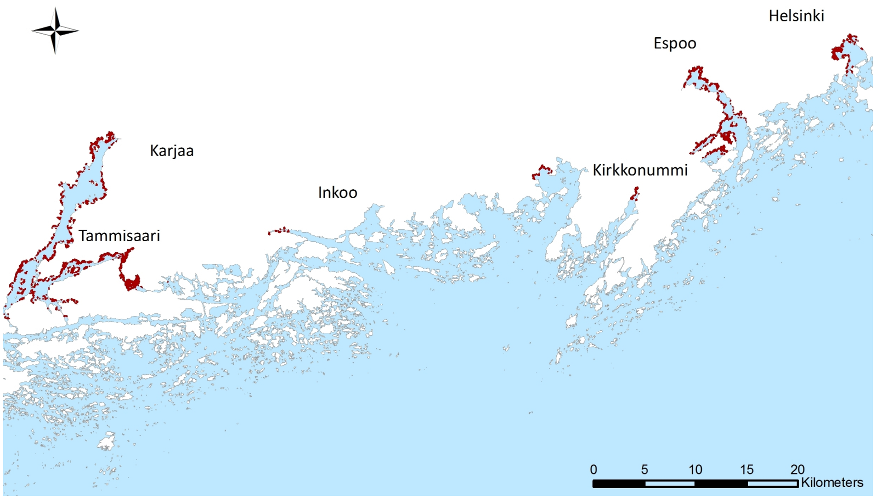
Theme 2 – How are essential fish habitats mapped and monitored? Methods, available maps, are there data for maps?

There was only one scheduled presentation under *Theme 2* (See Appendix 2, Program) and that one was given by Meri Kallasvuo, Finland. Some material from presentations under *Theme 1* and *Theme 3* was, however, also utilised within this section of case studies.

4.2.1 Case studies

In Finland, systematic mapping of reproduction habitats for coastal fish has been conducted in the extensive national VELMU program during the years 2004–2015. VELMU covers the entire Finnish archipelago with 46,000 km of shoreline. Within VELMU, new field survey and mapping methods have been developed and tested and these approaches have resulted in modelled distribution maps of key reproduction habitats for the most important coastal fish species (Fig. 4, HELCOM 2012, see also Veneranta *et al.* 2011). These maps serve as basic references and allow visual and numerical comparisons of coastal areas. They also provide concrete support to fisheries and environmental management and they have been especially useful when planning coastal areas (MSP) and setting local or national fishing restrictions. Also, the developed cost-effective field sampling methods have been useful when more detailed surveys for local planning are conducted. Nevertheless, major challenges have arisen from the high annual variation in and insufficiency of field survey data. In addition, large archipelago areas and often strong environmental gradients require environmental data of high resolution and the poor availability of such data is a challenge. Efforts have anyway been put into building a VELMU online map service (www.http://paikkatieto.ymparisto.fi/velmu/map.htm) to openly share the data and knowledge in an easily accessible format (Appendix 3. Meri Kallasvuo's abstract).

Figure 4: A predictive map of roach reproduction areas in the western Gulf of Finland

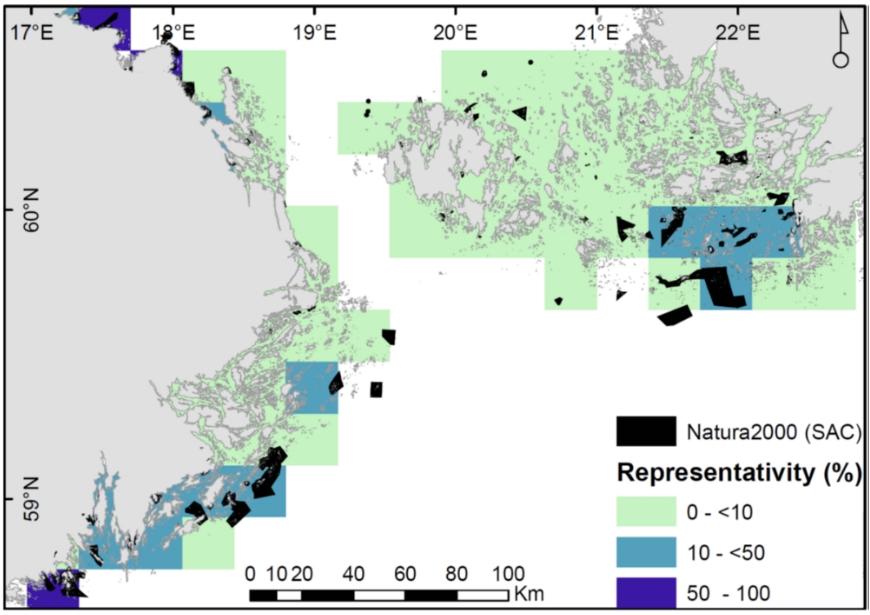


Source: Finnish Game and Fisheries Research Institute (From HELCOM 2012).

In Estonia, coastal habitats have been mapped through exercises in which direct “point data” and indicator species serve as inputs. Mapping has been done for soft sediments, sandy bottoms, sandbanks, reefs, “tidal” mudflats and sandflats. In 2011–2014, spawning grounds for the Baltic herring around the Estonian coast have also been mapped using several methods and predictive distributional maps of herring spawning areas have been created (Appendix 3. Lauri Saks’ abstract).

In Sweden, mapping of EFH has been initiated at various levels as an integrated part of the national management. Potential fish habitats may e.g. be mapped to indicate where one may expect certain life stages of specific fish to be distributed, i.e. where the environment is suitable for the species in question. Realized habitats, in turn, refer to habitats where the fish species actually are present, while effective habitats are those areas making a relatively high contribution to a fish population in comparison with adjacent areas. Species and habitat distribution maps may be used in marine spatial planning to protect sensitive areas from threats like shoreline development, dredging and boating (Fig. 5, Sundblad *et al.* 2011), and to evaluate and strengthen networks of marine protected areas (MPAs). To quantify threats to EFH, maps of the pressure variables, together with a mechanistic understanding of the effects of different threats on the habitats, are also needed. Having this information at hand, it is possible to perform scenario analyses to explore effects of different management regimes. Similar analyses may be useful in marine spatial planning for efficient use of space (Appendix 3. Göran Sundblad's and Ulf Bergström's abstracts).

Figure 5: Map showing the representativity of fish recruitment habitats in Stockholm archipelago and in the Finnish Archipelago Sea



Source: From Sundblad *et al*. 2011.

In Germany, information about the eel stock has previously been collected to develop new management plans and these data have more recently been combined with sonar measurements to correlate the number of caught eel with the structure of the bottom (Ubl and Dorow 2015) (Appendix 3, Peter Möller's abstract).

In Lithuania, the bottom structure of coastal waters has been roughly mapped already several decades ago. More detailed maps have been produced during the recent decade as the result of various research projects. For instance, multibeam bathymetry maps and seabed profiles were developed to detect herring spawning beds and a recent LIFE-NATURE project used mapping of twaite shad and whitefish (*Coregonus lavaretus*) abundances in trawling during 1995–2010 to suggest EFH species-specifically (Appendix 3. Linas Ložys' abstract).

4.2.2 Questions regarding Theme 2

Within the *Theme 2*-session, each country was asked to provide answers to a list of questions regarding the topic. The following questions were asked:

- If there is monitoring of essential fish habitats in the coastal areas of your country, what habitats and what fish species are covered/in focus?
- What methods are used for the monitoring (give a brief description with reference to publications or methodological standards?
- What is the coverage of the monitoring in terms of time (are there time-series around) and what is the geographical coverage?
- What are the purposes/motivation/aims of the monitoring?
- Are there available maps (in which form) or available data on essential fish habitats? Please describe this rather detailed.
- Is the information from monitoring and/or mapping used in spatial planning?
- In your country or in general, what do you feel is the future for monitoring and mapping of EFH (especially in light of the upcoming EU directive on marine spatial planning)? What indications are there from managers, stakeholders and politicians? Is there an increasing, stable or decreasing demand for this kind of information?

The results from this exercise can be found in Appendix 4 and they are also briefly summarised below.

4.2.3 Summary and conclusions of Theme 2

In summarising the presentations under *Theme 2* and the information collected within Appendix 4, there are considerable differences in mapping and monitoring of EFH between Baltic Sea countries with regard to fish species targeted, habitat characterization, methods used, spatial and temporal coverage, purpose/motivation and aims of the monitoring, as well as the availability of maps and data.

Regarding targeted fish species, some countries (e.g. Latvia, Lithuania) have mainly focused on specific species within targeted sampling programs, while others have sampled all or most occurring fish species (e.g. Estonia, Poland).

Regarding habitats, some countries have very detailed information on sampling and characterisation of the habitats (e.g. Estonia, Finland, Poland, Sweden), while there is yet quite little information from other countries or the information has been gathered within other specific sampling programs (e.g. Denmark, Germany, Latvia, Lithuania).

The methods for fish data collection include standardised monitoring routines for coastal areas of the northern Baltic Sea, fishers interviews (Denmark and Sweden mainly), multimesh gillnets (all countries), beach seines (all countries), white plates (Finland), detonations (Finland, Sweden), dipnets, pushnets, SCUBA-diving, underwater video cameras (Germany, Latvia), hydroacoustic surveys or sonars (Germany, Latvia, Lithuania, Sweden), eel sampling system (Germany, Latvia, Sweden), trawl nets (Germany, Lithuania), tags (inside and outside), electro fishing (Germany, Poland), egg sampling (Germany, Latvia, Sweden), fish traps, multibeam bathymetry (Latvia and Lithuania) and side-scan sonar, benthic roe samples, bongo net hauls, neuston net hauls and fyke nets (Estonia, Finland, Poland, Sweden).

Habitat information has been obtained by extensive field surveys including remote sensing, SCUBA-diving, drop-videos and grab samples, and habitat maps have been produced in combination with statistical modelling, or, as a first and simpler approach, by interview studies.

Regarding fish species, there is information on coastal and migratory marine species, anadromous and catadromous species, as well as freshwater species with a coastal distribution in the Baltic Sea. The life stages targeted range from eggs, larvae, YOY (young of the year) to adult fish.

Regarding mapping methods, the following techniques have been used:

- Overlay techniques and simple visualisation techniques using geographical information systems (GIS) to plot spatial distributions.
- Interpolation techniques using GIS.
- Statistical modelling using point data on fish and environmental variables and subsequent map predictions using full-coverage maps of predictor variables and GIS. Statistical methods used are different regression techniques (e.g. GLM, GAM), classification techniques (e.g. Random forest), Gaussian process modelling and machine learning methods (e.g. maximum entropy modelling).
- Comprehensive interview studies, where spawning areas pointed out by fishers are delineated using GIS.

When it comes to spatial coverage of the sampling, most areas of the Baltic Sea seem to be covered in Appendix 4, except for the Russian areas (both the inner Gulf of Finland and Kaliningrad area), Western Baltic Sea coast of Germany and part of the Polish coast. Regarding temporal coverage, most information is from year 2000 and onwards, but occasionally there is also information already from the 1990s (in Poland even from the 1970s and 1980s).

The purposes of sampling span from coastal fish monitoring, inventories, mapping, stock assessments, research, monitoring of invasive species to marine spatial planning. With regard to marine spatial planning, mainly Finland and Latvia claimed to carry out sampling specifically for this purpose.

