Integrating spatial processes into ecosystem models for sustainable utilization of fish resources

INSPIRE

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INSPIRE Overview

Process-based understanding of changes in commercial fish spatial distributions, and to disentangle the role of natural drivers and various anthropogenic impacts, is a challenging research topic with high relevance to resource management. The four-years BONUS INSPIRE project will fill in the most persistent gaps in knowledge of the spatial ecology of the major commercial fish and thereby support the effectiveness of the relevant policies and ecosystem-based management of the Baltic Sea. The project would serve as a *„framework axis project“* which other Baltic Sea research could be related to.

INSPIRE is designed to substantially advance our knowledge on the major commercial fish species – cod, herring, sprat and flounder, which represent key elements of the Baltic Sea ecosystems. The specific objectives of INSPIRE are to:

i. Quantify processes generating heterogeneity in spatial distributions of fish;
ii. Quantify and map potential hazards to the connectivity between identified key habitats, and assess the impact of anthropogenic and climatic environmental changes on habitat connectivity;
iii. Quantify the population dynamics and interactions of the fish species in a spatially explicit context;
iv. Develop spatially explicit advice for ecosystem-based fisheries management.

INSPIRE proposes pilot ecosystem integrated surveys to resolve the habitat requirements of different life-stages of fish species by combined use of traditional methods and application of modern advanced analysis techniques. The surveys are conducted in close collaboration with local fishermen.

www.bonus-inspire.org

Project partners:

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1. Executive summary

Spatial Distributions

The existence of two distinct flounder ecotypes, demersal and pelagic, was evidenced by the dual response of CPUEs to salinity and water depth. The abundance of the demersal spawning flounder was negatively related to the abundance of round goby and positively related with Secchi depth and cod abundance. Vegetation and substrate did not play an important role in the choice of habitat for the demersal ecotype. The abundance of the pelagic spawning flounder showed a negative relation with temperature and bottom current and a positive relation with salinity. The habitat availability for the pelagic spawning flounder decreased over the last 20 years in the central part of the Baltic Sea likely due to increased hypoxic areas.

For cod, it is possible to fish with gillnets during spring at long distance offshore banks and offshore deep areas as well as in shallow waters. Gillnet fishing during late autumn is also possible to perform although weather conditions can affect at times the operations. For flounder, the gillnet survey succeeded in covering both types of flounder habitat during spawning time (coastal and offshore) and large numbers of adult flounders were caught showing that this type of survey would be a complement for the BITS survey in covering the shallow areas as well as offshore banks were trawling is not possible. The timing of the survey however needs to be better adjusted to the local conditions to hit the peak spawning time when the two ecotypes are most diverse. Therefore, it is suggested to perform survey in the southern part of the Baltic Sea in March, in the central Baltic Sea in April and in the northernmost areas in May. The BONUS INSPIRE gillnet survey also showed that many environmental parameters could be collected in conjunction with the fishing and habitat could be successfully mapped with simple digital cameras attached to ropes.

Scaling from individuals to populations

To study habitat selection of larval Atlantic herring (*Clupea harengus*), size-specific distribution in a Baltic Sea retention area, free of lunar tides and directed current regimes, was investigated in Grefiswald Bay. A Lorenz curve originally applied in socio-economics to describe demographic income distribution was adapted to a 20-year time-series of weekly larval herring distribution revealing size-dependent spatial homogeneity. Additional quantitative sampling of distinct larval development stages across pelagic and littoral areas uncovered a loop in habitat use during larval ontogeny, revealing a key role of shallow littoral waters. It appeared that the yolk sac stage larvae left the shore zone and moved towards pelagic habitats of the basin. However, they remained aggregated in the vicinity of the spawning beds. Larvae in the intermediate development stage (pre-flexion, flexion) were found to be increasingly dispersed throughout the pelagic zone of the bay. In contrast, fish in the advanced stages (post-flexion) were found abundant in the upper littoral zone while almost absent in the pelagic zone. This loop in habitat use during larval ontogeny indicated an active habitat selection and revealed a key role of shallow littoral waters for larval herring retention.

Western Baltic populations of Atlantic herring (*Clupea harengus*) show a distinct homing behavior returning to particular spawning grounds every year during spring. Attributed to early life stage mortality, herring recruitment decreased in the western Baltic Sea during the past two decades. Since major drivers and stressors for herring reproduction are potentially introduced on the local scale of spawning and nursery grounds, the knowledge of the contribution of different nurseries to population dynamics is essential but challenging to investigate.

Distinct chemical separation between juvenile herring caught in the vicinity of the Island of Ruegen (south-western Baltic Sea) and other potential nursery areas further west in the Baltic Sea with high significant differences among all areas. Innovative elemental fingerprinting index was established, which allows comparisons of otolith multi-element patterns within certain nursery areas and between nurseries, indicating that otolith chemistry is a suitable tool for future habitat connectivity estimates.

Based on hydro-acoustic surveys of sprat stock in the Eastern Baltic Sea (ICES Subdivisions 26 and 28.) it appeared that the seasonal vertical distributional pattern of sprat is rather steady. However, the horizontal distribution could have differences between years.There are also substantial differences between distribution of younger and older age-groups of sprat. A hypothesis is put forward that Gotland Deep basin is the centre of distribution of sprat stock in the Baltic Sea.

Stock assessments

A variety of assessment models and methods for estimation of Maximum Sustainable Yield (MSY) reference points have been tested and applied. The set of analyses comprised age-based methods, different stock-production models, including state space models with random effects, length based approach as spawning potential ratio, equilibrium yield and biomass curves as basis for MSY parameters estimation. The methods were applied to stock structure defined within Inspire project on the basis of newly collected data within Inspire surveys.

Important elements of flounder fishery are discards. They could not be directly included into the assessments as time series of reliable discards estimates are very short. However, extensive analysis was conducted to test effects of different discards ratios on assessment results and management conclusions. For these analyses a few discards models were considered and applied. The general conclusion was that inclusion of discards increase estimates of biomass in similar rate as discards rate but has little effect on estimates of fishing mortality. Trends in biomass estimates with modelled discards included were similar to trends in biomass estimates without discards.

The conducted analyses indicate good state of flounder in ICES Sub-divisions (SD) 24-25; all models indicate that stock biomass is high, while fishing mortality is low and below F_{msy}. Similarly, some assessments indicate good status of flounder in SD 26; stock biomass is above B_{msy}, fishing mortality is below F_{msy}. On the contrary, state of flounder in SD 28 has been poor in recent years; stock biomass has been below B_{msy}, and fishing mortality has been above F_{msy}. The biomass of flounder in SD 27,29-32 declined but has been stable and above B_{msy} in recent years, while fishing mortality has been below F_{msy}. No assessment or evaluation model has indicated immediate danger for the stock.

Ecosystem based management
Potential warning indicators for the Eastern Baltic cod stock development have been examined. Indicators of recruitment environment, like depth at 11 psu isohaline, can be used as an “early warning” of potentially good or bad conditions for recruitment before survey and stock assessment data are available. Cod body condition has decreased from the mid 1990s and suggests high natural mortality, likely due to starvation. In the absence of analytical stock assessment, the rescaled Baltic International Trawl Survey index may be considered as an early warning indicator in estimating the cod stock size. Substantial environmental changes, like increased hypoxic bottom areas have caused changes in cod feeding level. The combined consequences of declining growth, reduced condition, and spawning at smaller sizes on individual egg production and viability of offsprings have remained unclear.

Major differences behind the fishery and trends of local herring stocks in the Gulf of Bothnia and the Gulf of Finland in the NE Baltic Sea were documented. Recent abundant presence of sprat in the NE Baltic Sea, which also affects herring fishery, is likely facilitated by superior competitive feeding to herring. The commercial extinction of the previously abundant autumn spawning herring in the early 1980s was likely due to too high fishing mortality. Spatial distribution and size composition of sprat and herring affect the individual performance in salmon and cod, suggesting the need for spatial management of sprat. In the eastern areas of the Baltic Sea, i.e. Gdansk Deep and Gotland Basin, the presently implemented area closures of cod fisheries are likely largely ineffective in enhancing the cod stock. The two stock subpopulations of flounder seem to use different areas following settlement.

The Baltic Sea is currently chosen as a pilot case for taking into account biological interactions in the new fisheries management plans. Its ecosystem has undergone major structural changes: decline in cod and herring biomass from the late 1980s to the 1990s and increase of sprat biomass. The spatial distributions of these species have changed as well as their interactions. With cod and sprat this has implied a change and a mismatch in the spatial overlap between them, affecting predator-prey interactions. In ICES stock assessments, e.g. genetic analyses and practical reasons have led to mainly combining a number of stocks of sprat, herring and flounder. When comparing stock assessments by former ICES Assessment Units with the larger, present ones, the results have been mainly compatible, but with sprat there was spatial contradiction that should be taken into account. A better understanding on the spatial processes for most stocks may potentially improve our ability to optimize stock management.

Dissemination
Close contacts have ensured efficient transfer of project results to stakeholders and interested public almost in a real time (essentially to various ICES expert groups and the Baltic Sea Advisory Council). The overall goal in dissemination work has been to show and apply the importance of spatial heterogeneity in the different activities. The project has organized, jointly with BONUS BIO-C3, BONUS symposium on ’Science delivery for sustainable use of the Baltic Sea living resources’ which accommodated over 100 presentations and had nearly 150 registered participants. The conference also includes stakeholder panel discussion

with panellists from all major Baltic Sea stakeholder organisations/institutions. INSPIRE web-site has been continuously updated, linking now publications, project reports with ‘public’ status, meta-databases and affiliated projects. During the final project year, one PhD was defended.

2. Scientific and/or technological results achieved

WP 1 Spatial Distributions

Lead: Michele Casini (P5, SLU)

1. Scientific highlights

The existence of two distinct flounder ecotypes, demersal and pelagic, was evidenced by the dual response of CPUEs to salinity and water depth. The abundance of the demersal spawning flounder was negatively related to the abundance of round goby and positively related with Secchi depth and cod abundance. Vegetation and substrate did not play an important role in the choice of habitat for the demersal ecotype. The abundance of the pelagic spawning flounder showed a negative relation with temperature and bottom current and a positive relation with salinity. The habitat availability for the pelagic spawning flounder decreased over the last 20 years in the central part of the Baltic Sea likely due to increased hypoxic areas.

For cod, it is possible to fish with gillnets during spring at long distance offshore banks and offshore deep areas (70 m) as well as in shallow waters (<5m). Gillnet fishing during late autumn is also possible to perform although weather conditions can affect at times the operations.

For flounder, the gillnet survey succeeded in covering both types of flounder habitat during spawning time (coastal and offshore) and large numbers of adult flounders were caught showing that this type of survey would be a complement for the BITS survey in covering the shallow areas as well as offshore banks were trawling is not possible. The timing of the survey however needs to be better adjusted to the local conditions to hit the peak spawning time when the two ecotypes are most diverse. Suggesting survey in March in southern parts of the Baltic Sea, in April in central Baltic and in May in northernmost areas.

The INSPIRE gillnet survey also showed that many environmental parameters could be collected in conjunction with the fishing and habitat could be successfully mapped with simple digital cameras attached to ropes. The INSPIRE beach seine survey showed that this type of survey is well suited to capture juvenile flounder.

2. Summary by task

WP1 encompasses a comprehensive data collection programme, and statistical as well as process-oriented analyses on the spatial distributions of the focal species at different spatial scales. Focus here is put on the distributions and their properties at different points in time, including environmental (habitat) impact factors, trophic interactions and fisheries.

The WP has the follwing objectives:

1. Develop a novel database on distribution of early life stages of cod and flatfish (especially flounder)
2. Develop data-based maps for the spatial distribution of cod, herring, sprat and flounder (both early life stages and adults) including time series of spatial overlaps

Task 1.1. Data collection and assembly in common databases
Completed during the 2nd project year.

Task 1.2. Mapping the spatial distribution of fish: linking existing data, new sampling and statistical analyses
Annual and seasonal maps of fish distribution in demersal and pelagic habitats from 1978 onwards are produced using advanced spatial statistics, using the data from existing international monitoring programs. Maps of the spatial distribution of sprat eggs and larvae, and their condition, are also produced using the INSPIRE pelagic field surveys. Indices of spatial overlap between predator/prey and competing species are produced to evaluate the potential predator-prey and competitive relationships in the Baltic Sea. The importance of distribution and overlapping for the diet composition of cod are examined as well as dietary habits of herring and sprat will be investigated.

Statistical habitat modeling is employed to relate the spatial distribution of different life stages of the target fish species to biotic (predators, preys, competitors) and abiotic (temperature, salinity, oxygen) factors, using both existing surveys (BITS, BIAS, BASS databases and newly compiled historical data) and the data from the INSPIRE field surveys (gillnets and ichtyoplankton/acoustic surveys) collected under Task 1.1.

Habitat characterization of nursery areas is done for settling flounder using the data gathered during the beach seine sampling under Task 1.1.

Based on experience gained during INSPIRE field surveys, guidelines to design future gillnet and beach seine surveys for flounder and cod are provided.

<u>Characterizing and predicting the distribution of Baltic Sea flounder during the spawning season</u>
We have addressed three main research questions: 1) What environmental conditions characterize the spatial distribution and abundance of adult flounder during the spawning season? 2) What are the main factors defining the habitats of the two flounder ecotypes during the spawning season? 3) Where are the potential spawning areas of flounder? We modelled catch per unit of effort of flounder from gillnet surveys conducted over the southern and central Baltic Sea in the spring of 2014 and 2015 using generalized additive models. The general model captured distinct ecotype-specific signals as it identified dual salinity and water depth responses. The model for the demersal spawning flounder revealed a negative relation with the abundance of round goby and a positive relation with Secchi depth and cod abundance. Vegetation and substrate did not play an important role in the choice of habitat for the demersal ecotype. The model for the pelagic spawning flounder showed a negative relation with temperature and bottom current and a positive relation with salinity. Spatial predictions of potential spawning areas of flounder showed a decrease in habitat availability for the pelagic spawning flounder over the last 20 years in the central part of the Baltic Sea. A paper was published in July 2017.

Paper: Orio, A., Bergström, U., Casini, M., Erlandsson, M., Eschbaum, R., Hüssy, K., Lehmann, A., Lozys, L., Ustups, D. and Florin, A.-B. (2017). Characterizing *and predicting the distribution of Baltic Sea flounder during the spawning season. Journal of Sea Research, 126: 46-55.*

<u>Design of a protocol for future surveys for flatfish and juvenile cod</u>
Protocols for gillnet surveys targeting adult flounder and small cod as well as beach seine surveys targeting juvenile flounder have been developed and tested within INSPIRE.

The results from the INSPIRE gillnet surveys suggest that future sampling designs of survey targeting adult flounder and small cod should be performed as follow.

Flounder: 1) Gillnet surveys should be designed to complement BITS survey; 2) Cover shallow coastal areas from 5-20 m depth as well as offshore banks to get demersal spawners and cover deeper than 50 m areas for pelagic spawners; 3) Consider geographically variable spawning time for sampling, targeting spawning flounder March in southern Baltic sea, April in central Baltic Sea and May in northern Baltic Sea; 4) Consist of an array of mesh size panels from 38 to 75 mm.
Cod: 1) Gillnet surveys should be designed to complement BITS survey; 2) The timing of the gillnet surveys should be complementary to the fall BITS survey; 3) The main effort of the survey should focus on the main distribution range of small cod, covering shallow areas from 5-20 m depth, but extend to 50 m in order to provide some depth overlap for calibration with BITS; 4) The surveys may need to be adapted to geographical differences in depth distribution. Since small cod in some areas (transects C and D off the Polish coast), occur as deep down as 70 m. In these areas sampling efforts also need to include these depths; 5) Consist of an array of mesh size panels, but not larger than 20 mm.

The results from the INSPIRE beach seine surveys suggest that: 1) Beach seine is appropriate sampling gear to estimate 0-group flounder abundance; 2) Depth of ≤1 m is sufficient; 3) In the Central Baltic sea July is the appropriate survey time to start to sample 0 group of flounder and the sampling should continue up to early-mid September to capture all potential 0-group cohorts; 4) Due to earlier spawning of flounder in south part of the Baltic Sea, sampling of 0 group flounder should start in June; 5) To assess the 0-group abundance, length distribution should be considered for 1) distinguishing 0-group from 1-group early in the season and 2) distinguish between arriving cohorts during the season.

Source: BONUS INSPIRE Deliverable 1.7

<u>Relation to Deliverables and Milestones</u>
D1.5 (Manuscript on habitat preferences of different life-stages of fish) has been fulfilled.
D1.7 (Design protocol for future surveys for flatfish and juvenile cod) has been also fulfilled.

Task 1.3. Population dynamic consequences of spatio-temporal shifts in predator-prey interactions and implementation into stock assessment

The spatial distribution of cod, sprat and herring are modeled using data extending back to the 1950s to evaluate the impacts of anthropogenic pressures (fishery), hydro-climatic factors (temperature, salinity, oxygen levels), species interactions (competition, predation, prey availability), or a combination of these different factors on observed distributional patterns. Different techniques are used to link species distribution to the predicting factors, such as statistical methods, and spatially explicit population dynamics.

<u>Spatially explicit population and food-web modelling – state of the art and where to go from here in INSPIRE</u>

Management of fisheries for cod can have an impact on fishing opportunities for sprat and herring, and vice versa. Cod are predatory, and their main prey is sprat and, to a lesser extent, herring and also juvenile cod (cannibalism). Growth of herring and sprat has been density-dependent. The relative distributions of predator (cod) and prey (herring and sprat, juvenile cod) have changed substantially during the last years, and for the time being much herring and sprat are outside the predatory reach of cod.

Preliminary model runs have indicated that the present distribution patterns of cod, herring and sprat imply that an increase in fishing mortality (F) on cod not necessarily will result in increasing Baltic wide clupeid stock sizes. Conversely a decrease in F on cod will not necessarily result in a decrease of the Baltic clupeid stock size if it will not be accompanied by a cod expansion to northern areas. Higher sustainable fishing mortalities for herring and sprat are also obtained when density dependent growth is assumed for the two species, as the stocks compensate by a higher growth at lower stock densities due to either higher fishing mortalities or predation.

A basic model has been developed that is purely length based and couples population dynamcis, foraging behavior and predator (cod) growth. The model will be expanded to account for different spatial units and apply the knowledge gathered in INSPIRE.

<u>Spatial food web modelling for the Baltic using Bayesian Belief Network</u>

Understanding the dynamics across the established regime shift observed in the late 1980s requires novel research into the spatial heterogeneity of the key processes. In this project with INSPIRE, the emphasis was given to develop more sophisticated models, based on enhanced field data, that help explore the spatial and temporal relationships. Here we develop a probabilistic model that couples key fish populations to a complex suite of trophic, environmental and geomorphological factors. Using 41 years of observations we model the changes in cod, herring and sprat for the Baltic Sea within a Bayesian Belief Network. The model predictions are spatially explicit and show the transfer of the central Baltic Sea from cod to sprat dominated ecology during the 41 years. This also highlights that the 2004 to 2014 years deviate in the typical cod-environment relationship with environmental factors, such as salinity, being less influential on Cod population abundances than in previous periods. The role of macrozoobenthos abundance, biotopic rugosity and flatfish biomass showed an increase influence in predicting cod biomass in the last decade of the study. Fisheries management that is able to accommodate shifting ecological and environmental conditions relevant to biotopic information will be more effective and realistic. Non-stationary modelling for all the homogeneous biotope regions while acknowledging that each has a specific ecology relevant to understanding the fish population dynamics is essential for fisheries science.

Source:
Kininmonth, S., Blenckner, T., Niiranen, S., Watson, J., Orio, A., Neuenfeldt, S., Bartolino, V., Hansson, M. and Casini, M. Is biotope information the missing link in coastal fisheries management? (manuscript).

<u>Relation to Deliverables and Milestones</u>
D1.6 (Manuscript on spatially explicit population and foodweb modelling) has been fulfilled.

3. Deviations from the work plan
D1.5 was originally planned for M34, but was postponed to M37 (4^{th} project year) due to delays in the data quality-check and delivery from the INSPIRE gillnet sampling.

WP 2 Passive movements, active migrations, and habitat connectivity Lead: Christian Möllmann (P8, UHAM)

1. Scientific highlights
WP2 has provided important scientific results on the importance of passive movements (i.e. drift) of early life-history stages to (i) identify hotspots of Eastern Baltic cod spawning areas, (ii) investigate survival and dispersal variability of pelagic eggs and yolk-sac larvae of Baltic flounder (iii) demonstrate spatio-temporal variability in mixing between the two Baltic cod stocks, (iv) reveal the connectivity of larval cod in the transition area between North and Baltic Sea, and (v) elucidate migration and migration rates of adult individuals within and between the sub-areas of the Baltic Sea. Below these highlights of WP2 are described in more detail.

Distinct spatial distribution patterns of Eastern Baltic cod early life stages and strong variations in Baltic Sea circulation patterns are a prerequisite to investigate the existence of self-sustaining components and mixed populations of cod. A hydrodynamic model combined with a Lagrangian particle tracking technique was utilized to provide long-term knowledge of environmentally-related survival probability and drift of eastern Baltic cod eggs and yolk-sac larvae. Simulations were performed to quantify processes generating heterogeneity in spatial distribution of Baltic cod early life stages. We evaluated the environmental conditions in the different spawning grounds with respect to suitability for spawning, egg survival probability, and estimated the population connectivity of Eastern Baltic cod eggs and yolk-sac larvae between the different spawning grounds. The extent of Baltic cod eggs represented as virtual drifters is primarily determined by oxygen and salinity conditions and the ability to obtain neutral buoyancy in the water column, which define the habitat requirement to which species' physiology is suited. Eggs initially released as drifters in the westernmost spawning grounds were more affected by sedimentation than those released in the eastern spawning grounds. For all spawning areas temperature dependent mortality was only evident after severe winters. Egg buoyancy in relation to topographic features like bottom sills and strong bottom slopes could appear as a barrier for transport of Baltic cod eggs and could potentially limit the connectivity of Baltic cod early life stages between the different basins in the central and eastern Baltic Sea.

A hydrodynamic model coupled with a Lagrangian particle tracking technique was utilized to simulate spatially and temporally resolved long- term environmentally related (i) size of habitat suitable for reproduction, (ii) egg/yolk-sac larval survival, (iii) separation of causes of mortality, and (iv) connectivity between spawning areas of Baltic flounder with pelagic eggs. Information on reproduction habitat requirements and mortality sources were obtained from field or laboratory studies. In our modelling study we only quantified physical processes generating heterogeneity in spatial distribution of eggs and yolk-sac larvae, as e.g. predation is not accounted for. The spatial extent of eggs and larvae represented as modelled particles is primarily determined by oxygen and salinity conditions. The reproduction habitat most suitable was determined for the Gdansk Deep, followed by the Bornholm Basin. Relatively low habitat suitability was obtained for the Arkona Basin and the Gotland Basin. The model runs also showed yolk-sac larval survival to be to a large extent affected by sedimentation. Eggs initially released in the Arkona Basin and Bornholm Basin are strongly affected by sedimentation compared with those released in the Gdansk Deep and Gotland Basin. Highest relative survival of eggs occurred in the Gdansk Deep and in the Bornholm Basin. Relatively low survival rates in the Gotland Basin were attributable to oxygen-dependent mortality. Oxygen content had almost no impact on survival in the Arkona Basin. For all spawning areas mortality caused by lethally low temperatures was only evident after severe winters. Buoyancy of eggs and yolk-sac larvae in relation to topographic features appear as a barrier for the transport of eggs and yolk-sac larvae and potentially limits the connectivity of early life stages between the different spawning areas.

In the Baltic Sea, two genetically distinct cod populations occur, the "Eastern" Baltic cod in ICES SDs 22-32 and the "Western" Baltic cod in SDs 22-24. Since 2006, cod abundance has increased 5 fold in the Arkona Basin in the eastern part of the "Western" cod's management unit (SD 24), but remained constant in SD 22, presumably due to mixing of the two stocks. The spatio-temporal dynamics of stock mixing were analysed using shape analysis of archived otolith, and the impact of "Eastern" cod's immigration on recruitment by hydrographic drift modelling. The percentage of "Eastern" Baltic cod in the Arkona Basin increased from ca. 20 % before 2005 to > 60 % in recent years. The spatial resolution of stock mixing suggests immigration occurring north of Bornholm, but propagating throughout the Arkona Basin. An age-related trend in immigration was evident, which started with age 4 year cod followed by progressively older individuals. The immigration cannot be attributed to spawning migration, as no seasonal trend in stock mixing was observed. Only between 20-50% of the available habitat was suitable for successful spawning of "Eastern" cod, limited by primarily low salinity.

Best conditions occurred irregularly in May-end June, interspersed with years where successful spawning was virtually impossible. On average, only 19 % of the eggs survive to the end of the yolk-sac, with mortality primarily after bottom contact due to low salinity. The general drift direction of the surviving larvae was towards the east. Albeit considerable, the immigration of “Eastern” cod does therefore not seem to contribute significantly to “Western” Baltic cod’s recruitment.

Connectivity of pelagic, early life stages via transport by ocean currents is of particular interest, as it may affect survival chances of offspring, recruitment success and mixing of stocks across management units. Based on drift model studies, the transport patterns of exogenously feeding cod larvae in the transition area between North Sea and Baltic was investigated in order to i) determine long-term trends and variability in advective transport of larvae from spawning grounds to juvenile nursery areas, ii) estimate the degree of exchange between different management areas and iii) compare the results with spatial distributions of juvenile cod. The transport of larvae showed a high intra- and inter-annual variability, but also some general, consistent patterns of retention within and dispersion to different management areas. Good agreement of drifter end positions, representing potential juvenile settlement areas, with actual catches of juveniles from bottom trawl surveys suggests that the drift simulations provide reasonable estimates of early life stage connectivity between cod populations in the investigated areas. High exchange rates of drifters between management areas of up to ca. 70% suggest that cod populations in the investigated areas are demographically correlated. Results are discussed in relation to their relevance for stock structuring, fish stock assessment and management.

Tag-recapture data-points indicate that cod in general do not perform long-distance migrations, but that only a small fraction (<10%) of the tagged population is conducting trans-basin migrations. Furthermore, the net displacement is independent of the time at large. This means that adult migrations probably do not contribute to whole Baltic scale re-distributions of cod. Furthermore, it implies that regional stock recovery might not lead to recovery of cod in the whole Baltic Sea, but rather to regional regulation of stock size due to density-dependent processes. An exception is the exchange between the Bornholm and Arkona Basins. The impact of eastern cod immigration on recruitment in the western Baltic Sea was investigated using hydrographic drift modelling (see above). The percentage of Eastern Baltic cod in the Arkona Basin increased from ca. 30% before 2005 to ca. 80% in recent years. Geographic patterns in stock mixing with a pronounced east–west trend suggest that immigration occurs north of Bornholm, but propagates throughout the Arkona Basin. The immigration cannot be attributed to spawning migration, as no seasonal trend in stock mixing was observed. These migrations affect the number of effective spawners. For the time period 1993–2010, our results revealed large variations in the horizontal extent of spawning habitat (1000–20 000km2) and oxygen-dependent egg survival (10–80%). At the same time, the spatial pattern of landings has changed substantially as the fishery of cod has shrunk to the southern and southwestern areas and the importance of north-eastern areas has increased in sprat and herring fishery.

Information about species interactions at a spatial scale comparable to the perceptive abilities of the involved species is crucial for the establishment of predictive, food consumption models at the population level. Nevertheless, such information is sparse due to methodological constraints. We studied the diel, vertical dynamics of species interactions between Atlantic cod *Gadus morhua* and its major clupeid prey sprat *Sprattus sprattus* at a location in the Bornholm Basin of the Central Baltic Sea during late winter. This was accomplished by combining acoustic information on diel vertical fish distribution, time of ingestion of individual sprat estimated from cod stomach content data and observed vertical profiles of salinity, temperature and oxygen content. Cod predation took place primarily at dusk and dawn during ascent and descent of sprat associated with school dissolution and formation. Cod resided close to the bottom outside these temporal predation windows. Sprat schools were located at the same depth or deeper than cod during light hours, whereas dispersed sprat at night were situated higher in the water column. These vertical dynamics could be explained by fitness optimization using bioenergetics and trade-offs between temperature, oxygen saturation of the water, and predation risk. The study thus forms the first step to providing a mechanistic background for the aggregate functional response of cod at basin scale and beyond.

2. Summary by task

WP2 contains statistical and process-based analyses of movements of the focal species at different temporal and spatial scales and in different life-stages. Besides quantifying these movements, emphasis is put on the characterization of obstacles for the transport or movement between nursery and feeding habitats, between feeding and spawning habitat, and (closing the life cycle) between early life stages habitats and nursery grounds. This includes the assessment-relevant movements between ICES sub-divisions

The workpackage has the following three objectives:

1. Develop and test estimates of drift pattern for early life stages of cod and flounder.
2. Estimate net migration rates of adult cod, herring and sprat between ICES sub-divisions.
3. Develop a mechanistic test for importance of migrations compared to fishing, predation and reproduction in relation to changes in the spatial distributions of cod, herring and sprat.

Task 2.1 Transport of early life stages from spawning area to nursery grounds

Completed during the 3rd project year.

Task 2.2 Migrations of adult individuals

Completed during the 2nd Project Year.

Task 2.3 Small scale movements relevant for species interactions

Completed during the 2nd Project Year.

3. Deviations from the workplan

There were no deviations from the workplan.

WP 3 Scaling from individuals to populations

Lead: Patrick Polte (P7, TI-OF)

1. Scientific highlights

Whether local hazards might shape large scale population abundance and recruitment strength and thus spatial distribution patterns was the major question to be addressed in this WP.

For the first time, a drift study has been performed in which fertilized cod eggs have been released in historically important Baltic cod spawning grounds. These eggs drifted at levels of neutral buoyancy until they entered the first feeding state (Hinrichsen et al. 2016). The end positions of this drift study were the starting positions for the subsequent drift study, where first feeding stage larvae drifted until they reached the age of settlement (90 days). Then after checking for suitable habitats, either the drift ended successfully or the particles were not counted as settled juveniles (Hinrichsen et al. 2017, Del. 3.1). The study has shown that also particles representing eastern Baltic cod juveniles settled to a relatively large extent in the western Baltic cod management area, and may significantly contribute to western Baltic cod recruitment. Therefore, it could be suggested that not only immigration but also larval and juvenile transport could contribute to recruitment in the western Baltic Sea. However, it is also evident that the stock component in the Gotland Basin only to a minor degree contributed particles to nursery grounds in other ICES subdivisions.

To study habitat selection of larval Atlantic herring (*Clupea harengus*), size-specific distribution in a Baltic Sea retention area, free of lunar tides and directed current regimes, was investigated in Grefiswald Bay. A Lorenz curve originally applied in socio-economics to describe demographic income distribution was adapted to a 20-year time-series of weekly larval herring distribution revealing size-dependent spatial homogeneity. Additional quantitative sampling of distinct larval development stages across pelagic and littoral areas uncovered a loop in habitat use during larval ontogeny, revealing a key role of shallow littoral waters. It appeared that the yolk sac stage larvae left the shore zone and moved towards pelagic habitats of the basin. However, they remained aggregated in the vicinity of the spawning beds. Larvae in the intermediate development stage (pre-flexion, flexion) were found to be increasingly dispersed throughout the pelagic zone of the bay. In contrast, fish in the advanced stages (post-flexion) were found abundant in the upper littoral zone while almost absent in the pelagic zone. This loop in habitat use during larval ontogeny indicated an active habitat selection and revealed a key role of shallow littoral waters for larval herring retention.

Western Baltic populations of Atlantic herring (*Clupea harengus*) show a distinct homing behavior returning to particular spawning grounds every year during spring. Attributed to early life stage mortality, herring recruitment decreased in the western Baltic Sea during the past two decades. Since major drivers and stressors for herring reproduction are potentially introduced on the local scale of spawning and nursery grounds, the knowledge of the contribution of different nurseries to population dynamics is essential but challenging to investigate.

We used elemental fingerprinting in otoliths of early herring life stages, caught in four known spawning and nursery areas along the Western Baltic Sea, to detect differences in the chemical composition based on varying water chemistry in particular areas. Results revealed a distinct chemical separation between juvenile herring caught in the vicinity of the Island of Ruegen (south-western Baltic Sea) and other potential nursery areas further west in the Baltic Sea with high significant differences among all areas. Furthermore, we created an innovative elemental fingerprinting index (*EFI*), which allows us comparisons of otolith multi-element patterns within certain nursery areas and between nurseries, indicating that otolith chemistry is a suitable tool for future habitat connectivity estimates. The aim is identification of herring offspring origin and therefore the contribution of particular nursery areas to the adult population, which could lead towards a more directed management.

Since 1981 Latvia performs regular hydro-acoustic surveys of sprat stock In the Eastern Baltic Sea (ICES Subdivisions 26 and 28.) Oceanographic surveys are carried out simultaneously with hydro-acoustic surveys. The peculiarities of sprat distribution were analysed in relation to season, size of the stock, size of the recruitment, and some environmental conditions like severity of winter, inflows of saline waters from the North Sea, water temperature and content of oxygen in the water. The analysis showed that seasonal vertical distributional pattern is rather steady while the horizontal distribution could have differences between years although main concentrations of sprat are over big depth in cold part of the year and closer to the coast in summer-fall period (Strods et al. unpublished). There are also differences between distribution of younger and older age groups of sprat. A hypothesis is put forward that Gotland Deep basin is the centre of distribution of sprat stock in the Baltic Sea.

The importance of early life stage ecology for recruitment of a population was exemplarily studied on two distinct Baltic spring herring populations: the Gulf of Riga herring (representing the gulf herring) and the Western Baltic herring (representing the sea herring). Presented here is a synthesis of three publications and one manuscript regarding findings on recruitment drivers which are considered as generic for the Baltic Sea spring herring populations. Amongst others, the role of small- and meso-scale drivers and stressors for the recruitment strength was investigated including effects of regional climate regimes and food availability on larval growth as well as consequences of single storm events on herring egg mortality.

For most herring populations in the Baltic Sea frequenting coastal zones and inner coastal waters for spawning and larval retention, this means that important drivers and stressors of recruitment dynamics are acting on the scale of regional basins or estuaries. This renders stocks vulnerable against (anthropogenic) alterations of coastal zones and regional climate regimes. Generally, reproductive success and year class strength of the Western Baltic herring population is strongly determined by the survival of early life stages such as eggs and larvae in local nursery areas. However, the explicit mechanisms by which local stressors might affect overall recruitment are currently not well understood. In the very shallow NE part of the Gulf of Riga, high summer temperatures, which likely exceed the physiological optimum, may negatively affect larval survival.

Therefore, the observed simultaneously high growth and mortality rates primarily resulted from a rapidly increasing and high water temperature that masked potential food-web effects. The investigation suggests that the projected climate warming may have significant effect on early life history stages of the dominating marine fish species inhabiting shallow estuaries. In the long-term perspective (since the 1950), hydroclimatic factors (significant were winter water temperature and annual sum of sun hors) appeared to be superior to biotic variables in explaining the inter-annual variability of recruitment abundance.

2. Summary by task

WP3 aims at quantifying the impact of individual scale movements on population scale spatial distributions. Besides the scaling from individuals' movement to populations' dispersion in space, focus in WP3 is on local scale mortality, for example hazards due to hot spot fisheries, predation on aggregations of juveniles, or climatic extremes such as severe winter storms. The question to be addressed is whether such local events shape larger, regional scale population abundance and recruitment strength and thus spatial distribution patterns.

The workpackage has the following two objectives:

1. To develop methods to scale individual movements of cod, herring, sprat and flounder (early life stages) to population distributions.
2. To perform process-studies collecting basic knowledge on regional hazards for population dynamics of Baltic herring and cod

Task 3.1 Scaling individual movements to populations' spatial distributions

Drift of fish eggs and larvae has been scaled to temporally and spatially resolved distribution and settlement probability maps focusing on relative densities of juveniles within the different nursery areas.

Observed distribution patterns of early life stages have been put in relation to individual movement and migration analysis. Results of this task have been provided by D3.1 (Hinrichsen et al. 2017) and completed in the 3rd project year.

