



BONUS INSPIRE publishable summary, third project period

Brief description of the project

Process-based understanding of changes in spatial distributions of cod, herring, sprat and flounder, and disentangling the role of natural drivers and various human induced impacts constitute the challenging topic for the research in BONUS INSPIRE. The project sets out to 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. BONUS INSPIRE is designed to substantially advance our knowledge on the four major commercial fish species in the Baltic Sea. These fish form more than 95% of the commercial catches, and represent key elements of the Baltic Sea ecosystems.

Work performed

- ✓ Data collections:
 - a. Finalization of data for creation of distribution maps for eggs, larvae, juveniles and adults of cod, flounder, sprat and herring, based on INSPIRE and other sources;
 - b. Standardization of the trawl catches from the DATRAS database and previously conducted surveys;
 - c. Start compilation of data and preparation of data base for evaluation or assessment of flounder stocks;
 - d. Continuing assembling historical data (e.g., zooplankton, tagging information, electronic data storage tags, larval herring and cod, fish stomach content data, acoustic survey data and international trawl survey data) into a common database.
- ✓ Modeling applications:
 - a. Simulation the fine-scale spatial distribution of cod in the central Baltic Sea by Generalized Additive Models;
 - b. Application of the Baltic Sea ice-ocean model (BSIOM) and Lagrangian particle-tracking technique to evaluate drift patterns of cod and flounder eggs and larvae;
 - c. Application of a Lorenz curve, originally used in socio-economics to describe demographic income distribution, to 20-year time-series of weekly larval herring distribution to reveal size-dependent spatial homogeneity;
 - d. Use of the Elemental Fingerprinting Index to measure of similarity of elemental composition in herring otoliths between spawning areas;
 - e. Sliding window approach to investigate the individual and combined effects of several abiotic and biotic variables on the inter-annual variability of the Gulf of Riga spring herring recruitment;
 - f. Analytical assessment of cod, sprat and herring stocks by several relevant assessment units, based on different combinations of ICES sub-divisions and incorporation biological/ecological knowledge of the assessed species;
 - g. Development of two specific stock-production models for flounder assessments.
- ✓ Collaborations and impact:
 - a. Close collaboration with ICES and the Baltic Sea Advisory Commission;
 - b. Continuation of national advisory role on fisheries and marine ecosystem management;
 - c. Establishing two new international collaborations;
 - d. Organising BONUS 2016 summer school (with BONUS BIO-C3, COCOA and BAMBI);
 - e. Continuous delivery of project news to BONUS projects website and real-time display of information (publications, meta-databases, affiliated projects) on INSPIRE website.

Main results

Spatial distributions

- ✓ At high stock size, adult cod is distributed over large area, whereas at low stock sizes the population contracts into the most favorable areas in terms of abiotic conditions, supporting thereby the existence of density-dependent habitat selection. Analyses of vertical distribution revealed a clear day/night pattern, confirming the overall migration of adult cod to the pelagic habitat during night.
- ✓ Temporal drop in the occurrence of cod in the distribution area of sprat and herring, and in the occurrence of large cod in the distribution area of small cod was observed. Prey occurrence in the areas occupied by cod was also observed, evidencing that lower feeding opportunities of cod on fish prey occurred during the past 20 years.
- ✓ The spatial dynamics in the taxonomic composition of herring and sprat stomachs broadly resembled that of the availability of prey with the intraspecific diet overlap being higher in the eastern Gulf of Finland than in the Baltic Proper.

Passive movements, active migrations and habitat connectivity

- ✓ Cod predation on sprat took place primarily at dusk and dawn associated with school dissolution and formation. The observed vertical dynamics of cod and sprat could be explained by fitness optimization using bioenergetics and trade-offs between temperature, oxygen saturation of the water, and predation risk. The study forms the first step to providing a mechanistic background for the aggregate functional response of cod at basin scale and beyond.

Scaling from individuals to populations

- ✓ A limited proportion of cod juveniles, hatched in the Arkona Basin and in the Gotland Basin successfully settled in suitable areas confirming thereby the importance of habitat availability and its effect on density dependence as a process relevant for recruitment success.
- ✓ Larval stage-specific active habitat selection takes place in the western Baltic spring herring population with elemental fingerprinting revealing specific signatures of the particular nursery areas. Local stressors, such as egg mortality caused by storm induced wave action might be important drivers for the year class variability.
- ✓ Linearly combined effects of annual sum of annual sunshine hours and winter water temperatures were the best predictors of the Gulf of Riga spring herring recruitment during 1957-2012.

Stock assessments

- ✓ Cod assessment models using natural mortality (M) related to growth performed much better than the standard assessment models in which M is assumed constant. The effects of parasitic infection of cod on its condition and possibly M mortality suggest that natural mortality of heavily infected cod increased. This is consistent with behaviour of assessment models with increasing M, and coupled together indicate that natural mortality of cod has probably increased markedly recently.
- ✓ Merging of two assessment units (SDs 25-27 and 28-29+32) into one Central Baltic herring assessment unit, and three (SDs 22-25, 26+28 and 27,29-32) into one sprat assessment unit is justified from the assessment point of view. However, spatial management of the stocks could be recommended, then assessment and data by multiple assessment units is needed.

Ecosystem based assessment and project impact

- ✓ Continuation of the revision of the existing management for cod, herring and sprat, based on new estimates on the spawner biomass and mortality by various combinations of ICES subdivisions;
- ✓ Refining the focus and strategy of the high-profile paper as the key-result of the project;
- ✓ Project members participations in 100 stakeholder committees during the third project year;

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