Figure 6: View of one of the workshop sessions within Theme 3 during Day 2

The use of habitat maps for management or for marine spatial planning is not very frequent or efficient yet, but the situation seems to be improving rapidly in many countries thanks to national and regional underwater mapping and inventory projects and programs. In Finland, for instance, there are now comprehensive maps on e.g. prediction maps for fish, benthic algae and macrofauna available from the national VELMU program (www.http://paikkatieto.ymparisto.fi/velmu/map.htm). In Germany, the monitored and mapped information is used to declare particular areas protected or even closed, like spawning grounds and also for planning marine construction projects, in particular the choice of areas suitable for wind mill parks (controversial discussions are currently going on).

According to the participating experts in the workshop, there is clearly an increasing demand for monitoring and mapping of EFH and quite a lot of activities are going on. Despite the recent progress, however, there are still needs to improve mapping and characterization of current distribution of key habitats and fish production areas, and their internal relationships also need to be better quantified in many areas (Sundblad *et al.* 2011). In this sense, not only habitat mapping and mapping of occurrence and abundance of different species and life stages of fish species are of importance. Also mapping of major pressures and environmental background conditions are needed in order to make maximum use of all information that may be needed for efficient management and improved marine spatial planning.

The most important notation regarding this theme is, however, that some useful information on EFH seems to be available from all eight participating Baltic Sea countries, despite the scatter in applied methodologies and the level of data resolution. One way forward to improve harmonization of the methods and data between countries is to use the gathered information, describe the various approaches used and their applicability and further try to evaluate which ones are the best for specific conditions and situations as summarized in Appendix 4.

4.3 Conservation of and threats to EFH

Theme 3 – Conservation of and threats to essential coastal habitats for fish.

Day 2 was largely devoted to *Theme 3* and oral presentations were given by:

- Patrik Kraufvelin, Finland/Sweden.
- Ulf Bergström, Sweden.
- Antti Lappalainen, Finland.
- Elliot John Brown, Denmark.
- Linas Ložys, Lithuania.
- Martin Snickars, Finland.
- Peter Möller, Germany.
- Zusana Celmer, Poland.

(Abstracts from the presentations can be found in Appendix 3).

In addition to presentations, each country was asked to provide answers to the following list of questions:

- What are the major threats to essential fish habitats (EFH) in coastal areas in your country?
- Is fisheries management (FM) and nature conservation (NC) split between authorities in your country? Is the situation changing?
- Is fish habitat protection an objective in NC?
- Is fish habitat protection an objective in FM?
- Are authorities aware of the importance of EFH? What about the public? Is the situation changing?
- Are fish habitat maps used in MSP (nationally or regionally)?
- Is maintenance/restoration of fish stocks an objective in NC?

4.3.1 Threats to EFH

Eutrophication, climate change, coastal construction and development, invasive species and fisheries have in general been acknowledged as the major threats to EFH (Turner *et al.* 1999, Jackson *et al.* 2001, Lotze *et al.* 2006, Orth *et al.* 2006). Among the abovementioned threats, physical pressures, including marine shipping and boat traffic with the infrastructure required (including dredging), coastal engineering measures in bays or on shores and trawl fishery (Kraufvelin *et al.* in prep.), are the ones most easily managed. Most of the stressors are more serious for fish reproduction and especially for juvenile stages, as these life stages are more strongly dependent on specific habitats and at the same time less mobile than the adult fish. It is noteworthy that the total impact of small boat traffic may be worse than the effect of ship traffic due to the high frequency of the former in shallow sheltered areas with fine sediment bottoms that are not naturally subjected to wave action, and because small boat traffic is most intense during the biologically most active and sensitive summer period (Sandström *et al.* 2005). To quantify threats to EFH, maps of the pressure variables, together with a mechanistic understanding of the effects of different threats on different habitats, are needed in addition to habitat maps (Appendix 3. Patrik Kraufvelin's abstract).

There were differences in the opinions of the experts regarding the major threats on the EHF between the Baltic Sea countries (Table 1). Likely explanations for the differences identified include for example geographic location, human development and economic status, type of coastline (archipelago versus open) and historical land use. The list only reflects the views of the participants in the workshop and not the official national views, which needs to be kept in mind. The following major threats were listed (number of countries that mentioned the threat/total number of countries):

- Eutrophication (7/8).
- Climate change (5/8).
- Coastal construction and development, including dredging (5/8).
- Invasive species (5/8).
- Fishing/fishery (legal/illegal) (3/8).

Marine litter, erosion, pollution, tourism, mussel fishery, marine extractions and wetland drainage are threats that were only mentioned by 1–2 countries each (Table 1).

Table 1: Summary of perceived threats to EFH

Country	Most important threat(s)	Important threat(s)	Other threats
Sweden	Eutrophication	Coastal construction and development	Fishing, climate change, invasive species, marine litter
Finland	Eutrophication and climate change	Coastal construction	Dredging
Estonia	Eutrophication (also effects from the past)	Dams (mainly past threats)	Climate change, draining of wetlands, marine extraction (sand removal)
Latvia	Erosion (wave impacts)	Invasive species	Eutrophication
Lithuania	Invasive species	Fishery	Cormorants, climate change
Poland	Construction and shipping	Tourism	Illegal fisheries, eutrophication, pollution, invasive species
Germany	Eutrophication (internal loading from sediments)	Coastal construction (marinas) and gravel dredging	Tourism
Denmark	Eutrophication and climate change	Coastal construction	Cormorants (inner waters) and seals, invasive species, mussel fishery, dredging, marine extraction

4.3.2 Current protection of EFH

The protection of EFH in the Baltic Sea varies greatly between countries and between types of habitats. In Finland for instance, shallow sandy beaches are protected by the Nature Conservation Act, small pristine flads (<10 ha) are protected by the Water Act and flads in Natura 2000 areas are protected by the Habitat Directive. There are also private conservation areas and fishing restrictions during spawning time. Inner bays and estuaries are generally not very strictly protected. In Estonia, large parts of the coastal area are relatively well protected, mostly as Natura 2000 areas, which have different restrictions that apply under various circumstances. For example, fishing restrictions for different areas can now be easily found at: http://pump.regio.ee/kalandus/public/ (Appendix 3. Antti Lappalainen's and Lauri Saks' abstracts).

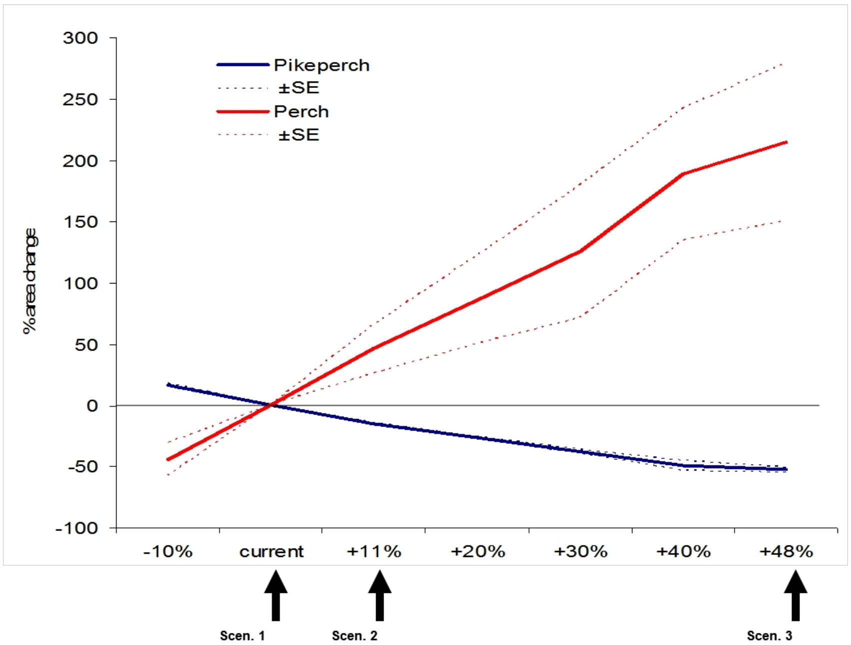
In order to attain a better protection of EFH, the value of habitats in supporting fisheries must, however, be investigated in a broader context emphasizing also the values of the habitats in providing ecosystem services. These values may thus include producing fish for commercial and recreational fisheries, aquaculture and biological regulation (i.e. regulation of eutrophication symptoms through top-down control of filamentous algae). The habitats are also of importance for protection against erosion, as nutrient filters, and for human recreation. Natural scientists should therefore consider all the ways in which coastal fish habitats provide value to society and use these as examples when communicating the need for the protection of EFH and their sustainability. In this context, the need for protection of EFH from diverse pressures and what level of sustainable use of EFH that can be permitted should also be clearly stated (Appendix 3. Elliot John Brown's abstract).

4.3.3 Current management of EFH

Management of fisheries and nature conservation have historically been separated in the Baltic Sea region, and the awareness of potential synergistic effects between the two has been low. Recently, several marine ecological studies have shown how mutual benefits may be reached through an integrated management of fisheries and the environment (Pikitch *et al.* 2004, Möllmann *et al.* 2014, Seitz *et al.* 2014, Sundblad *et al.* 2014). In contrast to the situation in northern Europe, there is much stronger focus on EFH in the research and management in e.g. the USA and Canada. In these countries, management of EFH is regulated by legal acts.

Healthy vegetated habitats are needed for the reproduction of many coastal fishes (Rangeley and Kramer 1995, Stål *et al.* 2007, Snickars *et al.* 2010, Seitz *et al.* 2014), while strong populations of predatory fish may support habitat-forming vegetation through maintaining trophic cascades (Norderhaug *et al.* 2005, Moksnes *et al.* 2008, Newcombe and Taylor 2010, Eriksson *et al.* 2011, Svensson *et al.* 2012). To increase the awareness of the benefits of integrating management of fisheries and habitat, the scientific community could contribute in many ways. This could, for example, be done by demonstrating ecological synergies that may be achieved by protecting EFH, developing methods for and carrying out large-scale mapping of EFH, quantifying the effects of different threats to EFH (see e.g. Fig. 7), and by communicating the importance of the habitats. The latter might be mediated through valuation of ecosystem services, such as food, recreation and biological regulation (Ahtiainen and Öhman 2014, Bryhn *et al.* 2015). An efficient way to increase awareness of and willingness to protect these sensitive coastal environments may also be through revealing their visual beauty with photos and videos (Appendix 3. Ulf Bergström's abstract).

Figure 7: Predicted effects on the distribution of recruitment areas (EFH) of perch and pikeperch as a response to changes in water transparency according to a set of eutrophication scenarios



Note: Curves show percentage change in areal cover with changes in Secchi depth, where numbers on x-axis denote % deviation from current Secchi depth level. Dotted lines show standard errors of predictions from three separate modelling methods. The arrows indicate, from left to right, the Secchi depth changes according to the scenarios business-as-usual (Scen. 1), Baltic Sea Action Plan (Scen. 2) and reference levels (Scen. 3).

Source: From Bergström *et al*. 2013.

In the Baltic Sea area, fisheries management (FM) and nature conservation (NC) are split among authorities in most countries with Sweden and partly Germany as exceptions. In Sweden, FM and NC are placed within the same authorities both regionally (county boards) and nationally (since 2011: Swedish Agency for Water Management), although they be-long to different ministries. In Germany, FM and NC are split on the federal level with the Federal Ministry of Food and Agriculture taking care of fisheries management and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety taking care of nature conservation. In Mecklenburg-Western Pomerania, however, FM and NC are both under the same roof, Ministry of Agriculture, Environment and Consumer Protection. In Denmark and Finland, where FM and NC are split between authorities, there are plans for fusion of ministries in the near future. In the other four countries, where FM and NC are split, i.e. in Estonia, Latvia, Lithuania and Poland, no changes are being scheduled.