Source: Hinrichsen, H.-H., von Dewitz, B., Lehmann, A., Bergström, U. and Hüssy, K. 2017. Spatio-temporal dynamics of cod nursery areas in the Baltic Sea. Progress in Oceanography 155: 28-40. http://dx.doi.org/10.1016/j.pocean.2017.05.007

Task 3.2 Quantifying effects of regional hazards on larger scale productivity and spatial distributions

Quantifying effects of regional hazards on larger scale productivity and spatial distributions) through investigating the life stage specific ecology of early ontogeny of the Baltic spring herring and the regional-specific factors affecting their survival. Specifically, we have investigated i) temperature-driven effects on larval growth and mortality, and associated likley impact on recruitment abundance; ii) local stressors, such as egg mortality caused by storm induced wave action as a driver reproduction success, ii) the individual and combined effects of several abiotic and biotic variables on the inter-annual variability in recruitment during 1957-2012. These investigations were performed for both gulf and Western sea herring populations, enabling therefore to generalise the findings at the pan-Baltic Sea scale.

The results of the different studies on active habitat selection and migration patterns conducted in WP3 indicate that distribution pathways are strongly species and life stage specific. Distribution models along major oceanography and specific current regimes as globally conducted should consider behavioural aspects and increasing individual mobility of successive developmental stages of fish larvae and juveniles. Although those models, if properly parameterized, are valuable tools to provide insight in spatial dispersal of pelagic fish eggs and early juvenile stages as demonstrated by D3.1, directed habitat use of advanced development stages should be increasingly considered and specific habitat requirements investigated along the entire fish ontogeny.

The majority of the dominant commercial fish species require shallow coastal nursery areas at some stage in early life history. With current rates of coastal change, our findings emphasize the importance of the near shore zone when considering reproduction of pelagic, ocean-going fish species. This highlights the need for a more sensitive management of regional coastal zones. Further research should be devoted to strengthen our knowledge on the contribution of certain juvenile habitats to adult populations. Within WP3 elemental fingerprinting of fish otoliths was identified as a suitable method to investigate the origin of juvenile herring from multiple juvenile habitats along the South-Western Baltic coasts. Such studies bear the potential to significantly advance our understanding of the role of spatial aspects and habitat characteristics in population dynamics and potentially provide important baselines to be incorporated into ecosystem-based fishery assessment.

Besides the question on regional hazards for fish recruitment, task 2 of WP3 investigated the distribution mechanisms which translate such local stressors to large scale population dynamics. The here presented deliverable 3.2 includes studies on the impact of active migrations to fish distribution patterns (as ammendment to the results presented in D3.1 that focussed on passive drift of juvenile stages). As provided as deliverable 3.3, multiple studies adressed life stage specific ecology of early Baltic herring ontogeny and the regional factors affecting their survival. The publication included in D3.2 includes novel studies on active habitat selection of larval herring In a major spawning- and larvae retention area in the western Baltic Sea (D3.2, Polte et al. 2017). Additionally, elemental fingerprinting from otoliths of young-of-the- year herring revealed specific signatures of the particular nursery areas for the population of western Baltic spring spawning herring (D3.2, Moll et al. in prep.).

An important focus of investigation in task 2 of WP3 is on the pathways of local and regional stressors (D3.3) to the scale of adult populations. The example of the Western Baltic herring stock illustrates how local stressors on early life stage survival in spawning grounds and larval retention areas can affect entire population dynamics on larger spatial scales (also see D3.3 and section of Western Baltic herring in D5.2). In the current understanding, dispersal of larval fish in the ocean is predominantly associated to exogenous mechanisms such as passive drift along ocean currents. Active migration and habitat selection is so far rather neglected in oceanographic distribution models and coastal zone management. Interestingly behavioral aspects of habitat selection and active migration are evidently important components of larval dispersal in inland river systems partly subjected to major hydrodynamics and current velocities. A potential shift from passive to active dispersal at an advanced larval stage prior to metamorphosis to the juvenile fish would render dispersal models, integrated over the entire larval phase, imprecise to an unknown extent. Clearly however an incorporation of behavioural aspects would potentially improve parameterization of such models. Here we investigated particular habitat use of differing herring larval stages revealing a so far undocumented loop in habitat use along the early ontogeny and underlining the importance of the shallow shore zone for larval retention. In a major spawning- and larvae retention area in the western Baltic Sea, results indicated an active habitat selection which differed between larval herring stages.

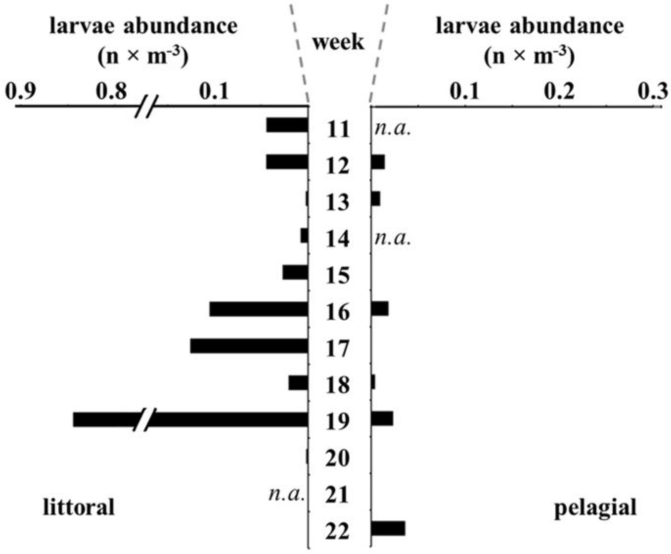

Figure 1. Left panel shows results of weekly beach seine samples in 2015 (littoral zone), while the right panel shows the abundances derived from ring trawl catches in corresponding weeks (pelagic zone). N.a. = not analysed and sample not taken, respectively. Note the fracture of the y-axis for the littoral data.

In a system without significant tidal forcing or large scale current regimes, such as the Baltic Sea, behavioural traits might be important mechanisms of larval dispersal. As littoral habitats in temperate waters are underrepresented as important habitats for larval fish by coastal zone management, there remains a potential risk that important fish resources are being affected by habitat degradation before fishes grow into size classes relevant for current stock assessment models.

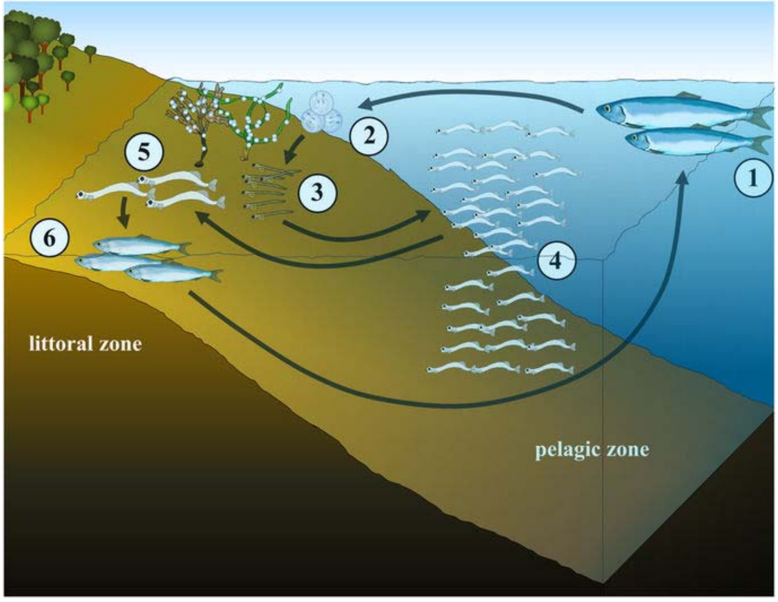

Figure 2 Adult herring (1) migrate from the offshore pelagial into inshore waters to spawn their adhesive eggs on littoral substrates such as macrophytes (2). Yolk-bearing hatchlings (3) appear concentrated in the vicinity of the spawning beds, while medium sized larvae (4) are rather well horizontally distributed in the pelagic area of the bay; however their vertical distribution in the water column is significantly heterogeneous. Advanced larvae (5) return to shallow littoral areas where they remain until after their metamorphosis to the juvenile fish (6). Growing juveniles migrate to offshore areas along their development and usually recruit to the spawning group after 2–3 years.

Source: Polte P., Kotterba P., Moll D., von Nordheim L. 2017. Ontogenetic loops in habitat use highlight the importance of littoral habitats for early-life stages of oceanic fishes in temperate waters. Scientific Reports 7:42709, DOI: 10.1038/srep42709

In a second study we used elemental fingerprinting in herring otoliths to detect differences in the chemical composition based on varying water chemistry in particular spawning areas along the Southwestern Baltic Sea coast. Cluster analysis revealed a distinct chemical separation between juvenile herring caught in the vicinity of the Island of Ruegen (south-western Baltic Sea) and other potential nurseries. This novel approach will increase our understanding of the contribution of particular coastal nursery areas to overall western Baltic herring productivity.

Along the range of spatial distribution a species might use a suite of differing juvenile habitats which might differ in extension and/or environmental habitat characteristics. Beck et al. (2001) in their “nursery-role hypothesis”, defined particular criteria to identify important nursery areas for marine fish and invertebrates that can drive a significant part of species reproduction success. An important-although difficult to assess- criterion is the quantification of the contribution of a single juvenile habitat to the productivity of the adult population.

Accordingly, a nursery area for a particular fish species is characterized by its superior contribution to adult population dynamics. Otolith microchemistry has the potential to broaden our understanding of fish migration patterns, homing behavior and connectivity between juvenile and adult habitats. Based on the method of elemental fingerprinting, a novel approach of multiple element analysis, we studied the elemental composition of juvenile herring otoliths from outer coastal waters and 0-group herring otoliths from four known inshore spawning and juvenile areas of Western Baltic herring using ICP-MS methods. Elemental fingerprinting from otoliths of young-of-the- year herring revealed specific signatures of the particular nursery areas for the population of western Baltic spring spawning herring. These findings will be immensely valuable for investigating the numerical contribution of different juvenile habitats to the adult population.

Source: Moll D., Kotterba P., von Nordheim L., Polte P. Using elemental fingerprinting in early life stages of Western Baltic herring (Clupea harengus) otoliths to distinguish different nursery areas (manuscript).

Within the framework of the INSPIRE project the database of historic Latvian acoustic surveys was created for sprat distribution. The data from this database were then used as a baseline for the analysis of long-term changes in sprat distribution. There were no evident variations from year to year in seasonal distribution character. Sprat in spring season aggregates usually over deeper waters and during spawning and intensive feeding season moves towards coastal waters and aggregates over 30-70m depth. The main factor determining aggregation and distribution pattern of sprat population during BASS surveys in May was winter severity. The main factor determining aggregation and distribution pattern of sprat population during BIAS surveys in September-October was water temperature in 50-100m depth layer, but in recent 7 year period distribution supposedly is determined by several factors simultaneously. In last two decades sprat distribution is shifted northward coinciding with an increase in winter temperatures and population size. More evident it is in spring season. The investigated area of Eastern central Baltic is supposedly important for the reproduction of sprat as the proportion of sprat spawning stock biomass significantly increases in years of rich year-class formation.

<u>*Gulf of Riga herring*</u>

In the Gulf of Riga the abundance of 1-year old spring spawning herring obtained from hydroacoustic estimates is statistically significantly (non-linear regression: $n = 9$, $r^2 = 0.63$, $P<0.01$) determined by the number of post-flexion herring larvae during 2005-2013. The abundance of consecutive developmental stages of larvae: yolk-sac, pre-flexion, flexion and post-flexion strongly correlated with each other, indicating that factors which already influence the yolk-sac stage are important in determining the abundance of postflexion herring larvae. Winter air temperature before spawning determined the timing of maximum abundance of pre-flexion herring larvae, but not their main prey: copepod nauplii, implying that different mechanisms governing major preconditions for the formation of year-class strength. The abundance of postflexion larvae displayed a potential dome-shaped relationship with sea surface temperature experienced after hatching.

We suggest that increased summer temperatures, which exceed the physiological optimum negatively, affect the survival of post-flexion herring larvae. Simultaneously high individual growth and mortality rates of herring larvae were also observed, which appread to be amongst highest observed elsewhere previously, evidencing that higher growth rate of marine fish larvae did not result in lower mortalities. We suggest that high growth and mortality rates primarily resulted from a rapidly increasing and high (>18 degrees °C) water temperature that masked potential food-web effects. Overall, the results suggest that the projected future climate warming may pose an additional risk to larval herring survival and may lead to a reduction in those herring stock which rely on recruitment from shallow coastal areas. The linearly combined effects of annual sum of sunshine hours (SH_A) and water temperature in January-March (T_{JFM}) resulted in highest explanatory power of the interannual variability of recruitment over the entire time series (1957-2012), while TJFM and the Baltic Sea Index in December-March were the best predictors of R during the periods of low and high SSB.

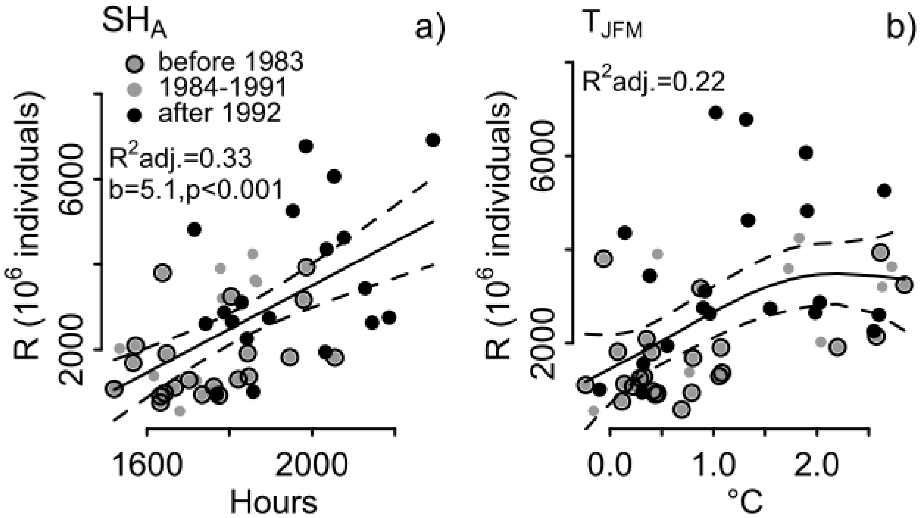

Figure 3. Gulf of Riga spring herring recruitment abundance as a function of SH_A (a) and T_{JFM} (b). Different colour and type of points separates the years before (<1983) and after (>1992) the regime shift, and the years between.

Although significant, the SSB as predictor was inferior compared to abiotic drivers. SSB was shown to have a notable effect on R during periods of relatively low water temperature, suggesting threshold-like transient links between R, SSB, and environmental forcing.

Source:

Arula, T., Raid, T., Simm, M., Ojaveer, H. 2016. Temperature-driven changes in early life-history stages influence the Gulf of Riga spring spawning herring (Clupea harengus m.) recruitment abundance. Hydrobiologia 767: 125-135.

Arula, T., Laur, K., Simm, M., Ojaveer, H. 2015. Dual impact of temperature on growth and mortality of marine fish larvae in a shallow estuarine habitat.

Estuarine, Coastal and Shelf Science, *http://dx.doi.org/10.1016/j.ecss.2015.10.004*

Ojaveer H., MacKenzie B. R., Raid T., Kornilovs G., Klais, R. Long-term transient recruitment dynamics of a herring population (manuscript)

Western Baltic herring

During their spring migration Atlantic herring populations in the Baltic Sea rely on shallow transitional waters, such as estuaries, bays and lagoons for spawning. Those inshore spawning grounds are ecologically important by providing suitable substrates for demersal egg deposition. However, these habitats are often highly impacted by multiple anthropogenic threats. Since the middle of the past century, eutrophication processes severely affected the depth distribution of aquatic macrophytes in the inner coastal waters of the Baltic Sea by increased water turbidity, and the corresponding reduced light availability. Consequently, depth distribution of vegetation, the main spawning substrate for Baltic herring populations, decreased significantly and spawning beds are nowadays limited to the shallow near shore zone. Hence, these remaining beds of appropriate spawning substrate are increasingly exposed to hydrodynamic forcing including storm induced wave action. Regarding the forecast that storm force and storm frequency will increase in the future it is important to know the impact of single storm events on herring egg mortality.

Hypothesizing that a water depth limit of vegetation causes increased herring egg mortality due to high exposure to storm induced hydrodynamics, we performed a combination of field experiments in an important herring spawning ground with quantitative herring egg sampling, investigating the impact of storm events on herring egg loss. Results of egg loss experiments and - quantification of eggs attached to aquatic plant litter on the shoreline revealed a total egg loss between 29 and 98% in one single spawning bed during a storm event within the spawning season. Even though high egg mortalities can be a natural consequence of excessive spawning, there is evidence that increased egg mortality can affect population dynamics.

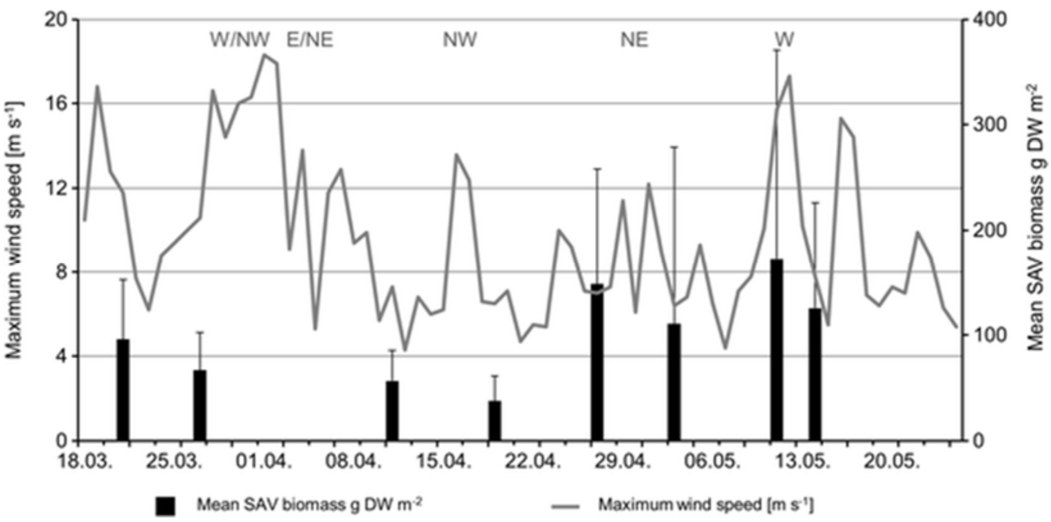

Figure 4. Mean SAV biomass g DW m^{-2} (*bars*) with standard deviation along the spawning season 2012. The *gray line* represents the daily maximum wind speed ($m\ s^{-1}$), and prevailing wind directions during four storm events are given in abbreviation. The first storm event end of March was characterized by changing wind regimes (north-westerly to north-easterly). (Moll et al. 2017).

Our results emphasize the potential of regional weather extremes such as storm events to act as influential stressors for herring reproduction. We conclude that regional storm events are crucial stressors for the reproduction success of inshore spawning herring and potentially other fish species. In addition to other local stressors, such as coastal modification and predation by estuarine fish community (Kotterba et al. 2014), synergistic impacts of eutrophication and increasing storm frequencies (Coumou and Rahmstorf 2012; Woth et al. 2006) might pose a threat to herring egg survival in inner coastal waters.

Table 1 The storm-induced observed egg loss numbers are indicated by maximum egg loss. Following the assumption that any loss of SAV directly results in a loss of adherent herring eggs, this calculated egg loss numbers are indicated as the minimum egg loss on the shallow spawning zone A (1 m depth). Minimum and maximum values for the first storm event are based on results from the experiment, and the other egg loss values are based on transect egg concentration data, taken along the entire spawning season 2012

	Egg loss in billions	
Storm event	**Min.**	**Max.**
28th March–04th April	17.2	55.7
11th April–19th April	32.7	94.7
27th April–03rd May	3.3	110.1
11th May–14th May	0	0
Estimated egg loss per spawning zone A (1 m depth) in 2012	**53.2**	**260.5**

Regional coastal zone management should consider those ecological cascades and implement appropriate strategies to maintain crucial habitats for early life stages of fish populations since local stressors negatively affect the population dynamics at on higher spatial scales.

Source: Moll D., Kotterba P., von Nordheim L., Polte P. 2017. Storm-induced Atlantic herring (Clupea harengus) egg mortality in Baltic Sea inshore spawning areas. Estuaries & Coasts, 41: 1–12. DOI 10.1007/s12237-017-0259-5

Despite the new knowledge gained about the non-stationary relationships between the Gulf of Riga spring herring recruitment abundance and environment in the long-term perspective (since the 1950s), we are still several steps away from operational application of these relationships in stock assessment. Some of the obstacles are purely organizational: for example, incorporating the annual sun hours in the forecast done by the ICES Baltic Fish Stock Assessment Working Group (WGBFAS) will not be feasible, because the variable itself, even if its mechanism will be explained in future, will not be available until the end of year, but the group meets already in April. Another important observation was that most in situ measured local ecosystem variables were not significant in the final model. The fact that local measurements of zooplankton abundance and water temperature did not perform well may partly be due to the inaccuracy or low representativeness of the point measurements when the dependent variable (R) is integrated basin-wide subject to year-round dynamics of drivers. However, one should remain optimistic that resolving the non-linearity and non-stationarity of the abiotic drivers will eventually improve both our understanding of recruitment dynamics, and modelling of the effect of different environmental and fishing scenarios on the future recruitment and stock dynamics.

Concerning spring spawning herring in the Western Baltic Sea, our studies revealed that major stressors on reproduction success are situated on the scale of local spawning grounds located in coastal transitional waters such as bays and estuaries. Those inner coastal systems also serve as important nurseries and retention areas for early herring life history stages. As local stressors to egg/larval survival become transported to population level by influencing annual stock recruitment strength, regional management of reproduction areas needs to be implemented into stock management plans. Currently management of Western Baltic herring applies when fishes are large enough to be captured in the fishery, leaving fishery regulation by catch quota as the only applicable management tool. However, in case of herring that spawns benthic eggs mainly on aquatic vegetation in inshore spawning areas, local alterations of the coastline as well as continuous eutrophication of inner coastal systems might limit reproduction success before current management procedures on international level can take effect. The lack of awareness that regional habitat management might affect internationally important fish resources becomes even more critical under the light of changing climate regimes. Response of population dynamics to increased storm frequencies and climate induced shifts in herring phenology are likely to be pronounced in shallow coastal systems less stable against extreme climate events compared to offshore systems. In synergy with high nutrient inputs by agriculture, increasing spring temperatures lead to an observed degradation of herring spawning grounds. Realizing their responsibility for international fish resources, regional/local stakeholders (including agriculture representatives) and governments should become increasingly included into international (ICES) stock assessment benchmark identification processes for Western Baltic herring. Simultaneously, research addressing the suite of ecological drivers and the role of highly productive inner coastal waters for Baltic Sea food webs should be promoted on national and international level.

Relation to Deliverables and Milestones

D3.2 (Manuscript on the impact of active migrations in the observed distributional changes of cod, herring and sprat) has been fulfilled.

D3.3 (Manuscript on the role of small- and meso-scale drivers and stressors for overall Baltic herring recruitment) has been fulfilled

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Kotterba, P., Kühn, C., Hammer C., Polte P.2014. Predation of threespine stickleback (*Gasterosteus aculeatus*) on the eggs of Atlantic herring (*Clupea harengus*) in a Baltic Sea lagoon. Limnology and Oceanography 59: 578 – 587.

Woth, K., Weisse R., Storch H. v. 2006. Climate change and North Sea storm surge extremes: an ensemble study of storm surge extremes expected in a changed climate projected different regional climate models. Ocean Dynamics 56: 3 – 15.

3. **Deviations from the workplan**

There were no deviations from the workplan

WP 4 Stock Assessments

Lead: Jan Horbowy (P3, MIR-PIB)

1. Scientific highlights

One of the major aims of WP4 was to provide assessment of the status of flounder in the Baltic, as a basis for its quantitative management. First, investigations of stock structure was performed using genetic and morphometric data. Genetics was used to estimate the proportions between pelagic and demersal ecotypes of flounder in given area, basing on data collected within Inspire surveys. These results were next used to define stock structure for assessments and management.

A variety of assessment models and methods for estimation of MSY reference points have been tested and applied. The set of analyses comprised age-based methods, different stock-production models, including state space models with random effects, length based approach as spawning potential ratio, equilibrium yield and biomass curves as basis for MSY parameters estimation. The methods were applied to stock structure defined within Inspire project on the basis of newly collected data within Inspire surveys.

Important elements of flounder fishery are discards. They could not be directly included into the assessments as time series of reliable discards estimates are very short. However, extensive analysis was conducted to test effects of different discards ratios on assessment results and management conclusions. For these analyses a few discards models were considered and applied. The general conclusion was that inclusion of discards increase estimates of biomass in similar rate as discards rate but has little effect on estimates of fishing mortality. Trends in biomass estimates with modelled discards included were similar to trends in biomass estimates without discards.

The conducted analyses indicate good state of flounder in sub-divisions 24-25; all models indicate that stock biomass is high, while fishing mortality is low and below F_{msy}. Similarly, SPiCT assessments indicate good status of flounder in sub-division 26; stock biomass is above B_{msy}, fishing mortality is below F_{msy}.
On the contrary, state of flounder in sub-division 28 has been poor in recent years; stock biomass has been below B_{msy}, and fishing mortality has been above F_{msy}.

The biomass of flounder in sub-divisions 27,29-32 declined but has been stable and above B_{msy} in recent years, while fishing mortality has been below F_{msy}. No assessment or evaluation model has indicated immediate danger for the stock.

2. Summary by task

WP4 includes knowledge on the processes shaping heterogeneity in spatial distribution of exploited species in the existing analytical assessments for cod, herring and sprat. Furthermore, analytical assessment for flounder will be provided, accounting for stock structure and spatial distribution of this species, as a basis for quantitative management of this species. Besides the traditional single- and multispecies stock assessments, input is generated to estimate indicators of good environmental status according to the Marine Strategy Framework Directive (in WP5).

The WP4 has the following two objectives:

1. to include and quantify the effects of migrations and spatial and temporal changes in exploited fish distribution (cod, herring, and sprat) on stock assessment,
2. to provide assessment of the status of flatfish in the Baltic, as a basis for quantitative management of these stocks.

Task 4.1 Assessment of fish stocks with inclusion of migration, spatial and temporal effects and taking into account impact of cod predation

The task and deliverable D4.1 was finished by 3rd project year but the results of conducted analyses (estimates of biomasses, recruitments, and biological data by former assessment units (AUs), i.e. herring in sub-divisions 25-27, herring in sub-divisions 28-29+32, sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32) were basis for the derivation of MSY parameters (MSY, F_{msy}, B_{msy}) for previous AUs. Next, stock dynamics in these AUs was compared with estimates of MSY parameters and conclusions on state of stocks in relation to MSY points were driven. It appeared that for all stocks (except sprat in sub-divisions 26+28) recent exploitation was not exceeding MSY parameters.

Relation to Deliverables and Milestones

D4.1 (Report on assessment of herring, sprat and cod, including spatial effects (biomass distribution, natural populations) has been fulfilled during the 3rd project year.

Task 4.2 Stock identification of flounder in the Baltic Sea

The aim of this task was to develop tools to be used for identification of different flounder stocks to enable allocation of catch to different spawning types of flounder in different fisheries in the Baltic Sea.

Using a subset of flounders of known spawning type (sampled in WP1) as reference material, different techniques (genetics, morphometrics & otolith chemistry) have been applied to develop tools for separating demersal and pelagic spawning flounder and enabling allocation of catch to different spawning types of flounder in different sub-divisions.

Results from the genetic study within INSPIRE were analysed, basing on over 1000 samples of adult flounders collected in the INSPIRE gillnet survey (and complemented by samples from the German Alcor survey) that were genotyped using 16 microsatellites. STRUCTURE analysis showed the existence of two distinct clusters (F=0.026) which was shown to correspond to demersal and pelagic spawning type of flounder. Within the clusters there was very little genetic differentiation. Estimating the proportion of flounders of the different types in the survey revealed that in sub-divisions 24-26 majority was pelagic type while in sub-divisions 28 & 32 the majority was demersal.

Assuming the gillnet survey is representative of the flounder population in the Baltic Sea this means that the current assessment and management units sub-divisions 24-25 consists of 84 % pelagic; sub-divisions 26 & 28 of 47% pelagic and sub-divisions 27-29,32 8% pelagic. Genetic results from more than 300 juveniles collected in the INSPIRE Beachseine survey in sub-division 25 and sub-division 28 showed that the demersal type dominated in Gotland and Gulf of Riga but in Hanöbay and the Latvian coast the proportion was almost equal.
Results of genetic and morphometric data from adult flounder were combined and investigated for the possibility of discriminating between ecotypes. Images of 200 genotyped flounders from sub-divisions 25 & 28 were analysed using 11 landmarks to create 18 morphometric distances. It was revealed that sex, area, and ecotype of flounder influenced the body shape of fishes. Using a discriminant analyze function 74 % of the fishes could be correctly classified to either demersal or pelagic type.

Source: BONUS INSPIRE Deliverable 4.2

<u>*Relation to Deliverables and Milestones*</u>
D4.2 (Database for flounder assessment or evaluation by stock) has been fulfilled.

Task 4.3. Data analysis and analytical assessment or evaluation of flatfish stocks

At present ICES evaluates state of the flatfish in the Baltic using approaches for Data Limited Stocks (DLS) and flounder are classified as category 3 stocks (ICES, 2017). The reason for this are limited data (some of poor quality) for assessment of flatfishes and so far accepted analytical assessments for flounder stocks were not agreed within ICES, even if a lot of effort was devoted for such tasks through workshops and benchmark assessments (ICES, 2012, 2014). Present ICES advice for flounder is based on the ratio of catches in most recent two years to catches in preceding three years, which is used to modify current catch level. Moreover, change in survey index and/or fishing effort is considered. Deliverable D4.3., i.e. Report on model and methods of assessment or evaluation of flounder stocks status, reflects work performed to realize 2nd of the WP-4 objectives. It aimed at assessment or evaluation of the flatfish stocks status using different approaches, depending on availability of the data: from simple length or age based equilibrium methods, through surplus production or difference models, length-based assessment models, to the more comprehensive age-structured models. In addition, stock structure was analysed and re-considered, leading to separation of flounder defined by ICES in sub-divisions 26+28 as one stock into two stocks, with pelagic component prevailing in sub-division 26 and demersal component prevailing in sub-division 28.

The compilation of data and preparation of data base for evaluation or assessment of flounder stocks was completed. This included age-structured data (catches and survey results by age), length distributions of catches and surveyed biomass, fishing effort and/or catch per unit of effort (CPUE), results of national surveys. The workshop on flatfish assessment was organised in early June to facilitate preparation of D4.3, i.e. report on the assessment of flatfish stocks (see Annex 1).

For the stock redefinition, the identified within Inspire project spawning components (pelagic and demersal) have been taken into account. The following stocks were defined:
- flounder in sub-division 24-25 (mainly pelagic component)
- flounder in in sub-division 26 (mainly pelagic component)
- flounder in in sub-division 28 (mostly demersal component)
- flounder in in sub-divisions 27 and 29-32 (mostly demersal component)

Methods

The data compiled within D4.2 (including ICES data) were used for the stock assessment or evaluation.

For flounder stock assessments several models and methods were applied. It were:

a. Extended Survivors Analysis (XSA, Shepherd, 1999), the age-structured model routinely used by ICES expert groups for stock assessment when age data are available,
b. Two models of the stock-production type: Schaefer model (1954) and difference model (Horbowy, 1992),
c. stochastic surplus production model in continuous time (SPiCT) **-** newly developed implementation of stock-production models formulated as state-space models, in which random variability in stock dynamics is separated from measurement error in survey indices (Pedersen & Berg, 2017); SPiCT contains both Pella & Tomlinson (1969) and Schaefer (1954) production models,
d. Length-based spawning potential ratio analysis (LB-SPR) (Hordyk et al., 2015a,b), which allows estimation of the proxy MSY reference points when length structure of the stock is available,
e. The method of equilibrium yield curves (Horbowy & Luzeńczyk, 2012) which allows to derive equilibrium yield and biomass and to estimate MSY parameters when age data and S-R relationship are known.

Important elements of flounder fishery are discards. Their rate and patterns depend on the country: in Polish fishery discards are low as there is a market for flounder catches, while in Scandinavian fishery most of caught flounder is discarded. Discard estimates have been collected for years, however, for stock in sub-divisions 24-25 their estimates are considered of good quality only for recent three years (2014-2016). Having no reliable estimates of discards in previous years we cannot include them into the assessments. Thus, to see their possible effects on assessments and management a range of possible discards patterns was simulated and included in the two assessments models: XSA and Schaefer stock-production model. That allowed for inspection of sensitivity of assessment results to level and pattern of discards. Such analysis has not been conducted so far for flounder in the Baltic. As a tool for the analysis the script in R was developed to perform the XSA with defined discards patterns; for Schaefer production model similar analyses were conducted in VisualBasic.

The method of equilibrium yield curves (Horbowy & Luzeńczyk, 2012) was extended for cases when analytical estimates of stock size and recruitment (needed to derive S-R relationship) were not available. It was shown that survey based S-R relationship may also be used for estimation of F_{msy}. That approach was applied to estimate F_{msy} for flounder in sub-division 27, 29-32.

Results

Flounder in sub-divisions 24-25

The estimates of biomass and fishing mortality (F) from different assessment models are presented in Figure 5. The models show quite consistent estimates of biomass and F; trends are similar and absolute values do not differ much in most cases. As XSA biomass the exploited biomass is shown as such biomass is represented in stock-production models, thus it is more comparable with production models biomass than spawning stock biomass. All models show about four fold biomass increase compared to the end of previous century. Fishing mortality declined from about 0.5 – 0.6 in middle of 1990s, to 0.1 – 0.2 in recent years. It may be concluded that in recent years stock biomass was high and fishing mortality was low.

The F_{msy} reference points for this stock were estimated in the range from 0.24-0.30 (Horbowy & Luzeńczyk approach) to 0.31-0.34 (Schaefer models). Thus present Fs are well below F_{msy}.

The inclusion of discard estimates into the assessments affected mainly biomass; the fishing mortality was only slightly changed. Similarly, estimates of F_{msy} in Schaefer model were only slightly affected by discard levels (Figure 2) Irrespective of discards patterns, the derived F_{msy} were constrained to range 0.26 – 0.31. Therefore, with discards considered in the models it may be also concluded that recent fishing mortalities were below F_{msy}.

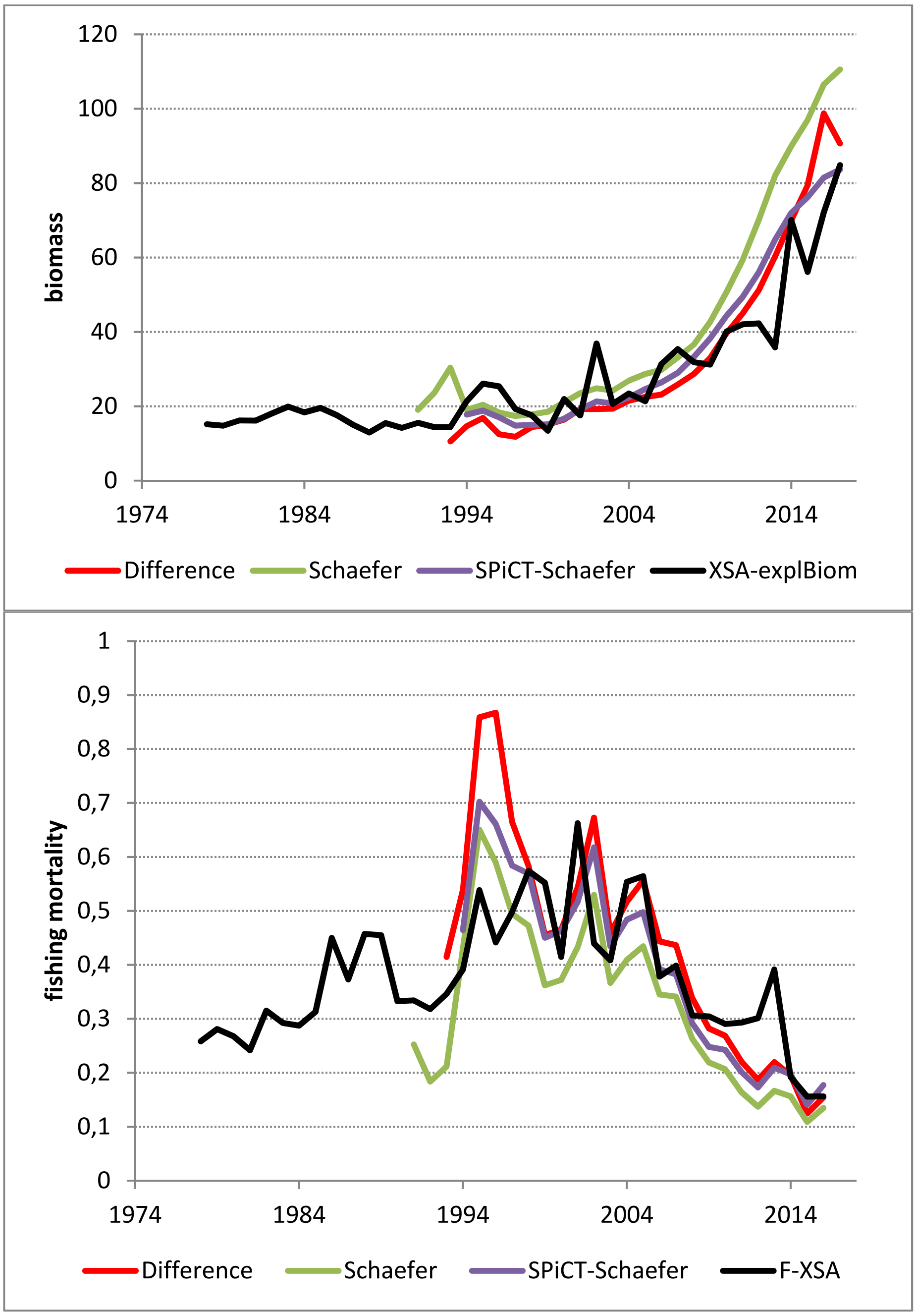

Figure 5. Estimates of biomass (kt) and fishing mortality from considered assessment models. In case of XSA exploited biomass is shown.

