Changes in reproductive life history and resource allocation impacting population dynamics of Baltic cod

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Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources, Section for Monitoring and Data, Section for Ecosystem based Marine Management, Institute Management
Authors: Tomkiewicz, J. (Intern), Huwer, B. (Intern), Cordón, C. T. F. (Intern), Storr-Paulsen, M. (Intern), Eero, M. (Intern), Köster, F. (Intern)
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Do spatio-temporal spawning closures promote the recovery of cod in the Baltic Sea?

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Authors: Eero, M. (Intern), Hinrichsen, H. H. (Ekstern), Huwer, B. (Intern), Köster, F. (Intern), Mosegaard, H. (Intern), Storr-Paulsen, M. (Intern)
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Eastern Baltic cod recruitment revisited—dynamics and impacting factors
The Eastern Baltic cod abundance started rapidly to increase in the mid-2000s as evidenced by analytical stock assessments, due to increased recruitment and declining fishing mortality. Since 2014, the analytical stock assessment is not available, leaving the present stock status unclear and casting doubts about the magnitude of the recent increase in recruitment. Earlier studies identified main factors impacting on cod reproductive success to be related to the loss of two out of three spawning areas in the 1980s caused by lack of major Baltic inflows with a concurrent reduction in salinity and oxygen. Other important factors include prey availability for first-feeding larvae, egg predation by sprat and herring and cannibalism on juveniles, all in one way or the other related to the prevailing hydrographic conditions. These factors cannot explain increased reproductive success in the last decade, as the period was characterized by an absence of large-scale Baltic inflows since 2003 and persistent anoxic conditions in the bottom water of the deep Baltic basins. This questions the perception of the increased recruitment in later years and challenges our present understanding of cod recruitment dynamics in the Baltic Sea. In this contribution, we review evidence from the recent literature supplemented by information from latest research cruises to elucidate whether cod reproductive success indeed has increased during the last decade, and we suggest the key processes responsible for the recent dynamics in cod recruitment and outline directions for future research.
Effects of changes in stock productivity and mixing on sustainable fishing and economic viability

Within the new FMSY European paradigm, this paper shows how a combination of changes in fish stock mixing, non-stationarity in productivity, and constraints on unit stock concepts undermine the effective management of fisheries, especially when management reference points are not adjusted accordingly. Recent changes in stock structures, conditions and stock mixing between eastern and western Baltic cod can jeopardize the reliability of stock assessments and of the fishery economy. We modelled how different management, individual vessel decision-making, and stock growth and mixing scenarios have induced alternative individual vessel spatial effort allocation and economic performance by affecting fishing costs and by changing the relative stock abundance and size distribution. Stock mixing heavily influences profit and stock abundance for stocks that have experienced increased fishing mortality (F) levels. Western cod F has increased from a higher total allowed catches (TAC) advised in the medium-term due to the westward migration of eastern cod while eastern cod F has increased from reduced growth in the east. Greater pressures on western cod and decreased eastern cod growth and conditions greatly reduce the overall cod spawning stock biomass, thus changing the landing size composition and associated fishery profits. As a cumulative effect, fishing efforts are redirected towards western areas depending on management (quotas). However, total profits are less affected when traditional fishing opportunities and switching possibilities for other species and areas are maintained. Our evaluation indicates that current management mechanisms cannot correct for potential detrimental effects on cod fisheries when effort re-allocation changes landing origins. By investigating different economic starting conditions we further show that Baltic cod mis-management could have resulted in unintended unequal (skewed) impacts and serious consequences for certain fleets and fishing communities compared with others. Our management strategy evaluation is instrumental in capturing non-linear effects of different recommendations on sustainability and economic viability, and we show that fixed F-values management is likely not an attainable or sufficient goal in ensuring the sustainability and viability of fisheries and stocks given changing biological conditions.
### Bibliographical note


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**Faster or slower: Has growth of juvenile eastern Baltic cod changed?**

**General information**

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Organisations: National Institute of Aquatic Resources, Section for Oceans and Arctic, Section for Ecosystem based Marine Management
Authors: Hüssy, K. (Intern), Radtke, K. (Ekstern), Eero, M. (Intern)
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**Fish egg predation by Baltic sprat and herring: do species characteristics and development stage matter?**

Predation of eggs by clupeids has been identified as a major factor contributing to early life stage mortality of Baltic cod. We used data from ichthyoplankton sampling and clupeid stomach analyses to investigate whether eggs of other fish species are to a similar extent subject to predation, and how predation pressure differs between egg development stages. Cod, sprat and rockling eggs dominated in the ichthyoplankton fraction in herring and sprat diet, whereas flounder and dab eggs occurred only occasionally. In spring, cod eggs at advanced development stages were positively and sprat eggs generally negatively selected by both predators, while fish eggs were non-selectively consumed in summer. Predation is suggested to account for a large fraction of mortality of cod eggs at older stages, i.e. those eggs, which have survived the often detrimentally low oxygen concentration in and below the permanent halocline. The consumption rates of sprat eggs at all development stages relative to production rates were considerably lower compared to cod, suggesting that egg
predation is of lesser importance for sprat recruitment.