Regarding the question if fish habitat protection is an objective of nature conservation or an objective of fisheries management, there are slight differences among the countries. Generally, fish habitat protection seems to be an objective within both FM and NC and this is the case for Denmark, Germany, Lithuania and Sweden (but for Sweden to a lesser extent in FM). In Poland, fish habitat protection clearly belongs to FM, while in Estonia and Latvia, fish habitat protection is mainly a task for NC. In Finland, there has not been very much focus on fish habitat protection in neither NC nor in FM, although the situation seems to be improving.

Generally, there is a need for more awareness of the importance of EFH among managers, politicians and the public, although the awareness seems to be increasing especially within authorities. Regarding the use of fish habitat maps in marine spatial planning, the information is used for these purposes in some countries and for some cases, but still, more advice on how to use the information and how to include it in marine spatial planning is needed. Finally, when it comes to maintenance and restoration issues of fish stocks as an objective in nature conservation, there is specific focus on salmonids, species included in the Habitats Directive, and also species that are red-listed. According to many experts, coastal habitats (benthic habitats – benthic fauna, macrophytes) in many countries have also been a focus of national conservation issues. In cases where there is focus on fish, it is, however, mainly for commercial and threatened species.

In summarising these results, it appears that the management of and the level of information and knowledge on EFH varies among countries. Awareness of the importance of EFH does, however, seem to be increasing among authorities. In contrast, the awareness of the importance of EFH among the general public, and more specifically among fishermen, is rather good, but knowledge on the threats to these habitats is considerably low. In some countries, the public does not seem to know much about these topics, which has also previously been concluded in other studies (Lotze 2004). In this sense, a great deal of outreach work is needed to increase awareness of the importance of EFH.

5. General conclusions

Available information suggests that fish habitats are essential for fish production and for the provisioning of rich fish communities in the Baltic Sea. Most likely the importance of EFH has been underestimated in the past and more studies could contribute to pinpoint their ecological importance. Sometimes, indirect evidence exists or the necessary data for quantitative examination of the importance of EFH for fish stocks may already be available, although no analyses have yet been undertaken.

Mapping and monitoring activities are generally well developed in different Baltic Sea countries with regards to a multitude of fish species including also different life stages. The methods used are diverse and differ between countries, species and life stages, partly by necessity but also partly by tradition. One way to initiate a harmonization of data collection methods and datasets would be to use the gathered information within this project and describe the various approaches used and their applicability and further try to evaluate which ones seem to be the best for specific conditions and situations. The use of habitat maps for EFH is generally rather poor, but seems to be rapidly improving in many countries as a result of national and regional underwater mapping and inventory programs. However, not only habitat mapping and mapping of fish occurrence or abundance are of importance, but also mapping of major pressures and environmental background conditions are needed in order to make maximum use of all information needed for efficient management and improved marine spatial planning.

With regard to the threats to EFH, eutrophication, climate change, coastal construction and development, invasive species and fishery were perceived as the most serious ones by the experts that participated in the workshop. Out of these, several are manageable in turn suggesting that the situation could be improved.

Management of fisheries and nature conservation have historically been separated in the Baltic Sea region, and the awareness of potential synergistic effects between the two areas has been low. However, the situation appears to be improving, and increased communication on the importance of the habitats is one way to mediate further progress. There is a great need for more knowledge about EFH and also for improved protection of the habitats. Currently the status of protection is rather low, primarily due to lack of research and information about the importance of EFH, as well as due to lack of maps depicting the spatial distribution of EFH to be used in spatial planning and other management purposes. In this respect, a great deal of outreach work should specifically be targeted towards managers, authorities, politicians, and users of the sea, such as fishers – but also towards media, teachers and the general public.

6. Future work

This project has brought about many suggestions for future work and co-operation. An important first step is that cooperation and discussions have now been initiated with regard to EFH all around the Baltic Sea. The long-term results of the work done so far will hopefully be the initiation of a Baltic-wide network of experts working on mapping and monitoring of EFH. Hopefully, this will create a common understanding of the role of EFH, how to investigate their importance for fish production, how to map and monitor them, and finally how to manage the threats to them and their status. Further studies seem to be especially urgent within the field of attaining quantitative data for the value of EFH for fish production including defining the key habitats for protection and restoration efforts. To improve the integration of habitat quality in fish stock assessment and ecosystem-based fishery management is also warranted (Seitz *et al.* 2014, Sundblad *et al.* 2014). An important part of this work should be formed by additional analyses on existing data as a lot of the needed information already seems to be available in many countries. Thus, the usage of some type of a meta-analytical approach could be worth considering. Common projects on e.g. mapping and interview studies could furthermore be other fruitful ways forward. There are also evident needs for projects to communicate the information (VELMU example), e.g. outreach efforts with needs to produce and assemble photos, maps, graphs, and education material for schools, teachers, managers and policy makers. In order to succeed with all these purposes, devoted projects focusing on EFH will be needed.

7. Communication

Besides this report, the results from this project will also be communicated as a review paper that will be submitted to an international scientific journal. In addition, the outcome of the project will be presented to national and local managers and stakeholders working with coastal ecosystem and fisheries issues in the countries participating in the workshop. For the international perspective, the results of the project was presented to relevant HELCOM groups HELCOM FISH PRO II (HELCOM expert group on coastal fish; presentation held at the HELCOM FISH PRO II meeting in Riga 16–18th of February 2016) and HELCOM FISH group (presentation held at the HELCOM FISH meeting in Gothenburg 11–12th of May 2016). The latter group focuses on bridging knowledge between nature conservation and fisheries management. The work will also provide important input for developing indicators and implementation of international agreements and legislative acts as the Baltic Sea Action Plan (BSAP, HELCOM 2007), the Habitat Directive (HD) and the Marine Strategy Framework Directive (MSFD, Anon 2008). The results will further be applied for guidance on current and future methods for how to map and monitor EFH in the Baltic Sea.

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Svensk sammanfattning

Många fiskarter i Östersjön är beroende av grunda och skyddade kusthabitat för lek, uppväxt, födosök och vid migration. Dessa essentiella fiskhabitats (EFH) roll för utvecklingen av fiskbestånd och fiskproduktion har trots detta fått relativt lite uppmärksamhet, fastän man inom vetenskapen är överens om deras kritiska betydelse. Man vet också ganska lite om de viktigaste hoten och påverkanstrycken mot EFH, samt deras bevarandestatus i olika Östersjöländer. Eftersom EFH ofta förekommer i de delar av kustzonen som värderas högt av människan, bör dessa kunskapsluckor fyllas. Följaktligen finns det ett akut behov av att mera grundligt fokusera på betydelsen, kartläggningen, övervakningen och skyddet av EFH och också på påverkanstryck och mekanismer bakom de förändringar vi kan observera i habitatens tillstånd. Detta för att kunna förutspå och minska framtida effekter av miljöförändringar i habitaten och kunna införa långsiktiga och anpassade förvaltningsplaner för EFH.

Målsättningarna med detta projekt var 1) att organisera en workshop med inbjudna experter kring Östersjön för att diskutera betydelsen och skyddet av samt hoten mot kustnära EFH (inklusive en sammanställning av metoder som används för kartläggning och övervakning av dessa habitat i olika länder), samt 2) på basen av resultaten från denna workshop skriva en artikel för en internationell vetenskaplig tidskrift kring det nuvarande kunskapsläget inom området i Östersjön, inklusive kunskapsluckor och framtida forskningsbehov. I denna rapport presenterar vi resultaten från detta projekt med specifikt fokus på utfallet av workshopen.

Från workshopen, som ordnades 2–4 juni 2015 i Öregrund i Sverige, kan man dra slutsatsen att det bara finns ett fåtal kvantitativa undersökningar från Östersjön gällande betydelsen av EFH för fiskbestånd. Bevisen är i sin tur rätt komplexa och ger inte nödvändigtvis enkla svar. Inte desto mindre finns det för några arter av kustfisk indirekta bevis och tillräcklig mängd data för att genomföra fortsatta kvantitativa analyser. Mera bevis om betydelsen av EFH för fiskproduktion kan möjligen erhållas genom fortsatt användning av rumsliga och tidsmässiga analyser, olika modelleringstekniker som fokuserar på fiskarnas olika livsstadier (t.ex. stadiestrukturerade modeller), samt otolitkemiska tekniker. Baserat på den information som finns att tillgå är EFH väldigt viktiga och värdefulla för tillhandahållandet av friska fisksamhällen och för produktion av fisk. Troligen har betydelsen av EFH underskattats och framtida undersökningar skulle kunna bidra med att klarlägga deras ekologiska betydelse.

Gällande olika aspekter kring övervakning och kartläggning av EFH i Östersjön verkar det finnas en hel del data tillgängligt. Olika provtagningsmetoder används för en stor mängd av fiskarter och livsstadier (från ägg och juveniler till vuxen fisk) och habitat (från kustnära områden till det öppna havet). Nyttjandet av dessa data som underlag för habitatkartor har länge varit relativt lågt. Situationen håller ändå nu på att förändras i många länder genom nyligen startade nationella och regionala program för inventering och kartläggning av undervattensmiljöer. Viktigt i detta sammanhang är att man i kartläggningen även bör fokusera på huvudsakliga hot, påverkanstryck och bakgrundsförhållanden för fisken och dess miljö. Detta kunde säkerställa en optimal tillgång till och användning av information som är väsentlig för en effektiv förvaltning och för en förbättrad marin planering.

Hoten mot, och bevarandestatusen för, EFH i Östersjön kräver brådskande och mångsidiga förvaltningslösningar. Eutrofiering, klimatförändring, kustexploatering, främmande arter och fiske verkar utgöra de främsta hoten för habitaten. Bland dessa hot är de fysiska påverkanstrycken (omfattande t.ex. marin trafik och dess infrastruktur såsom muddring), fysisk exploatering av strandmiljöer och trålfiske kanske de som är lättast att hantera förvaltningsmässigt. Dessa aktiviteter påverkar fiskhabitat både direkt och indirekt, och utgör i regel störst hot mot fiskens reproduktion och tidiga uppväxt (yngelstadier). Bevarandestatusen för EFH är i allmänhet låg, vilket huvudsakligen är en följd av att fiskeriförvaltningen och miljöförvaltningen historiskt sett har varit åtskilda i Östersjöregionen. Flera studier har dock visat att fördelar kan uppnås genom en integrerad förvaltning av fisken och dess habitat. Genom att föra samman fiskeriförvaltning med miljöförvaltning (t.ex. habitatskydd) får EFH en central roll inom förvaltningen samtidigt som också vetenskapliga intressen för relevanta frågeställningar för forskningen väcks.

Resultaten från detta projekt visar att 1) det finns tillgängliga data för kvantitativa analyser som kan stöda rollen av EFH för fiskproduktion, 2) det finns en potential för att initiera, utveckla och synkronisera framtida övervakning och kartläggning av habitaten, samt 3) att det finns en ökad medvetenhet kring skyddet av och ett hållbart nyttjande av dessa grunda kustnära system. Resultaten från detta projekt kan fungera som ett underlag för ett förbättrat samarbete mellan Östersjöländerna inom detta fält, vilket i det långa loppet kunde resultera i harmoniserade övervaknings- och kartläggningsmetoder för EFH i Östersjön samt stärkt förvaltning och skydd. Arbetet ger också ett viktigt bidrag till utvecklingen av indikatorer för att bedöma tillståndet av EFH och för genomförande av internationella överenskommelser och förordningar såsom HELCOMs Aktionsplan för Östersjön (Baltic Sea Action Plan, BSAP), Habitatdirektivet (HD) och Havsmiljödirektivet (Marine Strategy Framework Directive, MSFD).