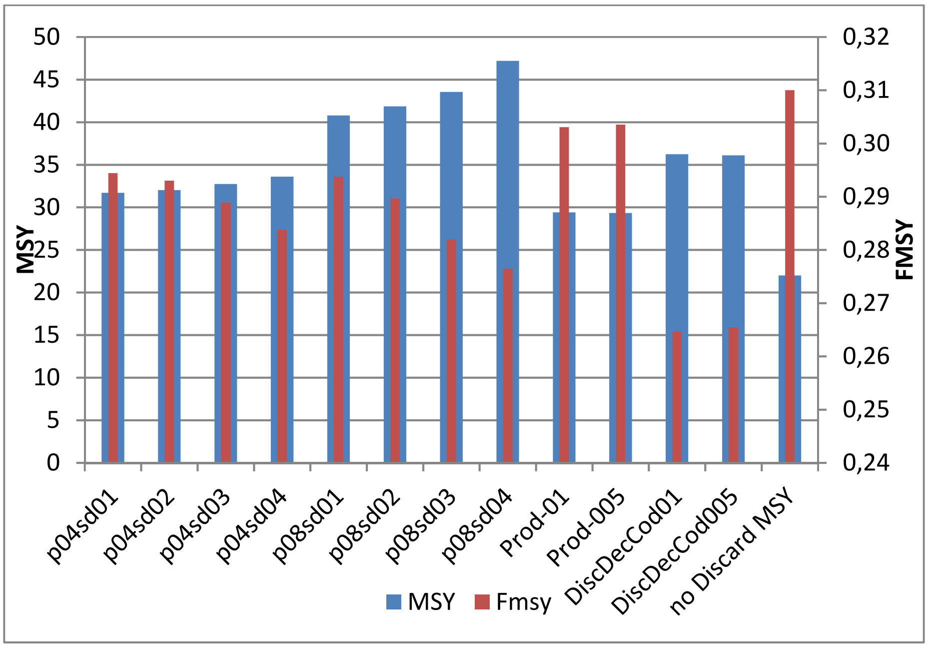

Figure 6. The average of estimates of flounder MSY (kt) and F_{msy} for different discards options. For each discards pattern 200 simulations with different realisations of random errors were performed. For comparison estimates with discards excluded from the model are shown. X-axis labels: p04=discard rate 0.4, p08=discard rate 0.8, DiscDecCod=discard proportional to cod catches, Prod=discard proportional to product of cod catches, flounder survey biomass, and flounder landings.

Flounder in sub-divisions 26 and Flounder in sub-division 28

Data available for these stocks enabled only fitting stock-production models and SPiCT approach was selected for such analyses. Both Pella & Tomlinson and Schaefer stock-production models were attempted within SPiCT. The model was tuned to BITS indices of stock size.

Stock in sub-division 26

For this stock there were difficulties in estimation of reasonable level of F_{msy}, which was obtained well above 1. To get more reasonable estimate of F_{msy}, the prior on parameter r was imposed basing on value of that parameter for pelagic stock in sub-divisions 24-25. Such approach led to estimate of F_{msy} at about 0.6 (Figure 7). Irrespective of difficulties in estimating of realistic level of F_{msy}, all attempted models showed similar trends in stock size and fishing mortality; stock was above B_{msy} and F below F_{msy} in recent years. In addition, Schaefer option produced quite consistent retrospective estimates of biomass and fishing mortality. Thus, the SPiCT model may be used for approximate evaluation of the state of flounder stock.

Stock in sub-division 28

All attempted models showed similar trends in stock size and fishing mortality; stock below B_{msy} and F above F_{msy} in recent years, indicating poor state of stock at present. The SPiCT with Schaefer option (Figure 4) was considered more realistic than Pella & Tomlinson approach, as the later one had very wide confidence intervals for shape parameter n. In the Schaefer option deterministic F_{msy} was estimated at 0.22 and MSY at over 800 tons.

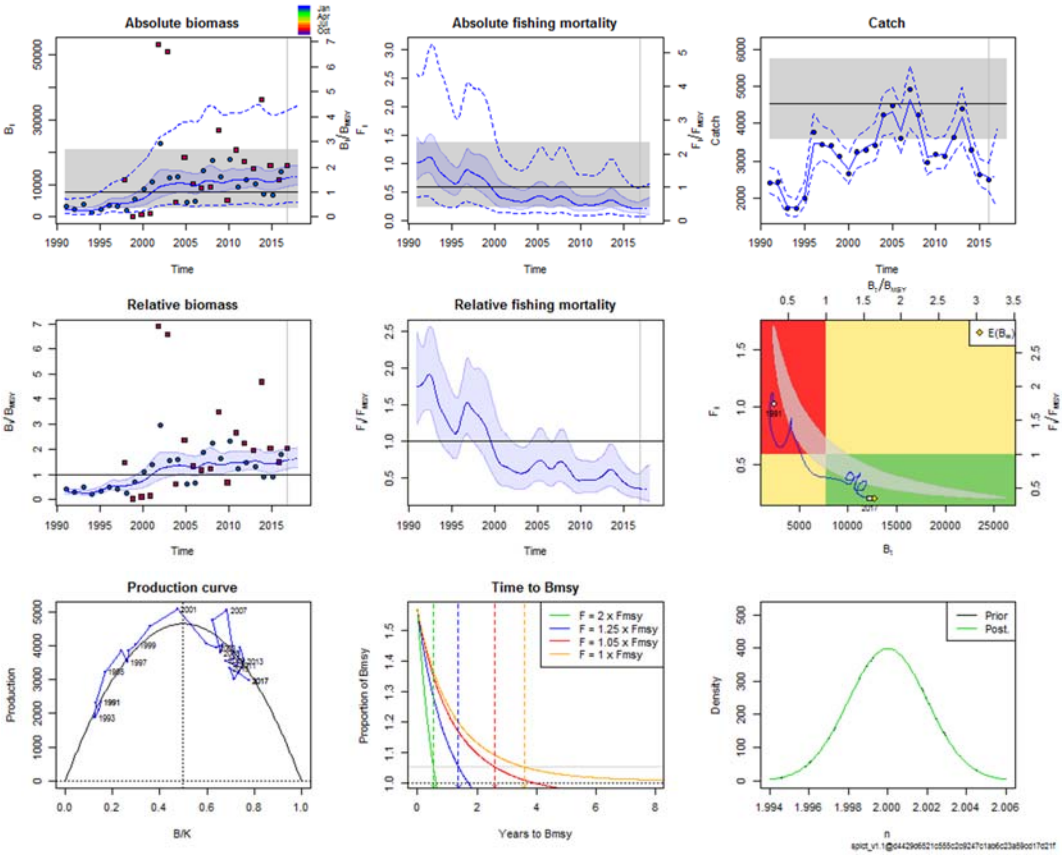

Figure 7. Summary of results from the SPiCT model (biomass, fishing mortality, production curve, stock in relation to MSY reference points) for flounder in-sub-division 26; Schaefer option was used, and prior on r assumed basing on results of the model fit for stock in sub-divisions 24-25.

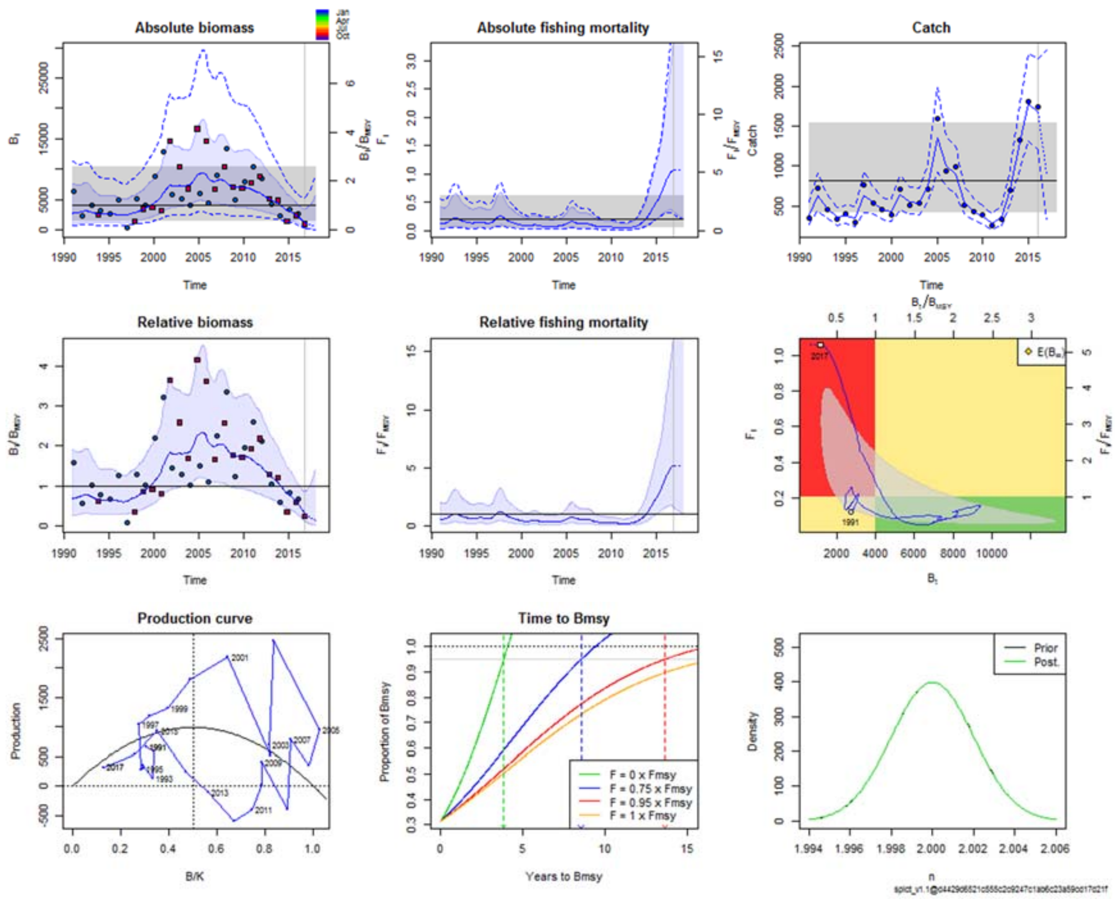

Figure 8. Summary of results from the SPiCT model (biomass, fishing mortality, production curve, stock in relation to MSY reference points) for flounder in-sub-division 28 and Schaefer option.

Flounder in sub-divisions 27, 29-32

In the analysis and evaluation of that stock the following methods were applied:

a. difference model of Horbowy (1992)
b. stochastic surplus production model in continuous time – SPiCT
c. length-based spawning potential ratio (LB-SPR) method (Hordyk et al., 2015a,b)
d. Modified version of equilibrium yield approach of Horbowy & Luzeńczyk (2012)

Comparison of assessment models results is presented in Figure 9. The estimates in absolute terms are not very different and the trends in their development are quite similar. For several years both biomass and fishing mortality have been declining. The estimate of F_{msy} for that stock is at 0.13 from Horbowy & Luzeńczyk (2012) method (recalculated as exploited biomass F) and at 0.08 from SPiCT model. Most recent F values are at or below these ranges indicating stock exploitation not exceeding MSY framework. Similarly, F_{msy} proxies from Hordyk et al (2015a, b) method suggest exploitation below the proxies levels.

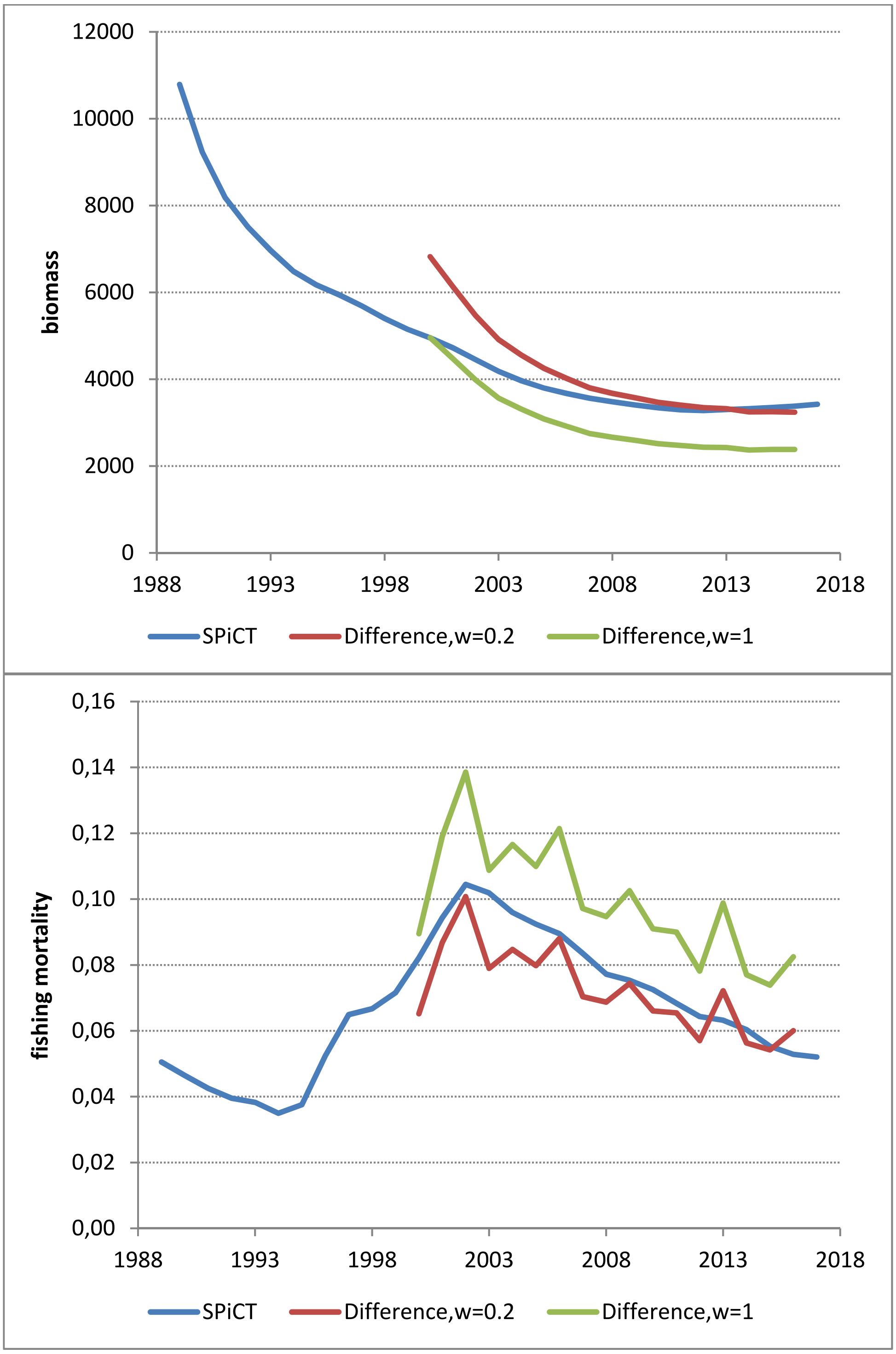

Figure 9. Estimates of biomass (tons) and fishing mortality from SPiCT (Schaefer option) and difference models (two options: weight of S-R term equal 0.2, and weight of S-R term equal 1).

Source: BONUS INSPIRE Delivrable 4.3

Relation to Deliverables and Milestones

D4.3 (Report on model and methods of assessment or evaluation of flounder stocks status) has been fulfilled.

3. Deviations from the work plan

There were no deviations from the updated (agreed with BONUS Secretariat) workplan.

The deadline for deliverable 4.2 was postponed by 2 months (from M36 to M38, approved by BONUS Secretariat) due to unexpected complexity of various sources and types of information, and additional time needed for validating and harmonizing data.

In agreement with the BONUS Secretariat, both the submission time and the nature of D4.3 were changed from manuscript in M44 to report in M48. The reason lies in the fact that the limited nature of the collected original material from field surveys, together with the associated scientific uncertainty in the obtained data was considered insufficient to come up with a scientific manuscript on the model and methods of assessment of flounder stocks. The data/knowledge limitation was not known during the project proposal writing /negotiation phase, and some of the uncertainties were resolved during the additional 4 months allocated for the work.

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WP 5 Ecosystem based management

Lead Jari Raitaniemi (P9, Luke)

1. Scientific highlights

Potential warning indicators for Eastern Baltic (EB) cod stock development have been examined. Indicators of recruitment environment, like depth at 11 psu isohaline, can be used as an “early warning” of potentially good or bad conditions for recruitment before survey and stock assessment data are available. Cod body condition has decreased from the mid 1990s and suggests high natural mortality, likely due to starvation. In the absence of analytical stock assessment, the rescaled Baltic International Trawl Survey BITS index may be considered as an early warning indicator in estimating the cod stock size. Massive environmental changes like increased hypoxic bottom areas have caused changes in cod feeding level. The combined consequences of declining growth, reduced condition, and spawning at smaller sizes on individual egg production and viability of offsprings have remained unclear.

Major differences behind the fishery and trends of local herring stocks in the Gulf of Bothnia and the Gulf of Finland in the NE Baltic Sea were documented. Recent abundant presence of sprat in the NE Baltic Sea, which also affects herring fishery, is likely facilitated by superior competitive feeding to herring. The commercial extinction of the previously abundant autumn spawning herring in the early 1980s was likely due to too high fishing mortality. Spatial distribution and size composition of sprat and herring affect the individual performance in salmon and cod, suggesting the need for spatial management of sprat. In the eastern areas of the Baltic Sea, i.e. Gdansk Deep and Gotland Basin, the presently implemented area closures of cod fisheries are likely largely ineffective in enhancing the cod stock. The two stock subpopulations of flounder seem to use different areas following settlement.

The Baltic Sea is currently chosen as a pilot case for taking into account biological interactions in the new fisheries management plans. Its ecosystem has undergone major structural changes: decline in cod and herring biomass from the late 1980s to the 1990s and increase of sprat biomass. The spatial distributions of these species have changed as well as their interactions. With cod and sprat this has implied a change and a mismatch in the spatial overlap between them, affecting predator-prey interactions. In ICES stock assessments, e.g. genetic analyses and practical reasons have led to mainly combining a number of stocks of sprat, herring and flounder. When comparing stock assessments by former ICES Assessment Units with the larger, present ones, the results have been mainly compatible, but with sprat there was spatial contradiction that should be taken into account. A better understanding on the spatial processes for most stocks may potentially improve our ability to optimize stock management.

2. Summary by task

WP5 critically revises the existing management for Baltic cod, herring and sprat, taking into account possible modifications and extensions when spatial heterogeneity is accounted for. Modification may include changes in maximum sustainable yield due to different perception of predation mortality and recruitment. Extensions may include regionalization of management measures due to local extremes in exploited fish biomass on. Furthermore, the implementation of the Marine Strategy framework Directive will be supported by linking MSFD indicators in a spatially explicit context.

The workpackage has the following three objectives:

1. Document and publish the importance of including spatial heterogeneity into ecosystem-based management in the Baltic
2. Report on the importance of spatial heterogeneity in defining Baltic-specific MSFD indicators
3. Develop proposals to include significant regional processes in Baltic ecosystem-based fisheries management

Task 5.1 Early warning indicators of cod stock development

The aim of this task was to examine the usefulness of different indicators in examining the Eastern Baltic (EB) cod (Gadus morhua callarias) stock development. Indicator based approaches are important for fish populations such as the EB cod that are strongly affected by climate induced environmental changes.

<u>Recruitment environment</u>

Of the examined variables, only abiotic ones showed significant relationships with the recruitment residuals (RecRes). Depth of the 11 psu isohaline in the Gotland Basin was the most obvious indicator. The reproductive volume of the combined central Baltic showed also coherence results in all tested periods. The indicators showed that the physical oceanographic conditions of the cod recruitment environment started to get detrimental at the beginning of the 1980s. This approach can be used as an “early warning” of potentially good or bad recruitment strength, before survey and stock assessment data are available.

<u>Body condition</u>

Data from the Baltic International bottom Trawl Survey (BITS) were used to follow cod body condition over time. The results in all ICES subdivisions showed that cod condition increased between the mid-1970s to the early 1990s, which was followed by a drop until the late 2000s and stabilization at low levels. The changes in cod condition were related to feeding opportunities, driven either by density-dependence or food limitation, and to the fivefold increase in the extent of hypoxic areas in the most recent 20 years. It is important to continue monitoring the cod body condition as an indicator of the effects of e.g. hypoxic areas.

<u>Stock abundance</u>

ICES has been unable to provide since 2013 analytical assessment of the EB cod stock size because of too many uncertainties in the biological variables of cod. A rescaled BITS index may be used as the indicator of stock development. The approach takes into account high correlation (R=0.97) between spawning stock biomass from the last accepted assessment and the index of stock size from BITS. The results indicate that the estimate of biomass for 2017 is very low.

Feeding level (1965-2014)

We estimated prey-specific energy consumption rates and trends in feeding level and calculated growth potential using a bioenergetics model. Preceding the regime shift in the early 1990s, small cod had the highest feeding level over the cod length range. This changed during the last decade: many small pre-spawning cod have presently feeding levels implying severe growth limitation and increased mortality. We recommend that stomach content data together with hydrographic data are sampled on a regular basis.

Size distribution (1991-2015) and L_{max} (1978-2014)

We utilized the BITS data of 1991-2015 from the Database of Trawl Surveys (DATRAS) for our calculations with the Eastern Baltic cod size distribution and maturity data. In the Eastern Baltic (EB) cod, the length at which 50% of the individuals have reached maturity (L_{50}, sexes combined) has decreased over the last 20 years, from 33–42 cm in the 1990s to 20–27 cm in the 2010s. In addition, declining growth, reduced condition, and spawning at smaller sizes have been observed. L_{50} can be further tested as a warning indicator. L_{max} data from SDs 25-28 were modelled using GAM (Orio et al. 2017). The time series shows the highest L_{max} of approximately 77 cm in the period 1983-1985, after which the L_{max} decreased steadily down to around 40 cm in 2014. The decrease in L_{max} took place simultaneously with the Eastern Baltic cod stock collapse. The drop in L_{max} has probably been caused by a mix of excessive fishing pressure and changes in growth. It is recommended to follow the development of the changes in L_{max}.

95th percentile of the fish length-frequency distribution in research vessel surveys (L_{95}) (1991-2015)

Similarly, the L95th percentile of the EB cod length frequency distribution in the research vessel surveys (L_{95}, Rochet et al., 2010), which captures the upper part of the length–frequency distribution, has decreased during the years 1991-2015.

90% of the stock total area occupied (1982-2011)

Data from BITS survey (CPUEs of cod > 30 cm), and precedent national surveys, were used to analyse, using GAMs, the changes in spatial distribution of cod between 1982 and 2011. The results showed that when cod population size was high, the occupancy index was above 70%, while when the population decreased, the habitat occupied was reduced to 57%. A slight increase in the area occupied was observed after 2005 (Bartolino et al. 2017). Spatial distribution and area occupied, especially in marginal habitats, have been proved to be a good early warning indicator.

Hypoxic benthic areas – trend (1965-2015)

Hypoxic areas in SDs 25–28 (SMHI) decreased from the late 1970s to the lowest levels in mid-1990s (approx. 10×10^3 km^2), increased strongly up to the mid-2000s, and remained constant afterwards at around 50×10^3 km^2. Hypoxic areas within the main depth interval of cod (i.e. down to 100m depth) showed very similar patterns. Suitable areas for cod increased from the late 1970s to the mid-1990s, decreased until the late 2000s and remained thereafter stable at around

90×10^3 km^2. In percentage, the decrease in suitable areas between the early 1990s and the late 2000s has been approximately 30%. It is important to follow the changes in cod suitable areas.

Relation to Deliverables and Milestones
D5.2 (Report on spatially explicit MSFD indicators) has been fulfilled.

Task 5.3 Manuscript on the role of spatial heterogeneity in Baltic ecosystem-based management
In this task, the results from WPs 1 to 4 will produce knowledge relevant to ecosystem-based management that cannot be applied within the currently existing assessment units. This could for example be regional differences in predation of cod on clupeids due to differences in predator-prey overlap, regional predation on herring larvae, migration highways of cod outside existing marine protected areas, or regional competition for sprat between cod and the fisheries. Proposals will be developed on how to include this knowledge into the current management routines and suggest modifications for improvement in management.

Clupeids
Temporal development in the herring fishery in the two neighbouring gulfs in the NE Baltic Sea – Gulf of Bothnia and Gulf of Finland – evidence major differences since 1990: while catches almost tripled in the Gulf of Bothnia, the trend in the Gulf of Finland was decreasing (Raid et al., 2018). The small sprat quota of Finland has become restrictive to the whole potential of herring fishery in the Gulf of Finland due to high proportion of sprat in mixed catches. In the NE Baltic Sea, sprat seems to be more successful in the competition than herring and its high density probably suppresses herring growth, when the zooplankton community is dominated by small-sized taxa (Ojaveer et al., 2018).

INSPIRE research revealed clear genetic differences between two herring ecotypes – spring and autumn spawning – and hence support their reproductive isolation (Bekkevold et al., 2016). Our recent research suggests that the sharp decline in the earlier very abundant autumn spawning herring in the 1960s and the 1970s was due to too heavy fishing mortality (MacKenzie & Ojaveer, submitted). Because of the poor knowledge, studies on their basic ecology should be encouraged.

It appeared that size-specific prey availability explained the proportion of sprat in salmon diet better than prey biomass and increased salmon body condition. Thus, food- and size-dependent processes influence the performance of planktovorous fish predators (Jacobson et al, 2018). An ecosystem approach should be facilitated for successful management of salmon in the Baltic Sea.

Fishing mortality in recent years in former assessment units (AUs) has been lower than the estimate of F_{msy}, except sprat in sub-divisions 26+28. In the fishery of sprat, it is recommendable to concentrate the fishing efforts on the northern Baltic areas, this would also leave more sprat as prey for the cod in the southern Baltic Sea. Estimates of MSY reference points by former AUs should be farther refined by compiling AUs based maturities and applying them in the estimation procedure.

Cod

Research in other INSPIRE workpackages has shown that spatial distribution of adult cod was mainly affected by cod population size. As population size decreases, the cod population concentrates to the southern part of the Baltic Sea, where the more marine environment conditions are encountered (Bartolino et al. 2017). The present data and knowledge do not provide evidence that the spawning closures in the Baltic Sea are improving cod stock structure, though at favourable salinity and feeding conditions, the area closure may be effective in protecting the spawners and their offspring.

Similarly, low survival of WB cod offspring in SD 24 implies limited effect of the spawning closure on cod recruitment in this area (Eero et al, submitted).
The use and design of spawning closures should be carefully considered and regularly evaluated, to avoid potential counterproductive effects. In a longer term, expansion of monitoring and dedicated research activities would be required in order to improve the scientific basis for design and evaluation of spatio-temporal measures such as spawning closures.

Flounder

The period of larval drift into a suitable nursery area is considered to be of great significance for recruitment variability in flatfish. The spatio-temporal dynamics of the probability to settle in preferred nursery habitat were examined. The study suggests that the majority of larvae drift towards coastal areas and settle at metamorphosis ≤20 km from a sandy habitat, enabling further migration to a preferred nursery area. The drift model results suggest that flounder hatching in the Arkona Basin and Bornholm Basin utilize nursery areas in mainly the SDs 22-25 and the Kattegat, whereas flounder hatching in the Gdansk Deep and Gotland Basin mainly utilize the southern and eastern coast of the SDs 25, 26 and 28. The model implies that spawning in the Bornholm Basin is of great importance for stock recruitment of deep basin spawning Baltic flounder (Hinrichsen et al, submitted).

Based on the present knowledge on flounder ecology and the presence and spatial distribution pattern of pelagic and demersal ecotypes in SDs 26&28, splitting this management unit into two can be suggested (BONUS INSPIRE D5.2). It is recommended to put more emphasis on length-based assessment methods (see BONUS INSPIRE D4.3).

Source:
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Relation to Deliverables and Milestones
D5.3 (Manuscript on the role of spatial heterogeneity in Baltic ecosystem-based management) has been fulfilled

Task 5.4 Manuscript on regionalization of Baltic Sea ecosystem-based management
The Baltic Sea is currently chosen as a pilot case for taking into account biological interactions (e.g. predator-prey interactions, competition, spatial aspects) in the new fisheries management plans being under development in the European Commission (ICES 2012; STECF, 2012).

The Baltic Sea ecosystem has undergone major structural changes. While there has been a more than 10-fold decline in cod and herring biomass from the late 1980s to the 1990s (Casini et al., 2009; Möllmann et al., 2009), the biomass of sprat has increased 5-fold after the early 1990s (Köster et al., 2003). Simultaneously, cod, sprat and herring have dramatically changed their spatial distributions during the past three decades, and therefore the interactions between the species (in terms of predation and competition,) have also changed (Casini et al., 2011, 2012).

Natural populations versus management units
In the attempts to distinguish different Baltic sprat stocks, Lindquist (1978) did not find significant differences in morphometric characters and vertebrate counts, whereas Ojaveer (1989) supported the existence of three different sprat stocks. Genetic analyses do not point clearly at different sprat populations (eg. Limborg et al. 2009, 2012). ICES defined in 1977 three sprat stocks (assessment units, AUs), but ended up in 1990 to merge the stocks to one AU (ICES, 1990).

Five spring-spawning populations of gulf herring and four sea herring populations can be distinguished. The gulf herring populations are e.g. adapted to considerably more continental conditions than sea herrings and live their whole lives at low salinities and generally do not undertake long migrations (Ojaveer, 1989 and references therein).

From 1974 to 1990, Baltic herring stocks were assessed in a number of units mostly corresponding to biological populations (ICES, 2002). However, some of these populations could not be separated in the catches, and the assessment process proved to be too costly. Thus, several herring populations were combined to one stock unit in 1990: Central Baltic herring (CBH), including herring stocks in the ICES SDs 25–28.2, 29 and 32; (ICES, 1990). Since 1991, the herring in the Baltic Sea has been assessed in five assessment units (Raid et al., 2016):

1. Herring in SDs (ICES Sub-Divisions) 22–24 (Western Baltic herring);
2. Herring in SDs 25–27, 28.2, 29 and 32 (Central Baltic Herring, CBH; also included the Gulf of Riga herring until 2002);
3. Gulf of Riga herring (SD 28.1); separate assessment and TAC since 2003);
4. Herring in SD 30 (Bothnian Sea);
5. Herring in SD 31 (Bothnian Bay).

In 2017, herring in SD 30 and herring in SD 31 were combined to herring in SD 30 and 31 (Gulf of Bothnia) (ICES, 2017).

On the basis of several characteristics, seven autumn-spawning herring populations can be discerned (Ojaveer, 1989 and references therein). Autumn and spring herring represent distinct ecotypes and are reproductively isolated (Bekkevold et al., 2016).

In the Baltic Sea, two flounder ecotypes differing in their spawning habitat and egg characteristics have been described (Nissling et al., 2002; Florin and Höglund, 2008; Ustups et al., 2013; Orio et al., 2017a). The most common is the pelagic spawning flounder, which spawns in spring in deep waters, where salinity conditions enable the 'floating' of eggs and fertilization. The demersal spawning flounder that mostly occurs in the northern, less saline waters, spawns directly on the bottom in shallow coastal areas and on offshore banks (Florin, 2005; Nissling et al., 2002). In the central areas of the Baltic Sea, e.g. in SDs 25 and 28, their spatial distribution is overlapping (Nissling et al., 2002; Florin and Höglund, 2008; ICES, 2014a; Orio et al., 2017a).

Until the end of 2013, 9 or 15 potential flounder stocks were identified, but they were assessed as a single management unit (SDs 22-32; Bagge, 1981; Bagge and Steffensen, 1989; Aro, 1989; Florin, 2005; Florin and Höglund, 2008). At present, there is evidence of only three stocks with pelagic eggs and one in the north with demersal spawning (ICES, 2014b). The two ecotypes mix in some areas and, according to Momigliano et al. (2017), are actually two different species.

Two genetically distinct cod stocks are currently managed separately: the Eastern Baltic cod (EBC) in ICES SD's 25-32 and the Western Baltic cod (WBC) in SD's 22-24.

<u>Predator-prey overlap affects the aggregate predator diet and prey population dynamics</u>

The EBC stock was uniformly distributed in the Baltic Proper in the early 1980s, with the highest biomass ever recorded, and was also occurring in most northern Baltic areas (Casini et al., 2012; Bartolino et al., 2017). In the mid-1980s, the declining stock concentrated in the south-western Baltic Sea (Casini et al., 2012; Bartolino et al., 2017), with better hydro-climate conditions. Currently, cod is also dwelling more in coastal areas, likely as a consequence of increased hypoxic deep waters (Casini et al., 2016a; Orio et al., in preparation). Sprat, the main pelagic prey of cod, showed an opposite pattern. Corresponding to its outburst in the early 1990s, the sprat stock concentrated in the northeastern areas, at least in autumn (Casini et al., 2011, Figure 10).

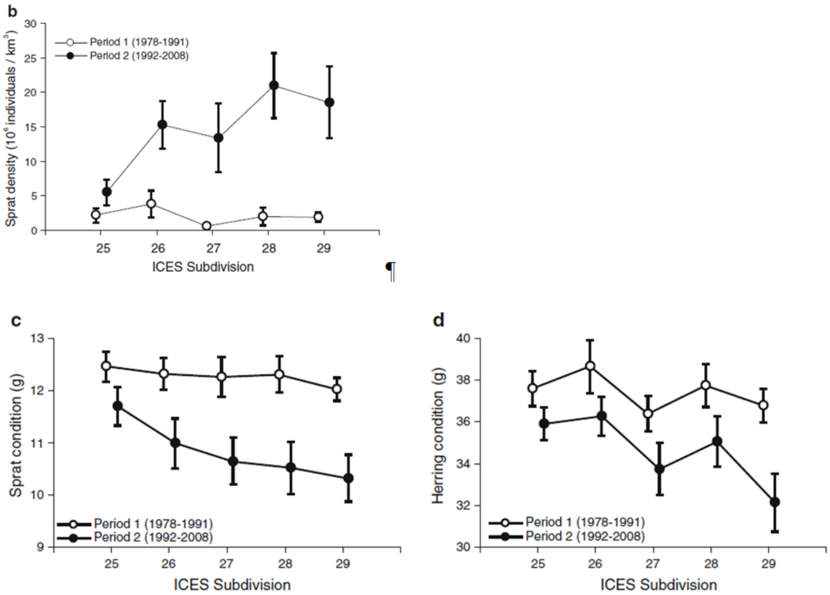

Figure 10. Mean sprat abundance in the different ICES Subdivisions (a). Mean sprat and herring condition in the different ICES Subdivisions (b, c). Updated from Casini et al. 2011.

As cod inhabited ~100% of the area occupied by sprat and herring until the early 1990s, currently only 60% of the area is inhabited by cod. This suggests a decrease in the predation pressure of cod on its prey species, due to predator-prey spatial mismatch, which could have contributed to the increase in both Baltic sprat and Central Baltic herring stocks.