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Authors: Neumann, V. (Intern), Köster, F. (Intern), Eero, M. (Intern)
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- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 1.354 SNIP 1.267
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 1.558 SNIP 1.553
- Web of Science (2005): Indexed yes
- Scopus rating (2004): SJR 1.744 SNIP 1.542
- Web of Science (2004): Indexed yes
Integration of fisheries into marine spatial planning: Quo vadis?
The relationship between fisheries and marine spatial planning (MSP) is still widely unsettled. While several scientific studies highlight the strong relation between fisheries and MSP, as well as ways in which fisheries could be included in MSP, the actual integration of fisheries into MSP often fails. In this article, we review the state of the art and latest progress in research on various challenges in the integration of fisheries into MSP. The reviewed studies address a wide range of integration challenges, starting with techniques to analyse where fishermen actually fish, assessing the drivers for fishermen's behaviour, seasonal dynamics and long-term spatial changes of commercial fish species under various anthropogenic pressures along their successive life stages, the effects of spatial competition on fisheries and projections on those spaces that might become important fishing areas in the future, and finally, examining how fisheries could benefit from MSP. This paper gives an overview of the latest developments on concepts, tools, and methods. It becomes apparent that the spatial and temporal dynamics of fish and fisheries, as well as the definition of spatial preferences, remain major challenges, but that an integration of fisheries is already possible today.
Quantifying predation on Baltic cod early life stages
Predation on cod (Gadus morhua) eggs by sprat (Sprattus sprattus) and herring (Clupea harengus) is known to be one of the processes influencing reproductive success of the eastern Baltic cod and has been reported to have contributed to lack of recovery of the stock in the 1990s. This study quantifies the predation on cod eggs in the Bornholm Basin, the major spawning area of cod in the central Baltic Sea, in the 1990s in comparison with the second half of the 2000s. The analyses involve estimating daily consumption rates of predator populations, which are then compared with corresponding daily egg production rates. As a methodological advancement compared with earlier studies, spatially resolved information on predator distribution and abundance is utilized in quantifying predator stock size. This resulted in more realistic consumption estimates in relation to overall egg production compared with earlier studies that consistently overestimated predation pressure by clupeids. Our results suggest a generally lower predation pressure on cod eggs in the mid- to late 2000s, due to a combination of reduced predator abundance and lower daily rations by individual predators.

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Trophic Interactions in the Baltic Sea: Clupeid predation on cod early life stages

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Authors: Neumann, V. (Intern), Köster, F. (Intern), Eero, M. (Intern), Schaber, M. (Ekstern)
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**Trophic Interactions in the Baltic Sea: Predation on cod eggs by clupeids**