Appendix 1 – Participants list

Table 2: Participants

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Appendix 2 – Schedule of the workshop

Essential Coastal Habitats for Fish Workshop (2nd–4th June, Öregrund).

Table 3: Schedule of the workshop, Day 1

2nd June Tuesday Day 1	
13:00–14:00	Lunch at Strandhotellet
14:00	Start – Welcome
	Introduction of the Institute of Coastal Research and SLU – Zeynep Pekcan-Hekim
	Introducing the workshop program and themes – Jens Olsson
Theme 1: The role of essential coastal habitats for fish – availability of quantitative evidence showing the importance of coastal habitats for fish stocks	
14:30	Göran Sundblad – Habitat population size relationships
14:45	Josianne Støttrup – Identifying and quantifying essential fish habitats
15:00	Henri Jokinen – Essential habitats and (unresolved) links to fish stocks on the Finnish coast: examples from flounder studies
15:15	Adam Woźniczka – The role of Baltic lagoon on forming the fish communities in coastal waters. Szczecin Lagoon – Pomeranian Bay case studies
15:30	*Coffee Break (30 mins)*
16:00	Didzis Ustups – Habitat use by early life stages of flounder in the Central Baltic Sea
16:15	Mehis Rohtla – Spawning habitat preference of Väinameri pike, ide and burbot
16:30	Timo Arula – Clupeid spawning ground surveys in the NE Baltic Sea
16:45	End of day – wrapping up day1
18:30	Boat Trip – meeting at the harbor see map

Table 4: Schedule of the workshop, Day 2

3rd June Wednesday Day 2	
Theme 2: How are essential coastal habitats for fish mapped and monitored? – methods, available maps, are there data for maps?	
9:00	Introduction to day 2
9:15	Meri Kallasvuo – Using high-resolution species distribution modelling to produce reproduction habitat maps of coastal fish to support marine spatial planning
9:30–12	Working group on *Theme 2* methods by country
12–13	*Lunch at Strandhotellet*
Theme 3: Conservation and threats on essential coastal habitats for fish	
13:00	Patrik Kraufvelin – Physical threats to essential coastal habitats for fish
13:15	Ulf Bergström – Essential fish habitats in management
13:30	Antti Lappalainen – Conservation and threats on essential coastal habitats for fish – Finland
13:45	Elliot John Brown – Conservation and threats on essential coastal habitats for fish: The need for protection of essential fish habitats
14:00	Lina Lozys and Justas Dainys – Essential coastal habitats for fish in Lithuania: threats and conservation
14:15	Coffee Break (30 mins)
14:45	Martin Snickars – Vulnerable Nursery Habitats – Coastal Lagoons
15:00	Peter Möller – Bottom habitat measures within the coastal areas of the State of Mecklenburg-Western Pomerania
15:15	Lauri Saks – Coastal marine habitats and their conservation status in Estonia
15:30	Zuzanna Celmer – Coastal fish habitats the Puck Bay case
15:45	Helmut Winkler – Coastal fish habitats in the Pomeranian Bay
16:00–17:00	Discussion on the current needs and trends in different countries on the protection of the essential coastal habitats for fish
19:00	Dinner at Societetshuset

Table 5: Schedule of the workshop, Day 3

4th June Thursday Day 3 (Meeting moves to SLU)	
9:00–12:00	Presentations on *Theme 2* summing up group work (By country) Continue discussions on *Theme 1* looking for evidence (Everyone)
12:00–13:00	*Lunch at Strandhotellet*
13:00–15:00	General discussion on the outcomes of the workshop Drafting the review Discussion on potential funding possibilities

Appendix 3 – Abstracts from presentations

Abstract Jens Olsson:Introduction to the workshop

Fish are important due to many reasons: in economic terms (commercial species); in socio-economical terms (coastal fish species – recreational fisheries); for ecosystem functioning – predatory fish counteract eutrophication symptoms; as indicators for ecosystem status and health; as segments of the MSFD and BSAP, as well as in focus of the CFP. In the Baltic Sea, the occurrence/distribution of fish is structured by many background factors such as: salinity, temperature, predation, pollution, nutrient enrichment, reproduction, fishery and finally, habitats – the central topic of this workshop. With this in mind and for the central purposes of the workshop, the following specific gaps in knowledge may be emphasized: the role of EFH is relatively little studied; the need for characterizing, mapping and monitoring of EFH; there is a lack of information about the most important threats to and their effects on these habitats; the fact that coastal habitats are under national jurisdiction (which potentially is affecting conservation and management issues). The workshop has specifically been organized for the following central target groups: for ourselves, for HELCOM, for ICES and for the scientific community, with the major reason being to search for ways in how to better connect fisheries and environmental management. The basic timeline for the work to be carried out looks as follows: workshop – June 2015; reporting of the outcome of the workshop – November 2015; writing a scientific review – late 2015 – early 2016; possible presentation at HELCOM FISH – 2016; possible common research proposal/application – 2016; preparation of a HELCOM guideline for mapping and monitoring EFH – 2018.

Abstracts from *Theme 1* – The role of essential coastal habitats for fish –

availability of quantitative evidence showing the importance of coastal habitats for fish stocks

Abstract Göran Sundblad

Habitat population size relationships

Many Baltic Sea fish species are dependent on coastal habitats. A recent review have shown that 44% of all ICES species utilize coastal habitats as spawning, feeding, nursery or migration areas, and these stocks contribute 77% of the commercial landings of ICES-advice species (Seitz *et al.* 2013). Additionally, by intuition, we know that a limited habitat supply must, by some means, control the size and dynamics of fish populations, but how can this be quantified? For species with ontogenetic habitat shifts, species distribution modelling has emerged as a tool to map life-stage specific habitat requirements. By relating the distribution of nursery habitats for perch and pikeperch to the adult population size in twelve archipelago areas between Sweden and Finland, the importance of nursery habitats could be quantified (Sundblad *et al.* 2014). Habitat availability explained almost half of the variation in population size, indicating that habitat availability plays a crucial role in limiting adult stock sizes. The relationships were non-linear suggesting that the effect of habitat loss or restoration would be largest in areas with little available habitat. Importantly, a map based spatial approach yields quantitative links, which allows for map based estimates of the regional distribution of large fish, scenario analyses etc. (e.g. Bergström *et al.* 2013).

It appears that the scientific literature is not abundant with quantitative evidence for the importance of coastal habitats, but some studies are available. These include i) model based approaches (e.g. Halpern *et al.* 2005, Minns *et al.* 1996), ii) the importance of specific habitat types using elemental fingerprinting (e.g. Fodrie and Levin 2008), habitat specific biomass and size distributions (e.g. Mumby *et al.* 2004) and nursery habitat size (Rijnsdorp *et al.* 1992), as well as iii) long term field experiments (Schmitt and Holbrook 2000), perhaps providing the strongest evidence for the importance of specific coastal fish habitat types.

Studies of fish populations appear to have evolved along two distinct paths, where one has centered on the dynamics of populations in relation to their exploitation and another has focused on the static relationships between fish and their habitats. As quantitative evidence for habitat limitation is accumulating, from different areas, species and with different methods for quantification, there is now an unprecedented possibility, as

well as need, to integrate habitat in fisheries management and nature conservation. Especially in the light of efforts towards an ecosystem based approach to (fisheries) management.

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Abstract: Støttrup, J.G., Sørensen, T.K., Egekvist, J., Vinther, M., Brown, J.E., Dinesen, G.E. and Hansen, F.I.

How can we quantify the importance of coastal habitats for fish stocks?

Essential fish habitats include nursery, feeding and spawning areas and migratory routes. The latter three habitats are targeted by fishermen and may be important for fishers because of high catches or value per fishery effort in these areas. Therefore some habitats are important both for fish stocks and targeted by fisheries which creates challenges for their sustainable management. Mapping these habits is essential for management but can be done at different levels. Potential fish habitats may be mapped to indicate where one may expect specific life stages of specific fish to be distributed. Realized habitat is where fish species are monitored as presence or abundance, but effective habitats are those areas with a relatively high contribution to a fish population in comparison to adjacent areas.

The Sound between Denmark and Sweden is a transitional sea between the Baltic and the North Sea with multiple uses such as commercial gillnet fishing, angling and sports diving as well as shipping, the wind energy sector and marine aggregate extraction. Conflicts arise e.g. between the fishing sector and sectors impacting the sea floor and its habitats. A project was therefore carried out in 2014–2015 in the Danish part of the Sound with the aim to collect information from all existing sources. Quantitative information from fishing surveys was lacking and the study relied on general descriptive information and interviews with small-scale commercial gillnetters and anglers to map the habitats of ecological importance for selected fish species of commercial value. The information and any data available was collated in GIS layers and integrated in map overlay using also GIS layers with depth, sediment or other environmental information. Habitat maps for seven commercially important fish species were produced and when compiled provided visualization of hotspot fishery/fish habitat areas, which would be most likely to create conflict between fishery and marine aggregate extraction.

Abstract: Henri Jokinen

Essential habitats and (unresolved) links to fish stocks on the Finnish coast: examples from flounder studies

Essential Coastal Habitats for Fish (EFH) are defined as environments necessary for any life-stage of a species. The importance of the different EFHs can be assessed as the effects of changes in the quantity and/or quality of these habitats on populations or stocks in time or space. The Finnish coast is characterized by a high diversity of habitats. Hence, spatial overlap and mixing between different EFHs is probable, making it difficult to distinguish their effects, and to establish their relative roles for fish stocks. To date only a few studies have tried to link EFHs and fish stocks in the coastal northern Baltic Sea. Shallow littoral areas provide generally good conditions for growth, survival and recruitment of juveniles to the adult population, if the nursery function of these areas is undisturbed, then constituting important coastal EFHs for many species. Flounder on the Finnish coast are facing multiple pressures due to on-going large-scale ecosystem changes linked to e.g. eutrophication and climate change. As a consequence of coastal eutrophication, vegetation coverage and filamentous algae have generally increased in shallow areas. Using available fishery-independent data on adult flounders as well as historical and present-state data on juvenile flatfish in nursery areas, from the Finnish coast, we demonstrate a change over time for both groups. We also examined the present occurrence of juvenile flatfish (flounder and turbot) in relation to vegetation/algae among other environmental factors in shallow juvenile habitats. Based on the available data it seems that both juveniles and adults on the Finnish coast have decline over time, during a period between the 80s and now, but relating these events is difficult because of the large time gap in juvenile data.

Due to restrictions of the data, it was not possible to assess changes over time in juvenile habitat quality or to establish that the decline in juveniles was caused by these changes during the post-settlement stage. The present low occurrence and frequent absence of juveniles in known nurseries further hampered the assessment of juvenile habitat quality on a spatial scale, despite some evidence for association of juveniles to less vegetated areas and for absence of juveniles in the most sheltered and turbid sites. In conclusion, it seems difficult to find quantitative evidence on the role of the juvenile EFHs for the adult flounder stock on the Finnish coast.

Abstract: Didzis Ustups, Ann-Britt Florin, Ulf Bergström and colleagues from BIOR

Habitat use by early life stages of flounder in the Central Baltic Sea

Flounder (*Platichthys flesus*) is a temperate marine fish that is well adapted to the brackish waters of the Baltic Sea. There are two sympatric flounder populations in the Baltic Sea, pelagic and demersal spawners, which differ in their spawning habitat and egg characteristics. In the present study, early life stages (eggs, larvae, juveniles) of flounder of the central Baltic Sea were studied. We examined whether variations in hydrological regime can explain fluctuations in pelagic flounder early life stages that have occurred over the past 30 years. We evaluate the hypothesis that the available reproductive volume (habitat), defined as the water column with dissolved oxygen larger than 1 ml/l and salinity between 10.6 and 12 PSU, affects the survival of flounder ichthyoplankton and determines recruitment success.