<u>Local density-dependence affects somatic growth</u>

The increase in the sprat population since the early 1990s increased intra-specific and inter-specific competition in the pelagic fish community, triggering a general decline in both sprat and herring mean size at age and condition (Casini et al., 2010). This decline was the most evident in the northeastern Baltic Proper (Casini et al., 2011; 2014).

Between 2007 and 2013, the number of EBC has increased regionally in SD 25 (Casini et al., 2016), whereas not prominently in SDs 26–32 (Eero et al., 2012, Orio et al., 2017b). The increase in SD 25 did not lead to recovery or redistribution of the stock. Instead, the body condition decreased (Casini et al., 2016), being accompanied by lower consumption rates of smaller cod (<35 cm), markedly decreased ration of benthic prey in the diet, and decreased somatic growth rates (Neuenfeldt et al. in preparation).

<u>Source-sink dynamics affect regional abundances</u>

The increase and collapse of the EBC population was parallelled by an expansion and subsequent contraction of its spatial distribution: at its highest in the late 1970s-early 1980s, EB cod spilled over into the northern Baltic (Casini et al., 2012; Bartolino et al., 2017). With the decline in the late 1980s, the population contracted back to the southern Baltic Sea. In the Gulf of Riga, cod appearance and subsequent disappearance propagated down the whole local food web: the Gulf of Riga herring, and in turn summer zooplankton and phytoplankton biomasses (Casini et al., 2012). Cod fishery, and salinity and oxygen levels are likely the major factors in the connectivity between the two systems, limiting cod population size and distribution range.

The waters of Greifswald Bay (GWB; SD 24) are considered a major spawning area of Western Baltic spring spawning herring. Continuous strong correlations of annual larval herring production in GWB with abundance of 1-yr juveniles indicate the dependence of the overall recruitment of the population on early life stage survival in these inshore, transitional waters (Polte et al., 2014). During the past decade, larval herring production in GWB decreased steadily reaching record low numbers in 2014 and 2016. Still the strong correlation with the 1-yr group in the western Baltic Sea remained valid.

Several case studies hint on a suite of local stressors of early life stage survival. High egg and larval mortality during recent mild winter temperatures is potentially triggered by a combination of steep spring temperature gradients and high level of eutrophication, evidently increasing herring egg mortality (Aneer, 1987; V. Nordheim, unpublished). Additionally, spring storms can drastically increase egg mortalities by up-rooting macrophytes covered by herring eggs (Moll et al., 2017). Predation on early life stages might also represent important drivers of reproductive success. There is a strong spatio-temporal overlap with three-spined sticklebacks (*Gasterosteus aculeatus*). In a scenario where stickleback densities are increased by over exploiting predatory fish (Bergström et al., 2015), this could result in over proportional herring egg mortalities.

<u>Stock mixing affects local abundance dynamics</u>

Historic tagging studies document considerable stock mixing of EBC and WBC in the Arkona Basin (SD 24) (Aro, 1989 and references therein; Nielsen et al., 2013). In the late 2000s, the abundance of adult cod in the Arkona Basin rapidly increased, while their abundance remained at a lower, stable, level in SD 22. EBC have always been present in the Arkona Basin, increasing from around 30% before 2005 to >70% in recent years (Hüssy et al., 2016).

Examples for sensitivity of stock assessments

The present ICES assessment and advice of Baltic herring and sprat stocks uses predation pressure from cod, not differentiated by areas. However, for several years the distribution of cod has been constrained to southern Baltic mainly. In practice, predation pressure in northeastern waters is low. The assessments of herring and sprat stocks were performed by AUs that were used up to 1990 for comparison with present routine assessments by ICES (Horbowy et al., in preparation). In this approach, the overlap between clupeids and cod may be considered more realistic than in standard ICES assessment through adopting area based estimates of predation mortality. The assessments indicated that for both herring and sprat the sum of stock estimates over former assessment units is very close to present ICES estimates. Similarly, average weighted fishing mortality by AUs was similar to present ICES estimates.

The stock assessments by former AUs gave basis for the estimation of stock based MSY reference points (F_{msy} and MSY) and comparisons of fishing mortality with the reference points. In recent years, fishing mortality of all stocks except sprat in SDs 26+28 has been below or at F_{msy}. Thus, both western and northern sprat stocks are underexploited in relation to F_{msy}. This is in contradiction to the ICES routine assessment that indicated overexploitation for the whole sprat stock in the most recent years. For herring, the relation of recent fishing mortality to F_{msy} by AU is more consistent with the ICES evaluation for CBH stock, but suggests stronger exploitation of herring in the southern Baltic.

Implications and outlook

The increased mismatch in spatial overlap between cod and sprat has been hypothesized as one of the causes of the decrease in cod condition during the past two decades (Casini et al., 2016b). One possibility to aid stock rebuilding is to restrict fishing on sprat in the main cod area (mainly SD 25) and simultaneously increase fishing in the more northern areas (northern SDs 28, SD 29 and SD 32), although maintaining the total fishing mortality for the stock unchanged (ICES, 2017).

The increased and varying extent (and depth) of hypoxic areas also calls for an improvement of the fisheries-independent surveys used for cod monitoring. Under hypoxic conditions at the bottom, cod becomes more pelagic (Schaber et al., 2012), therefore changing the catchability of the bottom trawls. We suggest therefore that the estimation of cod abundances in the demersal habitat (BITS) is complemented with estimations in the pelagic water, using e.g. the already existing acoustic fish surveys.

With flounder, recent genetic studies (unpublished data) conducted during the BONUS INSPIRE project have suggested the need for a revision of the current flounder management unit in SDs 26 and 28, which in WKBALT (ICES, 2014b) was considered to be inhabited by the pelagic ecotype. A significant part of flounder in SD 28 appear to belong to the demersal ecotype and in SD 26 to the pelagic ecotype. If the ecotypes were not separated, it would overshadow the developments in the “real” demersal component in the demersal management unit. Spawning of pelagic flounder in SD 28 occur on the slopes of Gotland Deep (Ustups et al., 2013) and, due to unfavorable hydrological conditions on last decade, the proportion of pelagic flounder could significantly decrease (Orio et al., 2017a). This hypothesis is also in line with the work of Orio et al. (2017b), which shows different trends in abundance and in maximum length of flounder belonging to SDs 26 and 28. Also length at age and age at maturity have recently been shown to differ between SDs 26 and 28 (Erlandsson et al., 2017).

In general, the recruitment of Western Baltic spring spawning herring might be rather sensitive against environmental alteration of regional coasts. Since spawning grounds and nursery areas are located inshore in estuaries, bays and lagoons, local coastal zone management should be aware of their responsibilities for herring populations, and juvenile habitat requirements should be incorporated into fishery management plans.

Spatial structure affects food-web interactions, density-dependence and the population- level responses to abiotic drivers. Each of these central issues has to be addressed to increase the accuracy of estimates of historical stock development, the setting of associated reference points, and the short-term advice to management. A better understanding on the underlying spatial processes for fish stocks may potentially improve our ability to optimize stock management.

<u>Novelty in exploited ecosystem challenges assessment of living marine resources</u>

Humans are fundamentally transforming the abiotic and biotic conditions on Earth. Unprecented rates and magnitudes of this change have caused widespread novelty in ecological systems and in the future these will be significantly different from those we know from the past. Ecological novelty often comes as a surprise through cumulative external pressures causing non-linear dynamics between ecosystem components. Hence, novelty leads to unpredictability which we argue here especially challenges the management of living marine resources requiring accurate assessments of the future effects of exploitation pressure. Using the Baltic Sea as an example we show how novelty in a heavily exploited and eutrophied large marine ecosystem resulted in a false appreciation of the state of its major fisheries target species cod (*Gadus morhua callarias*). We review how increased oxygen deficiency strongly affects the spatial distribution and productivity of Baltic cod causing today´s management areas and assessment routines to be invalid. We expect similar developments to be ubiquitous in marine ecosystems strongly altered by human impact, and discuss ways toward assessment and management strategies that better account for ecological novelty through more holistic and participative approaches. We conclude that under increased novelty significant modifications are required in assessment and management of fisheries resources to safeguard the credibility and legitimacy of the governance system.

Source:
Neuenfeldt, S., Casini, M., Hüssy, K., Horbowy, J., Eero, M., Lucéncyk, A., Polte, P., Orio, A., Bergström, U., Ustups, D., Florin, A.-B., Moll, D. and Ojaveer, H. Integrating spatial processes into ecosystem-based fisheries management – the Baltic experience (submitted to Fish and Fisheries)

Möllmann, C., Neuenfeldt, S., Casini, M., Frelat, R., Hinrichsen, H.-H., Lehmann, A., Levin, P.S., Lindegren, M., Ojaveer, H., Orio, A., Otto, S.A., Sguotti, C., Uusitalo, L., Voss, R. and Blenckner, T. Novelty in exploited ecosystem challenges assessment of living marine resources (manuscript)

<u>Relation to Deliverables and Milestones</u>
D5.4 (Manuscript on regionalization of Baltic Sea ecosystem-based management) has been fulfilled

3. Deviations from the workplan
Based on the approval of the BONUS Secretariat, there was a change in the delivery date of task 5.3 from the initially scheduled M46 to M48, to be able to capture the BONUS concluding symposium (M45) outputs into the deliverable. With the task 5.4, also based on the approval of the BONUS Secretariat, the delivery date was changed from the initially scheduled M46 to M48, to be able to capture the BONUS concluding symposium (M45) outputs into the deliverable M48, and further to M49 due to unforeseen circumstances of the lead author.

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WP 6 Dissemination

Lead: Stefan Neuenfeldt (P2, DTU-Aqua)

1. Highlights

By the close contact to various ICES expert groups and Baltic Sea Advisory Council, INSPIRE results have also during the fourth project year been made available to the stakeholders and interested public almost in real time. During the fourth year of the project, these activities continued substantially supporting the Eastern Baltic cod initiatives and contributing to diverse ICES working groups. The INSPIRE web-site has been continuously updated, linking now publications, project reports with 'public' status, meta-databases and affiliated projects. During the fourth project year, one PhD thesis was defended.

2. Summary

Scientists are criticized for poor communication of research to a non-scientific audience. The formats for communication that are respected in the scientific community (peer-reviewed publications and conference talks), are not appropriate to disseminate research to policy and decision makers. WP 6 will use a variety of proven non-technical communication means and methods to adapt the project's knowledge output to the evolving needs of the high-level end users through regular interaction with decision makers and to connect with the public through media, open access to research. This multi-faceted approach allows each target audience to be addressed in the most effective manner in order to best engage, exchange and inform.

The workpackage aims to engage key target audiences downstream of the RTD core of the project, using a broad variety of engagement approaches:
1. Policy makers, by putting the latest research in policy-relevant context;
2. Non-specialist audiences, through effective use of press and medias;
3. Society at large, by providing full Open Access to projects' research publications.

Task 6.1 Participation at expert groups coordinates the consortium capacity to transfer the latest research into the "policy informing" domain, via consortium partners' participation in the relevant ICES expert groups, consultations via HELCOM and interaction with the relevant environmental stakeholders for the Baltic Sea Region and beyoned (e.g., EU). In total, INSPIRE scientists have 88 participations at various stakeholder committees (Annex 2).

Like in previous project years, Eastern Baltic cod stock has been in strong focus, due to difficulties with providing analytical assessment and the fact that the stock is now classified as a 'data-poor' stock.

This work was continued during the ICES Working Group on Baltic Fish Stock Assessments held in Copenhagen, Denmark, April 2017, and the ICES/HELCOM Working Group on Integrated Stock Assessments held in Lisbon, Portugal 2017.

INSPIRE work was presented at several ICES expert groups, such as Working Group on History of Fish and Fisheries (WGHIST), Working Group on Atlantic Fish Larvae and Eggs Surveys (WGALES), Working Group on Integrated Assessments in the Baltic Sea (WGIAB), Workshop on Evaluation of Input data to Eastern Baltic Cod Assessment (WKIDEBKA), Baltic Sea Advice Drafting Group (ADGBS) and Workshop on Biological Input to Eastern Baltic Cod Assessment (WKBEBCA).

Besides these ‘hands-on’ activities, the INSPIRE project and the BONUS framework were presented at two international science events with ICES involvement:

1. ICES/PICES Early Career Scientist Conference: Climate, Oceans and Society - Challenges & Opportunities, Busan (Korea), 30 May-2 June 2017.
2. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

In addition, INSPIRE scientists presente their work also at the following international events:

1. Baltic Sea Science Congress ’Living along gradients: past, present, future. Rostock, Germany, June 12-16, 2017.
2. PICES International Symposium: Drivers of dynamics of small pelagic fish resources Victoria BC, Canada, 6-11. March 2017.
3. International Flatfish symposium, Saint Malo, France, 11-16. November 2017.
4. ASLO Aquatic Sciences Meeting, Honolulu (Hawaii), 26 February-3 March 2017.
5. Workshop “Marine ecological-economic systems: Shifting the baseline to a regime of sustainability”, Tilburg University (The Netherlands), 22-23 September 2017.
6. 17th International Congress of the International Maritime Association of the Mediterranean, Lisbon (Portugal), 9-11 October 2017.

Task 6.2 Public awareness collaborates with the project research authors and ensure that 100% of the postprint versions of the projects` peer-reviewed manuscripts are accessible free of charge via EC FP7 Infrastructures OpenAIRE research repository (www.openaire.eu), boosting access to policy-relevant research, and increasing the visibility of the project and its publications authors.

Several advisory-related activites started previously, were continued during the third project year. These include, for instance:

1. Review of the ICES management options on Baltic Sea fish stocks in order to advice the European Commission implementing the EU Common Fisheries Policy, and analysis of effort allocation in European fisheries in the Baltic Sea in order to advice the European Commission implementing the EU Common Fisheries Policy;
2. Providing advice services to national ministries for fisheries on stock management;
3. Advisory services nationally to marine management beyond (but incorporating) fisheries issues (such as MPA’s and EBSA’s).

In addition, the following activities related to updates of the existing databases were continued during the reporting period with involvement of many INSPIRE partner institutes:

1. Contribution of BIAS and BAS data to BAD database;
2. Entry of data into Baltic International Fish Survey (BIFS) and Baltic International Trawl Survey (BITS) databases;
3. Entry of Baltic International Trawl Survey (BITS) data to DATRAS database;
4. Entry of data to the ICES Acoustic database from the Baltic International Acoustic survey (BIAS) and Baltic Acoustic Spring Survey (BASS)

5. Entry of data into Intercatch, Entry of data to Fishframe
6. Entry of data to pan-Baltic zooplantkon database

The following previously started international scietific collaborations were continued in the reporting period: partnership within the global research network 'Oceans Past Initiative' (OPI, www.oceanspast.net); partnership with the EU COST Action 'Oceans Past Platform' (OPP; H. Ojaveer, UT-EMI); pan-Baltic regional study on the Baltic Health Index (BHI), by involving cooperation from outside the Baltic Sea - Ben Halpern and the Ocean Helth Index team (T. Blenckner SU, S. Neuenfeldt DTU-Aqua, C. Möllmann UHAM, H. Ojaveer UT-EMI); membership of the LENFEST Fishery Ecosystem Task Force, led by Tim Essington and Phil Levin, to develop Ecosystem Management Plans for the US (C. Möllmann UHAM).

Blogs from INSPIRE young scientist can be found at:
http://www.bonusprojects.org/bonusprojects/blogs/inspire_me
and
http://www.bonusprojects.org/bonusprojects/blogs/data_cruncher/delicate_business_of_sharing_the_data.2586.blog
and
http://www.bonusprojects.org/bonusprojects/blogs/inspire(d)

In addition, INSPIRE has performed several other national public outreach activites. These are:
1. In total of 10 interviews to national radio and TV (in Estonia, Sweden and Finland)
2. In total three popular science papers in national fishery journals (Estonia, Finland)

And finally, INSPIRE has made available 32 metadata sheets at the project website (http://www.bonus-inspire.org/metadata, Annex 3). These provide information on the data used in all relevant peer-reviewed papers published so far.

The popular science book for children „Have you seen the fish?" was finished and can be found at http://www.bonus-inspire.org/Publications/Popular-science-book

Task 6.3 Training school and concluding symposium conducts a summer school and a concluding symposium together with other, close related BONUS projects.

The two training schools were held in 2015 and 2016. The title of the concluding symposium was 'BONUS SYMPOSIUM: Science delivery for sustainable use of the Baltic Sea living resources' and it was held in Tallinn, 17-19. October. 2017. The symposium was also endrosed by ICES and included into the science events of the Estonian Presidency in EU (for brief report, see Annex 4; but see also INSPIRE D6.3).

3. Deviations from the worklan

In agreement with BONUS Secretariat, the BONUS symposium was held in M45 (instead or the orginally planned M48).

WP7 Management

Lead: Henn Ojaveer (P1, UT-EMI)

1. Highlights

Efficient internal communication, systematic contacts with the BONUS Secretariat and continuous monitoring of the progress by the project coordination unit has secured timely science delivery according to the project workplan.

2. Summary

This workpackage has the following five generic objectives:

1. Ensuring that project objectives are achieved on time and within the costs estimated;
2. Co-ordinating all work conducted in the project,
3. Overseeing the task and work-packages,
4. Ensuring the development and production of deliverables, as well as reporting.
5. Ensuring that appropriate levels of communications are maintained among partners in order to achieve expected levels of scientific outputs.

The coordinator carried out the day to day monitoring and management of the project, ensure co-ordination between the project partners and the circulation of project documents and data, and organize meetings and discussions. Work package leaders will keep the coordinator informed of the ongoing status of work packages. The coordinator was responsible for communications with BONUS. The coordinator organized annual project meeting (report of the project final annual meeting can be found in Annex 5). The coordinator administered a budget for travel and subsistence costs for members of the Advisory Board to attend the project meetings and participate in the project. The coordinator was responsible for financial and management reporting, as required by BONUS and defined in the workplan. The coordinator was also responsible for finalising all the reports, with input from work-package leaders. The co-ordinator will make sure that the final report reflects a consensus of all partners. The coordinator took responsibility for ensuring that the project results are appropriately disseminated.

The coordinator was responsible for the organisation of the BONUS SYMPOSIUM on ’Science delivery for sustainable use of the Baltic Sea living resources’, held in Tallinn, 17-19. October. 2017.

3. Promoting an effective science-policy interface to ensure optimal take up of research results

INSPIRE strategy is to ensure efficient and timely two-directional communication with stakeholders. In this regard, communication and cooperation with Baltic Sea Advisory Commission (BSAC) and International Council for the Exploration of the Sea (ICES) is our priority. BSAC representative (Pehr Eriksson) is involved in scientific discussions in INSPIRE and is regularly attending project annual meetings and integrating workshops. In total, INSPIRE scientists had 88 participations in local, national and international stakeholder committees (Annex 2) with the dominating role in fisheries and ecosystem-oriented groups in ICES. In addition, several scientists are performing permanent advisory role at national and international levels (incl. in relation to EU Common Fisheries Policy, EU Marine Strategy Framework Directive and Multiannual management of Baltic fish stocks), which has expanded beyond fisheries management (e.g., advisory role on identifying the Ecologically and Biologically Significant Areas). The key activity was arranging the stakeholder panel discussion during the BONUS concluding symposium, with participation of representatives from e.g., the EU, ICES, BSAC, HELCOM, WWF and several Estonian national ministries.

4. Collaboration with relevant research programmes and the science communities in the other European sea basins and on international level

Several project partners are involved in international collaboration beyond the Baltic Sea. The nature and framework of the collaboration is varying and spanning from formal long-standing global international reserach networks (such as ‘Oceans Past Initiative’ and ’Indicators for the Seas’) to more regional and narrower activities (US LENFEST Fishery Ecosystem Task Force) and attendances of workshops focussing on modeling of ecological systems and performing ecosystem assessments. Strong collaboration in several ICES expert groups has been established and it forms backbone for some of the ecosystem-related research in INSPIRE. During the reporting period, one new collaboration was established (see performance statistic #5 for DTU-AQUA below).

5. Progress in comparison with the original research and financial plan, and the schedule of deliverables

The project was progressing according to the research plan without any deviations affecting achieving its aims and goals. Fourteen deliverables sceduled to year #4 (D1.6, D1.7, D3.2, D3.3, D4.2, D4.3, D5.1, D5.2, D5.3, D5.4, D6.3, D6.4, D7.6, D7.7) were submitted according to SoD. Minor modifications in the original financial plan have occurred in several partner institutes without implications to the workplan and science delivery.

6. Amendments to the description of work and schedule of deliverables

No changes to DoW has occurred. However, there are few important changes, driven from the motivation to increase efficiency of the science in the project in altered external conditions, which will not affect planned science delivery, but will increase visibility and impact of the project results.

i) Arrange dedicated flounder workshop (Gdynia, Poland in M41 (June 2017)), to discuss and agree the assessment methods to be used for flounder stock assessments/evaluations in order to achieve D4.3. The workshop will be hosted by INSPIRE Partner 3 (MIR-PIB) and co-chaired by Ann-Britt Florin and Jan Horbowy.

ii) Shift timing of D4.2 (from M36 to M38) due to unexpected complexity of various sources and types of information, and additional time needed for validating and harmonizing data.

iii) Change D4.3 from ‘manuscript’ to ‘report’. The reason for such request lies in the fact that the limited nature of the collected original material from field surveys, together with the associated scientific uncertainty in the obtained data is insufficient to come up with a scientific manuscript on the model and methods of assessment of flounder stocks. The change will actually not reduce the number of deliverables in INSPIRE consisting of a manuscript, as D 4.1, instead of being a report, contains two already published assessment-oriented papers. This request was approved by the BONUS Secretariat.

iv) Shift timing of BONUS symposium, 4th annual meeting and final SC meeting from M48 to M45. This request was approved by the BONUS Secretariat.

v) Shift timing of D5.4 from M48 to M49 for unforeseen critical personal reasons of key contributor. This request was approved by the BONUS Secretariat.

7. Performance statistics

The information below is given by project partners for the first project years by using institional short names as indicated on page 4 above.

1. **Number of times the project has contributed significantly to the development and implementation of ’fit-to-purpose’ regulations, policies and management practices on international, European, the Baltic Sea region or national level aimed at safeguarding the sustainable use of ecosystem’s goods and services.**

2014
UT-EMI

Review of the ICES management options on Baltic Sea fish stocks for 2015 in order to advice the European Commission implementing the EU Common Fisheries Policy +(2014-06_STECF 14-10 - BALTIC ADVICE for 2015_JRC90504.pdf)

Analysis of effort allocation in European fisheries in the Baltic Sea in order to advice the European Commission implementing the EU Common Fisheries

Policy (STECF [2014-12 Evaluation of Fishing Effort Regimes - p2_JRC93183.pdf])

Advisory servicies for the Estonian Ministry of Environment on fisheries management options in the Baltic Sea (EU Common Fisheries Policy).

Contribution to the national process of MSFD to propose monitoring scheme and start to develop program of measures.

BIOR
Participation in national and international (BaltFish) meetings on fishing possibilities in the Baltic Sea. Important component of these meeting have been proposing management options of fishing effort distribution in the Baltic Sea in pelagic fisheries that is closely connected with the INSPIRE objective to elaborate a spatially explicit advice for ecosystem-based fisheries management.

MIR-PIB
Attendance of the meeting at EC discussing the Multiannual plan for the Baltic Sea fisheries (by Jan Horbowy).

2015
DTU-Aqua
Advisory services for the Danish Ministry of Environment, Agriculture and Fisheries on fisheries options in the Blatic Sea with spoecial focus on cod fisheries and the Common Fisheries Policy.

MIR-PIB
Formulating management advice of the Baltic fish stocks to ICES, and providing evidences of increasing natural mortality of cod.

Providing advice services to Polish Ministry responsible for fisheries on stock management, incl. reporting on indicators of balance between fishing capacity and fishing opportunities.

SLU
Contribution to HELCOM for the development of indicators of the state of offshore fish community and for the HOLAS II project.

Advisory servicies for the Swedish Agency for Marine and Water Management on fisheries management options in the Baltic Sea with special focus on cod fisheries and the Common Fisheries Policy.

2016
UT-EMI
Proposals of methodology and data requirements for EU Member States for reporting on the EU Landing Obligation Proposed types of information, metrics and indicators that would be useful in reporting on the elements defined in the legislation (Omnibus Article 9 additions as applied to Article 15 of the CFP) (STECF EWG 16-13).

SLU
Advisory service to Swedish Agency for Marine and Water Management on maritime spatial planning

2017
SLU
Advisory service to Swedish Agency for Marine and Water Management on identifying Ecologically and Biologically Significant Areas.

2. **Number of suggestions for designing, implementing and evaluating the efficacy of relevant public policies and governance on international, European, the Baltic Sea region or national level originating from the work of the project.**

2014
BIOR
National discussion on the fishing possibilities in 2015, distribution of the fishing effort in pelagic fisheries.

2015
DTU-Aqua
National discussions and suggestions on limiting sprat fisheries in ICES SD 25 in order to increase living conditions for cod.

MIR-PIB
National discussions at the Department of Fisheries on developing measures to improve cod stock and fisheries in the Baltic Sea.

2017
None

3. **Number of times the scientists working in the project have served as members or observers in stakeholder committees.**

INSPIRE scientists have in total 88 participations in stakeholder committees during the fourth project year (for details, please see Annex 2).

4. **Number of international, national and regional stakeholder events organised by the project** (include information about number of participants and kinds of sectors represented)

2014
None

2015
LUKE
Open doors at survey vessel RV Aranda 09/2015. The scientists from Luke presented fisheries research and stock assessment work to media and public. 900 participants.

2016
UT-EMI
National BONUS BAMBI/BIO-C3/INSPIRE seminar on 'The new challenges in management of the Baltic Sea', Tallinn, Estonia, 27 April 2016. Attended by about 30 participants from Ministry of Environment, Ministry of Rural Affairs and Ministry of Education and Research.
2017
UT-EMI
BONUS symposium on Science delivery for sustainable use of the Baltic Sea living resources. Tallinn, Estonia, 17-19. October 2017 (for requested details, see BONUS INSPIRE D6.3)

5. **Number of joint events/co-operation activities/partnerships of the project with non-Baltic research actors and other European marine basins**.

2014

UT-EMI

Partnership within the global research network 'Oceans Past Initiative' (OPI, www.oceanspast.net) and the EU COST Action 'Oceans Past Platform' (OPP).

Participation in the global science initiative 'Indicators for the Seas, (IndiSeas).

DTU-AQUA

Participation in the the 3rd NMFS National Ecosystem Modeling Workshop held by NOAA in Seattle, WA, USA. The workshop was focused on ensemble modelling of ecological systems, and Stefan Neuenfeldt was invited to present some of the INSPIRE concepts to NOAA scientists.

Particiaption in Knowledge Based Bio-Economy (KBBE) workshop on MICE models, multispecies models, and harvest strategies for lowinformation stocks in Wellington, NZ. The workshop was focused on Models of Intermediate Complexity for Ecosystem assessments, and Stefan Neuenfeldt was invited to present the modelling strategy in INSPIRE in relation to identification of potential target levels for Central Baltic Sea fishing mortalities taking species interactions and spatial overlap into account.

SU

Pan-Baltic regional study on the Baltic Health Index (BHI), scientifically led by Thorsten Blenckner was initiated, where INSPIRE is also expected to contribute. It involves also cooperation from outside the Baltic Sea - Ben Halpern and the Ocean Helth Index team.

UHAM

Christian Möllmann is member of and has participated in 2 meetings of the LENFEST Fishery Ecosystem Task Force lead by Tim Essington and Phil Levin. The Task Force develops Ecosystem Management Plans for the US. Christian Möllmann is the selected European expert.

UU

Co-operation with Pedro Morais, Portugal in a planned pan-European project „Causes and mechanisms explaining fish life history plasticity“ focusing on flounder. Otoliths (for trace element analysis) and tissue samples (genetical analysis) from flounder from the Baltic will be included in the comparison.

2015

TI-OF

Workshop on larval herring ecology in Greifswald Bay to establish cooperation with Canadian scientists (Université Laval Département de biologie). Thuenen-Institute of Baltic Sea Fisheries 20-24. August 2015 (12 participants).

UU

Incolved in a U.S. National Science Fundation project concerning effects of hypoxia on growth in fish; including fish from the Gulf of Mexico, Great Lakes and the Baltic Sea. From the Baltic, microchemistry analysis of otoliths from cod and flounder are used to identify whether indivuduals have been subjected to low oxygen concentration or not.

2016

DTU Aqua

Contributing to the Seanors initiative with the aim to develop an integarted view on the so-called ’Seas of Norden’. Particiaptionin a workshop held by Oslo University and resutling manuscript in Nature Climate Change.

SU

Cooperation with Benjamin Halpern and the global Ocean Health Index team to develop Baltic Health Index. Two days meeting organised at SU in January 2017.

UU

Cooperation with Karin Limburg and Melvin Samson from State University of New York College of Environmental Science and Forestry US on flounder otolith microchemistry research.

2017

DTU-AQUA

Leading the PANDORA (Paradigm for Novel Dynamic Oceanic Resource Assessments) project proposal to EU H2020, that was granted acceptance in Dec 2017. Partial goal is to implement INSPIRE findings also in other

Europena regions. PANDORA consist of 25 partners from 9 European countries.

6. **Number of persons (1) and working days (2) spent by foreign scientists on research vessels** participating in the cruises arranged by the project.

2014
None

2015
DTU-Aqua
At the combined INSPIRE/BIO-C3 research cruise in the Bornholm Basin (ICES SD 25), DTU-Aqua hosted 1 research scientist from GEOMAR (PhD Cornelia Jaspers, and one from IOW (PhD Jörg Dutz), Warnemünde. The 15 days cruise took place in September 2015

UHAM
Research cruise on RV Alkor in the Bornholm Basin in April 2015. UHAM hosted 1 research scientist from DTU-Aqua (Stefan Neuenfeldt) for two days cruise.

2016
None

2017
None

7. **Number of persons and working days spent by foreign scientists using other major research facilities involved in the project**.

2014
None

2015
LU
Post-doc Mikael van Deurs from DTU-AQUA Denmark has used laboratory facilities at LU, working on cod biology 365 days.

UU
PhD Melvin Samson, SUNY-ESF U.S. stayed at the Ar Research Station, Uppsala university for preparation of flounder otoliths within the U.S. National Science Fundation project concerning effects of hypoxi on growth in fish 12 days.

2016
None

2017
None

8. **Number of peer-reviewed publications arising from the project research with authors from, at least, two different participating states**.

2014
None

2015
UT-EMI
Ojaveer, H., Tomkiewicz, J., Arula, T., Klais., R. (2015). Female ovarian abnormalities and reproductive failure of autumn-spawning herring (*Clupea harengus membras*) in the Baltic Sea. ICES Journal of Marine Science. 72(8), 2332–2340

DTU-AQUA
Eero, M., Hjelm, J., Behrens, J., Buchmann, K., Cardinale, M., Casini, M., Gasyukov, P., Holmgren, N., Horbowy, J., Hüssy, K., Kirkegaard, E., Kornilovs, G., Krumme, U., Köster, F. W., Oeberst, R., Plikshs, M., Radtke, K., Raid, T., Schmidt, J., Tomczak, M. T., Vinther, M., Zimmermann, C., Storr-Paulsen, M. 2015. Eastern Baltic cod in distress: biological changes and challenges for stock assessment. ICES Journal of Marine Science, http://icesjms.oxfordjournals.org/content/72/8/2180

Hüssy, K., Hinrichsen, H. H., Eero, M., Mosegaard, H., Hemmer-Hansen, J., Lehmann, A. and Lundgaard, L. S. (2015) Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment ICES Journal of Marine Science . fsv227. DOI 10.1093/icesjms/fsv227.

Hüssy, K., Gröger, J., Heidemann, F., Hinrichsen, H.-H., and Marohn, L. 2015. Slave to the rhythm: seasonal signals in otolith microchemistry reveal age of eastern Baltic cod (*Gadus morhua*). ICES Journal of Marine Science, http://icesjms.oxfordjournals.org/content/early/2015/12/18/icesjms.fsv247

BIOR
Ustups, D., Bergström, U., Florin, A.B., Kruze, E., Zilniece, D., Elferts, D., Knospina, E. & Uzars, D. 2016. Diet overlap between juvenile flatfish and the invasive round goby in the central Baltic Sea. J. Sea Res. 107, pp. 121-129

GEOMAR
H.-H. Hinrichsen, A. Lehmann, C. Petereit, A. Nissling, D. Ustups, U. Bergström, K. Hüssy. 2016. Spawning areas of eastern Baltic cod revisited: Using hydrodynamic modelling to reveal spawning habitat suitability, egg survival probability, and connectivity patterns. Progress in Oceanography. http://dx.doi.org/10.1016/j.pocean.2016.02.004

Hinrichsen H.-H, von Dewitz B, Dierking J, Haslob H, Makarchouk A, Petereit C, Voss R. 2016 Oxygen depletion in coastal seas and the effective spawning stock biomass of an exploited fish species. R. Soc. open sci. 3: 150338. http://dx.doi.org/10.1098/rsos.150338

2016

UT-EMI

Bekkevold, D.; Gross, R.; Arula, T.; Helyar, S.J.; Ojaveer, H. 2016. Outlier loci detect intraspecific biodiversity amongst spring and autumn spawning herring across local scales. PLoS ONE 11(4): e0148499

Klais, R., Lehtiniemi, M., Rubene, G., Semenova, A., Margonski, P., Ikauniece, A., Simm, M., Põllumäe, A., Griniene, E., Mäkinen, K., Ojaveer, H. (2016). Spatial and temporal variability of zooplankton in a temperate semi-enclosed sea: implications for monitoring design and long-term studies. Journal of Plankton Research 38: 652−661

DTU-Aqua

Casini, M., Käll, F., Hansson, M., Plikshs, M., Baranova, T., Karlsson, O., Lundström, K., Neuenfeldt, S., Gardmark, A. and Hjelm, J. 2016. **Hypoxic areas, density-dependence and food limitation drive the body condition of a heavily exploited marine fish predator.** Royal Society Open Science 3: 160416 http://rsos.royalsocietypublishing.org/content/3/10/160416

Huwer, B., Hinrichsen, H.-H., Hüssy, K., and Eero, M. Connectivity of larval cod in the transition area between North Sea and Baltic Sea and potential implications for fisheries management**.** ICES Journal of Marine Science, doi: 10.1093/icesjms/fsw043 http://icesjms.oxfordjournals.org/content/early/2016/03/28/icesjms.fsw043

SU

Griffiths, J.R., Kadin, M., Nascimento, F.J.A, Tamelander, T., Törnroos, A., Bonaglia, S., Bonsdorff, E., Brüchert, V., Gårdmark, A., Järnström, M., Kotta, J., Lindegren, M., Nordström, M.C., Norkko, A., Olsson, J., Weigel, B., Žydelis, R., Blenckner, T., Niiranen, S. and Winder, M. 2017. **The importance of benthic-pelagic coupling for marine ecosystem functioning in a changing world.** Global Change Biology, http://onlinelibrary.wiley.com/doi/10.1111/gcb.13642/full

SLU

Bartolino V, Tian H, Bergström U, Jounela P, Aro E, Dieterich C, Meier H. E. M., Cardinale C, Bland B, Casini M (2017). Spatio-temporal dynamics of a fish predator: density-dependent and hydrographic effects on Baltic Sea cod population. PLoS ONE, 12(2): e0172004.

Torres, M.A., Casini, M., Huss, M., Otto, S.A., Kadin, M. and Gårdmark, A. (2017). Food-web indicators accounting for species interactions respond to multiple pressures. Ecological Indicators, 77: 67-79.

BIOR

Orio, A., Florin, A.-B., Bergström, U., Sics, I., Baranova, T., and Casini, M. (2017). Modelling indices of abundance and size-based indicators of cod and flounder stocks in the Baltic Sea using newly standardized trawl survey data. ICES Journal of Marine Science. doi:10.1093/icesjms/fsx005.

LUKE

Raid, T., Järv, L., Pönni, J., Raitaniemi, J. and Kornilovs, G. 2016. Central Baltic herring stock: What does the assessment of combined stock say about the status of its components? In: Guedes Soares,C. & Santos, T.A. (Eds). Maritime Technology and Engineering. Taylor & Francis Group, London: 961-966. ISBN 978-1-138-03000-8

GEOMAR

Lehmann, A., Hinrichsen, H-H., Getzlaff, K. and Myrberg, K. 2014. Quantifying the heterogeneity of hypoxic and anoxic areas in the Baltic Sea by a simplified coupled hydrodynamic-oxygen consumption model approach. Journal of Marine Systems 134: 20-28.

Hinrichsen, H. H., Petereit, C., Nissling, A., Wallin, I., Ustups, D., and Florin, A. B. (2016). Survival and dispersal variability of pelagic eggs and yolk-sac larvae of central and eastern baltic flounder (Platichthys flesus): application of biophysical models. ICES Journal of Marine Science: Journal du Conseil, fsw163.

Lehmann, A., Höflich, K., Post, P., Myrberg, K., 2017. Pathways of deep cyclones associated with large volume changes (LVCs) and major Baltic inflows (MBIs). Journal of Marine Systems, 167, 11-18. http://dx.doi.org/10.1016/j.jmarsys.2016.10.014

LU

van Deurs, M., Persson, A., Lindegren, M., Jacobsen, C., Neuenfeldt, S., Jørgensen, C. and Nilsson, A.P. 2016. **Marine ecosystem connectivity mediated by migrant–resident interactions and the concomitant cross-system flux of lipids.** Ecology and Evolution, doi: 10.1002/ece3.2167 http://onlinelibrary.wiley.com/doi/10.1002/ece3.2167/full

2017
UT-EMI

MacKenzie, B. R., and Ojaveer, H. 2018. Evidence from the past: exploitation as cause of commercial extinction of autumn spawning herring in the Gulf of Riga, Baltic Sea. ICES J.Mar.Sci. (in press, doi:10.1093/icesjms/fsy028).

SU

Otto, S.A., Kadin, M., Casini, M., Torres, M.A. and Blenckner, T. 2018. **A quantitative framework for selecting and validating food web indicators**. Ecological Indicators 84: 619-631

SLU

Bartolino V, Tian H, Bergström U, Jounela P, Aro E, Dieterich C, Meier H. E. M., Cardinale C, Bland B, Casini M (2017). Spatio-temporal dynamics of a fish predator: density-dependent and hydrographic effects on Baltic Sea cod population. PLoS ONE, 12(2): e0172004.

Bauer, B., Meier, M., Casini, M., Hoff, A., Margoński, P., Orio, O., Saraiva, S., Stenbeek, J. and Tomczak, M. (2018). Reducing eutrophication increases spatial extent of communities supporting valuable commercial fisheries: a model case study. ICES Journal of Marine Science, in press. Doi:10.1093/icesjms/fsy003.

Kraufvelin P, Pekcan-Hekim Z, Bergström U, Florin AB, Lehikoinen A, Mattila J, Arula T, Briekmane L, Brown EJ, Celmer Z, Dainys J. et al. (2018) Essential coastal habitats for fish in the Baltic Sea. Estuarine, Coastal and Shelf Science. https://doi.org/10.1016/j.ecss.2018.02.014

Orio, A., Bergström, U., Casini, M., Erlandsson, M., Eschbaum, R., Hüssy, K., Lehmann, A., Lozys, L., Ustups, D. and Florin, A.-B. (2017). Characterizing and predicting the distribution of Baltic Sea flounder during the spawning season. Journal of Sea Research, 126: 46-55.

LUKE

Raid, T.; Järv, L.; Pönni, J.; Raitaniemi, J. 2018. Main drivers of herring fishery in the two neighboring gulfs of the Northern Baltic Sea. Maritime Transportation and Harvesting of Sea Resources, 2: 17th International Congress of the International Maritime Association of the Mediterranean, Lisbon, 9-11 October 2017. Ed. Guedes Soares, C.; Teixeira, A.P.Taylor and Francis, Boca, Raton, London, New York, Leiden: 1267−1274.

GEOMAR

Hinrichsen H-H, von Dewitz B, Lehmann A, Bergström U, Hüssy K 2017. Spatio-temporal dynamics of cod nursery areas in the Baltic Sea. Progress in Oceanography 155: 28–40

UU

Nissling, A., Sofia Nyberg, Christoph Petereit. 2017. Egg buoyancy of flounder, *Platichthys flesus*, in the Baltic Sea – adaptation to salinity and implications for egg survival. Fisheries Research 191:179-189.

9. **Number of entries to existing openly accessible common databases, storing original data from the entire Baltic Sea system or larger geographical area.**

2014

UT-EMI

Entry of the Gulf of Riga larval herring data (2004-2013) into ICES ichtyoplankton database.

Assembling pan-Baltic zooplantkon database (joint activity with BIO-C3; see http://kodu.ut.ee/~riina82/index.html). The metadatabase is under preparation and will be uploaded to the website as soon as ready.

MIR-PIB
Multiple data entries to BITS database.
Multiple data entries to INTERCATCH database.

LUKE
Entry of data into Baltic International Fish Survey (BIFS) and BITS databases.

2015
UT-EMI
Entry of data to pan-Baltic zooplantkon database (together with BIOR and MIR-PIB; this is a joint activity with BONUS BIO-C3; http://kodu.ut.ee/~riina82/index.html).

DTU-Aqua
Entry of stomach content data in the ICES database (together with SLU).

MIR-PIB
Entry of BITS data to DATRAS database (together with BIOR, SLU, DTU-Aqua, UT-EMI and LUKE).

SLU
Contribution of BIAS and BAS data to BAD database (together with DTU-Aqua, BIOR, MIR-PIB, UT-EMI and LUKE).

TI-OF
Entry of the Rügen larval herring data (1992-2015) into the ICES ichtyoplankton database.

LUKE
Entry of data to ICES INTERCATCH database (together with BIOR, DTU-Aqua, SLU, MIR-PIB and UT-EMI).

2016
SLU
Entry of data in the Swedish national database on coastal fish (KUL)

LUKE
Entry of data into the Finnish national database (Suomu 2)

2017
UT-EMI
Entry of clupeid feeding data from INSPIRE clupeid feeding survey to PANGAEA repository (https://doi.pangaea.de/10.1594/PANGAEA.884553)

10. Number of popular science papers produced by the project.

2014

None

2015

UT-EMI

Ojaveer, H. 2015. Sprat. In: Kalastaja, pg. 112 (national fishery journal).

LUKE

Jari Raitaniemi and Jukka Pönni 2015. Torsken återhämtar sig. Fiskarposten no 9, pp. 4. (in Swedish; popular article in Finnish national fisheries newspaper 'Fiskarposten' about Baltic fish stocks).

2016

UT-EMI

Ojaveer, H. 2016. Changing relations between the man and the sea. Sirp (newsletter on Estonian culture), 17. June.

Ojaveer, H. 2016. Investigations on pelagic fish feeding: what and why? Kalastaja (national fishers journal), 81: 115-117
Raid, T. 2016. On the status, fishery and catch outlook of herring, sprat and cod stocks on the Baltic. Eesti Kalamajandus 2014-2015: 38-50 (in Estonian).

LUKE

Raitaniemi, J., Pönni, J., Lilja, J. & Leskelä, A. Still high density of sprat in the Baltic Sea close to Finland (in Swedish) 2016. Fiskarposten no 9: 4.

2017

UT-EMI

Klais, R. 2017. Warm winter promote life in the coastal seas. Eesti Loodus (national nature journal). September, 2017.

LUKE

Pönni, J., Raitaniemi, J. & Lilja, J. 2017: Again an abundant year class of sprat, the near coming years with herring in the Bothnian Sea are uncertain. Kalastaja (national fishery journal).

Pönni, J., Raitaniemi, J. & Lilja, J. 2017: Again an abundant year class of sprat, the near coming years with herring in the Bothnian Sea are uncertain. Fiskarposten (national fishery journal, in Swedish).

11. Number of interviews to media given by the members of the project's consortium.

2014

MIR-PIB

Interview to Polish TV by Jan Horbovy (September 2014).

SLU

Michele Casini, phone interview, 16-09-2014. Radio Germany: Current Research, “Fishery-induced changes in fish population structure, with Baltic Sea focus”.

Ann-Britt Florin, 10-05-2014, Gotlands Allehanda – local Swedish newspaper, ”Fiskar efter svar om östersjöns arter” (Fishing after answers about Baltic species).

UU

Anders Nissling, local radio (Radio Gotland), Sweden, January 2015 (topic: saline water inflow & potential effects on fish stocks).

2015

SLU

Michele Casini, radio interview, 22-01-2016. Sveriges Radio, P4 Blekinge: “Miljonsatsning ska kartlägga torsken i Östersjön” (”Million effort to map cod in the Baltic Sea”).

UU

Anders Nissling, local radio (Radio Gotland), Sweden, April 2015 (topic: flounder ecology; life-history strategy of the respective flounder ecotype).

2016

UT-EMI

Interview to national TV (H. Ojaveer) on climate impacts to the Baltic Sea (25 October 2016)

Interview to national radio (H. Ojaveer) on various marine and maritime issues (17 June 2016)

Interview to national radio (R. Klais) about the interactions between climate and biological processes in the Baltic Sea (14 April 2016)

DTU-Aqua

Interview (Stefan Neuenfeldt) to a journalist from regional TV on the impact of the February flood on the Baltic cod stock (4 January 2017)

MIR-PIB

Interview to Polish TV TVN on management of Baltic stocks (J. Horbovy)

SLU

Michele Casini, radio interview, 30-01-2017. *P4 Gotland*: ”Artontusen torskar i Östersjön registreras” (”18000 cod in the Baltic Sea are registered”).

Michele Casini, radio interview, 17-06-2016. *Vetenskapsradion* and *Dagens eko*: ”Östersjön strömmingar allt magrare” (”Baltic herring increasingly thinner”).

Michele Casini, TV interview, 23-05-2016. *SVT Nyheter*: “18000 torskar märks med telefonnummer” (“18000 cods will be tagged with phone number”).

Michele Casini, newspaper interview, 15-11-2016. *Skärgården*: ”*Syrebristen orsak till mager torsk*” (”Lack of oxygen the cause of thin cod”).

Michele Casini, newspaper interview, 27-10-2016. *Sydsvenskan: ”Brist på syre och föda hotar torsken”* (”Lack of oxygen and food threaten the cod”).

Michele Casini, newspaper interview, 03-08-2016. *Svenska Dagbladet SvD: ”Många fiskarter trivs i Östersjön-men inte torsken”* (”Many fish species thrive in the Baltic Sea - but not the cod”).

Michele Casini, newspaper interview, 03-08-2016. *Svenska Dagbladet SvD: “Nya kemikalier hotar Östersjön-upptäcks inte”* (”New chemicals threat the Baltic Sea – but they are difficult to detect”).

BIOR
Interview to national radio (D. Ustups) on various marine and maritime issues (20 September 2016)

Interview to national TV (G. Kornilovs) on various marine and maritime issues and ICES Annual Science Conference (24 September 2016)

2017
UT-EMI
Interview to national radio (Riina Klais) on various Baltic Sea state related issues (based on HELCOM HOLAS II) (11 February 2017)

Interview to the national TV (Henn Ojaveer) about the BONUS conference (17. October 2017)

Interview to local TV (Tallinn TV; Henn Ojaveer) about the BONUS conference (17. October 2017)

Interview to local radio (Radio 4; Henn Ojaveer) about the BONUS conference (17. October 2017)

SLU
TV interview (Michele Casini), 02-11-2017. *Mitt i Naturen*: reportage about the Bluefin tuna tagging project in the Scandinavian waters. ”När naturen behöver hjälp” (”When nature needs help”).

Radio interview (Michele Casini), 31-10-2017. *SVT Nyheter*: “Kris för torsken I Ålands hav” (”Crise for cod in the Ålands Sea”).

TI-OF
TV interview (Patrick Polte) in June 2017 about regional impacts of changing climate regimes on herring productivity for ’Wenn das Eis bricht forscher im Kampf gegen die Zeit (https://www.arte.tv/de/videos/078142-000-A/wenn-das-eis-bricht/)

LUKE
Interview for the news agency 'Nyhetsbyrån FNS' (Jukka Pönni). 07-08-2017. On the status of the Baltic herring and sprat stocks, herring catches, herring consumption and health risks through dioxin, dioxin levels In herring, herring import and export, other fish stocks

Newspaper interview (Jukka Pönni) for Kymen Sanomat, 03-01-2018. About the tatus of the Baltic herring and sprat stocks

Magazine interview (Jari Raitaniemi, Jukka Pönni), 15-08-2017. 'Finlands Natur'. About the Eastern Baltic cod.

UU
Radio interview (Anders Nissling). Swedish Radio (Vetenskapsradion). Aabout potential interactions between flounder and round goby.

12. **Number of multi-media products and TV episodes produced by the project with dissemination purpose**.

2014
None

2015
None

2016

UT-EMI
Riina Klais: Blog "Data cruncher" in the BONUS blogspace (4 entries in 2016). http://www.bonusprojects.org/bonusprojects/blogs/data_cruncher

TI-OF
Dorothee Moll: "INSPIRE(D) Blog – BONUS INSPIRE" in the BONUS blogspace (1 entry); https://www.bonusprojects.org/bonusprojects/blogs/inspire(d)

2017
UT-EMI
Riina Klais: Blog "Data cruncher" in the BONUS blogspace (5 entries in 2017)
Riina Klais: national blog (zooloogiablogi.ee) (5 entries in 2017)

DTU-AQUA
Popular Science book: „Have you seen the fish?", http://www.bonus-inspire.org/Publications/Popular-science-book

13. **Number of other international, national and regional communication, dissemination and public outreach initiatives to disseminate the project's research results.**

2014
UT-EMI
Ojaveer, H. 2014. BONUS INSPIRE: Integrating spatial processes into ecosystem models for sustainable utilization of fish resources. Written communication to HELCOM FISH-ENV 10-2014.

Ojaveer, H. et al. 2014. Integrating spatial processes into ecosystem models for sustainable utilization of fish resources. Poster presentation at ICES ASC.

Ojaveer, H. 2014. Integrating spatial processes into ecosystem models for sustainable utilisation of fish resources. Baltic Maritime Spatial Planning Forum. 17-18. June 2014, Riga, Latvia.

Arula, T., Ojaveer, H. 2014. Can we predict Baltic spring spawning herring *Clupea harengus membras* recruitment form larval abundance? EU FP7 project VECTORS Final Meeting in La Grande Motte (France) in 17-21 November 2014. Poster presentation.

2015
UT-EMI
Arula, T., Laur, K., Simm, M. and Ojaveer, H. 2015. Dual impact of temperature on growth and mortality of marine fish larvae in a shallow estuarine habitat. Estuarine, Coastal and Shelf Science, http://dx.doi.org/10.1016/j.ecss.2015.10.004

Arula, T., Raid, T., Simm, M., Ojaveer, H. 2015. Temperature-driven changes in early life-history stages influence the Gulf of Riga spring spawning herring (*Clupea harengus* m.) recruitment abundance. Hydrobiologia. doi:10.1007/s10750-015-2486-8.

Raid, T., Arula, T., Kaljuste, O., Sepp, E., Järv, L., Hallang, A., Shpilev, H., Lankov, A. 2015. Dynamics of the commercial fishery in the Baltic Sea: What are the driving forces? In: Towards Green Marine Technology and Transport – Guedes Soares, Dejhalla & Pavleti (Eds). Taylor & Francis Group, London

Arula, T., Ojaveer, H., Raid, T. Mortality and growth at larval stage: advancing the understanding of stock dynamics processes in the Gulf of Riga spring spawning herring (Clupea harengus membras). 10th Baltic Sea Science Congress, 15-19 June 2015, Riga, Latvia.

Arula, T., Raid, T., Simm, M. and Ojaveer, H. Factors affecting the abundance of spring spawning herring (*Clupea harengus membras*) larvae in the Gulf of Riga. ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Arula, T., Raid, T., Simm, M., Ojaveer, H. Importance of plankton seasonality on larval herring and year-class abundance of the Gulf of Riga spring spawning herring (*Clupea harengus m*.). 39th Annual Larval Fish Conference. Vienna, Austria; 12-17. July 2015.

Klais, R., Lehtiniemi, M., Teder, M., Rubene, G., Semenova, A., Margonski, P., Ikauniece, A., Simm, M., Põllumäe, A., Griniene, E., Mäkinen, K. and Ojaveer, H. 2015 Spatiotemporal variability of the Baltic Sea mesozooplankton. ICES WKSPATIAL (Rome, Italy, 3-6. Nov. 2105).

Klais, R., Lehtiniemi, M., Teder, M., Rubene, G., Semenova, A., Margonski, P., Ikauniece, A., Simm, M., Põllumäe, A., and Ojaveer, H. 2015 Spatial and temporal variability of mesozooplankton in the Baltic Sea. ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Ojaveer, H. Moderating panel discussion exploring how the BONUS, PRIMA and JPI Oceans initiatives can cooperate and contribute to the Horizon 2020 marine research priorities in the areas of Blue Economy and Resource Efficiency. Cooperation in Marine Science around the Baltic Sea and beyond: a contribution to Europe’s Societal Challenges. Event organised by Estoanian Research Council. Brussels, Belgium, 22. April 2015.

Ojaveer, H. What kind of shift your project will bring to scientific basis of fisheries management? BONUS projects’ kick-off meeting, triple meeting and a BONUS information event for the European community, Brussels, 1-2 December 2015.

Ojaveer, H. 2015. Representing INSPIRE project at a panel session discussion on ’Science and knowledge’ of the Annual Forum of the EU Strategy for the Baltic Sea Region, 16 June 2015, Jurmala.

Ojaveer, H. BONUS projects INSPIRE and BIO-C3. Conference about international cooperation. Tallinn, Estonia, 3. December 2015.

Ojaveer, H., Teder, M., Simm, M., Raid, T. and Klais, R. 2015. Feeding ecology of pelagic fish in the Gulf of Riga. ICES WKSPATIAL (Rome, Italy, 3-6. Nov. 2105).

Raid, T., Arula, T., Kaljuste, O., Sepp, E., Järv, L., Hallang, A., Shpilev, H., Lankov, A. Dynamics of the commercial fishery in the Baltic Sea: What are the driving forces? 16th Congress of the Maritime Association of the Mediterranean, IMAM, 21-24 September 2015, Pula, Croatia.

DTU-Aqua

Bekkevold, D., Gross, R., Arula, T. and Ojaveer, H. 2015. Spring and autumn spawning herring in the Gulf of Riga: intraspecific biodiversity across small local scales. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Karin Hüssy, Henrik Mosegaard, Christoffer, Moesgaard Albertsen, Jakob Hemmer-Hansen, Margit Eero. 2015. Stock mixing of eastern and western Baltic cod in SD 24. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Margit Eero, Helén Andersson, Elin Almroth Rosell, Brian R. MacKenzie. 2015. Has human-induced eutrophication promoted fish production in the Baltic Sea? Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Ojaveer, H., Tomkiewicz, J., Arula, T. and Klais, R. Female ovarian abnormalities and reproductive failure of autumn spawning herring (*Clupea harengus membras*) in the Baltic Sea. ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Stefan Neuenfeldt, Christian Möllmann 2015. Net displacement and time at large: Adult migrations probably do not contribute to whole Baltic scale redistribution of cod (Gadus morhua L.). Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Stefan Neuenfeldt, 2015. Eastern Baltic cod consumption and energy uptake decreased. Presentation at ICES WGSAM (Woods Hole, USA, via skype, September 2015).

Stefan Neuenfeldt, 2015. Eastern Baltic cod prey dependent growth. Presentation and ICES WKSPATIAL (Rome, USA, Italy, September 2015).

MIR-PIB

Horbowy, J., Podolska, M. 2015. Does parasitic infection effect natural mortality of cod? Working document for ICES WKBALCOD [in: ICES. 2015. Report of the Benchmark Workshop on Baltic Cod Stocks, 2–6 March 2015, Rostock, Germany. ICES CM 2015/ACOM:35].

Horbowy, J., Luzeńczyk, A. 2015. Cod in the eastern Baltic - assessment with stock-production models. Working document for ICES WKBALCOD [in: ICES. 2015. Report of the Benchmark Workshop on Baltic Cod Stocks, 2–6 March 2015, Rostock, Germany. ICES CM 2015/ACOM:35].

Horbowy, J., Podolska, M., Nadolna-Ałtyn, K. 2016. Increasing occurrence of anisakid nematodes in the liver of cod (Gadusmorhua) from the Baltic Sea: Does infection affect the condition andmortality of fish? Fisheries Research 179: 98–103. http://dx.doi.org/10.1016/j.fishres.2016.02.011

SU

Thorsten Blenckner, Viktorsson, L., Schewenius, M., Elwing, T. Rockström, J., Halpern, B. 2015. Assessing the ocean health of the Baltic Sea. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Meeting with Her Royal Highness Crown Princess Victoria from Sweden to present the ongoing work on the Baltic Sea ecology and management (23. Sepember 2015).

SLU

Casini, M., Käll, F., Hjelm, J. 2015. Changes in the body condition of the Eastern Baltic cod - potential explanations. Working document for ICES WKBALTCOD [in: ICES. 2015. Report of the Benchmark Workshop on Baltic Cod Stocks, 2–6 March 2015, Rostock, Germany. ICES CM 2015/ACOM:35]

Orio, A. 2105. Understanding the spatio-temporal dynamics of demersal fish species in the Baltic Sea. Aqua Introductory Research Essay 2015:1 Department of Aquatic Resources. Swedish University of Agricultural Sciences, Drottningholm Lysekil Öregrund. 29 p. http://pub.epsilon.slu.se/12864/7/orio_a_151126.pdf.

Casini, M. Käll, F., Hansson, M. And Hjelm, J. 2015. Dead zones relate to the body condition of the Baltic Sea cod. Oral presentation at the “ICES Annual Science Conference”, Copenhagen (Denmark), 21-25 September 2015.

Alerssandro Orio and Michele Casini 2015. Modelling the spatio-temporal dynamics of cod and flounder in the Baltic Sea using bottom trawl surveys data. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Casini, M. “Spatio-temporal changes in exploited fish populations in the Baltic Sea: patterns, causes and consequences”. Oral presentation at the Annual Congress of the Swedish Society of Marine Sciences, Lund (Sweden), 18-20 November 2015. Key-note speaker.
Organising workshop on Essential Coastal Habitats (SLU, Öregrund, Sweden, 2-4 June 2015).

BIOR

Makarchouk, A. and Arula, T. 2015. Changes in spation-temporal distribution of eggs and larvae of sprat (Sprattus sprattus) in the Gotland Basin (Baltic Sea) in 2004-2014. ICES CM 2015/Q:16. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Briekmane L., Ustups D., Berzins V. and Plikshs M. 2015. Changes in fish communities in the coastal area of Baltic Sea and Gulf of Riga during last decade. ICES CM 2015/Q:32 Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

TI-OF

Moll Dorothee; Kotterba Paul; Polte Patrick 2015. Spawning bed selection of Atlantic herring (*Clupea harengus*) in coastal waters of the Western Baltic Sea. Presentation at 39th Annual Larval Fish Conference. Vienna, Austria, 12-17. July 2015.

Moll Dorothee; Kotterba Paul; Polte Patrick 2015. Spawning bed selection of Atlantic herring in coastal waters of the Western Baltic Sea. Presentation at European Marine Biology Symposium, 21.-25. September 2015. Helgoland, Germany.

Polte, Patrick, Paul Kotterba, Julia Heiler, Sarah Beyer, Dorothee Moll, Lena v. Nordheim 2015. Loops of near shore habitat use by early herring (*Clupea harengus*) life stages in the Western Baltic Sea. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Polte, Patrick, Paul Kotterba, Dorothee Moll, Lena v. Nordheim 2015 Drivers and stressors of Atlantic herring (*Clupea harengus*) recruitment in inshore Baltic Sea spawning areas. Presentation at CERF 2015, Grand Challenges in Coastal & Estuarine Science: Securing Our Future, Portland, Oregon, USA, 8.-12- November.

Paulsen Matthias; Clemmesen Catriona; Hammer Cornelius; Malzahn Arne; Patrick Polte; Peck Myron. 2015. Investigating nutritional effects on growth rates of larval herring in the vestern Baltic Sea**.** Presentation at 39th Annual Larval Fish Conference. Vienna, Austria; 12-17. July 2015.

LUKE

STOCK DIVERSITY OF HERRING IN THE NORTHERN BALTIC: IS THE SEPARATE ASSESSMENT OF THE HERRING IN THE GULF OF FINLAND POSSIBLE? Tiit Raid Jukka Pönni and Jari Raitaniemi Gulf of Finland Trilateral Co-operation Scientific Forum, 17-18 November 2015, Tallinn, Estonia.

PELAGIC FISH STOCKS IN THE GULF OF FINLAND - LIFE ON THE EDGE OF THE SEA Heikki Peltonen, Tiit Raid and Jukka Pönni Gulf of Finland Trilateral Co-operation Scientific Forum, 17-18 November 2015, Tallinn, Estonia.

Participating at international/regional communication: trilateral cooperation Finland-Estonia-Russia / Gulf of Finland studies.

GEOMAR

Andreas Lehmann, Hans-Harald Hinrichsen, Katharina Höflich. 2015. Spawning areas of eastern Baltic cod revisited: Using hydrodynamic modeling to identify hotspots. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

Katharina Höflich, Andreas Lehmann, Piia Post, Klaus Getzlaff and Kai Myrberg. 2015. On the atmospheric and oceanic conditions associated with large volume changes (LVCs) and major inflows (MBIs) to the Baltic Sea. Presentations at BSSC (Riga, Latv15-19 June 2015).

LU

Anders Persson, Peter Ljungberg, Anders Nilsson. 2015. Predicting spatial and temporal use of coastal habitats by Atlantic cod using foraging theory. Presentation at ICES ASC (Copenhagen, Denmark 21-25. September 2015).

UU
Wallin, Isa 2016. Opportunities for hybridization between two sympatric flounder (*Platichtys flesus*) ecotypes in the Baltic Sea. Master thesis in biology, Biology Education Centre, Uppsala university (supervisor Anders Nissling).

Nyberg, Sofia 2015. Egg buoyancy and survival probabilities of the Baltic flounder (*Platichtys flesus*); differences between spawning areas and interannual variation in conditions for reproduction. Bachelor thesis in biology, Biology Education Centre, Uppsala university (supervisor Anders Nissling; assistant supervisor Christoph Petereit).

2016
UT-EMI
<u>Publication:</u>
Ojaveer, H., Lankov, A., Teder, M., Simm, M., Klais, R. (2016). Feeding patterns of dominating small pelagic fish in the Gulf of Riga, Baltic Sea. Hydrobiologia, DOI 10.1007/s10750-016-3071-5

<u>Presentations:</u>
Klais, R., Otto, A.S., Teder, M., Simm, M., Ojaveer, H. Climate effects on small copepods [Oral presentation]. ICES/PICES 6th zooplankton production symposium Bergen, Norway 9-13 May, 2016

Klais, R., Otto, S., Teder, M., Simm, M. and Ojaveer, H. 2016. Long-term dynamics of small copepods in a coastal area of the Baltic Sea. [Oral presentation]. ICES ASC Riga, Latvia, 26-30 September 2016

MacKenzie, B., Ojaveer, H. 2016. Uncovering the past dynamics of a collapsed fish stock: Gulf of Riga autumn-spawning herring [Oral presentation]. ICES WGHIST, Copenhagen, Denmark, 6-9 September 2016

Ojaveer, H. and Klais, R. 2016. The spatial dynamics in quantitative and qualitative feeding of sprat and herring and their dietary overlap [Oral presentation]. ICES WKSPATIAL, Riga, Latvia, 8-10 October 2016

Ojaveer, H. and Klais, R. 2016. Dynamics of pelagic fish, their feeding and prey. National BONUS BAMBI/BIO-C3/INSPIRE seminar on The new challenges in management of the Baltic Sea. Tallinn, Estonia, 27 April 2016

Raid, T. 2016. Herring stocks in the open Baltic Sea and Gulf of Finland. National BONUS BAMBI/BIO-C3/INSPIRE seminar on The new challenges in management of the Baltic Sea. Tallinn, Estonia, 27 April 2016

DTU-Aqua
<u>Publications:</u>
Andersen, N.G., Chabot, D. and Couturier C.S. 2016 Modelling gastric evacuation in gadoids feeding on crustaceans. Journal of Fish Biology 88, 1886–1903

Ross, S.D., Andreasen, H., Andersen, N.G. 2016. An important step towards accurate estimation of diet composition and consumption rates for the harbor porpoise (*Phocoena phocoena*). Marine mammal science 32: 1491-1500.

Presentations:
Neuenfeldt, S. Et al. (2016) Feeding and growth potential of Atlantic cod in the Baltic Sea in the wake of climate change. ICES ASC Riga, Latvia, 26-30 September 2016

Neuenfeldt, S. (2016) Further analyses of the stomach content database for the Baltic Sea ICES WKSPATIAL, Riga, Latvia, 8-10 October 2016

MIR-PIB
Publications:
Horbowy, J., Luzenczyk, A. 2016. Effects of multispecies and density dependent factors on MSY reference points: Example of the Baltic Sea sprat. Can. J. Fish. Aquat. Sci. DOI: 10.1139/cjfas-2016-0220 (accepted, October 2016)

Horbowy, J. 2016. Effects of varying natural mortality and selectivity on the assessment of eastern Baltic cod (*Gadus morhua* Linnaeus, 1758) stock. Journal of Applied Ichthyology, 32: 1032-1040. doi:10.1111/jai.13202

Presentations:
Horbowy, J. 2016. Presentation for „Forum of Baltic Fisheries“ (national meeting) on Baltic fishery management plan. Gdynia, Poland, 25. October 2016.

Horbowy, J. 2016. Presentation on the dynamics of cod stock. 4th International Maritime Congress, Szczecin, Poland, 8-10 June 2016.

Podolska, M., Horbowy, J., Nadolna-Ałtyn, K. 2016. Perils of the sea - parasites transmitted by seals. Presentation and abstract at Conference „Baltic – a small sea with big management problems“, Gdynia, Poland, 5. October 2016

SLU
Publications:
Casini, M., Käll, F., Sorais M. and Larson N. (2016). Mapping the ecological status of the fish community in the pelagic habitat: spatio-temporal trends of size-based indicators in the Baltic Sea. ICES CM 2016/J:573.

Otto, S. A., Kadin, M., Torres, M. A., Casini, M., Huss, M., Blenckner, T. and Gårdmark, A. (2016). Ecosystem-based approach for developing pelagic food-web indicators. Project final report. Naturvårdsverket, 30 pp.

Erlandsson, M. (2016) Ensemble modelling of the habitat of turbot based on video analyses and fish survey data (in Swedish), Master thesis, Uppsala University & Swedish University of Agricultural Sciences.

Presentations:
Casini, M. et al. “Mapping the ecological status of the pelagic fish community: spatio-temporal trends in size-based indicators in the Baltic Sea”. Oral presentation at the “5th EcoSummit Conference: Ecological Sustainability”, Montpellier (France), 29 August-1 September 2016.

Casini, M. Käll F, Sorais M. Larson N. “Mapping the ecological status of the fish community in the pelagic habitat: spatio-temporal trends of size-based indicators in the Baltic Sea”. Oral presentation at the “ICES Annual Science Conference”, Riga (Latvia), 19-23 September 2016.

Florin, A.-B., Palm, S., Ustups, D., Hüssy, K., Casini, M., Nissling, A., Limburg, K., & Schade, F. “Using genetics to identify management units of European flounder in the Baltic Sea“. Oral presentation at the Fisheries Society of the British Isles Symposium on ’Fish Genes and genomes: Contributions to Ecology, Evolution and Management’, Bangor, UK, 18-22 July 2016.

BIOR
Publication:
Svecovs F., Ozernaja O., Fettere F., Strods G., Vingovatova A. 2016. Baltic sprat fishery, stock assessment and prediction. Maritime Technology and Engineering III: Proceedings of the 3rd International Conference on Maritime Technology and Engineering (MARTECH 2016, Lisbon, Portugal, 4-6 July 2016). June 21, 2016 by CRC Press. II: 973-978 pp. ISBN 9781138030008 – CAT# K30346.

Presentations:
Ustups, D., Samson, M.A., Florin, A.-B., Zilniece, D. and Limburg, K. 2016. Otolith microchemistry: A tool to solve a mystery of the Baltic Sea flounder (*Platichys flesus*) Oral presentation at the “ICES Annual Science Conference”, Riga (Latvia), 19-23 September 2016.

Plikss, M. 2016. Eastern Baltic cod cannibalism: stock dependent or occasional effects. Oral presentation at ICES WKSPATIAL, Riga, Latvia, 8-10 October 2016.

TI-OF
Publications:
Polte, P., Kotterba, P., Moll, D. and von Nordheim, L. 2017. **Ontogenetic loops in habitat use highlight the importance of littoral habitats for early life-stages of oceanic fishes in temperate waters.** Scientific Reports 4: 42709 http://www.nature.com/articles/srep42709

Polte P., Knecht N., Nordheim L.v., Oeberst R., Kotterba P. 2016. Potential effects of climate change on herring recruitment phenology in a Baltic Sea retention area. Report to ICES Working Group on Atlantic Fish Larvae and Eggs Surveys (WGALES), Thessaloniki, 17-21 October 2016.

<u>Presentations:</u>
Moll, D., Kotterba, P., von Nordheim, L., Polte, P. 2016. Estimating the contribution of single nursery areas to the overall herring (*Clupea harengus*) population in the western Baltic Sea by otolith chemistry. Presentation at the 51 th European Marine Biology Symposium (EMBS), September 26 -30 2016, Rhodes, Greece

von Nordheim, L., Polte, P., Kotterba, P., Moll, D. 2016. Effects of benthic substrate complexity on egg mortality of Atlantic herring (*Clupea harengus)* in the Baltic Sea. Presentation at the 51 the European Marine Biology Symposium (EMBS), September 26 -30 2016, Rhodes, Greece

Kotterba, P., Moll, D., von Nordheim, L., Hammer, C., Peck, M.A., Oesterwind, D., Polte, P. (2016) Predator impacts on inshore Baltic herring (*Clupea harengus*) larvae: Lions, tigers and bears – but where? Best-poster-award at the 51 the European Marine Biology Symposium (EMBS), September 26 -30 2016, Rhodes, Greece

LUKE
<u>Presentation:</u>
Raid, T., Pönni, J. & Raitaniemi, J. Central Baltic herring stock – What does the assessment of combined stock say about the status of its components? Oral presentation in 3rd International Conference on maritime technology and Engineering (Martech), Portugal, 4-6 July 2016**.**

GEOMAR
<u>Presentations:</u>
Lehmann, A., Höflich, K., Post, P. and Myrberg, K. 2016. Pathways of deep cyclones associated with large volume changes (LVCs) and major Baltic inflows (MBIs). European Geoscience Union General Assembly, Vienna, Austria, 17-22 April 2016.

Höflich, K., Lehmann, A., and Myrberg, K.. 2016. Disentangling the role of atmospheric and oceanic conditions in the occurrence of major Baltic inflows: The importance of haline stratification in the Belt Sea. European Geoscience Union General Assembly, Vienna, Austria, 17-22 April 2016.

Lehmann, A., Höflich, K., Post, P. and Myrberg, K. 2016. Pathways of deep cyclones associated with large volume changes (LVCs) and Major Baltic Inflows (MBIs).1st Baltic Earth Conference, Nida, Lithuania, 13-17 June, 2016.

Höflich, K., Lehmann, A. and K. Myrberg. 2016. On the role of the haline conditions in the Belt Sea in the formation of highly saline barotropic inflows to the Baltic Sea. 1st Baltic Earth Conference, Nida, Lithuania, 13-17 June, 2016.

LU
<u>Publication:</u>
Berndt, K. 2016 Fishing the gene pool: Genetic structure, admixture and behavioural complexity in fisheries management (Supervisors Anders Persson, Rosa Figueroa and Johan Hollander). PhD Thesis. Lund University.

UU

Publication:

Wallin, I. 2016. Opportunities for hybridization between two sympatric flounder (*Platichtys flesus*) ecotypes in the Baltic Sea Supervisor Anders Nissling). MSc thesis. Uppsala University.

2017

UT-EMI

Publications:

Ojaveer, H., Lankov, A., Raid, T., Põllumäe, A. and Klais, R. 2018. Selecting for three copepods – feeding of sprat and herring in the Baltic Sea. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsx249

Presentations:

Klais, R., Teder, M., Simm, M., Ojaveer, H. 2017. Winter spring climate effects on small copepods in coastal Baltic Sea. Baltic Sea Science Congress 2017, Rostock, 12-16 June 2017.

Klais et al. 2017. Baltic Sea mesozooplankton network and database. Baltic Sea Science Congress 2017, Rostock, 12-16 June 2017.

Klais, R., Otto, SA., Rubene, G., Einberg, H., Kornilovs, G., Raid, T., McKenzie, B., Simm, M., Ojaveer, H. 2017. Detecting causality in observational data. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

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Ojaveer et al. 2017. Selecting for the dominance – feeding of sprat and herring in the Baltic Sea. Baltic Sea Science Congress 2017, Rostock, 12-16 June 2017.