Both reproductive volume and spawning stock biomass were significant factors determining flounder ichthyoplankton abundance. However, recruitment did not correlate to the supply of larvae what could indicate that important bottlenecks are in nursery grounds in the coastal habitats.

Costal habitats (sandy beaches) are important nursery grounds for pelagic and demersal flounder of Central part of the Baltic Sea. The data for beach seine surveys shows that the smallest flounder juveniles in the end of the summer lives in shallow waters while in the autumn they slowly migrate to deeper waters. The preliminary results indicated two different peaks in the length distribution of flounder juveniles what could be two types (pelagic and demersal) of flounder. Using genetic and otoliths microchemistry analyse it is planned to determine exact proportion of those two types.

Since 2004 an invasive fish species round goby is registered in the coastal waters of Latvia. In the study area (sandy beaches, Pape – Jurmalciems, close to Latvian – Lithuanian border) round goby for the first time was observed in 2009. No changes of flounder recruitment was observed since introduction of round goby while reproduction success of turbot was significantly lower in the last years.

Abstract: Rohtla, M., Vetemaa, M., Svirgsden, R., Taal, I., Saks, L. and Verliin, A.

Spawning habitat preference of Väinameri pike, ide and burbot
Spawning habitat preference (i.e. fresh or brackish water) was investigated in brackish water living populations of pike (*Esox lucius*), ide (*Leuciscus idus*) and burbot (*Lota lota*). Otolith Sr:Ca profiles were used to determine the hatching biome. Of all the adult pike sampled around the Väinameri Sea area (n=435) a total of 90% hatched in fresh water and only 10% in brackish water. These results suggest that brackish water spawning pike may not be as common in the Väinameri Sea as they were suggested to be before the 1970s. Deterioration of brackish water spawning grounds due to the negative effects of eutrophication could be the factor behind low brackish water recruitment. Of all the ide collected from three sites in the Väinameri Sea (n=111) 72% hatched in seasonally freshwater bays (SFB) and only 28% in rivers. The importance of true lotic spawning has decreased substantially in Saunja (most fish hatched in SFB; stocks in the lows) and Käina Bays (all fish hatched in SFB; abundant ide stock). Only Matsalu Bay ide were mostly lotic spawners (stocks in the lows). Of all the burbot collected from the Väinameri Sea (n=74), 96% hatched in fresh water and 4% showed signs of hatching in an environment with Sr:Ca slightly higher than the freshwater threshold, possibly in river mouths. It is concluded that burbot is a fully freshwater spawner in the Väinameri Sea area.

Abstract: Timo Arula

Clupeid spawning ground surveys in the NE Baltic Sea

In this talk results of the four different surveys were discussed: long-term spring herring larval surveys in NE Gulf of Riga (GoR), spring herring spawning ground mapping in Estonian coast, autumn spawning herring in Gulf of Riga and Baltic sprat eggs and larval surveys in the Baltic proper.

NE part of the GoR has been the most important spawning and nursery ground for GoR herring population, where larval herring and related environment was regularly studied since 1947. Larval herring samples were collected weekly from May to August with Hensen larval net and samples were preserved in 4% formalin seawater solution. Individuals were counted and digitalized in lab conditions using zooscanner and later measured from images. We found that the abundance of 1-year old spring spawning herring is statistically significantly ($r2 = 0.74$) determined by the number of postflexion herring larvae in the Gulf of Riga (Baltic Sea) in 2004–2013. The abundance of postflexion larvae, in turn, displayed dome-shaped relationship with sea surface temperature experienced since hatching ($r2 = 0.69$). Winter air temperatures substantially affected seasonality of herring larvae, but not their prey, being thus important factor regulating temporal overlap between them. Most importantly, we have identified a new bottleneck – too high temperature that probably exceeds physiological thermal optimum – for the survival of postflexion herring larvae in shallow estuarine habitats. Future climate warming points to a risk for a decrease in larval herring survival, which may lead to reduction in herring stocks relying in recruitment from shallow coastal areas.

In the 2011–2014 Baltic herring spawning grounds around Estonian coast were mapped using number of different methods, like: underwater bottom recording to identify bottom substrate, hydrology, exposure to the waves, depth e.g. Using recorded data and based on scientific and expert knowledge, MaxEnt (Maximum Entropy Modeling) was applied to create predictive distributional map of herring spawning areas around the Estonian coast.

Baltic autumn spawning herring landings constituted up to 47% in total herring landings in GoR, but dropped drastically to <1% in most recent decades. There has been slight signs on recovery of autumn spawners in GoR. In 2009–2012 historically important spawning and larval herring nursery ground were visited in GoR and distribution and abundance of larvae were compared with historical data. It appeared that the same nursery ground are in use as well as the number of larvae is comparable what it was in 1960s and 1970s before population collapsed.

Baltic sprat eggs and larvae distribution was studied in two consecutive years in Baltic proper (Estonian and Latvian EEZ) using Isaac-Kidd larval fish net. Altogether 68 stations were visited in May and June, to collect sprat eggs and larvae towing the net horizontally near the sea surface and vertically from 130m until surface. In each station, CTD was launched to measure water temperature, salinity, oxygen, chl *a*, turbidity from surface to sea bottom. It appeared that bulk of sprat eggs distributed near the south border of Latvian sea zone, and fewer eggs were found in the western part of the Gulf of Finland. In addition, most of the sprat larvae were found from the southern part of Latvian water's and there was no sprat larvae in Estonian waters.

Abstract from *Theme 2* – How are essential habitats for fish mapped and monitored? Methods, available maps, are there data for maps?

Abstract: Meri Kallasvuo

Using high-resolution species distribution modelling to produce reproduction habitat maps of coastal fish to support marine spatial planning

Productive commercial and recreational fisheries are strongly linked to the ecological state of the habitats. Especially the early life stages of fish are very sensitive and the reproduction habitats are usually the most limited habitat type. In the northern Baltic Sea the fish reproduction in most cases takes place in the heavily exploited coastal zone. Therefore in the Finnish national VELMU underwater habitat inventory programme (2004–2015), systematic mapping of the coastal fish reproduction habitats has been conducted. The VELMU programme covers the entire Finnish archipelago with 46,000 km of shoreline. Large spatial and temporal environmental gradients are typical for the extensive archipelago area. In the VELMU programme we have developed and tested new field survey and mapping methods and produced modelled distribution maps of the key reproduction habitats of the most important coastal fish species. These maps serve as basic reference data and allow visual and numerical comparison of coastal areas. They provide concrete support to fisheries and environmental managers. Especially useful these maps have been when planning coastal areas (MSP) and setting local or national fishing restrictions. Also the developed cost-effective field sampling methods have been useful when consults etc. conduct more detailed surveys for local planning. Main challenges have arisen from the high annual variation and sufficiency of field survey data. The detailed archipelago and large environmental gradients require high-resolution environmental data, of which availability is a challenge. Effort has also been put into building a VELMU online map service to openly share the data and knowledge in as easy-to-understand-form as possible.

Abstracts from *Theme 3* – Conservation and threats on essential coastal habitats for fish

Abstract: Patrik Kraufvelin

Physical threats to essential coastal habitats for fish
In addition to ongoing global environmental change (climate change, eutrophication, overfishing, invasive species, etc.), there is a multitude of physical threats to essential coastal habitats for fish. This presentation focuses on the major physical threats, the kind of disturbances/stresses they impose and their implications for coastal fish habitats. Among the worst physical threats, there is marine ship/both traffic and its infrastructure, coastal engineering measures in bays/on shores and trawling. Less serious or more local threats are imposed by road traffic and its infrastructure, marine extractions, marine renewable energy production, pipelines and cables, vegetation-changing activities and recreation. The different physical threats may disturb fish habitats through direct substrate destruction/loss, erosion, increased sediment cover and turbidity, oxygen deficiency, temperature and salinity changes, noise, changes in water movement/circulation and water level and release of nutrients and pollutants. Most of these stresses are more serious to fish reproduction and juvenile stages, while adult fish sometimes can escape the problem. Noteworthy, the total impact of small boats may be worse than ship traffic due to the high frequency of the former (it is occurring everywhere, also in shallow waters) and because small boat traffic is most intense during the biologically most active and sensitive summer period. Socio-ecologically it is evident that also man will be affected if key-habitats for fish disappear and many ecosystem services are indeed threatened by anthropogenic physical activities.

Abstract: Ulf Bergström

Essential fish habitats in management

Management of fisheries and nature conservation has historically been separated in the Baltic Sea region, and the awareness of potential synergistic effects between the two has been low. Recently, several marine ecological studies have shown how mutual benefits may be reached through an integrated management of fisheries and habitats. Healthy vegetated habitats are needed for the reproduction of many coastal fishes, while strong populations of predatory fish may through maintaining trophic cascades support habitat-forming vegetation. To increase the awareness of the benefits of integrating management of fisheries and habitat, the scientific community may contribute by: 1) demonstrating the ecological synergies that may be achieved by protecting essential fish habitats (EFH), 2) developing methods for and carrying out large-scale mapping of EFH, 3) quantifying the effects of different threats to these habitats, and 4) communicating the importance of the habitats.

Habitat maps are produced by extensive surveys, usually combined with statistical modelling, or, as a first and simpler approach, by interview studies. The maps may be used in marine spatial planning to protect sensitive areas from threat like shoreline development, dredging, boating etc. They can also be used to evaluate and strengthen MPA networks. To quantify threats to EFH, maps of the pressure variables, together with a mechanistic understanding of the effects of different threats on the habitats, are needed in addition to habitat maps. Having this information at hand, it is possible to perform scenario analyses to explore the effects of different management regimes. Similar analyses may be useful in marine spatial planning for efficient use of space. The importance of EFH may be communicated through valuation of ecosystem services, such as food, recreation, biological regulation. An efficient way of increasing the awareness of these sensitive coastal environments and the will to protect them is to reveal their beauty visually through photos and videos.

Abstract: Antti Lappalainen, Meri Kallasvuo

Conservation and threats on essential coastal habitats for fish – Finland

In Finland, three typical reproduction habitats for coastal fish exist: shallow sandy beaches, flads and inner bays and estuaries are. 1) Shallow sandy beaches are important habitats for sea-spawning whitefish larvae and YOY flounder and turbot. Sandy beaches are protected by Nature Conservation Act. Eutrophication forms the main threat causing accumulation of drifting filamentous algae and in extreme cases, even slow transformation into reed belt shores in sheltered areas. 2) There are around 10,000 flads or small lagoons in Finland. They are important reproduction habitats for perch and pike, especially in the Gulf of Bothnia. Small pristine flads (<10 ha) are protected by Water Act and flads in Natura 2000 areas protected by Habitat Directive. Land lifting is a natural threat to flads especially in the Quarken area, but also various coastal activities and eutrophication endanger these habitats. 3) Inner bays and estuaries are main reproduction areas for pike, pikeperch, cyprinids, perch and burbot. These habitats are generally not very strictly protected. Inner bays and estuaries are a common habitat type, especially in the southern and southwestern Finland. As a whole, these habitats are perhaps not yet seriously threatened. However, eutrophication and climate change are altering also inner bays and estuaries.

To conclude, Finnish coast consists of diverse coastal reproduction habitats. Eutrophication and climate change threaten quality of the habitats. Anthropogenic activities, such as dredging and coastal constructions, are more or less local problems. Conservation by protected areas is implemented on several levels: e.g. by Natura 2000, private conservation areas and fishing restrictions during spawning time.