Ojaveer et al. 2017. Selecting for the dominance – feeding of sprat and herring in the Baltic Sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Raid, T. et al. 2017. Central Baltic Herring: does the assessment of combined stock compelex describe adequately the trends in its components? BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

DTU-AQUA

Publication:

Andersen, N.G., Lundgren, B., Neuenfeldt, S. and Beyer, J.E., 2017. Diel vertical interactions between Atlantic cod Gadus morhua and sprat Sprattus sprattus in a stratified water column. *Marine Ecology Progress Series*, *583*, pp.195-209.

Presentations:
Eero, M. et al. 2017. Do spatio-temporal spawning closures promote the recovery of cod in the Baltic Sea? BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Hüssy, K. et al. 2017. Faster or slower: Has growth of juvenile eastern Baltic cod changed? BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

MacKenzie, B. and Ojaveer, H. 2017. Uncovering the Past Dynamics of a Collapsed Fish Stock: Gulf of Riga Autumn-Spawning Herring. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Neuenfeldt, S. et al. (2017) Baltic cod growth ICES WKBEEBCA, Gothenburg, Sweden, 1-2 March 2017.

Neuenfeldt, S. et al. (2017) Food limitation and growth potential of a heavily exploited marine fish predator under environmental change – are all places the same? BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Neuenfeldt S et al. From climate changes to vanishing fishes – warmer surface waters in prolonged periods may keep cod away from the coasts in the western Baltic Sea. Baltic Sea Science Congress 2017, Rostock, 12-16 June 2017.

Neuenfeldt, S. (2017) Baltic cod cannibalism, ICES WKIDEBCA, Copenhagen, Denmark, 22-25 January 2017.

MIR-PIB
Presentations:
Horbowy, J. et al. 2017. The method for estimating MSY reference points incorporating density dependence in growth and predation mortality. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Horbowy, J. et al. 2017. Management of herring and sprat stocks in the Baltic taking into account spatial effects. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

SU
Presentations:
Kininmonth et al. 2017. Disentangling environmental and trophic volatility for a fishery in flux: Non-Stationary modeling of the Baltic Sea system. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Niiranen et al. 2017. Predator–prey size relationships in a low diversity marine system: The Eastern Baltic cod case study. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

SLU

Publication:

Jacobson, P., Gårdmark, A., Östergren, J., Casini, M. and Huss, M. (2018). Size-dependent prey availability affects diet and performance of predatory fish at sea: a case study of Atlantic salmon. Ecosphere, 9(1):e02081.

Svedäng, H., Hornborg, S. 2017. Historic changes in length distributions of three Baltic cod (*Gadus morhua*) stocks: Evidence of growth retardation. Ecology and Evolution**,** doi:10.1002/ece3.3173

Presentations:

Casini, M. and Orio, A. Summary of the INSPIRE project. Presentation for the Swedish Agency for Marine and Water Management. 21 November 2017.

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Orio, A. and Casini, M. Historical spatiotemporal dynamics of Baltic cod and flounder as analysed using standardized fishery-independent data. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Casini, M. (2017). Threshold dynamics in the Baltic Sea pelagic food-web, with focus on fish-zooplankton interactions: possible implications for fisheries management. Workshop “Marine ecological-economic systems: Shifting the baseline to a regime of sustainability”, Tilburg University (The Netherlands), 22-23 September 2017.

Bauer, B., Bartolino, V., Casini, M., Hoff, A., Meier, M., Margoński, P., Müller-Karulis, B., Orio, A., Rahikainen, M., Saraiva, S., Warzocha, J., Kownacka, J., Steenbeek, J. and T. Tomczak, M. Effects of underwater habitat quality on the top predator Baltic cod and its food web interactions. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Orio, A. and Casini, M. Historical spatiotemporal dynamics of Baltic cod and flounder as analysed using standardized fishery-independent data. ICES/PICES Early Career Scientist Conference: Climate, Oceans and Society - Challenges & Opportunities, Busan (Korea), 30 May-2 June 2017.

Limburg, K.E., Walther, B., Lu, Z., Casini, M., Altenritter, M., Samson, S. Hypoxia as perceived by fish: empirical observation and modelling. ASLO Aquatic Sciences Meeting, Honolulu (Hawaii), 26 February-3 March 2017.

Orio, A. and Casini, M. Historical spatiotemporal dynamics of Baltic cod and flounder as analysed using standardized fishery-independent data. ASLO Aquatic Sciences Meeting, Honolulu (Hawaii), 26 February-3 March 2017.

Orio, A. and Casini, M. Changes in horizontal and vertical distribution of Baltic cod and flounder as analysed using standardised fishery-independent data. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Frelat, R., Casini, M., Merigot, B., Orio, A., Otto, S.A., Sguotti, C., and Möllmann, C. Dissecting the spatio-temporal dynamics of Baltic fish communities and its relation to environment. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Bergström, U., Orio, A., Bergström, L., Erlandsson, M., Eschbaum, R., Florin, A.-B., Fredriksson, R., Hüssy, K., Lehmann, A., Ložys, L., Polte, P., Radtke, K., Ustups, D. and Casini, M. Different nursery habitat requirements of two nearby cod populations. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Orio, A., Florin, A.-B., Bergström, U., Šics, I., Baranova, T. and Casini, M. Modelling indices of abundance and size-based indicators of cod and flounder stocks in the Baltic Sea using newly standardized trawl survey data. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Orio, A., Bergström, U., Casini, M., Erlandsson, M., Eschbaum, R., Hüssy, K., Lehmann, A., Lozys, L., Ustups, D. and Florin, A.-B. Characterising and predicting the distribution of Baltic Sea flounder during the spawning season. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

BIOR

Presentations:

Baranova et al. 2017. Long-term changes in the annual reproductive cycle of eastern Baltic cod in the Gotland Basin. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Makarchouk et al. 2017. Match-mismatch of the horizontal distribution of adult sprat and its eggs. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Makarchouk, A. 2017. Changes in the horizontal distribution of mortality of sprat eggs. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.
Plikshs et al. 2017. Has climate change affected the body condition of Baltic cod *Gadus morhua* L. in the eastern Baltic Sea? BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Sics et al. 2017. Possible impact of size selective gillnet fishery on the cod stock in the Eastern Baltic Sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Strods et al. 2017. Some evident particularities of sprat – *Sprattus sprattus* balticus (Schneider) spatial distribution over the Gotland Deep in the Baltic sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Svecovs F. et al. 2017. A comparative analysis of performing and data processing methods of hydro-acoustic surveys in the Baltic Sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Vingovatova A. et al. 2017. Length-at-age based calculations of sprat stock structure determined by the hydroacoustic surveys in the Baltic Sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Makarchouk, A., Sics, I. & Baranova, T. Changes in the size structure of spawning cod in the Baltic Sea could have caused depensation. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Makarchouk, A. Influence of global warming on vertical distribution of sprat eggs in the Eastern Baltic and its possible impact on recruitment success. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Plikshs, M., MacKenzie, B.R. & Müller-Karulis, B. Multi-decadal cod reproductive habitat variability in the Baltic Sea and its impact on reproductive success. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Samson, M.A., Limburg, K.E., Ustups, D., Florin, A.-B., Nissling, A. & Zilniece, D. Identifying spawning ecotypes in Baltic Sea flounder using otolith microchemistry. ICES Annual Science Conference, Fort Lauderdale (USA), 18-21 September 2017.

Ustups, D. and Zilniece, D. Turbot *Scophthalmus maximus* in the Baltic Sea – what could we learn from the last two decades. 2017. International Flatfish symposium, Saint Malo, France, 11-16. November 2017.

TI-OF

<u>Presentations:</u>

Polte P., Moll D., Kotterba P., von Nordheim L. Drivers of herring (Clupea harengus) early life stage mortality in inshore spawning areas of the Western Baltic Sea. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Kotterba P., Moll D., von Nordheim L., Polte P. (2017) Atlantic herring Clupea harengus within the coastal food web of shallow inshore waters. PICES International Symposium: Drivers of dynamics of small pelagic fish resources (6-11. March 2017), Victoria BC, Canada.

Polte P. Integration räumlicher Verbreitungsprozesse in Ökosystemmodelle zur nachhaltigen Nutzung von Fischereibeständen – Projekt INSPIRE. BSH-Meeresumwelt-Symposium - Aktuelle Probleme der Meeresumwelt (14. June 2017), Hamburg, Germany.

Moll D., Kotterba P., von Nordheim L., Polte P. (2017) Using elemental fingerprinting in Western Baltic juvenile herring (Clupea harengus) otoliths to distinguish different nursery areas. PICES International Symposium: Drivers of dynamics of small pelagic fish resources (6-11. March 2017), Victoria BC, Canada

von Nordheim, L., Kotterba, P., Moll, D. & P. Polte (2017). Impact of spawning substrate complexity on egg survival of Atlantic Herring (Clupea harengus, L.) in the Baltic Sea. Conference poster, BCDC (Biology Conference of Doctoral Candidates), University of Hamburg, Germany, 9. june 2017.

GEOMAR

Presentations:

Hinrichsen et al. 2017. Survival and dispersal of eggs and larvae of central and eastern Baltic flounder (*Platichthys flesus*) by biophysical modelling. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Lehmann et al. 2017. Climate variability of hydrographic conditions of the Baltic Sea and their impact on cod nursery areas. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

Lehmann, A., Höflich, H.-H., Hinrichsen, H.-H. 2017. Climate variability of hydrographic conditions of the Baltic Sea and their impact on cod nursery areas. 11th Baltic Sea Science Congress 'Living along gradients: past, present, future. Rostock, Germany, June 12-16, 2017.

UU

Presentations:

Nissling et al. 2017. Egg buoyancy of flounder, *Platichthys flesus*, in the Baltic Sea – adaptation to salinity and implications for egg survival. BONUS Symposium, Tallinn, Estonia, 17-19 October 2017.

14. Number of post graduate courses organised by the project (1) and persons participating (2).

2014

None

2015

None

2016

DTU-Aqua

BONUS BIO-C3/INSPIRE/COCOA/BAMBI 2016 Summer School: Modelling Biodiversity for Sustainable Use of Baltic Sea Living Resources; August 21–27, 2016, Søminnestationen, Holbæk, Denmark. 23 student participants and 7 lecturers.

2017

None

15. Number of mobility activities – persons (1), visit days (2) – From the project to the other BONUS projects.

2014

UT-EMI

Participation in BONUS BIO-C3 work: meetings and initiation of joint activities: Baltic Sea zooplankton study (http://kodu.ut.ee/~riina82/) and BONUS Theme Session at ICES ASC 2015 (http://www.ices.dk/news-and-events/asc/ASC2015/Pages/Theme-Sessions.aspx).

MIR-PIB

Participation (A. Luzeńczyk) at BIO-C3 kick-off meeting.

UU

Anders Nissling participated on a survey with R/V Alkor & provided Jan Dierking (BIO-C3) with flounder samples for isotope analysis.

2015

UT-EMI

Attendance (H. Ojaveer) at BONUS BIO-C3 annual meeting in Kiel, Germany; 30. June – 3. July 2015 (4 days).

Working visit (7 days) of H. Ojaveer to DTU-AQUA for collaboration with BONUS BIO-C3.

DTU-Aqua

S. Neuenfeldt visited UHAM 2 times á 2 days to coordinate with BONUS BIO-C3 participants.

UU

Sofia Nyberg participated on a survey with R/V Alkor (BIO-C3) (time spent 15 days) sampling flounder for determination of ecotype & performed measurements of egg specific gravity.

2016

UT-EMI

Attendance (H. Ojaveer) at BONUS BIO-C3 annual meeting in Tallinn, Estonia; 28-30 June 2016 (3 days)

Attendance and hosting (H. Ojaveer) BONUS BIO-C3 Baltic Sea round goby workshop in Tallinn, Estonia; 27. June 2016 (1 day)

Attendance (H. Ojaveer) at BONUS GOHERR fieldwork near Pärnu (Estonia); 14. May (1 day)

LUKE
Attendance (J. Raitaniemi) at BONUS GOHERR workshop in Copenhagen, Denmark; 16-17 February 2016 (2 days)

2017
UT-EMI
Attendance (H. Ojaveer) at BONUS BIO-C3 annual meeting in Kiel, Germany; 26-29 June 2017 (4 days)

16. **Number of PhD students (1) and the number of post-docs (2) funded by the project** as well as the number of **doctoral thesis defended (3)**.

2014
SU
One post doc (Susa Niiranen) started in SU in 2014**.**

SLU
One PhD student (Alessandro Orio) started in SLU in 2014.

BIOR
One PhD student (Ivars Putnis) is a part-time participant and one Post doc (Didzis Ustups) started in INSPIRE project.

TI-OF
One PhD student (Dorothee Moll) started in TI-OF in 2014.

UHAM
One Post doc (Klas Ove Möller) and one PhD student (Muriel Kroll) started in UHAM in 2014.

GEOMAR
One PhD student (Katharina Höflich) started in GEOMAR in 2014

2015
MIR-PIB
Two PhD students (Anna Luzeńczyk and Szymon Smoliński) and one Post doc (Krzysztof Radtke) started in INSPIRE project.

LU
PhD student (Kim Berndt) is working for INSPIRE project in 2015.

2016
SU
Post doc (Stuart Kininmonth) started in INSPIRE in 2016**.**

BIOR
Post doc (Maris Plikss) started in INSPIRE project in 2016.

GEOMAR
Two post docs (Klaus Getzlaff and Hans-Harald Hinrichsen) started in INSPIRE in 2016.

LU
PhD thesis defended: Berndt, K. 2016 Fishing the gene pool: Genetic structure, admixture and behavioural complexity in fisheries management. Shared supervision together with Anders Persson, assistant supervisors Rosa Figueroa and Johan Hollander. Defended 18. May 2016.

2017
TI-OF
One post doc (Paul Kotterba) was employed by INSPIRE in 2017.

MIR-PIB
PhD thesis defended: Luzeńczyk, A. 2017. MSY (maximum sustainable yield) approach in fish stock management: an example of the Baltic Sea. Supervisor Jan Horbowy. Defended 11. October 2017.

8. Distribution of the project ‘s research staff and research organisations involved by age class, seniority and gender

Age group	PhD students		Post-docs		Assistants, lecturers, instructors and eq		Associate professors and eq		Professors and eq	
	F	M	F	M	F	M	F	M	F	M
<= 24	0	0	0	0	1	0	0	0	0	0
25 - 49	4	6	2	7	17	14	9	11	0	5
50 - 64	0	0	0	2	5	9	2	13	0	5
>= 65	0	0	0	0	2	3	0	2	0	0

Annex 1

REPORT of THE BONUS INSPIRE WORKSHOP

on

THE FLOUNDER STOCKS IDENTIFICATION

and

ASSESSMENT or EVALUATION

12-14 June, 2017

National Marine Fisheries Research Institute (MIR-PIB)

Gdynia, Poland

1. Introduction

The basic aim of the meeting was to advance realization of the tasks and deliverables related to assessment of flounder stocks in the Baltic (Tasks 4.2-4.3, WP-4, deliverable D4.3). The decision on conducting the workshop was undertaken by SC meeting in Hamburg in January 2017 (see below):

Agenda item #9: Any Other Business

1. Request changes in the deliverables: D4.3 to be changed from 'manuscript' to 'report'. The reason for such request lies in the fact that the limited nature of the collected original material from field surveys, together with the associated scientific uncertainty in the obtained data is insufficient to come up with a scientific manuscript on the model and methods of assessment of flounder stocks. Such a proposed change will, however, actually not reduce the number of deliverables in INSPIRE consisting of a manuscript, as D 4.1, instead of being a report, contains two already published assessment-oriented papers.
2. To organise flounder workshop in Gdynia, Poland in M41 (June 2017), to discuss and agree the assessment methods to be used for flounder stock assessments/evaluations in order to achieve D4.3. The workshop will be hosted by INSPIRE Partner 3 (MIR-PIB) and co-chaired by Ann-Britt Florin and Jan Horbowy.

The meeting was co-chaired by Jan Horbowy (stock assessment/evaluation part) and Ann-Brit Florin (stock identification part). In the meeting participated:

- 4 persons from MIR-PIB, Poland (Jan Horbowy, Anna Luzeńczyk, Zuzanna Mirny, Szymon Smoliński)
- 2 persons from BIOR, Latvia (Didzis Ustups and Maris Plikshs)
- 2 person from UT-EMI, Estonia (Kristiina Hommik and Tiit Raid)
- 1 person from SLU, Sweden (Ann-Britt Florin).

As introduction to the workshop Jan Horbowy presented INSPIRE commitments on flounder, especially related to task 4.3 and deliverable 4.3. Commitments within task 4.2 were presented in details by Ann-Britt Florin.

Agenda of the meeting is presented in Appendix 1.

Participant list and the presence at the meeting are shown in Appendix 2.

2. Presentations and discussions of data and methods for stock assessment

Jan Horbowy presented several assessment methods, which could be used in assessment of flounder stocks in the Baltic (Appendix 3). In the presentation data requirements for the models/methods and availability of software to conduct assessments were discussed. First, most comprehensive age – structured models were presented (XSA, SAM, CAGEAN, separable VPA). Other considered approaches were length based methods, stock-production models, survey based methods, and methods based on equilibrium assumptions (e.g. catch curve, mean length combined with growth parameters). In addition, method of equilibrium curves of catch and biomass as basis for estimation of BRPs was presented.

Szymon Smoliński presented two R scripts which may be very helpful in stock assessments, not only for flounder. The first one enables to perform several different parameterisations of XSA in one run. The stock assessor obtains diagnostics, retrospective analyses, and graphs for these different parameterisations. The use of such script allows for quick tests of sensitivity of assessments to different assumptions and makes selection of best assessment easier.

Second script allows for testing sensitivity of XSA to different assumptions on discard levels. The user can inspect how strongly assessment results are dependent on level and pattern of discards. This is very important as reliable discard estimates for flounder are available for a few years only, too short time series to be directly used in stock assessment.

Anna Luzeńczyk presented exploratory runs of two **stock assessment** models for **flounder in sub-division 24-25**. Both models (XSA and SAM) showed similar trends in the case of spawning stock biomass (SSB), fishing mortality (F) and recruitment (R). In the recent years recruitment and F were decreasing, while SSB was increasing. The settings of the XSA were the following: age 2 for catchability independent of size and age 5 for catchability independent of age. Standard error (SE) of the mean to which the estimates were shrunk was set at 0.75.

The biggest differences between the results of XSA and SAM were visible in the case of fishing mortality. The trends were the same, but Fs from SAM were much more smooth, which is common when random walk is applied to simulate fishing mortality. The suggestions on parameterisations discussed during the meeting were:
- to check no shrinking option in the XSA model,
- to set catchability plateau at age 4 instead of 5,
- to establish plus group at age 10 instead of age 8,
- to combine tuning fleets for quarters 1 and 4 for each of the subdivisions.

Jan Horbowy presented assessment of flounder in sub-division 24-25 using stock-production models. Schaefer and difference models (Horbowy, 1992) were applied. Models were fitted to index of stock size from BITS. In addition, difference model was fitted to recruitment (age 3) from BITS. Results (trends and biomass levels in recent years) were comparable with stock estimates using both XSA and SAM assessments.

Szymon Smoliński presented results of biochronological studies based on flounder otoliths (Smoliński and Mirny, 2017). The objective of this project was to identify the factors that influence the annual growth patterns of the European flounder (Platichthys flesus) based on an analysis of otolith increments. Linear mixed models were applied to develop a 74-year long chronology that reflects the inter-annual variations in flounder growth rates using otolith samples collected from 1957 to 2016 in the southern part of the Baltic Sea. By analysing the widths of otolith increments the existence of common environmental factors that influence fish growth was revealed. Recent method to identify the optimal time window for climatic factors was incorporated in the mixed modelling framework. The most significant effects of the mean Baltic Sea Index during August–December and of the mean sea surface temperature from April–June were shown. Change point analysis on the developed chronology identified major alterations occurred in flounder growth in 1988, 1992 and 2006. This result is in accord with published studies on regime shifts in the Baltic Sea ecosystem. This paper reports information concerning the response of the commercially important European flounder to the changing environment that may support future ecosystem-based management of fish stocks. Moreover, the results also highlight the potential for applying biochronological techniques to identify rapid regime shifts in marine ecosystems (Smoliński & Mirny, 2017).

Didzis Ustups presented assessment data and discussed possible assessments for flounder in sub-divisions 26+28. He noted big difference in length at age for Latvian and Russian data. Latvian age determination was based on recommended technics while Russia applied old and not recommended method. Basing on this comparison it is suggested to not use Russian age data in the assessment. Stock-production models (and possibly length based models) should be tested. Data for length based assessment exist, however, it would be necessary to separate males and females, due to growth differences between sexes.

Preliminary run of stock-production model (SPiCT package) for the stock was performed.

Kristiina Hommik presented assessment data and discussed possible assessments for flounder in sub-divisions 27, 29-32. BITS survey does not cover this area, however, two national surveys (gillnet surveys from Estonia and Sweden) are available for this stock. Difference production model and survey based stock-recruitment analysis were among the models suggested to be attempted. Simulations with difference model were initiated.

Ann-Britt Florin presented the standardisation and modelling of historic BITS data by Alessandro Orio et al (2017a) for flounder in the Baltic Sea. Data where standardised to kg/h per swept area from 1978-2014 for the flounder stock in SD 26 & 28 stock and 1988-2014 for the flounder stock in SD 24-25. The modelling showed that flounder were most abundant in SD 28 and it dominated the stock in SD 26 & 28 but flounder in SD 28 decreased strongly since 2010. The maximum length of flounder in the survey had also decreased from 36 cm to 34 cm in SD 24 & 25 and from 37 cm to less than 30 cm in SD 28. In SD 26 maximum length had increased from 30 to 33 cm.

Ann-Britt Florin presented the characterisation and prediction of distribution of flounder during spawning time based on the INSPIRE gillnet survey (Orio et al 2017b).

3. Stock identification

Ann-Britt Florin presented the commitments for 4.2: using a subset of flounders of known spawning type (sampled in WP1) as reference material, different techniques (genetics, morphometrics & otolithchemistry) have been applied to develop tools for separating demersal and pelagic spawning flounder and enabling allocation of catch to different spawning types of flounder in different SD:s.

Ann-Britt Florin presented results from the genetic study in INSPIRE. Over 1000 samples of adult flounders collected in the INSPIRE gillnet survey and complemented by samples from the German Alcor survey have been genotyped using 16 microsatellites. STRUCTURE analysis showed the existence of two distinct clusters (F=0.026) which was shown to correspond to demersal and pelagic spawning type of flounder. Within the clusters there was very little genetic differentiation. Estimating the proportion of flounders of the different types in the survey revealed that in SD 24-26 majority was pelagic type while in SD 28 & 32 the majority was demersal. Assuming the gillnet survey is representative of the flounder population in the Baltic Sea this means that the current assessment and management units SD2425 consists of 84 % pelagic; SD2628 of 47% pelagic and SD2732 8% pelagic. Genetic results from more than 300 juveniles collected in the INSPIRE Beachseine survey in SD 25 and SD 28 showed that the demersal type dominated in Gotland and Gulf of Riga but in Hanöbay and the Latvian coast the proportion was almost equal.

Ann-Britt Florin presented results of morphometric data from adult flounder and the possibility for discriminating between ecotypes. Images of 200 genotyped flounders from SD25 & 28 were analysed using 11 landmarks to create 18 morphometric distances. It was revealed that both sex, area and ecotype of flounder influenced the body shape of fishes. Using a discriminant analyze function 74 % of the fishes could be correctly classified to either demersal or pelagic type.

Didzis Ustups presented results from the otolith chemistry data analysed in collaboration with Karin Limburg and Melvin Samson at SUNY –ESF. Results were inconclusive and needs to be verified by the genetic data.

4. Conclusions

The current management unit of SD 2425 is ok from a genetic perspective but ME 2628 and NE2732 is highly problematic since SD28 probably hold both types of flounder in large quantities. Using the probability distribution model from Orio et al (2017b) in combination with the proportions of the different types in the survey revealed by the genetic study, the proportion of the two types of flounder in different can be estimated. Furthermore, the developed genetic protocol with 16 msats and the

1000 flounders can be used for future investigations of proportion of flounders types in different areas and/or fisheries.

5. References

Horbowy, J. 1992. - The differential alternative to the Deriso difference production model. - ICES J. mar. Sci., 49: 167-174

Smoliński S, Mirny Z. 2017. Otolith biochronology as an indicator of marine fish responses to hydroclimatic conditions and ecosystem regime shifts. Ecological Indicators, 79, 286–294.

Orio, A., Florin, A.-B., Bergström, U., Sics, I., Baranova, T. & Casini, M. 2017a. Modelling indices of abundance and size-based indicators of cod and flounder stocks in the Baltic Sea using newly standardized trawl survey data ICES Journal of Marine Science, doi:10.1093/icesjms/fsx005

Orio, A., Bergström, U., Casini, M., Erlandsson, M., Eschbaum, R., Hussy, K., Lehman, A., Lozys, L., Ustups, D. &Florin A.-B. 2017b. Characterizing and predicting the distribution of Baltic Sea flounder (*Platichthys flesus*) during the spawning season. Journal of Sea Research, http://dx.doi.org/10.1016/j.seares.2017.07.002

Appendix 1.

Agenda
for the Inspire workshop
on flounder stock identification and assessment/evaluation
(12-14 June, 2017)

Lunch breaks: 13:00-14:00
Coffer breaks: 11:00-11:30 and 15:30:16:00

MONDAY, 12 June, 10:00-18:00

Morning

1. Welcome of participants and practicalities
2. Discussion of Agenda
3. Inspire commitments on Flounder, tasks 4.2-4.3 (Jan Horbowy, task 4.2 will be presented in details on Tuesday by Ann-Britt Florin)
4. Possible assessment methods (Jan Horbowy)
5. Procedures developed in R for XSA testing and discards modeling (Szymon Smoliński)
6. Data and assessment of Flounder in sub-div. 24-25 using age-structured models (Anna Luzeńczyk/Zuzanna Mirny)

Afternoon

1. Assessment of Flounder in sub-div. 24-25 using stock-production models (Jan Horbowy)
2. Data and assessment of Flounder in sub-div. 26+28 (Didzis Ustups)
3. Data and assessment of Flounder in sub-div. 27, 29-32 (Kristina Hommik/A.-B. Florin)
4. Presentation of standardization of historic BITS series (Alessandro Orio/A.-B .Florin)
5. Individual/group work on assessments

TUESDAY, 13 June, 9:00-18:00
Morning

1. Presentation of habitat modeling of flounder (Alessandro Orio/A.-B .Florin)
2. Inspire commitments 4.2 and presentation of genetic data of flounder (A.-B. Florin)
3. Presentation of morphometric data – possibility for discriminating between ecotypes (A.-B. Florin)
4. Presentation of otolith chemistry data (Didzis Ustups)
5. Szymon & Zuzia presentation on otoliths
6. Discussion about proper assessment units; decision about how to best estimate proportion of different stocks within SD:s

Afternoon

1. Individual/group work testing assessment in suggested units

WEDNESDAY, 14 June, 9:00-15:00

1. Presentation of results from new stock units

2. Concluding remarks and developing
    a. plan for fulfilling/finishing tasks 4.2-4.3
    b. plan for producing deliverable 4.3

Annex 2

Participation in stakeholder committees

No	Last name	First name	Affiliation short	Committee
1	Hommik	Kristiina	UT-EMI	ICES WGBFAS
2	Klais	Riina	UT-EMI	IOC TrendsPO
3	Ojaveer	Henn	UT-EMI	ICES WGHIST
4	Ojaveer	Henn	UT-EMI	OPI Executive Committee
5	Ojaveer	Henn	UT-EMI	ICES HAPISG
6	Ojaveer	Henn	UT-EMI	ICES SCICOM
7	Ojaveer	Henn	UT-EMI	ICES WGBOSV
8	Ojaveer	Henn	UT-EMI	ICES WGITMO
9	Ojaveer	Henn	UT-EMI	ICES WGCHAIRS
10	Ojaveer	Henn	UT-EMI	ICES WGMABS
11	Ojaveer	Henn	UT-EMI	ICES Awards Committee
12	Ojaveer	Henn	UT-EMI	HELCOM MARITIME
13	Raid	Tiit	UT-EMI	ICES WGBFAS
14	Raid	Tiit	UT-EMI	ICESWGBIFS
15	Raid	Tiit	UT-EMI	ICES Baltic Sea Advice Drafting Group
16	Raid	Tiit	UT-EMI	ICES North Sea Advice Drafting Group
17	Raid	Tiit	UT-EMI	EC STECF EWG 1705 Fisheries - dependent information
18	Raid	Tiit	UT-EMI	EC STECF EWG 1707. Evaluation of Member States Annual DCF Reports.
19	Raid	Tiit	UT-EMI	EC STECF EWG1713 Pevaluation of Member States Annual DCF Workplan Amendments
20	Raid	Tiit	UT-EMI	ICES WGBIOP
21	Raid	Tiit	UT-EMI	ICES PGDATA
22	Neuenfeldt	Stefan	DTU Aqua	ICES WGIAB
23	Neuenfeldt	Stefan	DTU Aqua	ICES WKBEBCA
24	Neuenfeldt	Stefan	DTU Aqua	ICES WKIDEBCA
25	Eero	Margit	DTU Aqua	ICES WGIAB
26	Eero	Margit	DTU Aqua	ICES WGBFAS
27	Eero	Margit	DTU Aqua	ICES WKBEBCA
28	Eero	Margit	DTU Aqua	ICES WKIDEBCA
29	Hüssy	Karin	DTU Aqua	ICES WKBEBCA
30	Hüssy	Karin	DTU Aqua	ICES WKIDEBCA
31	Horbowy	Jan	MIR-PIB	ICES WGBFAS
32	Horbowy	Jan	MIR-PIB	ICES ACOM
33	Horbowy	Jan	MIR-PIB	ICES ADGBS
34	Horbowy	Jan	MIR-PIB	ICES IBPArcticCod
35	Horbowy	Jan	MIR-PIB	ICES WKBEBCA
36	Luzeńczyk	Anna	MIR-PIB	ICES WGBFAS

37	Radtke	Krzysztof	MIR-PIB	ICES WGBIFS
38	Radtke	Krzysztof	MIR-PIB	ICES WGRFS
39	Radtke	Krzysztof	MIR-PIB	Baltic Sea Advisory Council, Executive Committee
40	Mirny	Zuzanna	MIR-PIB	ICES WGBFAS
41	Mirny	Zuzanna	MIR-PIB	ICES WGBIOP
42	Smoliński	Szymon	MIR-PIB	ICES WGBIFS
43	Smoliński	Szymon	MIR-PIB	ICES WKPELA
44	Smoliński	Szymon	MIR-PIB	HELCOM FISH-PRO II
45	Blenckner	Thorsten	SU	ICES WGIAB
46	Niiranen	Susa	SU	ICES WGIAB
47	Blenckner	Thorsten	SU	ICES COMEDA
48	Casini	Michele	SLU	ICES WGBFAS
49	Casini	Michele	SLU	ICES ADGBS
50	Casini	Michele	SLU	ICES WKIDEBCA
51	Casini	Michele	SLU	ICES WKBEBCA
52	Orio	Alessandro	SLU	ICES WKIDEBCA
53	Orio	Alessandro	SLU	ICES WGBFAS
54	Orio	Alessandro	SLU	ICES WGHIST
55	Bergström	Ulf	SLU	Sea and Water Forum (Havs- och vattenforum), Sweden
56	Bartolino	Valerio	SLU	ICES HAWG
57	Bartolino	Valerio	SLU	ICES WGSAM
58	Bartolino	Valerio	SLU	ICES WKPELA
59	Bartolino	Valerio	SLU	ICES WKSANDMAN
60	Bartolino	Valerio	SLU	ICES ADGSAND
61	Bartolino	Valerio	SLU	Workshop on Elicitation of stakeholders preferences and presentation for the MareFrame DSTv2
62	Florin	Ann-Britt	SLU	ICES WGITMO
63	Florin	Ann-Britt	SLU	ICES WGBFAS
64	Kornilovs	Georgs	BIOR	ICES WGBFAS
65	Kornilovs	Georgs	BIOR	ICES SCICOM
66	Ustups	Didzis	BIOR	ICES WGBFAS
67	Ustups	Didzis	BIOR	BALTFISH
68	Ustups	Didzis	BIOR	ICES ACOM
69	Plikss	Maris	BIOR	ICES WGBFAS
70	Plikss	Maris	BIOR	ICES WKIDEBSA
71	Svecovs	Fausts	BIOR	ICES WGBIFS
72	Strods	Guntars	BIOR	ICES WGBIFS
73	Polte	Patrick	TI-OF	ICES WGALES
74	Polte	Patrick	TI-OF	ICES WGIPS
75	Polte	Patrick	TI-OF	ICES WKPELA
76	Möllmann	Christian	UHAM	ICES/HELCOM WGIAB
77	Otto	Saskia	UHAM	ICES/HELCOM WGIAB

78	Möllmann	Christian	UHAM	ICES WGCOMEDA
79	Pönni	Jukka	Luke	ICES WGBFAS
80	Pönni	Jukka	Luke	ICES WGBIFS
81	Pönni	Jukka	Luke	ICES WGBIOP
82	Pönni	Jukka	Luke	ICES WKBALT
83	Pönni	Jukka	Luke	RCM Baltic, Turku
84	Raitaniemi	Jari	Luke	ICES ADGDEEP
85	Raitaniemi	Jari	Luke	ICES WGBIOP
86	Raitaniemi	Jari	Luke	ICES WGBFAS
87	Raitaniemi	Jari	Luke	ASCOBANS Bycatch WG
88	Raitaniemi	Jari	Luke	RCM Baltic, Turku

Metadata sheets

1. Slave to the rhythm: Seasonal signals in otolith microchemistry reveal age of eastern Baltic cod (*Gadus morhua*)
2. Autumn herring in the Gulf of Riga
3. Baltic cod condition
4. Eastern Baltic cod spatial distribution
5. Herring and sprat feeding in the Gulf of Finland and the NE Baltic Proper
6. Ichthyoplankton in the Gotland Basin and the Gulf of Finland
7. Baltic Sea standardized bottom trawl data
8. Baltic Sea standardized pelagic trawl data
9. Cod stomach content database
10. Early life stage survival and connectivity of Baltic cod
11. Effects of multispecies and density dependent factors on MSY reference points: Example of the Baltic Sea sprat
12. Effects of varying natural mortality and selectivity on the assessment of eastern Baltic cod stock
13. Egg specific gravity of Baltic flounder
14. Baltic Sea flounder genetic data
15. Baltic flounder spawning habitat
16. Baltic Sea gillnet and beach seine surveys
17. Greifswald Bay environment, macrophyte coverage and herring egg concentration, impact of storm event
18. Gulf of Riga autumn herring reproduction
19. Gulf of Riga hydroclimate, zooplankton and herring
20. Herring and three-spined stickleback feeding in the Gulf of Riga
21. Herring eggs, predator exlusion
22. Effect of substrate complexity on herring egg mortality
23. Stock structure and main parameters of the Baltic herring in Subdivisions 28.2, 29, 32 and their combinations
24. Herring fishery in SD 30 and 32
25. Spatio-temporal overlap of larval herring and sticklebacks
26. Stock structure and main parameters of internationally managed fish species of the Baltic Sea (excl. salmon and plaice)
27. Baltic Sea mesozooplankton dataset
28. Oxygen-related Baltic cod egg survival data
29. Pärnu Bay environment and fish larvae
30. Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment
31. Herring otolith chemistry
32. Spatial distribution of larval herring in Greifswald Bay

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Slave to the rhythm: Seasonal signals in otolith microchemistry reveal age of eastern Baltic cod (*Gadus morhua*)
2	General description	Microchemistry analysis of adult cod otoliths from The eastern Baltic Sea and for comparison from the wester Baltic Sea and North Sea
3	Data type (observational/model)	Observational
4	Parameters	Concentration of elements in the otoliths (Cu, Zn, Rb, Mg, Mn, Sr, Ba, Pb)
5	Area covered	Eastern and western Baltic Sea, North Sea
6	Spatial resolution	20 degrees longitude, 4 degrees lattitude
7	Time span	1998
8	Temporal resolution	Single sampling event
9	Entry date	7. March 2016
10	Institution	National Institute of Aquatic Resources, Technical University of Denmark
11	Contact name	Karin Hüssy
12	Contact e-mail	kh@aqua.dtu.dk
13	Publication where data used	Hüssy, K., Gröger, J., Heidemann, F., Hinrichsen, H.-H., and Marohn, L. 2015. Slave to the rhythm: seasonal signals in otolith microchemistry reveal age of eastern Baltic cod (*Gadus morhua*). ICES Journal of Marine Science. http://icesjms.oxfordjournals.org/content/early/2015/12/18/icesjms.fsv247

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Early life stage survival and connectivity of Baltic cod
2	General description	Data bases on meteorology, river runoff and hydrography
3	Data type (observational/model)	Model data
4	Parameters	Survial and connectivity patterns of Baltic cod eggs / yolk-sac larvae
5	Area covered	Arkona, Bornholm, Gotland Basin and Gdansk Deep, Baltic Sea
6	Spatial resolution	2.5 km horizontal, 3 m vertical
7	Time span	1971-2010
8	Temporal resolution	10 days
9	Entry date	27. February 2016
10	Institution	GEOMAR, Kiel, Germany
11	Contact name	Hans – Harald Hinrichsen
12	Contact e-mail	hhinrichsen@geomar.de
13	Publication where data used	Hinrichsen, H.-H., Lehmann, A., Petereit, C., Nissling, A., Ustups, D., Bergström, U., Hüssy, K. 2016. Spawning areas of eastern Baltic cod revisited: Using hydrodynamic modelling to reveal spawning habitat suitability, egg survival probability, and connectivity patterns. Progress in Oceanography, 143: 13-25. http://dx.doi.org/ 10.1016/pocean.2016.02.004

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Effects of multispecies and density dependent factors on MSY reference points: Example of the Baltic Sea sprat
2	General description	Input data (sprat): weight at age, predation mortality at age, stock size Output data: Estimates of sprat F_{MSY} and B_{MSY} with inclusion of density dependent factors
3	Data type (observational/model)	Observational and model data
4	Parameters	Estimates F_{MSY} and B_{MSY} with inclusion of density dependent factors, sprat example
5	Area covered	Baltic Sea (ICES sub-divisions 22-32)
6	Spatial resolution	Data refer to whole area covered
7	Time span	For input data 1974-2014
8	Temporal resolution	1 year
9	Entry date	22. October 2016
10	Institution	MIR-PIB, Gdynia, Poland
11	Contact name	Jan Horbowy
12	Contact e-mail	horbowy@mir.gdynia.pl
13	Publication where data used	Horbowy, J., Luzenczyk, A. 2016. Effects of multispecies and density dependent factors on MSY reference points: Example of the Baltic Sea sprat. Can. J. Fish. Aquat. Sci. (doi: 10.1139/cjfas-2016-0220)

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Effects of varying natural mortality and selectivity on the assessment of eastern Baltic cod stock.
2	General description	Input data: data bases on cod catches and survey estimates of stock size Output data: Estimates of stock size, fishing mortality and natural mortality
3	Data type (observational/model)	Observational and model data
4	Parameters	Estimates of stock size, fishing mortality and natural mortality
5	Area covered	ICES sub-divisions 25-32, eastern Baltic cod
6	Spatial resolution	Data refer to whole area covered
7	Time span	1990-2013
8	Temporal resolution	1 year
9	Entry date	22. October 2016
10	Institution	MIR-PIB, Gdynia, Poland
11	Contact name	Jan Horbowy
12	Contact e-mail	horbowy@mir.gdynia.pl
13	Publication where data used	Horbowy, J. 2016. Effects of varying natural mortality and selectivity on the assessment of eastern Baltic cod (*Gadus morhua* Linnaeus, 1758) stock. Journal of Applied Ichthyology, doi:10.1111/jai.13202 (available on-line)

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Egg specific gravity of Baltic flounder
2	General description	Egg characteristics and egg survival probabilities in different spawning areas
3	Data type (observational/model)	Observational
4	Parameters	Egg specific gravity, egg diameter, egg dry weight; changes in egg specific gravity during ontogeny; survival probabilities
5	Area covered	Baltic Sea: ICES SD 22, 24-26 and 28
6	Spatial resolution	The Baltic Sea deep basins and the east coast of Gotland
7	Time span	1990-2015
8	Temporal resolution	Spawning time; February-May
9	Entry date	08 March 2017
10	Institution	GEOMAR, Kiel, Germany
11	Contact name	Christoph Petereit
12	Contact e-mail	cpetereit@geomar.de
13	Publication where data used	Nissling, A., Nyberg, S., Petereit, C. Egg buoyancy of flounder, *Platichthys flesus*, in the Baltic Sea – adaptation to salinity and implications for egg survival. Fisheries Research (accepted 27 February 2017)

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic Sea flounder genetic data
2	General description	Genotypes for 16 msat markers of individual flounders mainly sampled in INSPIRE gillnet and beach seine surveys
3	Data type (observational/model)	Observational
4	Parameters	Genotypes, location, sampling depthstrata
5	Area covered	ICES SDs 22, 24-26, 28, 32 and North Sea
6	Spatial resolution	Transects and stations according to INSPIRE gillnet and beach seine survey design
7	Time span	2014-2015
8	Temporal resolution	April-June
9	Entry date	07. March 2017
10	Institution	SLU, Institute of Coastal Research
11	Contact name	Ann-Britt Florin
12	Contact e-mail	ann-britt.florin@slu.se
13	Publication where data used	Manuscript, Florin et al. presented at FSBI 2016 conference.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic flounder spawning habitat
2	General description	Biological and hydrological data from INSPIRE gillnet samping; prediction maps of potential spawning habitats
3	Data type (observational/model)	Observational and model data
4	Parameters	CPUE of flounder, cod and round gobies; salinity, temperature, oxygen from CTDs; habitat characteristic from video recordings (substrate, vegetation and blue mussles' coverage), bottom current velocity, wind exposure; hydrographic parameters (temperature, salinity, oxygen) from Baltic Sea Ice-Ocean Model for predictions
5	Area covered	Southern and central Baltic Sea (ICES SDs 24-29)
6	Spatial resolution	Transects along inshore-offshore gradients
7	Time span	2014-2015
8	Temporal resolution	March-May
9	Entry date	10. November 2017
10	Institution	SLU Aqua, Sweden
11	Contact name	Alessandro Orio, Ann-Britt Florin, Michele Casini
12	Contact e-mail	alessandro.orio@slu.se; ann-britt.florin@slu.se
13	Publication where data used	Orio, A., Bergström, U., Casini, M., Erlandsson, M., Eschbaum, R., Hüssy, K., Lehmann, A., Lozys, L., Ustups, D. and Florin, A.-B. (2017). Characterizing and predicting the distribution of Baltic Sea flounder during the spawning season. Journal of Sea Research, 126: 46-55. Doi:10.1016/j.seares.2017.07.002.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic Sea gillnet and beach seine surveys
2	General description	Environmental data and fish catch data from INSPIRE gillnet and beach seine surveys
3	Data type (observational/model)	Observational
4	Parameters	Species composition and abundance, individual lenght and weight; salinity, water temperature, Secchi depth, bottom substrate characteristics
5	Area covered	ICES SDs 24-26, 28, 29, 32
6	Spatial resolution	Exact location in decimal degrees
7	Time span	2014-2015
8	Temporal resolution	March-May and Oct-Dec
9	Entry date	07. March 2017
10	Institution	SLU, Institute of Coastal Research
11	Contact name	Ann-Britt Florin (SWE, LIT), Meri Kallasvuo (FIN), Redik Eschbaum (EST), Didzis Ustups (LAT), Krzysztof, Radtke (POL), Dorothee Moll (GER), Karin Hüssi (DEN)
12	Contact e-mails	ann-britt.florin@slu.se, Meri.Kallasvuo@luke.fi, redik.eschbaum@ut.ee, Didzis.Ustups@bior.lv, krzysztof.radtke@mir.gdynia.pl, dorothee.moll@ti.bund.de, kh@aqua.dtu.dk
13	Publication where data used	Ustups et al. 2016. Diet overlap between juvenile flatfish and the invasive round goby in the central Baltic Sea. J. Sea Res.107: 121-129. Manuscript, Orio et al. Submitted to J.Sea Res.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Greifswald Bay environment, macrophyte coverage and herring egg concentration, impact of storm event
2	General description	Weekly samples of macrophytes and herring eggs during the spawning season in 2015, three transects in different depth zones, 2 sampling activities storm litter on beach
3	Data type (observational/model)	Observational
4	Parameters	Sea surface temperature, turbidity, salinity, oxygen, herring egg abundance, categories dead eggs and alive eggs, macrophyte composition
5	Area covered	Greifswald Bay, SD 24
6	Spatial resolution	A few metres
7	Time span	March 2015 – June 2015
8	Temporal resolution	Weekly
9	Entry date	7. March 2016
10	Institution	Thuenen Institute of Baltic Sea Fisheries, Rostock
11	Contact name	Dorothee Moll
12	Contact e-mail	Dorothee.moll@ti.bund.de
13	Publication where data used	

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Gulf of Riga autumn herring reproduction
2	General description	Autumn herring collected for general biological and ovarian analysis from spawning areas in gillnets from the northern Gulf of Riga throughout the spawning season.
3	Data type (observational/model)	Observational (except water temperature)
4	Parameters	Wind speed, water temperature, ovarian microphotographs, proportion of abnormal ovaries, fish length/weight/age/body condition
5	Area covered	Northern Gulf of Riga
6	Spatial resolution	On the scale of kilometres
7	Time span	2011-2013
8	Temporal resolution	Bi-weekly/monthly (water temperature hourly)
9	Entry date	08. January 2016
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Henn Ojaveer
12	Contact e-mail	henn.ojaveer@ut.ee
13	Publication where data used	Ojaveer, H., Tomkiewicz, J., Arula, T., and Klais, R. Female ovarian abnormalities and reproductive failure of autumn-spawning herring (*Clupea harengus membras*) in the Baltic Sea. ICES Journal of Marine Science, 72: 2332–2340.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Gulf of Riga hydroclimate, zooplankton and herring
2	General description	Larval fish sampled from 9 and CTD/zooplankton from 2 stations in Pärnu Bay from May to July
3	Data type (observational/model)	Observational (excl. herring recruitment abundance)
4	Parameters	Winter air and sea surface temperature, zooplankton density, herring larvae and recruitment abundance
5	Area covered	Pärnu Bay (Gulf of Riga)
6	Spatial resolution	A few kilometres
7	Time span	2004-2013
8	Temporal resolution	Weekly for temperature, zooplankton and fish larvae
9	Entry date	09. December 2015
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Henn Ojaveer
12	Contact e-mail	henn.ojaveer@ut.ee
13	Publication where data used	Arula, T., Raid, T., Simm, M., Ojaveer, H. 2015. Temperature-driven changes in early life-history stages influence the Gulf of Riga spring spawning herring (*Clupea harengus m.*) recruitment abundance. Hydrobiologia, DOI 10.1007/s10750-015-2486-8

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Autumn herring in the Gulf of Riga
2	General description	Dataset covers variety of historical sources and parametres, originated both from catch statistics and biological observations, with different types and certainty of information over time between 1928-2014
3	Data type (observational/model)	Observational, model
4	Parameters	Landings (coastal, offshore), numbers by age groups, immature catch, fishing mortality, spawning stock biomass
5	Area covered	Gulf of Riga
6	Spatial resolution	Data available generally for the gulf, except some landings data recorded by fishing districts
7	Time span	1928-2014
8	Temporal resolution	Annual
9	Entry date	19 March 2018
10	Institution	DTU-AQUA Estonian Marine Institute, University of Tartu
11	Contact name	Brian MacKenzie, Henn Ojaveer
12	Contact e-mail	brm@aqua.dtu.dk, henn.ojaveer@ut.ee
13	Publication where data used	MacKenzie, B.R, and Ojaveer, H. Evidence from the past: exploitation as cause of commercial extinction of autumn spawning herring in the Gulf of Riga, Baltic Sea. ICES JMS, http://dx.doi.org/10.1093/icesjms/fsy028

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Herring and three-spined stickleback feeding in the Gulf of Riga
2	General description	Fish collected during pelagic fish hydroacoustic surves (264 trawls) by commercial trawl. Stomachs of 20 fish per haul were collected for adult and juvenile herring, and three-spined stickleback. Zooplankton samples obtained from each station by vertical tows of Juday net.
3	Data type (observational/model)	Observational
4	Parameters	Zooplankton by species and stations. Qualitative and quantitative feeding of fish by hauls: biomass proportion and frequency of occurrence of different prey taxa in stomachs, number of taxa in stomachs, percentage of empty stomachs, stomach fullness index.
5	Area covered	Gulf of Riga
6	Spatial resolution	In the range of kilometres
7	Time span	1999-2015 (late July – early August)
8	Temporal resolution	One survey lasted for about one week.
9	Entry date	24. May 2016
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Riina Klais
12	Contact e-mail	Riina.Klais@ut.ee
13	Publication where data used	Ojaveer, H., Lankov, A., Teder, M., Simm, M., Klais, R. (2016). Feeding patterns of dominating small pelagic fish in the Gulf of Riga, Baltic Sea. Hydrobiologia, DOI 10.1007/s10750-016-3071-5

Metadata sheet

No	Descriptor	Information
1	Title of dataset	Herring eggs, predator exlusion
2	General description	Experimental case study using exclusion experiments to quantify predation effects on herring egg mortality
3	Data type (observational/model)	Experimental, observational
4	Parameters	Herring egg abundance, stickleback abundance
5	Area covered	Greifswald Bay, Gahlkower Haken spawning site
6	Spatial resolution	metres
7	Time span	2012
8	Temporal resolution	weekly
9	Entry date	28. Nov 2017
10	Institution	Thünen-Institute of Baltic Sea Fisheries, Rostock, Germany
11	Contact name	Paul Kotterba
12	Contact e-mail	paul.kotterba@thuenen.de
13	Publication where data used	Kotterba P, Moll D, Hammer C, Peck M, Oesterwind D, Polte P (2017) Predation on Atlantic herring *(Clupea harengus)* eggs by the resident predator community in coastal transitional waters. Limnol Oceanogr:62, 2017, 2616-2628., DOI:10.1002/lno.10594

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Effect of substrate complexity on herring egg mortality
2	General description	Experimental case study using artificial substrate to investigate substrate effcts on herring egg mortality
3	Data type (observational/model)	Experimental
4	Parameters	Herring egg abundance and mortality
5	Area covered	Greifswald Bay, Gahlkower Haken spawning site
6	Spatial resolution	metres
7	Time span	2015
8	Temporal resolution	weekly
9	Entry date	28. Nov 2017
10	Institution	Thünen-Institute of Baltic Sea Fisheries, Rostock, Germany
11	Contact name	Lena von Nordheim
12	Contact e-mail	lena.nordheim@thuenen.de
13	Publication where data used	Nordheim L von, Kotterba P, Moll D, Polte P (2017) Impact of spawning substrate complexity on egg survival of Atlantic Herring (*Clupea harengus*, L.) in the Baltic Sea. Estuaries Coasts:in press, DOI:10.1007/s12237-017-0283-5

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Stock structure and main parameters of the Baltic herring in Subdivisions 28.2, 29, 32 and their combinations
2	General description	Information on SSB, stock abundance, landings and Fishing mortalities of herring in Subdivisions 28.2, 29, 32 and their combinations
3	Data type (observational/model)	Observational and modelled
4	Parameters	SSB, SSN, F, landings, distribution pattern
5	Area covered	Baltic Sea , Subdivisions 28.2, 29, 32
6	Spatial resolution	ICES Sub-divisions
7	Time span	1990-2014
8	Temporal resolution	From monthly to quarterly
9	Entry date	20. March 2017
10	Institution	Estonian Marine Institute, University of Tartu; Natural Resources Institute, Finland; Fish Resources Research Institute, Latvia
11	Contact name	Tii Raid; Jukka Pönni, Georgs Kornilovs.
12	Contact e-mail	tiit.raid@ut.ee
13	Publication where data used	Raid, T., Järv, L., Pönni, J., Raitaniemi, J. and Kornilovs, G. 2016. Central Baltic herring stock: What does the assessment of combined stock say about the status of its components? In: Guedes Soares,C. & Santos, T.A. (Eds). Maritime Technology and Engineering. Taylor & Francis Group, London: 961-966. ISBN 978-1-138-03000-8

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Herring fishery in SD 30 and 32
2	General description	Harmonized dataset from institutional monitoring programs of several countries around Baltic Sea
3	Data type (observational/model)	Observational
4	Parameters	Catch in weight and numbers at age by fleets and weights at age by ICES subdivision from Intercatch. Maturity ogives by ICES subdivision and fishing effort were derived from ICES reports/assessments. Acoustic indexes for SD 30 was derived from ICES assessments/reports and for SD 32 from ICES Acoustic database.
5	Area covered	ICES subdivisions 30 and 32 in the northern Baltic Sea
6	Spatial resolution	50 km statistical squares
7	Time span	1974–present
8	Temporal resolution	Year quarter
9	Entry date	23 March 2017
10	Institution	Estonian Marine Institute, University of Tartu Natural Research Institute Finland
11	Contact name	Tiit Raid, Jukka Pönni
12	Contact e-mail	tiit.raid@gmail.com, jukka.ponni@luke.fi, jari.raitaniemi@luke.fi
13	Publication where data used	Raid, T., Järv, L., Pönni, J. and Raitaniemi, J. (2018). Main drivers of herring fishery in the two neighboring gulfs of the Northern Baltic Sea. Maritime Transportation and Harvesting of Sea Resources, 2: 17th International Congress of the International Maritime Association of the Mediterranean, Lisbon, 9-11 October 2017. Ed. Guedes Soares, C.; Teixeira, A.P. Taylor and Francis, Boca, Raton, London, New York, Leiden: 1267-1274

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Spatio-temporal overlap of larval herring and sticklebacks
2	General description	Case study on top-down control of larval herring using weekly abundance of prey and predators and predators gut content data
3	Data type (observational/model)	Observationall
4	Parameters	Larval herring abundance, stickleback abundance, stickleback stomach contents
5	Area covered	Greifswald Bay
6	Spatial resolution	Kilometres
7	Time span	2011
8	Temporal resolution	weekly
9	Entry date	28. Nov 2017
10	Institution	Thünen-Institute of Baltic Sea Fisheries, Rostock, Germany
11	Contact name	Paul Kotterba
12	Contact e-mail	Paul.kotterba@thuenen.de
13	Publication where data used	Kotterba P, Moll D, Nordheim L von, Peck M, Oesterwind D, Polte P (2017) Predation on larval Atlantic herring *(Clupea harengus)* in inshore waters of the Baltic Sea. Estuar Coast Shelf Sci 198:1-11, DOI:10.1016/j.ecss.2017.08.017

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Stock structure and main parameters of internationally managed fish species of the Baltic Sea (excl. salmon and plaice)
2	General description	Information on SSB, stock abundance, landings, fishing mortalities and TACs of herring, sprat, and cod stocks
3	Data type (observational/model)	Observational and modelled
4	Parameters	SSB, SSN,F, TAC, landings, distribution pattern
5	Area covered	Baltic Sea
6	Spatial resolution	ICES Sub-divisions
7	Time span	1978-2013
8	Temporal resolution	From monthly to quarterly
9	Entry date	20. March 2017
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Tiit Raid
12	Contact e-mail	tiit.raid@ut.ee
13	Publication where data used	Raid, T., Arula, T., Kaljuste, O., Sepp, E., Järv, L., Hallang, A., Shpilev, H. and Lankov, A. 2015. Dynamics of the commercial fishery in the Baltic Sea: What are the driving forces? In: Dejhalla and Pavleti (Eds) Towards Green Marine Technology and Transport – Guedes Soares. Taylor & Francis Group, London, pp. 897-906.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic Sea mesozooplankton dataset
2	General description	Harmonized dataset from institutional monitoring programs of several countries around Baltic Sea
3	Data type (observational/model)	Observational
4	Parameters	Taxonomic composition and abundance of mesozooplankton (incl rotifers, cladocerans, and copepods)
5	Area covered	Baltic Sea (incl. Kattegat)
6	Spatial resolution	A few kilometres
7	Time span	1957-present
8	Temporal resolution	From daily to monthly
9	Entry date	08. January 2016
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Riina Klais
12	Contact e-mail	Riina.klais@ut.ee
13	Publication where data used	Klais R., Lehtiniemi, M., Rubene, G., Semenova, A., Margonski, P., Ikauniece, A., Simm, M., Põllumäe, A., Grinienė, E., Mäkinen, K., Ojaveer, H. 2016. Spatial and temporal variability of zooplankton in a temperate semi-enclosed sea: implications for monitoring design and long-term studies. Journal of Plankton Ecology (doi:10.1093/plankt/fbw022)

Metadata sheet

No	Descriptor	Information
1	Title of dataset	Oxygen-related Baltic cod egg survival data
2	General description	CTD and Baltic cod egg data sampled from 45 stations in Bornholm Basin (1993-2010), ICES hydrographic data base (1951-2010), ICES-Reports (WGBFAS)
3	Data type (observational/model)	Observational and model data
4	Parameters	Temperature, salinity, oxygen concentration, Baltic cod egg sizes, Baltic cod recruitment and SSB
5	Area covered	Bornholm Basin, Baltic Sea
6	Spatial resolution	Meso-scale to basin-wide
7	Time span	1951-2010
8	Temporal resolution	Baltic cod data – annual; physical parameters – monthly.
9	Entry date	11. January 2016
10	Institution	GEOMAR, Kiel, Germany
11	Contact name	Hans – Harald Hinrichsen
12	Contact e-mail	hhinrichsen@geomar.de
13	Publication where data used	Hinrichsen, H.-H., von Dewitz, B., Dierking, J., Haslob, H., Makarchouk, A., Petereit, C., Voss, R. 2016. Oxygen depletion in coastal seas and the effective spawning stock biomass of an exploited fish species. Royal Society open science, DOI 10.1098/rsos.150338

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Pärnu Bay environment and fish larvae
2	General description	Daily samples on environment and larval herring and *Pomatoschistus* spp. in three stations
3	Data type (observational/model)	Observational
4	Parameters	Sea surface temperature, turbidity, salinity, oxygen, zooplankton density; larval fish abundance, individuaal growth and mortality rate
5	Area covered	Pärnu Bay (Gulf of Riga)
6	Spatial resolution	A few kilometres
7	Time span	June 2011
8	Temporal resolution	Daily
9	Entry date	08. January 2016
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Henn Ojaveer
12	Contact e-mail	henn.ojaveer@ut.ee
13	Publication where data used	Arula, T., Laur, K., Simm, M., Ojaveer, H. 2015.Dual impact of temperature on growth and mortality of marine fish larvae in a shallow estuarine habitat. Estuarine, Coastal and Shelf Science, http://dx.doi.org/10.1016/j.ecss.2015.10.004

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic cod condition
2	General description	Biological data from bottom trawling (BITS, and historical Swedish and Latvian data), seal counts (Swedish Museum of Natural history) and hydrological data (SMHI)
3	Data type (observational/model)	Observational and model data
4	Parameters	Cod condition, hypoxic areas, cod suitable areas, sprat and herring biomass, cod abundance, seal abundance
5	Area covered	Central Baltic Sea (ICES SDs 25-28)
6	Spatial resolution	Sub-basins (ICES SDs)
7	Time span	1976-2014
8	Temporal resolution	Annual (October)
9	Entry date	03. November 2016
10	Institution	SLU Aqua, Sweden
11	Contact name	Michele Casini
12	Contact e-mail	michele.casini@slu.se
13	Publication where data used	Casini, M., Käll, F., Hansson, M., Plikshs, M., Baranova, T., Karlsson, O., Lundstrom, K., Neuenfeldt, S., Gårdmark, G. and Hjelm J. (2016). Hypoxic areas, density dependence and food limitation drive the body condition of a heavily exploited marine fish predator. Royal Society Open Science, 3: 160416. Doi: 10.1098/rsos.160416.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment
2	General description	1) Estimation of stock mixing proportions based on otolith shape analysis 2) Estimation of recruitment probability based on drift modelling
3	Data type (observational/model)	1) Observational (stock mixing) 2) Modelling (recruitment)
4	Parameters	1) Season, year, location 2) Salinity, temperature, oxygen, water currents
5	Area covered	Arkona Basin
6	Spatial resolution	200 kilometers
7	Time span	20 years
8	Temporal resolution	Seasonal over the entire time span
9	Entry date	7. March 2016
10	Institution	National Institute of Aquatic Resources, Technical University of Denmark
11	Contact name	Karin Hüssy
12	Contact e-mail	kh@aqua.dtu.dk
13	Publication where data used	Hüssy, K., H.-H. Hinrichsen; M. Eero; H. Mosegaard; J. Hemmer-Hansen; A. Lehmann; L. S. Lundgaard. 2015 Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment. ICES Journal of Marine Science http://icesjms.oxfordjournals.org/content/73/2/293

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Herring otolith chemistry
2	General description	Elemental fingerprints of hwestern baltic herring otolith cores for analyses on spawning ground origin (laser-ablation mass spectroscopy)
3	Data type (observational/model)	Observationall
4	Parameters	Elemental concentrations
5	Area covered	Southwestern Baltic Sea, Oeresund
6	Spatial resolution	Kilometres
7	Time span	2015-2016
8	Temporal resolution	yearly
9	Entry date	28. Nov 2017
10	Institution	Thünen-Institute of Baltic Sea Fisheries, Rostock, Germany
11	Contact name	Dorothee Moll
12	Contact e-mail	dorothee.moll@thuenen.de
13	Publication where data used	-

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Spatial distribution of larval herring in Greifswald Bay
2	General description	Pelagic and littoral herring larvae abundance and vertical distributions.
3	Data type (observational/model)	Observational
4	Parameters	Larvae abundance, lenght distribution, spatial homogeneity
5	Area covered	Greifswald Bay, SW Baltic Sea (ICES SD 24)
6	Spatial resolution	Exact location in decimal degrees
7	Time span	Single year case studies (2011-2015)
8	Temporal resolution	March-June
9	Entry date	13. March 2017
10	Institution	TI-OF, Thünen-Institute of Baltic Sea Fisheries
11	Contact name	Patrick Polte, Dorothee Moll, Paul Kotterba
12	Contact e-mail	patrick.polte@thuenen.de dorothee.moll@thuenen.de, paul.kotterba@thuenen.de
13	Publication where data used	Polte P., Kotterba P., Moll D., von Nordheim L. (2017) Ontogenetic loops in habitat use highlight the importance of littoral habitats for early-life stages of oceanic fishes in temperate waters. Scientific Reports 7:42709, DOI: 10.1038/srep42709

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Eastern Baltic cod spatial distribution
2	General description	Biological data from bottom trawling (BITS, and historical national data) and hydrological data (SMHI)
3	Data type (observational/model)	Observational and model data
4	Parameters	CPUE of cod, modelled hydrographic parameters (temperature, salinity, oxygen) from RCO-SCOBI model and commercial landings
5	Area covered	Central Baltic Sea (ICES SDs 25-28)
6	Spatial resolution	Individual trawl hauls
7	Time span	1982-2014
8	Temporal resolution	Annual
9	Entry date	11. November 2017
10	Institution	SLU Aqua, Sweden
11	Contact name	Michele Casini
12	Contact e-mail	michele.casini@slu.se
13	Publication where data used	Bartolino, V., Tian, H., Bergström, U., Jounela, P., Aro, E., Dieterich, C., Meier, H.E.M. Cardinale, M., Bland, B. and Casini, M. (2017). Spatio-temporal dynamics of a fish predator: density-dependent and hydrographic effects on Baltic Sea cod population. PLoS ONE, 12(2): e0172004. Doi:10.1371/journal.pone.0172004.

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Herring and sprat feeding in the Gulf of Finland and the NE Baltic Proper
2	General description	Fish collected from 30-minute hauls by pelagic commercial trawl during the daytime. From each haul, up to 10 individuals per species per 0.5 cm length group were analysed. Zooplankton samples obtained from each trawling station by vertical tows of Juday net.
3	Data type (observational/model)	Observational
4	Parameters	Zooplantkon abundance and biomass by species and stations. Qualitative and quantitative feeding of clupeids: percentage of empty stomachs, stomach fullness index, biomass proportion of different prey taxa in stomachs, dietary overlap.
5	Area covered	NE Baltic Proper, Gulf of Finland
6	Spatial resolution	Five transects (in total 12 trawls)
7	Time span	July 2015
8	Temporal resolution	One survey (lasted 4 days)
9	Entry date	24. May 2016
10	Institution	Estonian Marine Institute, University of Tartu
11	Contact name	Henn Ojaveer
12	Contact e-mail	Henn.ojaveer@ut.ee
13	Publication where data used	Ojaveer, H., Lankov, A., Raid, T., Põllumäe, A. and Klais, R. 2018. Selecting for three copepods – feeding of sprat and herring in the Baltic Sea**.** ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsx249

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Ichthyoplankton in the Gotland Basin and the Gulf of Finland
2	General description	Pelagic fish eggs and larvae sampled from 35–68 stations in the Gotland Basin and the Gulf of Finland in May and June. Samples were taken from the vertical haul and from the towing of the net on water surface in each station
3	Data type (observational/model)	Observational
4	Parameters	Abundances of fish eggs and larvae, developmental stages composition of eggs, length distribution of larvae, size distribution of eggs
5	Area covered	Gotland Basin, Gulf of Finland
6	Spatial resolution	On average 15 kilometres
7	Time span	May and June in 2014 and 2015
8	Temporal resolution	Month
9	Entry date	7. March 2016
10	Institution	Institute of Food Safety, Animal healt and Environment
11	Contact name	Andrejs Makarčuks
12	Contact e-mail	Andrejs.Makarcuks@bior.lv
13	Publication where data used	

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic Sea standardized bottom trawl data
2	General description	Data on CPUE (catch per unit effort) per size-class of cod and flounder, from DATRAS and historical Latvian and Swedish surveys.
3	Data type (observational/model)	Observational
4	Parameters	CPUEs (kg/h and no/h) per size-class per trawl haul
5	Area covered	SDs 24-29
6	Spatial resolution	Single trawl haul
7	Time span	1978-2014
8	Temporal resolution	Daily
9	Entry date	25. February 2016
10	Institution	SLU, Institute of Marine Research
11	Contact name	Alessandro Orio Michele Casini
12	Contact e-mail	alessandro.orio@slu.se michele.casini@slu.se
13	Publication where data used	Orio, A., Florin, A.-B., Bergström, U., Šics, I., Baranova, T. and Casini, M. (2017). Modelling indices of abundance and size-based indicators of cod and flounder stocks in the Baltic Sea using newly standardized trawl survey data. ICES Journal of Marine Science, doi:10.1093/icesjms/fsx005

Metadata sheet

No	Descriptor	Information
1	Title of dataset	Baltic Sea standardized pelagic trawl data
2	General description	Data on CPUE (catch per unit effort) of cod ≥ 30 cm from acoustic surveys control hauls
3	Data type (observational/model)	Model
4	Parameters	CPUEs (kg/h and no/h)
5	Area covered	SDs 25-32
6	Spatial resolution	ICES statistical rectangles
7	Time span	1979-2014
8	Temporal resolution	Quarter 4
9	Entry date	25. February 2016
10	Institution	SLU, Institute of Marine Research
11	Contact name	Michele Casini
12	Contact e-mail	michele.casini@slu.se
13	Publication where data used	-

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Metadata sheet

No	Descriptor	Information
1	Title of dataset	Cod stomach content database
2	General description	Ca. 110 000 individual-based samples of cod stomach contents for the Eastern Baltic Sea.
3	Data type (observational/model)	Observational
4	Parameters	Predator/prey size, ICES Subd, rectangle, prey weight in the stomach (by individual prey item)
5	Area covered	East off Bornholm
6	Spatial resolution	ICES rectangle
7	Time span	1964-2014
8	Temporal resolution	Daily
9	Entry date	08. January 2016
10	Institution	Technical Uiversity of Denmark, National Insitute for Aquatic Resources
11	Contact name	Stefan Neuenfeldt
12	Contact e-mail	stn@aqua.dtu.dk
13	Publication where data used	-

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Annex 4

REPORT

BONUS SYMPOSIUM: Science delivery for sustainable use of the Baltic Sea living resources

Venue and dates: Tallinn, Estonia, 17-19. October 2017

Conveners: Henn Ojaveer (Estonia), Jan Dierking (Germany) and Stefan Neuenfeldt (Denmark).

Science Steering Group: Andris Andrusaitis (chair, Finland), Fritz Köster (Denmark), Thorsten Reusch (Germany), Jason Link (USA), Herman Hummel (Netherlands), Adriaan Rijnsdorp (Netherlands), Leena Bergström (HELCOM), Riina Klais (Estonia).

Local organisng commitee: Sirli Peda (Tallinn University), Maria Habicht (Estonian Research Council), Kristina Tiivel (University of Tartu).

The symposium was organised by two EU BONUS projects: Integrating spatial processes into ecosystem models for sustainable utilisation of fish resources (INSPIRE) and Biodiversity changes – investigating causes, consequences and management implications (BIO-C3). It consisted of science delivery not only for the scientific community but also, through stakeholder panel discussions, for the policy-relevant cross-sectoral audience of key end users. The following BONUS projects contributed to the symposium: GOHERR, BALTICAPP, BAMBI, BLUEWEBS, CHANGE, BALTCOAST, OPTIMUS and INTEGRAL.

The conference had nearly 150 registered participants. The participants came from 13 countries: Austria, Belgium, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Netherlands, Norway, Poland, Sweden and US.

During the conference 74 talks, 32 posters and 3 key note addresses were presented. The conference talks were arranged into 5 following sessions:

Session 1: Potential and genetic basis for colonisation, acclimation and adaptation (to report advances in our knowledge relative to the potential and genetic basis for colonisation, acclimation and adaptation of selected native and alien invasive species/populations).

Session 2: Process-based knowledge on spatial population dynamics, species interactions and habitat connectivity (to quantify population dynamics and species interactions of key Baltic species in a spatially explicit context, and identify processes generating spatial structure and heterogeneity; to also address potential hazards to the connectivity between identified key habitats, including the impact of human induced and climatic environmental changes on habitat connectivity).

Session 3: Ecosystem internal and external drivers of change affecting biodiversity (to further advance the knowledge on functional links between selected biodiversity metrics and single/synergistic external pressures (e.g., fishing, eutrophication, climate change, biological invasions) and resulting alterations in food-web interactions affecting biodiversity).

Session 4: Temporal dynamics in biodiversity (to focus on the past patterns and future projections in biodiversity under changes in key drivers and pressures affecting biodiversity).

Session 5: Ecosystem-based adaptive management in the context of new understanding in spatio-temporal heterogeneity (to report on (1) advances to expand the knowledge base in the field of spatially explicit advice for ecosystem-based adaptive management, accounting for the spatial heterogeneity in species distributions, and (2) showcase the emerging socio-economic dimensions of marine management).

The three keynote addresses were:

- ✓ Spatial and temporal dimensions in European marine biodiversity research: Geographic gradients in benthic biodiversity over the Baltic and Europe, and a reflection on European developments in marine biodiversity networking (by Herman Hummel)
- ✓ Response of North Sea flatfish populations to centuries of exploitation: lessons for management (by Adriaan Rijnsdorp, Georg Engelhard, Katrien Lescrauwaet, Jan Jaap Poos, Tobias van Kooten);
- ✓ How to catch fish, preserve habitat, conserve other critters, derive energy, avoid too much bad stuff, have lots of tourists, utilize the ocean, and keep people happy all at once (by Jason Link)

The stakeholder panel discussion on 'Science delivery for sustainable use of the Baltic Sea living resources – where to go from here?' was arranged into three panels:

1. Main challenges of integrating multiple interests in sustainable ecosystem management (moderated by Georg Martin, University of Tartu).
   Panellists: Jason Link (NOAA, USA), Rene Reisner (Estonian Ministry of Environment), Jannica Haldin (HELCOM), Aleksei Lotman (Estonian Fund for Nature).

2. Main challenges of sustainable balanced management in fisheries (moderated by Kaire Märtin, Ministry of Environment of Estonia).
   Panellists: Pehr Eriksson (BSAC), Michele Casini (ICES/SLU, Sweden), Ain Soome (Estonian Ministry of Rural Affairs), Howard Browman (IMR, Norway).

3. Main challenges for matching research and policy/management needs (moderated by Liina Eek, Estonian Research Council).
   Panellists: Siegelinde Gruber (EC), Sebastian Valanko (ICES), Herman Hummel (NIOZ, The Netherlands), Olavi Petron (Estonian Ministry of Rural Affairs), Ene Kadastik (Estonian Ministry of Education and Research).