Abstract: Elliot John Brown

Conservation and threats on essential coastal habitats for fish: The need for protection of essential fish habitats

The tension between the protection of productive, diverse near-coast, marine habitats and the pressures placed upon them by largely coastal human populations is well documented. This conflict is often referred to by natural scientists when introducing specific investigations into anthropogenic impacts. The conclusions from these studies often use the effects on fish populations and fisheries catches as evidence of the need for changes to regulatory protection. However, to effectively communicate this, one must consider the value that society at large places on both fish stocks and the resources that their habitats provide. This presentation investigates the value of fisheries and the supporting habitats to humans in a broader context than fisheries data and uses specific examples with the intention to initiate discussion on the need to protect essential fish habitats from a diversity pressures. Examples of values include: (1) The effects of commercial fishery collapses and closures on regional economies and the individuals within. (2) Non-commercial catches – how they can be undervalued and their scale. Physical habitat as a resource; (3) rock, sediment, minerals (4) seawater and (5) space. (6) Finally, the indirect value given to the knowledge of an improved and healthy environment. In summary, as natural scientists we should consider all of the ways in which coastal fish habitats provide value to society and use these as examples when communicating the need for the protection of essential fish habitats.

Abstract: Linas Ložys and Justas Dainys

Essential coastal habitats for fish in Lithuania: Threats and conservation

The Baltic Sea coastline of Lithuania is only about 100 km long. Freshwater Curonian Lagoon is connected with the Baltic Sea through Klaipeda port channel. It is the main gate for fish migrations between the Baltic Sea, Curonian Lagoon and further upstream to the basin of the Nemunas River or *vice versa*. Few abundant fish species are spawning in Lithuania's coastal waters: herring (*Clupea harengus*), flounder (*Platichthys flesus*), turbot (*Psetta maxima*) and round goby (*Neogobius melanostomus*) – recent invader of Ponto-Caspian origin. Perch (*Perca fluviatilis*), ruff (*Gymnocephalus cernuus*) and most *Cyprinid* species spawn in the Lagoon, while pike-perch (*Sander lucioperca*), smelt (*Osmerus eperlanus*), burbot (*Lota lota*),

vimba (*Vimba vimba*), salmon (*Salmo salar*) and sea trout (*Salmo trutta*) migrate for spawning to Nemunas River and tributaries.

The bottom structure of Lithuania's coastal waters is mapped roughly long decades ago. More detailed maps are developed during the recent decade as the result of various research projects. E.g. multibeam bathymetry maps and seabed profiles were developed as part of PhD project at Klaipeda University aiming to detected herring spawning beds; the study revealed most essential herring spawning sites in the areas of bottom elevations and their slopes in the Lithuania coastal waters. As the result of recent LIFE-NATURE project (DENOFLIT) twaite shad and whitefish (*Coregonus lavaretus*) abundance in trawling surveys in the Baltic Sea in Lithuania's EEZ during 1995–2010 was mapped and it suggests most essential habitats for these species at the Baltic Sea. Recent decline of twaite shad and whitefish stocks is presumably related to overfishing at spawning sites in the Curonian Lagoon. Such threats as Cormorant predation on whitefish juveniles, eutrophication and change in temperature regime at spawning sites may also be related to the decline of whitefish population. Mapping of *Salmonids* migration through the Curonian Lagoon is based on the detail analysis of fishery logbooks' daily data. The mapping done allows improving protection of *Salmonids* by closing fishery in most essential for the species migration areas during particular periods. Cormorants are often blamed as one of most essential threats for fish stocks in the Curonian Lagoon and coastal waters. However, monitoring of fish stock and stabile landings in the fishery suggest minor effect of Cormorants on the local fish populations. At the same time Cormorants play positive role in ecosystem recently by controlling of round goby abundance in the coastal waters and the Curonian Lagoon. Abundance of round goby especially peaked in 2011 after first record of the species in Lithuania in 2002. This invasive species is evidently among most essential threats for the ecosystem in coastal waters. Round gobies dramatically reduced numbers molluscs, such as *Mytilus edulis. Mytilus edulis* are habitat-forming species on soft and especially on hard bottoms, their recent decline as the result of Round goby predation results in loss of overall bottom habitat diversity. Decline of *Mytilus edulis* and associated species makes essential threat for many other fish species as well as wintering birds. A decline of some wintering bird species in the area is hypothetically associated with effects of decline in invertebrate species typically used by birds during wintering period.

Abstract: Martin Snickars

Coastal lagoons – vulnerable nursery habitats
In many coastal waters of the Baltic Sea, shallow vegetated areas constitute essential fish habitats for fish species, such as perch, pike and cyprinids, which use these habitats for spawning, nursery and feeding. Coastal lagoons, e.g. silled flads, are one type of nursery habitats. Naturally, silled lagoons become gradually isolated from the sea due to the on-going land-uplift. The isolation process creates beneficial nursery habitat as temperature and vegetation cover increase with topographic isolation, and continues to do so as long as the sill area is unaltered.

However, shallow, wind-protected bays and lagoons are also attractive sites for marinas and recreational activities, which may compromise the function of these habitats. Major threats are dredging, boating, and infrastructure. Studies have shown that anthropogenic stressors are equally important as environmental variables, and that coastal lagoons in natural conditions are becoming rare. The results highlights that the species composition of vegetation sensitive vs. tolerant species) affects the abundance of juvenile fish. The abundance increases with the cover of sensitive species, suggesting that pressures affect the ecosystem functioning by altering the vegetation community. Effective conservation of nursery areas is important as many shallow vegetated habitats are vulnerable to major threats of coastal areas.

Abstracts: Peter Möller

Bottom habitat measures within the coastal areas of the State of Mecklenburg-Western Pomerania
It is not allowed to use bottom trawls within the 3 nm zone off the Mecklenburg-Western Pomerania coast and in the inner parts (lagoons). Exceptions are catch of live bait for personal use by long-line fishing (rather seldom) and for touristic activities, the use of trawls with drifting (sailing) boats (Zeesenfischerei, zeese fishery by one or two boats) in the inner parts of the coast (e.g. in the Darß-Zingst Bodden Chain). Fishermen have to apply for permission.

There are different government acts (State of Mecklenburg-Western Pomerania and EU Commission) to protect several marine and terrestrial areas (e.g. Bird Directive, Habitat Directive, Water Framework Directive, Maritime Spatial Planning of the State M-WP (see map or Regierungsportal www.regierung-mv.de). Within National Parks (e.g. Nationalpark

Nordvorpommersche Boddenlandschaft), no bottom disturbing activities (e.g. drilling or sand extraction) are allowed.

In the Baltic Sea Exclusive Economic Zone (EEZ), 5 Natura 2000 areas (Flora Fauna Habitat Directive (92/43/EWG): Adlergrund (DE 1251-301), Fehmarn Belt (DE 1322-301), Kadetrinne (DE 1339-301), Pommersche Bucht mit Oderbank (DE 1652-301), Westliche Rönnebank (DE 1249-301) and 1 Special Protected Area (Bird Directive (79/409/EWG): Pommersche Bucht (DE 1552-401) exist. There is still an ongoing discussion between the Federal Ministry of Environment and the Ministry of Agriculture about a management plan in these areas concerning fishing activities. A sediment map can be found at www.geoseaportal.de. There are several seasonal closed spawning areas within the inner parts of the coastal area where fishing is forbidden at main spawning season, but this is not a "habitat" protection measure. Every activity in the coastal zone is regulated by different acts.

Projects of the Institute of Fisheries, State Research Centre of Agriculture and Fisheries and the Research Association Fish and Environment

Eel project: The EU required data from all member states about the situation of the eel stock to develop a new management plan for eel (2007). To collect data about the density of eel in the coastal waters of Mecklenburg-Western Pomerania an enclosure sampling gear was developed by our fisheries engineer (Research Association Fish and Environment). The transportable fishing system consists of two parts. The external part consists of a boundary net arranged in a 100 m × 100 m square so as to enclose an area of 1 ha. The mesh size of the lead line weighted boundary net is 10 mm and net height is 1.8 m. The boundary net has fyke net chambers (mesh size 11 mm) at each at its four corners. Additionally, six chains of fyke nets (in total 4 double chamber fyke nets for one chain, 3 funnels in each chamber and 40 cm high leaders) with a mesh size of 10 mm in the end chamber are deployed to increase the likelihood of catching as many eels as possible within the boundary net. In total, 200 samples were taken in 2008–2011 (see Ubl and Dorow *et al.* 2014). From 2011 on, some of the sampling areas were completely recorded with sonar. It was a test to correlate the number of caught eel with the structure of the bottom.

Artificial Reefs: The reef area is more or less 1 nautical mile out on the sea, in front of the summer resort area of Nienhagen (Mecklenburg-Western Pomerania). First, a project study was started from 1994–1996 and small structures were installed in 1996. 2,000 tons of natural stones were added in 1998. The major project started in 2002. In 2003, concrete elements were added to it and the reef area grew up to 4 hectare and finally a research platform, for measurement and a radio connection to send data to a terrestrial station, was built in 2010. Several projects took place in this area. Currently, the final reports are being prepared. It is a kind of man made refuge for fish. And that causes very heated debates about the pros and cons of artificial reefs. Some people think it is a useful tool as a measure to outbalance construction projects and create refuges for several species. Others see that as a far too strong influence or change in the bottom habitat.

Abstract: Saks, L., Vetemaa, M., Taal, I., Verliin, A. & Rohtla, M.

Coastal marine habitats and their conservation status in Estonia
Coastal habitats of Estonia are mapped by modelling exercises in which direct "point data" and indicator species serve as model inputs. This has been done for soft sediments, sandy bottoms, sandbanks, reefs, "tidal" mudflats and sandflats. Large part of the Estonian coastal sea is relatively well protected, mostly as Natura 2000 nature protection areas. All these areas have different restrictions which apply in various circumstances. For example, different fishing restriction can be now easily found at: http://pump.regio.ee/kalandus/public/

Abstract: Zusana Celmer

Coastal fish habitats – the Puck bay case
The Puck Bay is one of the most important coastal habitats for fish in Polish waters. The water body is very shallow and therefore amplitudes of water temperature are high. Water exchange is difficult due to occurrence of underwater sandy reef. The basin provides suitable conditions for feeding and spawning for many fish species.

In the 60s the Puck Bay was in a healthy condition. Probably, due to direct discharge of sewage from the surrounding area, the state has deteriorated markedly. The majority of vascular plants were replaced by filamentous algae (bladderwrack disappeared). Feeding, reproduction and also nursery grounds for larvae and adults of some species were lost. In recent years, the situation has markedly improved as the consequence of the activity of sewage treatment plant. Although seagrass meadows slowly reborn, it seems unlikely to achieve the environment observed 60 years ago. Since 2004, the Puck Bay has been protected under the Natura 2000 (Habitats and Birds directive). The current major threats are unregulated tourism, fishing poaching, excessive growth of filamentous algae, high abundance of stickleback and unbalanced development of the maritime infrastructure.