Annex 5

Integrating spatial processes into ecosystem models for sustainable utilization of fish resources (INSPIRE)

Report

Third Annual Meeting

16 October 2017

Tallinn, Estonia

Agenda item #1: Arrival and registration
Third annual meeting of INSPIRE was held in Tallinn, Estonia, on 16. October 2017, in conjunction of the BONUS symposium. The meeting was hosted by UT-EMI and held in premises of Estonian Ministry of Environment (Narva Rd. 6, Tallinn. The meeting agenda can be found in Annex 1. The meeting was attended by 17 participants (Annex 2).

Agenda item #2: Project coordination and reporting update (incl. databases, publications, etc.)
The project coordinator described and explained the requirements and needs for the project annual reporting. Reports of work package leads and project partner institute PI's according to the required format is due 10. March. This will allow sufficient time for the coordinating partner to assemble all input and finalise the report to BONUS (due 31. March 2018).

Agenda item #3: Review of the progress by WP's

WP1 Spatial distributions (Lead Michele Casini, SLU)
WP 1 focuses on understanding the spatial distribution and habitat preferences of the focus species, cod, flounder, herring and sprat.

The status of the Deliverables was presented by the WP1 coordinator. A summary of the Deliverables already submitted, together with the analyses envisaged to tackle the future Deliverables are provided.

D1.1 Database from first surveys to initiate habitat modelling and spatial distribution analyses (M14)
The databases of INSPIRE gillnet and beach seines surveys, as well as of the ichthyoplankton surveys, are finalized. The data are quality-checked and ready to perform the analyses to address future deliverables and additional analyses.

The Deliverable has been submitted and accepted by BONUS.

D1.2 Report on distribution maps for different life-stages (M28)
An existing hydrodynamic model (BSIOM) was combined with a Lagrangian particle-tracking technique to resolve drift patterns of cod and flounder eggs and larvae and predict their abundances in the Baltic seascape. These maps represent a significant step forward in the knowledge on essential reproduction habitats for Baltic cod, and will be of use in both fisheries management and marine spatial planning.

Using an extensive dataset of trawl survey data that has been collated from different national sources around the Baltic and then standardized, the spatial distribution of different life-stages of cod and flounder was statistically related to hydrographic and geographic predictors, taking year-by-year variation into account. The resulting statistical models were then used to produce spatial predictions of abundance of cod and flounder across the Baltic Proper every year from 1979 to 2014. The resulting map predictions of juvenile cod show a contraction and an increase in abundance of small cod individuals in the southern SDs of the Baltic Sea. The maps of adult cod show that the cod was distributed in high abundances in the whole area of study in 1985 and then started contracting in SDs 24-26 in the 90s and 2000s. The maps of flounder show that in 1985 the highest abundances were in SD 24 and on the eastern coast of the Baltic. In 1995 the abundance of flounder generally increased in the whole area and in 2005 it is possible to see particularly high abundances of flounder in the coastal areas of SD 28. In 2014 the high abundances in SD 28 are still present but a great increase in abundance of flounder can be seen in SDs 24 and 25.

Data from the Baltic International Acoustic Survey (BIAS) was used to produce distribution maps of herring and sprat biomass. These maps were then used to study the spatial overlap over time between cod (D1.4), sprat and herring which is used to evaluate the potential predator-prey and competitive relationships in the Baltic Sea.

The data from the ichtyoplankton survey were used to map the spatial distribution of sprat eggs and larvae and its changes, to detect correlations between spatial patterns and the hydrographic situation, and also the correlation between spatial distribution of eggs and larvae and success of recruitment of sprat in the area. In May sprat eggs were abundant only in the southern and central parts of the Gotland Basin. In June sprat eggs appeared in big numbers also in the northern regions. The amount of sprat larvae was rather low in both years.

The habitat use of herring larvae have been mapped in a major spawning area in the southwestern Baltic Sea, in the Greifswald Bay. The weekly survey on this detailed station grid provides a rather high resolution of larval herring distribution patterns throughout early life stage retention in the sheltered lagoon. From a total length (TL) of 11 mm on, larvae were found to be increasingly dispersed throughout the pelagic zone of the bay. However, all size classes were found in high concentrations in the connecting sound (Strelasund) at the western entrance to the bay. It is currently unclear if this is due to increased migration through this pass way or due to an increased likelihood of sampling larvae because the limited extension of the water body potentially increases larval densities (Polte et al. 2016).

The Deliverable has been submitted and accepted by BONUS.

D1.3 Manuscript on simulating spatial distributions of key exploited stocks (M28)
Generalized Additive Models were used to investigate the spatio-temporal dynamics of the Eastern Baltic cod stock during the past 35 years in view of density-dependence and hydrographic variability. The results showed that adult cod distribution was mainly affected by cod population size, and to a minor degree by small-scale hydrological factors and the extent of suitable reproductive areas. As population size decreases, cod population concentrates to the southern part of the Baltic Sea, where the preferred more marine environment conditions are encountered. Using the fitted models, the Baltic cod distribution was predicted back to 1970s and a temporal index of cod spatial occupation was developed. This study will contribute to the management and conservation and of this important resource and of the ecosystem where it occurs, by showing the forces shaping its spatial distribution and therefore the potential response of the population to future exploitations and environmental changes (Bartolino et al. 2017).

The Deliverable has been submitted and accepted by BONUS.

D1.4 Report on spatial overlap between predator-prey and competing species (M28)
Data from ICES currently coordinated surveys and historical data newly compiled and standardized within INSPIRE were used to produce maps of spatial distribution from which simple estimations of spatial overlap were performed. The main results show a temporal drop in the occurrence of cod in the distribution area of sprat and herring, and a similar drop in the occurrence of large cod in the distribution area of small cod. This put in evidence a potential decrease in predation pressure by cod on its prey (including cannibalism) due to spatial mismatch. On the other hand, prey occurrence in the areas occupied by cod did not change as much during the past 35 years. Moreover, sprat occurrence in the rectangles occupied by herring increased in the period 1985-2014 indicating a potential increased competition by sprat on herring stock.

To better characterize the actual competition between the herring and sprat, dietary habits and diet overlap of herring and sprat were also investigated. Both species consumed predominantly the small-sized copepods (*Temora longicornis*, *Eurytemora affinis* and *Acartia* spp.) with *E. affinis* and *T. longicornis* being generally positively selected by both species. The analyses showed that the spatial dynamics in the taxonomic composition of clupeid stomachs broadly resembled that of the availability of prey. Stomach fullness of fish increased with the increasing proportions of prey taxa in the zooplankton community. Pairwise dietary overlap between fish decreased when zooplankton diversity increased. Dietary overlap was also lowest among the individuals of sprat. Our results point to high interspecific competition, although sprat seems to be more successful than herring in finding and consuming prey, and therefore may have an advantage over herring when the zooplankton community is dominated by small-sized prey (Ojaveer et al., conditionaly accepted).

The Deliverable has been submitted and accepted by BONUS.

D1.5 Manuscript on habitat preferences of different life-stages of fish (M34)
Habitat characterization of the two flounder ecotypes (pelagic and demersal) at spawning time was performed using the data from INSPIRE gillnet sampling 2014 and 2015. Generalized Additive Models were used to answer three main research questions: 1) What environmental conditions characterize the spatial distribution and abundance of adult flounder during the spawning season? 2) What are the main factors defining the habitats of the two flounder ecotypes during the spawning season? 3) Where are the potential spawning areas of flounder? The model for the demersal spawning flounder revealed a negative relation with the abundance of round goby (*Neogobius melanostomus*) and a positive relation with Secchi depth and cod abundance. Vegetation and substrate did not play an important role in the choice of habitat for the demersal ecotype. The model for the pelagic spawning flounder showed a negative relation with temperature and bottom current and a positive relation with salinity. The potential spawning areas of flounder decreased for the pelagic spawning flounder over the last 20 years in the central part of the Baltic Sea. Spatiotemporal modelling of habitat availability can improve our understanding of fish stock dynamics and may provide necessary biological knowledge for the development of marine spatial plans (Orio et al. 2017).

The Deliverable has been submitted and accepted by BONUS.

D1.6 Manuscript on spatially explicit population and food-web modeling (M40).
Using 41 years of observations we model the changes in cod, herring and sprat (*Gadus morhua*, *Clupea harengus* and *Sprattus sprattus* respectively*)* for the Baltic Sea within a Bayesian Belief Network. The model predictions are spatially explicit and show the transfer of the central Baltic Sea from cod to sprat dominated ecology during this time period. This also highlights that the 2004 to 2014 years deviate in the typical cod-environment relationship with environmental factors, such as salinity, being less influential on Cod population abundances than in previous periods. The role of macrozoobenthos abundance, biotopic rugosity and flatfish biomass showed an increase influence in predicting cod biomass in the last decade of the study. Fisheries management that is able to accommodate shifting ecological and environmental conditions relevant to biotopic information will be more effective and realistic. Non-stationary modelling for all the homogeneous biotope regions while acknowledging that each has a specific ecology relevant to understanding the fish population dynamics is essential for fisheries science (Kininmonth et al. 2016).

The Deliverable has been submitted and accepted by BONUS.

D1.7 Design protocol for future surveys for flatfish and juvenile cod (M44)
Protocols for gillnet surveys targeting adult flounder and small cod as well as beach seine surveys targeting juvenile flounder were developed and tested. The Deliverable includes recommendations on sampling season, depth and mesh sizes, for future sampling.

The Deliverable has been submitted and accepted by BONUS.

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WP2 Passive movements, active migrations, and habitat connectivity (Christian Möllmann, UHAM)

WP2 has the following objectives:

1. Develop and test estimates of drift pattern for early life stages of cod and flounder.
2. Estimate net migration rates of adult cod, herring and sprat between ICES sub-divisions.
3. Develop a mechanistic test for importance of migrations compared to fishing, predation and reproduction in relation to changes in the spatial distributions of cod, herring and sprat.

D2.1 Database on traditional tagging data (M12)
D2.2 Manuscripts (2) on tracking eggs and larvae (M18)
D2.3 Manuscripts (2) on migrations of adult individuals (M24)
D2.4 Report on migration estimates (M24)
D2.5 Database on small scale distribution of cod, herring and sprat (M30)
D2.6 Manuscript on small scale movements (M36)

All Deliverables have been submitted and accepted by BONUS.

WP 3 Scaling from individuals to populations (Patrick Polte, TI-OF)

The scope of WP 3 is to quantify the impact of small and meso-scale ecosystem drivers and stressors on population scale, spatial distributions and species recruitment dynamics. Especially for fish species with a high degree of habitat fidelity according to spawning grounds or nursery areas, impacts of local hazards might be transported to larger spatial scales and affect entire stock dynamics. The focus of the WP is on the contribution of certain spawning grounds/juvenile habitats to adult populations and effects of local scale mortality, for example hazards due to hot spot fisheries, predation on aggregations of juveniles, or regional climatic extremes such as severe storm events.

The question to be addressed is whether local hazards might shape large scale population abundance and recruitment strength and thus spatial distribution patterns.

WP3 includes two major objectives:

1. To develop methods to scale individual movements of cod, herring, sprat and flounder (early life stages) to population distributions.
2. To perform process-studies collecting basic knowledge on regional hazards for population dynamics of Baltic herring and cod

Task 3.1 Scaling individual movements to populations' spatial distributions

Observed distribution patterns of early life stages were put in relation to individual movement and migration analysis. Simulations were performed to quantify processes generating heterogeneity in spatial distribution of cod early life stages. The environmental conditions were tested in the different spawning grounds for suitability of spawning and egg survival probability. Furthermore, the population connectivity of eastern Baltic cod eggs and yolk-sac larvae was estimated. The development of the tracking model and according model simulations were also conducted for flounder. The results provided temporally and spatially resolved distribution and settlement probability maps focusing on relative densities of juveniles within the different nursery areas.

The basis of the drift model study is a realistic 4-dimensional temperature, salinity, oxygen and current velocity data set provided by BSIOM. The hydrodynamic model is coupled with an oxygen sub-model which describes the dissolved oxygen distribution in the water column with its seasonal and quasi-permanent extended areas of oxygen deficiency. This allows the consideration of oxygen concentration as the major contributor to egg-mortality and habitat suitability for the eastern Baltic Cod stock.
The study has shown that also particles representing eastern Baltic cod juveniles settled to a relatively large extent in the western Baltic cod management area, and may significantly contribute to western Baltic cod recruitment. Therefore, it could be suggested that not only immigration but also larval and juvenile transport could contribute to recruitment in the western Baltic Sea. However, it is also evident that the stock component in the Gotland Basin only to a minor degree contributed particles to nursery grounds in other ICES subdivisons.

D3.1 Manuscript on distribution probability maps for juvenile cod and flounder (M36)

The Deliverable has been submitted and accepted by BONUS.

Hinrichsen H.-H., von Dewitz B., Lehmann A., Bergström U., Hüssy K. (2017) Spatio-temporal dynamics of juvenile cod's nursery areas in the Baltic Sea. Progress in Oceanography 155: 28-40

Task 3.2 Quantifying effects of regional hazards on larger scale productivity and spatial distributions

To study habitat selection of larval Atlantic herring (*Clupea harengus*), size-specific distribution in a Baltic Sea retention area, free of lunar tides and directed current regimes, was considered as a natural mesocosm. A Lorenz curve originally applied in socio-economics to describe demographic income distribution was adapted to a 20 year time-series of weekly larval herring distribution revealing size-dependent spatial homogeneity. Additional quantitative sampling of distinct larval development stages across pelagic and littoral areas. After hatching, larvae in the yolk sac stage left the shore zone and moved towards pelagic habitats of the basin. However, they remained aggregated in the vicinity of the spawning beds. Larvae in the intermediate development stage (pre-flexion, flexion) were found to be increasingly dispersed throughout the pelagic zone of the bay. In contrast, fish in the advanced stages (post-flexion) were found abundant in the upper littoral zone while almost absent in the pelagic zone. This loop in habitat use during larval ontogeny indicated an active habitat selection and revealed a key role of shallow littoral waters for larval herring retention.

Western Baltic populations of Atlantic herring (*Clupea harengus*) show a distinct homing behavior returning to particular spawning grounds every year during spring. Attributed to early life stage mortality, herring recruitment decreased in the western Baltic Sea during the past two decades. Since major drivers and stressors for herring reproduction are potentially introduced on the local scale of spawning and nursery grounds, the knowledge of the contribution of different nurseries to population dynamics is essential but challenging to investigate.

We used elemental fingerprinting in otoliths of early herring life stages, caught in four known spawning and nursery areas along the Western Baltic Sea, to detect differences in the chemical composition based on varying water chemistry in particular areas. Results revealed a distinct chemical separation between juvenile herring caught in the vicinity of the Island of Ruegen (south-western Baltic Sea) and other potential nursery areas further west in the Baltic Sea with high significant differences among all areas. Furthermore, we created an innovative elemental fingerprinting index (*EFI*), which allows us comparisons of otolith multi-element patterns within certain nursery areas and between nurseries, indicating that otolith chemistry is a suitable tool for future habitat connectivity estimates. The aim is identification of herring offspring origin and therefore the contribution of particular nursery areas to the adult population, which could lead towards a more directed management.

Since the early beginnings of fishery science it is acknowledged that crucial recruitment bottlenecks are often located in the earliest stages of fish life history.
How early life stage mortality in specific spawning and nursery areas translates to over-regional population dynamics and the particular mechanisms and ecological cascades at work was exemplarily studied on two distinct Baltic spring herring populations: the Gulf of Riga herring (representing the gulf herring) and the Western Baltic herring (representing the sea herring). Presented here is a synthesis of three publications regarding findings on recruitment drivers which are considered as generic for the Baltic Sea spring herring populations. Amongst others, the role of small- and meso-scale drivers and stressors for the recruitment strength was investigated including effects of regional climate regimes and food availability on larval growth as well as consequences of single storm events on herring egg mortality.

For most herring populations in the Baltic Sea frequenting coastal zones and inner coastal waters for spawning and larval retention, this means that important drivers and stressors of recruitment dynamics are acting on the scale of regional basins or estuaries. This renders stocks vulnarable against (anthropogenic) alterations of coastal zones and regional climate regimes. Generally, reproductive success and year class strength of the Western Baltic herring population is strongly determined by the survival of early life stages such as eggs and larvae in local nursery areas. However, the explicit mechanisms by which local stressors might affect overall recruitment are currently not well understood. In the very shallow NE part of the Gulf of Riga, high summer temperatures, which likely exceed the physiological optimum, may negatively affect larval survival. Therefore, the observed simultaneously high growth and mortality rates primarily resulted from a rapidly increasing and high water temperature that masked potential food-web effects. The investigation suggests that the projected climate warming may have significant effect on early life history stages of the dominating marine fish species inhabiting shallow estuaries. In the long-term perspective (since the 1950), hydroclimatic factors (significant were winter water temperature and annual sum of sun hors) appread to be superior to biotic variables in explaining the interannual variability of recruitment abundance.

D3.2 Manuscript on the impact of active migrations in the observed distributional changes of cod, herring and sprat (M40)

The Deliverable has been submitted and accepted by BONUS.

Polte P., Kotterba P., Moll D., von Nordheim L. (2017) Ontogenetic loops in habitat use highlight the importance of littoral habitats for early-life stages of oceanic fishes in temperate waters. Scientific Reports 7:42709, DOI: 10.1038/srep42709
Moll D., Kotterba P., Jochum, K.P., Pröfrock, D., von Nordheim L., Polte P. Using elemental fingerprinting in Western Baltic juvenile herring (*Clupea harengus*) otoliths to distinguish different nursery areas (manuscript)

D3.3 Manuscript on the role of small- and meso-scale drivers and stressors for overall Baltic herring recruitment (M40)

The Deliverable has been submitted and accepted by BONUS.

Arula, T., Laur, K., Simm, M., Ojaveer, H. 2015. Dual impact of temperature on growth and mortality of marine fish larvae in a shallow estuarine habitat. Estuarine, Coastal and Shelf Science, 167: 326-335.
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Ojaveer H., MacKenzie B. R., Raid T., Kornilovs G., Klais, R. Long-term transient recruitment dynamics of a herring population (manuscript).
Moll, D., Kotterba, P., von Nordheim, L. and Polte, P. 2017. Storm-induced Atlantic herring (*Clupea harengus*) egg mortality in Baltic Sea inshore spawning areas. Estuaries and Coasts, DOI 10.1007/s12237-017-0259-5.

WP4 on Stock assessments (Jan Horbowy, MIR-PIB)
The WP4 has two major objectives:
1. to include and quantify the effects of migrations and spatial and temporal changes in exploited fish distribution (cod, herring, and sprat) on stock assessment, and
2. to provide assessment of the status of flatfish in the Baltic, as a basis for quantitative management of these stocks.

D4.1. Report on assessments of herring, sprat and cod, including spatial effects (biomass distribution, natural populations) (M36)
Deliverable 4.1 indicated that sum of biomass obtained in assessments by former assessment units is very similar to biomass in present ICES assessment for both herring and sprat. Intensity of exploitation, however, largely differs depending on stock. In later analyses, MSY parameters were estimated by former assessment units and Fmsy were compared with stocks exploitations in recent years. In all cases, except for sprat in sub-division 26+28, fishing mortalities were lower than respective Fmsy. This result is different from present ICES evaluation of exploitation status for sprat.

The Deliverable has been submitted and accepted by BONUS.

D4.2. Database for flounder assessment or stock evaluation by stock (M38)

D4.2 comprises database which contains basic data necessary for assessment or evaluation of status of flounder stocks. Wherever available, age structured data were included. This data were derived using recommended by ICES age determination method. As such data are not available for all stocks, also data used for evaluation of data-limited stocks were compiled. It includes length distributions, growth data, fishing effort, results of national surveys.

The Deliverable has been submitted and accepted by BONUS.

D4.3. Report on model and methods of assessment and evaluation of flounder stocks status (M46).

The work is in progress. To facilitate this work and advance required analyses the Flounder Workshop was organized and held in Gdynia (12-14 June, 2017). Scientists from Estonia, Latvia, Sweden, and Poland were participated in the meeting. During the Workshop the WP coordinator and participants

a) Presented potential assessment methods, including age based and length based models, production models, survey based models, equilibrium analyses;
b) Presented two R based scripts developed within the project at NMFRI for
   a. optimisation of XSA assessments,
   b. simulation of discards, as reliable discard estimates cover only a few years;
c) Presented results of some preliminary assessments of flounder in sub-divisions 24-25; it were both age-structured and stock-production models assessments;
d) Presented available data and discussed possible assessment (evaluation) methods for flounder stocks (stocks in sub.24-25, in sub. 26+28, and in sub.27,29-32);
e) Presented and discussed results of stock identification for separation of demersal and pelagic components of flounder.

Taking into account available data and methods it was agreed which methods should be tested and applied for given flounder stocks. Below agreed approaches and advances of the work conducted so far are shortly presented.

1. Flounder in SD 24-25

Both age-based methods (XSA, SAM) and stock-production models (difference model (Horbowy, 1992)); stochastic surplus production model in continuous time (SPiCT, (Pedersen and Berg, 2017)) were applied. Reliable discard estimates refer to recent 3 years only, so different assumptions on possible levels of historical discards were considered and used in assessment models. In this way the sensitivity of assessment models to discard levels may be evaluated. In addition, equilibrium yield and biomass estimates following Horbowy and Luzeńczyk (2012) approach were used to derive reference points related to MSY. This method is being considered both on the basis of stock-recruitment (S-R) relationship from analytical models and from the survey. This will provide the test if the method of Horbowy and Luzeńczyk may be applied for data limited stocks.

2. **Flounder in SD 26+28**

It was indicated that estimation of reliable age structure may be difficult for that stocks as in some cases still old (not recommended) technique of age determination is used. Thus, the stock-production models were applied (SPiCT), and the analysis is in progress. In addition, analyses of spawning components indicated that the sub-division 26 is inhabited mainly by pelagic stock component while in sub-division 28 mainly demersal component is present. So, assessment of stock status will be conducted separately for both sub-divisions.

3. **Flounder in SD 27, 29-32**
BITS covers only partly the stocks, but national survey exists (gillnets from Estonia & Sweden) and may be tested in assessment or stock evaluation. These data were used in stock-production models (both SPiCT and difference model (Horbowy, 1992)). Equilibrium yield & biomass using survey-based S-R relationship were used to derive MSY reference points. Length based spawning potential ratio (Hordyk et al. 2015), was used as the estimate of the MSY proxy parameters.

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Pedersen, M.W & Casper W Berg. 2017. A stochastic surplus production model in continuous time. Fish and Fisheries. 18, 226–243.

WP5 on Ecosystem-based management (Jari Raitaniemi, LUKE)
WP5 critically revises the existing management for Baltic cod, herring and sprat, taking into account possible modifications and extensions when spatial heterogeneity is accounted for. The implementation of the Marine Strategy Framework Directive will be supported by linking MSFD indicators in a spatially explicit context.

D5.1 Report on the early warning indicators of cod stock development (M40)
Indicator based approaches are important for fish populations such as the Eastern Baltic cod (*Gadus morhua callarias*) that are strongly affected by climate induced environmental changes. During the INSPIRE integrating workshop #4 (BONUS INSPIRE D7.7), the content of D5.1 was discussed and agreed, with outlining the list of early warning indicators of the eastern Baltic cod stock (Table 5.1).

Table 1. Early warning indicators of the Baltic eastern cod stock development, as agreed during INSPIRE integrating workshop #4.

Indicator	Notes / ref levels	People	
Recruitment environment	Thresholds for envir. variables	Möllmann	Analysis done
Condition (1976-2014)	< 0.8 is critical, what proportion of the stock to choose?	Casini/Neuenfeldt	Early warning analysis
Stock Abundance (1966-2012)	Last accepted assessment	Horbowy	Early warning analysis
Consumption/feeding level (1965-2014)	<0.4 is critical, what prop?	Neuenfeldt	Early warning analysis
Recruitment (1966-2012)	Last accepted assessment time series	Neuenfeldt	Early warning analysis
Size distribution (1991-2015)	Reference level?	Luzenczyk	Early warning analysis
L_{max} (1978-2014)	Reference level?	Orio	Early warning analysis
.95 length percentile (1991-2015)	Reference level?	Luzenczyk	
90% of the stock total area occupied (1982-2011)	Reference level – proportion of the max	ICES WKSPATIAL Casini/Neuenfeldt	Early warning analysis
Hypoxic benthic areas – trend (1965-2015)		ICES WKSPATIAL Neuenfeldt/Casini	Early warning analysis

Core Activity 1: Recruitment environment

Especially indicators for potential recruitment success and thresholds discriminating between good and bad environmental conditions may be useful early warning indicators to be used in ecosystem-based management. The study shows the importance of physical oceanographic variables for evaluating the quality of the recruitment environment of this important fish population.

Furthermore, a routine for selecting indicators of recruitment environment is presented using modern regression techniques, an approach that can be easily transferred to other fish species and areas as a prompt assessment for recruitment success to help overcome uncertainties associated with recruitment predictions.

The results of our indicator selection routine show that only abiotic variables showed significant relationships with the recruitment residuals (RecRes). None of the indicators turned out to be suitable when only considering the R_2 (1987-2003) time period. Depth of the 11 psu isohaline in the Gotland Basin was the most obvious indicator to have a significant relationship with the RecRes of all tested periods as it explained 48–66 % of the variance in EB cod recruitment success. The reproductive volume of the combined central Baltic showed also coherence results in all tested periods, explaining 32–51 % of variance. Reproductive volume of the Gotland Basin showed significant results in the long and standard time period (explained variance 68 and 44 % respectively), revealing a spatially important area for EB cod recruitment success.

Based on the selected indicators and their respective thresholds we were able to describe changes in the EB cod recruitment environment. All RV indicators showed that the physical oceanographic conditions of the cod recruitment environment started to get detrimental ("bad conditions") at the beginning of the 1980s, irrespective of the length of the period used. Only single years revealed positive deviations ("good conditions") from the threshold, i.e. in the Gotland Basin. Conducting the analysis for the depth of the 11 psu isohaline, a similar pattern became evident: a 20 year detrimental phase (~ 1982 - ~ 2002) for all time periods tested.

The approach can be used as an "early warning" of potentially good or bad recruitment strength before survey and stock assessment data are available.

Core Activity 2: Body condition (1976-2014)

Cod body condition has decreased from the mid-1990s and has been very low since the mid-2000s. Currently, a large proportion of cod have a condition that is close to the lethal level, suggesting that the population suffers from high natural mortality, likely due to starvation. Time-series of cod body condition, and of the proportion of cod with very low condition, can be used as indicators of feeding opportunities and natural mortality, respectively.

Data from the Baltic International Trawl survey were used to follow the development of cod body condition (Fulton $K = W/L^3$) over time. The results showed that cod condition increased between the mid-1970s to the early 1990s, followed by a drop until the late 2000s. After that the condition stabilized at low levels. The same pattern was observed for all the ICES Subdivisions (SDs 25-28) and all the length classes (Casini et al. 2016a). The proportion of cod with very low condition (<0.8) increased sharply from the mid-2000s, reaching values around 20% after 2010 (Eero et al. 2015).

It is important to continue following the temporal changes in cod body condition and since it mirrors changes in prey availability and hydro-climate changes such as hypoxic areas. It is also important to follow the proportion of cod with very low condition in the population, which could be used as proxy for variations in natural mortality (Casini et al. 2016b).

Core Activity 3: Stock Abundance (1966-2017)

In the absence of analytical stock assessment, the Baltic International Trawl Survey (BITS) indices of stock size have been rescaled to correspond with stock size estimates from the last accepted analytical assessment (State based Assessment Model (SAM) that covers the period 1966–2011). Rescaled indices for recent years (2012–2017) may be used as indicators of stock size in the perspective of its historical dynamics observed since 1966.

Usually, stock size estimates are available from standard ICES assessment with analytical models, however, in the case of the eastern Baltic cod, they have been lacking for a few years. Thus, the proposed way of estimating present stock size may be considered as an early warning indicator, as in the absence of analytical stock assessment, it shows the recent biomass estimate in much broader perspective (more years included) than BITS index itself.

Core Activity 4: Consumption/feeding level (1965-2014)

Massive environmental changes, including water stagnation with consequent reduction of oxygen content in the bottom water, decreased benthic productivity, and strongly varying population abundances of cod and sprat that is the main fish prey for cod and also an exploited fish population, have occurred in the Baltic Sea during the past 40 years. In this study, five decades of stomach content data allowed detailed insight into long-term changes in diet composition, energy uptake and the resulting changes in growth potential of Baltic cod.

Massive environmental changes have caused changes in cod diet composition, energy uptake and hence, reduced growth rate. The observed decrease of benthos in the cod diet is most probably a consequence of increased hypoxic bottom areas and hence subjected to environmental variability and eutrophication. While large cod can compensate for the lack of benthic food in their diet by increasing predation on larger forage fish and cannibalism, small cod have stronger limits on this compensatory behavior. In consequence, many small pre-spawning cod have presently feeding levels that imply severe growth limitation and increased mortality. The low growth rate of the small cod is carried through life and manifested as lower size at age for larger individuals.

We recommend that cod stomach content data together with hydrographic data are sampled on a regular basis. The material will allow to constantly monitor the average energy that is available to cod for growing and maturation, and will be an important corner stone in constantly assessing cod growth. This might well be a crucial element in any length-based assessment and management model, since age determination for cod remains problematic.

Core Activity 5: Size distribution (1991-2015)

The length, at which 50% of the individuals have reached maturity (L_{50}) of sexes, has decreased from 33-42 cm to 20-27 cm over the last 20 years in the Eastern Baltic cod. Identification of fish as reproductive or non-reproductive is very useful for fish stock management, as it gives the answer for the question whether enough individuals reach maturity before becoming vulnerable to fishing mortality.

Among the methods using size distribution and maturity data, L_{50} can be further tested as a warning indicator. However, the combined consequences of declining growth, reduced condition, and spawning at smaller sizes on individual egg production and viability of offspring in Eastern Baltic cod are to date not clear (Köster et al. 2017).

Core Activity 6: L_{max} (1978-2014)

The maximum length of cod in the years 1978-2014 shows a steep decreasing trend from the mid-1980s until most years. The time series shows the highest L_{max} of approximately 77 cm in the period 1983-1985, then the L_{max} decreased steadily down to around 40 cm in 2014. Thus, the average maximum length of the Eastern Baltic cod has become almost half of the time-series maximum.

It is recommended to follow the development of the changes in maximum length of the cod stock since they are indicators of stock status. The quality of the analysis could be improved by including historical trawl survey data from a larger number of Baltic countries than so far, and by including data from coastal areas not covered by the trawl surveys used in this study.

Core Activity 7: 95% -percentile of the fish length–frequency distribution in research vessel surveys (L_{95}) (1991-2015)

L_{95} is a stock size structure indicator, which captures the upper part of the length–frequency distribution. It is sensitive to fishing and increased abundance of small individuals. L_{95} for cod in ICES Subdivisions 25-32 has decreased from above 60 cm to around 40 cm since 1991, but the status of the stock cannot be estimated as the value of L_{inf} has also changed in the last decades.

For L_{95}, the conservation-threshold $>L_{inf}*0.8$ was suggested by ICES (2015) as one of the length-based indicators describing length frequencies of landings.

Core Activity 8: 90% of the stock total area occupied (1982-2011)

The area occupied by cod was above 70% in the early 1980s when the cod population size was high, while it reduced along the decrease of the population size down to 57%. After the year 2005, a slight increase in the area occupied has occurred, which could be interpreted as a partial re-expansion of the spatial distribution of the population, as also evidenced by the commercial catches (Bartolino et al 2017).

It is important to follow the development of the area occupied by cod. Spatial distribution and area occupied, especially in marginal habitats, have been proved to be a good early warning indicator for fish stock developments, including stock collapses.

Core Activity 9: Hypoxic benthic areas – trend (1965-2015)

The extent of hypoxic areas has increased fivefold since the early 1990s. This has caused a compression of the demersal habitat suitable for cod, likely triggering crowding and density-dependent processes on cod growth and condition.

Suitable areas for cod (areas with oxygen concentration>1ml l^{-1} excluding depths shallower than 20m and deeper than 100 m (Schaber et al. 2012)) increased from the late 1970s to the mid-1990s (approx. 140×10^3 km^2, corresponding to 90% of the total area), decreased until the late 2000s and remained thereafter stable at around 90×10^3 km^2 (corresponding to 65% of the total area). In percentage, the decrease in suitable areas between the early 1990s and the late 2000s has been approximately 30%.

It is important to follow the development of hypoxic areas (where cod cannot occur) to follow the changes in cod suitable areas. Increased hypoxia forces cod to either move its distribution in shallower areas or dwell more in the pelagic zone. Moreover, hypoxic areas influence benthic productivity, therefore affecting negatively one of the main prey types for cod, the benthos (e.g. *Saduria entomon*).

The Deliverable has been submitted and accepted by BONUS.

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WP6 on Dissemination (Stefan Neuenfeldt, DTU-Aqua)

Dissemination has continued to facilitate, by the close contact to various ICES expert groups and Baltic Sea Advisory Council, that project results have been made available to stakeholders and interested public almost in a real time.

Deliverable 6.1 (Website, M3)

The project web-site has been constantly updated by adding information on new publications, metadatabases and affiliated projects.

Deliverable 6.3 (Symposium M45)

The symposium will be held at Tallinn University Conference Center, 17.-19. October 2017. It will summarise and synthesise the recent scientific findings by providing: i) new evidences on the spatiotemporal dynamics of Baltic Sea biodiversity at various levels of organisation, and its relationship with changing environmental conditions, ii) new basic knowledge on the ecology of the main commercial species – cod, herring, sprat and flounder, incl. habitat requirements, connectivity, migrations, species interactions and impact of external drivers, and iii) improved assessment methods and tools for the management of marine living resources, thereby assisting to address several regional (HELCOM) and EU legislative frameworks.

Deliverable 6.4 (Popular science book M48)
The activity is advancing well. The advanced draft is ready and is currently being finalized, based on the feedback received. It was previously decided to focus the book on children, that can easily be translated into all languages represented in INSPIRE.

Agenda item #4 Planning of the remaining deliverables

The following deliverables were discussed:

D4.3 Manuscript on model and methods of assessment or evaluation of flounder stocks status (lead Jan Horbowy, MIR-PIB);
D5.3 Manuscript on the role of spatial heterogeneity in Baltic ecosystem-based management (lead Henn Ojaveer, UT-EMI);
D5.4 Manuscript on regionalization of Baltic Sea ecosystem-based management (lead Stefan Neuenfeldt, DTU-QUA).

The discussions were continued during the BONUS conference as well as during the dedicated meeting held on 20. October, the day immediately following the BONUS conference. The key idea behind the dedicated small group meeting (attended by Michele Casini, Stefan Neuenfeldt, Jan Horbowy, Thorsten Blenckner, Patrick Polte, Henn Ojaveer and Jan Dierking from BONUS BIO-C3) was to incorporate relevant key messages and emerged ideas from the BONUS conference.

Annex 1. Meeting agenda

Agenda

INSPIRE 2017 Annual Meeting

Tallinn, Estonia (Ministry of Environment, Narva Rd. 7a)

16. October 2017

9:00-9:30	**Agenda item #1**: Arrival and registration /with coffee and tea/
9:30-10:00	**Agenda item #2:** Project coordination and reporting update (incl. databases, publications, etc.)
10:00-11:00	**Ageda item #3** Review of the progress by all WP's (short discussion-type reporting á 15 minutes by WP leads on the progress/achievements and compare with DoW)
11:00-11:15	Coffee/Tea
11:15-12:00	**Agenda item #3** continues
12:00-13:00	Lunch
13:00-15:00	**Agenda item #4** Planning of the remaining deliverables
15:00-15:15	Coffee/Tea
15:15-16.30	**Agenda item #4** continues
17:00-18:00	Steering Committee meeting

Annex 2. List of participants

	Name	Partner
1	Henn Ojaveer	UT-EMI
2	Tiit Raid	UT-EMI
3	Kristiina Hommik	UT-EMI
4	Marge Simo	UT-EMI
5	Georgs Kornilovs	BIOR
6	Michele Casini	SLU
7	Jukka Pönni	LUKE
8	Alessandro Orio	SLU
9	Stefan Neuenfeldt	DTU-AQUA
10	Karin Hüssy	DTU-AQUA
11	Andreas Lehmann	GEOMAR
12	Jari Raitaniemi	LUKE
13	Jan Horbowy	MIR-PIB
14	Anna Luzenczyk	MIR-PIB
15	Patrick Polte	TI-OF
16	Pehr Eriksson	BSAC
17	Elo Rasmann	Ministry of Environment