Appendix 4 – Information from Baltic Sea countries about mapping and monitoring of essential fish habitats

Table 6: Denmark

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Cod, plaice, turbot, brill, eel, lumpfish, sole	Combination of fisher interviews, VMS data for vessels > 12 m, IBTS data	GIS layers-map, overlay-maps on sediment, depth maps combined with fish presence maps	For fisher interviews: Murray *et al.* 2008ab; Neis *et al.* 1999; Gunnartz *et al.* 2011	Habitat variables used: sediment maps, depth maps, macroalgal coverage	The Sound 2015	Provide fish habitat maps for management of marine aggregate extraction	GIS maps, interview notes, VMS data, Fish Atlas data (available after publication)	DTU Aqua (fish VMS and fisher interview), Zoological museum (Fish Atlas), GEUS (sediment maps); Thomas Kirk Sørensen
20 species monitored	International standardised fish monitoring	From monitoring data and other information, maps of spawning areas, juvenile areas and nursery areas from different time periods of different species	Warnar *et al.* 2012	No information	All Danish waters	Baseline for MSFD	Warnar *et al.* 2012.	DTU Aqua; Josianne Støttrup
All species caught in gillnets or fykenets	Standardised fykenets or one mesh-size gillnets. Fishermen registrations	No mapping as yet	HELCOM GUIDELINES (modified) and latest report: Kristensen *et al.* 2014	Temperature loggers	All inner Danish waters	Year round sampling (fish sampled monthly, year-round unless ice cover, data registered by recreational fishermen)	No maps yet	DTU Aqua; Josianne Støttrup

Table 7: Estonia

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
23–36 species	Standardised coastal fish monitoring routines for coastal areas of the northern Baltic Sea, with some modifications	No mapping as yet	HELCOM GUIDELINES (modified)	Secchi depth, temperature	Matsalu Bay 1993–2014; Vaindlo 1997–2014; Saarnaki 1998–2014; Vilsandi 1993–2014; Käsmu Bay (Eru Bay) 1997–2014; Kihnu 1997–2014; Kõiguste 2005–2014; Küdema Bay 2000–2014; Pärnu Bay 2000–2014	Coastal fish monitoring	Excel files	EMI; Markus Vetemaa
10–29 species	Standardised coastal fish monitoring routines for coastal areas of the northern Baltic Sea, with some modifications	No mapping as yet	HELCOM GUIDELINES (modified)	Secchi depth, temperature	Väike väin 2008; Vilsandi 2009; Aksi 2009; Häädemeeste 1999 and 2002; Heltermaa 1998, 2009–2010; Käina Bay 2005, 2010; Kõpu 2011; Lahepera Bay 2013; Laidevahe 2000; Naissaar 2004–2005, 2009–2010; Neugrund 2007–2008; Narva Bay 2007–2014; Pakri 2009; Paldiski 2001–2002; Prangli 2004–2006, 2009; Rohuküla 2009–2010, 2014; Ruhnu 2008; Kuressaare Bay 1999, 2002; Gulf of Finland (Tallinna madal etc.) 2012; Suur väin (Great belt) 2008–2009; Tamme (Küdema Bay) 2005–2007; Virtsu 1993, 1999, 2009–2010; Uudepanga Bay 1999; Vormsi 2000; Matsalu bay 2001–2002. Käsmu bay 2003–2004	Inventory (Year-round sampling was undertaken in Matsalu bay during 2001–2002 and in Käsmu bay during 2003–2004. See e.g. Vetemaa *et al*. 2006 for details)	Excel files	EMI; Markus Vetemaa
13 species	Standardised coastal fish monitoring routines for coastal areas of the northern Baltic Sea were followed	No mapping as yet	HELCOM GUIDELINES	Water chemical properties, salinity, macrophytes, zooplankton (1993)	Saunja 1993?, 2005	Inventory	Excel files	EMI; Markus Vetemaa

Table 8: Estonia (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
20 species	Multimesh gillnets (nordic coastal)	No mapping as yet	BONUS INSPIRE, manual	Secchi depth, temperature, salinity, bottom type, oxygen	Dirhami 2014	Inventory	Excel files	EMI; Markus Vetemaa
8 species	Lacustrine gillnets	No mapping as yet	HELCOM GUIDELINES (modified)	Secchi depth, temperature	Sutlepa Sea 2005	Inventory	Excel files	EMI; Markus Vetemaa
13–26 species	Beach seine	No mapping as yet	Taal *et al.* 2014	Temperature	Eru Bay 2008–2009; Mõntu 2004–2006; Saarnaki 2004–2005; Ruhnu 2004; Parasmetsa Bay 2004–2005; Panga 2004–2006; Pakri 2006; Kõiguste 2006	Inventory (Fish were sampled monthly during ice-free period from April 2008 to December 2009 only in Eru bay)	Excel files	EMI; Markus Vetemaa
Baltic herring (*Clupea harengus*)	Field work combined with remote sensing data	MaxEnt (Maximum Entropy Modeling), raster dataset on environmental variables (based on scientific and expert knowledge)	No reference	CTD data	All Estonian coast 2011–2014	Map Baltic herring spawning grounds in Estonian coast	GIS predictive distributional maps	EMI; Jonne Kotta
Baltic herring (*Clupea harengus*)	Field work combined with remote sensing data	Modeling, raster dataset on environmental variables	Saat 2015	CTD data	All Estonian coast 2011–2014	Map Baltic herring spawning grounds in Estonian coast	GIS predictive distributional maps	EMI; Jonne Kotta

Table 9: Estonia (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Benthic macrophyte communities	Field work combined with remote sensing data	MaxEnt, raster dataset on environmental variables	HELCOM 1998	Algae, aquatic plants, bottom animals by scuba-diving, drop-videos, grab samples etc.	All Estonian coast 2005–2013	Habitat mapping	GIS predictive distributional maps	EMI; Georg Martin
Distribution of habitats and key species In Estonian territorial waters	Modelled by using direct “point data“ and by using indicator species	Modeling, raster dataset on environmental variables	Herkül 2014	Algae, aquatic plants, bottom animals, etc.	All Estonian coast 2005–2013	Habitat mapping	GIS predictive distributional maps	EMI; Kristjan Herkül

Table 10: Finland

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Newly hatched larvae of pike, roach (other cyprinids), (burbot), (sticklebacks)	White plate	Species distribution modelling by logistic regressions	Kallasvuo 2010	VELMU program: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Vegetated shores along the Finnish southern and southwestern coast 2004–2010 (May–July)	Habitat mapping for management and MSP	Freely available 01/2016 in a map portal	Luke; Meri Kallasvuo
Newly-hatched larvae of whitefish, vendace	Beach seine	Species distribution modelling by Gaussian processes	Vanhatalo *et al*. 2012, Veneranta *et al*. 2013	VELMU program and Intersik / Norrsik: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Shallow sandy beaches along the Finnish coast 2009–2010, 2013 (April–May)	Habitat mapping for management and MSP	Freely available 01/2016 in a map portal	Luke; Meri Kallasvuo and Lari Veneranta
YOY/juveniles of flounder, turbot	Beach seine	Only point data, no modelling	Wijkmark *et al*. 2014	VELMU program: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Shallow sandy beaches along the Finnish southwestern coast 2010–2015 (May, September–October)	Habitat mapping for management and MSP	Freely available 01/2016 in a map portal	Luke; Meri Kallasvuo and University of Helsinki; Henri Jokinen
European flounder, (turbot)	Beach seine	Point data	Jokinen *et al*. 2016	No	Four (five) sites on the Åland Islands and two sites at the Hanko peninsula in two periods: 1979–1992 and 2012–2014 (biannually: late October and early May)	To assess temporal changes in juvenile flounder abundances	Available upon request	Luke (1979–1992 data), H. Jokinen (Eero Aho) / Tvärminne zoological station, University of Helsinki (2012–2014 data)

Table 11: Finland (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
European flounder and turbot (+ Pomatoschistus sp., Ammodytes, Gasterosteidae, other littoral species)	Beach seine	Point data	Epifauna with drop trap sampling (Nohrén *et al*. 2009);	Sediment grain size, organic content, salinity, pH, turbidity, vegetation / algae cover and biomass, infauna, depth, exposure index	21 sites around Hanko peninsula in mid-August 2013	Investigation of current occurrence of juvenile flatfish, characterization of juvenile flatfish habitats and assessment of juvenile occurrence in relation to vegetation / algae and other habitat characteristics	Available upon request	Tvärminne zoological station (University of Helsinki); Henri Jokinen
Newly-hatched larvae of Baltic herring, pikeperch, perch, smelt, (gobies)	Gulf ichthyoplankton samplers	Species distribution modelling by Gaussian processes	Veneranta *et al*. 2011, Kallasvuo *et al*. in prep.	VELMU program: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Entire Finnish coastal area 2007–2014 (May–June)	Habitat mapping for management and MSP	Freely available 01/2016 in a map portal	Luke; Meri Kallasvuo
YOY/juveniles of pike, perch, cyprinids, sticklebacks, species with swimbladder	Detonations	Mainly point data, but species distribution modelling (GAM, MARS, RF) has been conducted using detonations in the Archipelago Sea	Snickars *et al*. 2007	VELMU program: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Vegetated shallow bays in SW Finland and Åland archipelago 2002–2004, 2006 (July–September)	Habitat mapping for management and MSP	Available by request	Luke; Meri Kallasvuo and Åbo Akademi University; Martin Snickars
Trials on other larvae/juvenile fish	Dipnet, pushnet, scuba-diving, gillnets	Only point data, no modelling	Not available	VELMU program: Algae, aquatic plants, bottom animals by scuba-diving, drop videos, grab samples, environmental background data	Entire Finnish coastal area 2004–2014 (April–September)	Habitat mapping for management and MSP	Available by request	Luke; Meri Kallasvuo

Table 12: Germany

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
European eel, non-target species	Underwater video cameras, sonars, eel sampling system	Surfer Golden Software	Non, newly developed	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, currents, scuba diving photo and video	Coastal areas M-WP, since 2010	Correlation habitat and abundance	Yes, XYZ data shapes	Federal research centre M-WP and Fish and Environment; www.verein@fischumwelt.de, Peter Möller, Olaf Krüger
Whitefish, non-target species	Underwater video cameras, trawl net (zeese), beach seine	Surfer Golden Software	HELCOM GUIDELINES (modified)	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, current	Coastal areas and lakes M-WP, Since 1995	Stock assessment, spawning areas, reproduction	Yes, XYZ data shapes	Fish and Environment; www.verein@fischumwelt.de, Thomas Lorenz
Cod, non-target species on artificial reefs	Underwater video cameras, tags (inside & outside), gillnets, fish traps	Surfer Golden Software	HELCOM GUIDELINES (modified)	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, current, scuba diving photo and video	Coastal areas M-WP, since 2002	Local stock assessment, food web, migration	Yes, XYZ data shapes	Federal research centre M-WP and Fish and Environment; www.verein@fischumwelt.de, Bodo Dolk, Olaf Krüger, Peter Möller
Seatrout	Underwater video cameras, tags (inside & outside), gillnets, electro fishing	Surfer Golden Software	HELCOM GUIDELINES (modified)	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, current, scuba diving photo and video	Coastal area and creeks M-WP, since 1993	Stock assessment, spawning areas, reproduction	Yes, XYZ data shapes	Federal research centre M-WP and Fish and Environment; www.verein@fischumwelt.de, Harry Hantke
Fishes of the Adlergrund	Underwater video	Videos	HELCOM GUIDELINES (modified)	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, current, scuba diving photo and video	EEZ Germany	Fish composition of the Adlergrund	Yes, XYZ data shapes	Palaemon Aquatic service; www.verein@fischumwelt.de, Thomas Lorenz

Table 13: Germany (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Fishes of the Szczecin Lagoon and Peenestrom	Underwater video, egg sampling	Maps	HELCOM GUIDELINES (modified)	Water temperature, salinity, pH, oxygen level, visibility, wind, weather, current, scuba diving photo and video	Szczecin Lagoon and Peenestrom, 1997–1998	Spawning grounds	Yes, XYZ data shapes	Fish and Environment; www.verein@fischumwelt.de, Thomas Lorenz
Flounder, perch, pikeperch, round goby etc.	Bottom trawling; eel trawl since 2012 (bottom otter trawl OTB-TV3-520)	Abundance and biomass per area at different sampling sites	No reference	Temperature, oxygen, salinity, bottom type	Pomeranian Bay between Usedom island and Oderbank 2003–2015	Monitoring of fish biodiversity	Access database	German Sea fishery institute, University of Rostock; Winkler Helmut and Böttcher Uwe
YOY fish (smelt, gobies,etc.)	Special bottom trawl for small fish	Abundance and biomass per area at different sampling sites	No reference	Temperature, Oxygen, salinity, bottom type, nutrients, zooplankton	Darss-Zingst lagoon 1998–2015	Monitoring of YOY fish biomass	Exel database	University of Rostock; Winkler Helmut

Table 14: Latvia

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Round goby	Gillnets, beach seine, video, scuba	Not available	No reference	Vegetation, Bottom type	Latvian coast 2015–2016	Round goby distribution in Latvian coast	Not yet	BIOR and LHEI; Didzis Ustups and Strake
Flounder	Beach seine	Not available	BONUS INSPIRE, manual	Vegetation, Bottom type	Irbe Strait 2014–2015	Distribution of flounder juveniles	Not yet	INSPIRE and BIOR; Didzis Ustups
Flounder, cod	Gillnets	Not available	BONUS INSPIRE, manual	Vegetation, Bottom type	Latvian coast, SD 28, 5 to 50 m transect (one location) 2014–2015	Spatial planning	Not yet	INSPIRE and BIOR; Didzis Ustups
Sprat, herring	Hydroacoustic survey	Surfer Golden Software	No reference	No	Baltic Sea 2004–2013, Gulf of Riga 2004–2013	Spatial planning	jpg (shape)	BIOR; Didzis Ustups
Cod, flounder	BITS	Not available	No reference	No	Baltic Sea 2004–2013	Spatial planning	jpg	BIOR; Didzis Ustups
Round goby	Commercial catches, gill net surveys, beach seine	Information from commercial log books are used as input data	Knospina and Putnis 2014	No	Latvian coastal area 2004–2015	Spatial planning	jpg (shape)	BIOR; Elina Knospina

Table 15: Lithuania

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Herring	Multibeam bathymetry, Scuba diving, side-scan sonar, benthic roe samples	Spawning sites marked on multibeam bathymatry map, seabed profiles analysed.	Šaškov *et al.* 2014	Bathymetry, sediments, Broad BPI (Bentic position index), Slope	Lithuanian coastal waters 2009–2010	PhD-thesis	Maps	Saskov, A. and Linas Lozys
Whitefish, twaite shad, cod, flounder, others	Bottom trawling	CPUE visualised using GIS	Maps are available at http://corpi.ku.lt/denoflit/	No	Lithuanian coastal waters and EEZ waters 1995–2010	Inventory of fish distribution in Lithuanian marine waters	Maps	Lithuanian fishery service and nature research centre; Linas Lozys
Commercially exploited fish species	Daily and/or monthly records of logbooks	CPUE visualised using GIS	Various project reports e.g. "LITCOAST"	No	Lithuanian coastal waters and the Curonian lagoon 1998–2015	Fishery control and species distribution research	Maps, excel files	Ministry of environment, Ministry of agriculture, Nature research centre; Linas Lozys
Biological and geological features of bottom habitats	Remote video cameras; standard grab sampling; sampling by SCUBA, side scan surveys	Data visualised using GIS	Martin *et al.* 2010	Bentic fauna, depth, vegetation	Lithuanian coastal waters 2006–2007	Life project	Maps	Daunys, D. and Linas Lozys
Fish juveniles	Beach seine	Data not mapped yet	No reference	No	Lithuanian coastal waters 2005–2007	Life project	Excel files	Linas Lozys
Fish juveniles	Beach seine	Data not mapped yet	No reference	Sediments, macrophyte abundance, depth, temperature, salinity	Curonian lagoon (Lithuanian part) 2009–2015	Monitoring	Excel files	Linas Lozys

Table 16: Poland

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
All	Review and synthesis of available data and maps	Different mapping methods	No reference	Sediments, macrophytes, zoobenthos	All Polish EEZ, with special emphasis to Puck Bay, Slupsk Bank, and Rowy-Ustka coastal area. Archive data, the oldest from 1970s and 1980s.	To start marine habitat mapping in Poland	www.pom-habitaty.eu/en	?
Only habitat mapping	Direct observations (macrophytes), sediment samples, modified Bongo net hauls, ortophotomaps analyses	Basic bathymetry of the shallow coastal zone – point measured depth, analyses of distribution of hard bottom vegetation from orthophotomaps (aerial scanning material). Synthesis based on GIS methods	No reference	Depth, basic sediment analyses (mean grain size, silty-clay content, organic matter), macrophytes (taxonomy, species composition, distribution)	Szczecin Lagoon 2012–2015	Research project (Habitat mapping of shallow (coastal) areas of Polish part of the Szczecin Lagoon)	Not available before the end of the project	NMFRI; Adam Woźniczka
Pikeperch, bream	Fish larvae sampled by neuston net (2x1 m, 500 µm). Fish sampled by Nordic survey nets, "regular" gill and fyke nets, beach seine and electrofishing	Mapping of spawning grounds	Official methods accepted according to WFD monitoring in Poland	?	Vistula lagoon 2010–2012	Research project (Habitat mapping of shallow (coastal) areas of Polish part of the Szczecin Lagoon)	Limited availability, only via contact person	NMFRI; Dariusz Fey
Herring (larvae)	Bongo net and neuston net hauls	Distribution maps based on sampling data (Bongo and neuston net hauls). GIS methods.	No reference	Salinity, temperature, depth	Vistula Lagoon, Pomeranian Bay, since 2007	Research project (Regular monitoring of herring larvae on important spawning areas)	Not available before the end of the project	NMFRI; Dariusz Fey

Table 17: Sweden

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Turbot, flounder, whitefish, pike-perch, herring, vendace	Interview study with commercial fishermen and managers	Delineation of spawning areas on maps	Gunnartz *et al*. 2011	Species, year, time of spawning, origin of information, spawning indications, substrate, depth	Baltic Proper, Bothnian Sea, Bothnian Bay. Interviews performed 2003	Obtaining full cover maps of spawning areas based on local knowledge	Freely available (without attributes) from Swedish national authorities	SWaM; Ulrika Gunnartz
Perch, pike, pike-perch, cyprinids, sticklebacks	Underwater detonations	Species distribution modelling	Snickars *et al*. 2007, Sundblad *et al*. 2014, Bergström *et al*. in prep.	Depth, substrate, macrophytes, temperature, salinity, turbidity	Baltic Proper, Bothnian Sea, Bothnian Bay. Approximately 11,000 detonations between 2001 and 2014	Juvenile fish surveys. Mapping within research projects as well as regional mapping efforts	Variable. Nursery habitats have been predicted in five counties, and are available	Regional authorities; Göran Sundblad, AquaBiota Water Research
Whitefish, vendace, stickleback	Beach seine	Species distribution modelling	Florin *et al*. in prep	Substrate, vegetation cover, algal mats, depth, temperature, salinity	Baltic Proper, Bothnian Sea, Bothnian Bay	Mapping project	Will eventually be freely available pointdata in SLU database KUL	SLU, HaV, Regional County Boards; Ann-Britt Florin
Flounder, turbot	Beach seine	Only point data, no modelling	Survey Protocol Beachseine surveys BONUS INSPIRE, Nissling *et al*. 2007, Martinsson 2011	Substrate, turbidity, cover of vegetation, depth, temperature, salinity, wave height	Baltic Proper	Research project	2014 and 2015 data freely available after BONUS INSPIRE project finishes in 2018; older data available upon request to UU	BONUS INSPIRE 2014–2015 and older data from Uppsala University; Anders Nissling, UU

Table 18: Sweden (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Perch	Visual observation of egg strands by snorkelling	Habitat modelling on some of the data	For sampling: Snickars *et al*. 2010; For production of maps: Sundblad *et al*. 2011; Additional data from: Sundblad *et al*. 2014	Vegetation (species and cover), depth, temperature, salinity, turbidity	Baltic Proper, Bothnian Sea 2003 and 2007	Research project	Available in Sweden (Regional county board of Stockholm)	Maps from Regional county board of Stockholm; Göran Sundblad, AquaBiota Water Research
Herring, sprat, sticklebacks	Hydroacoustics	Species distribution modelling	Nyström Sandman *et al*. 2013ab	Not available	Baltic Proper 2011	Mapping project	Free at low resolution	Regional county boards in Stockholm and Söder-man-land; Tomas Didrikas, AquaBiota Water Research
Flounder, cod, turbot, round goby	Gillnets	Species distribution modelling	Survey Protocol Gillnet surveys BONUS INSPIRE; Willebrand 2015, Öhnstedt 2015	Salinity, temperature, oxygen, variables from dropvideo: vegetation, substrate and occurence of mussels	Baltic Proper, Bothnian Sea, Bothnian Bay	Research project	2014–2015 data from Baltic Proper freely available after BONUS INSPIRE project finishes in 2018	BONUS INSPIRE; Ann-Britt Florin
Cod, sole, eel, labrids	Fyke nets	Species distribution modelling	Fredriksson *et al*. 2010	Salinity, temperature, oxygen, water depth, secchi depth	Kattegat, Skagerrak	Mapping project	Available in Swedish reports	Ulf Bergström

Table 19: Sweden (continued)

Species that are mapped and monitored	Observation / Monitoring Method	Mapping Method (brief description)	Reference for methods used	Habitat variables collected	Geographical coverage and years of data collection	Purpose	Availability of data or maps (format)	Data owner; contact person
Perch, pikeperch, cyprinids, whitefish etc.	Multimesh gillnets (Nordic coastal)	Data not mapped yet	Survey: "Provfiske i Östersjöns kustområden – Djupstratifierat provfiske med Nordiska kustöversiktsnät"	Temperature, Secchi depth, salinity	Baltic Proper, Bothnian Sea, Bothnian Bay	Several mapping projects + monitoring programmes	Data from 2002–2015 available through SLU database KUL	SLU, HaV, NV, Regional County Boards; Ulf Bergström
Flounder, turbot	Push nets	Species distribution modelling	Reference for point data: Florin *et al.* 2009	Meiofauna, macrofauna, epifauna, substrate, filamentous algae, turbidity, salinity, structural habitat complexity	Baltic Proper 2006	Research project	No maps	SLU Aqua; Ann-Britt Florin
Habitat mapping targeting vegetation and benthic fauna	Drop video, diving, grab samples	Almost 700 habitat maps of vegetation, benthic fauna, natural values, Helcom underwater biotopes	See comment	See comment in reference	Baltic Proper, Bothnian Sea, Bothnian Bay	Mapping projects	Free at low resolution	County Boards; AquaBiota Water Research

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Essential fish habitats (EFH)

Many fish species in the Baltic Sea are dependent on shallow and sheltered near-shore habitats for their spawning, nursery, feeding and migration. Still, the role of these essential fish habitats, EFH, for the development and support for fish production has received little attention. As coastal EFH often are found in areas heavily impacted by humans, they are subject to many threats and therefore management needs are urgent. EFH also provide and support important ecosystem services and are included in national/international agreements and legislative acts. Despite this, the conservation status of EFH is generally poor in the region. Due to these shortcomings and needs, a workshop was set up to review the importance and protection of as well as threats to coastal EFH in the Baltic Sea. This report describes the outcome of the workshop and future directions for work in this research area.

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