Cod (Gadus morhua), sprat (Sprattus sprattus) and herring (Clupea harengus) are key species of the upper trophic levels in the Baltic Sea ecosystem and are strongly interlinked: The piscivore cod is the main predator on the planktivores sprat and herring, which feed, amongst others, on cod eggs. Egg predation by sprat and herring has earlier been suggested as one of the factors limiting cod recruitment success in the Baltic Sea in the 1990s. Since then, changes have taken place in cod recruitment as well as in the ecological factors potentially influencing egg predation. The overall aim of this thesis is to elucidate possible changes in predation pressure on cod early life stages in the 2000s compared to the 1990s, as well as to enhance our understanding of the processes impacting on egg predation and its implications for cod recruitment. The investigations of this thesis are based on extensive datasets on stomach contents of sprat and herring, ambient hydrographic conditions, ichthyoplankton distribution and abundance as well as predator distribution and abundance from hydroacoustic data for the 1990s and 2004-2008. Changes in diet composition of sprat and herring were investigated, including temporal and spatial variability in egg predation. The changes were driven by ambient hydrographic conditions, cod egg abundance, predator-prey overlap as well as abundance of alternative prey (Paper I). Next, cod egg consumption by herring and sprat was quantified and compared with revised estimates from the 1990s to elucidate potential changes in predation mortality of cod eggs (Paper II). A major methodological focus in this investigation was related to resolving the spatial distribution of sprat and herring to obtain realistic estimates of predator abundances in the area overlapping with cod eggs. As a next step, predation pressure was quantified separately for egg development stages, both for cod and sprat (Paper III). Furthermore, ichthyoplankton prey selection by clupeids was investigated, with specific focus of predation on different fish egg species.
and development stages, to improve our understanding of the mechanisms underlying egg predation. Finally, the results on predation pressure on cod eggs were reviewed in the context of other processes acting on early life stage survival and influencing cod recruitment in the Baltic Sea (Paper IV). The results showed that diet composition of both sprat and herring in terms of major taxonomic groups was generally similar in the 1990s and 2000s. Although higher proportions of cod eggs occurred in the diet in the 2000s, the overall quantities of cod eggs in the diet were generally lower in the 2000s compared to the 1990s (Paper I). This suggests reduced predation on cod eggs in latter period, which was further confirmed in quantitative analyses of predation mortality on cod eggs (Paper II). The lower predation pressure on cod eggs in the 2000s compared to the 1990s was related to a combination of reduced predator abundance and lower daily rations by individual predators. Reduced predation pressure was identified as one of the factors contributing to relatively higher year-classes of cod recruitment in the 2000s (Paper IV). Predation was found to affect mainly eggs at older development stages (mainly stage III), i.e. those eggs which have survived two out of three critical development phases in the often detrimental hydrographic conditions in and below the permanent halocline (Paper III). This suggests a higher impact of predation on cod recruitment than formerly thought. In contrast, investigations on sprat egg mortality (Paper III) found that consumption rates of sprat eggs at all development stages relative to production rates were considerably lower compared to cod, suggesting egg predation to be of a lesser importance for sprat recruitment. The results of this thesis provide new knowledge on clupeid foraging, including identifying processes and mechanisms behind fish egg consumption in the central Baltic. Further, the thesis contributes improved methodology for quantifying cod and sprat egg predation by egg development stages. Both in combination can be considered as a major advancement in this field of research, as predation pressure on early life stages is generally extremely difficult to quantify and comparable studies are scarce. Hence, the thesis provides useful ecological and methodological input to other ecosystems and investigations, where predation on early life stages is an important factor in influencing fish recruitment.
Connectivity of larval cod in the transition area between North Sea and Baltic Sea and potential implications for fisheries management

Connectivity of pelagic, early life stages via transport by ocean currents may affect survival chances of offspring, recruitment success, and mixing of stocks across management units. Based on drift model studies, transport patterns of particles representing exogenously feeding cod larvae in the transition area between North Sea and Baltic were investigated 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 particles showed considerable intra- and interannual variability, but also some general patterns of retention within and dispersion to different management areas. Good spatial overlap of particle end positions, representing potential juvenile settlement areas, with observed distributions of juveniles in 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 particles 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 structure, fish stock assessment, and management.

General information
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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Section for Ecosystem based Marine Management, GEOMAR - Helmholtz Centre for Ocean Research Kiel
Authors: Huwer, B. (Intern), Hinrichsen, H. (Ekstern), Hüsey, K. (Intern), Eero, M. (Intern)
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Ecosystem indicators in the context of fisheries management: example of cod in the Baltic Sea

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Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Ecology and Oceanography, Institute Management
Authors: Eero, M. (Intern), Casini, M. (Ekstern), Hüsey, K. (Intern), Köster, F. (Intern), MacKenzie, B. (Intern), Neuenfeldt, S. (Intern), Tomkiewicz, J. (Intern)
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Evaluation of otolith shape as a tool for stock discrimination in marine fishes using Baltic Sea cod as a case study

In the Western Baltic Sea two genetically distinct cod stocks "Eastern Baltic cod" and "Western Baltic cod" occur with considerable mixing of stocks. In this study we evaluated the applicability of otolith shape for classification of individuals caught in the mixed stock cod fishery, using SNP (single nucleotide polymorphism) based genetic assignment of otolith shape baselines. We further developed a management aimed approach for mixed stock assignment by robust stochastic baseline selection and posterior bias correction by individual reassignment of the least likely classifications into the alternate stock. Classification criteria selected by Monte Carlo runs of Linear Discriminant Analysis were captured by otolith area and 20 Elliptic Fourier Descriptors of primarily low frequency harmonics. Classification success was considerably lower when using a baseline of spawning individuals only, compared to the better spatial coverage of a combined baseline also including genotyped individuals from the mixed stock area. Furthermore, the inclusion of genotyped individuals balanced the baseline size composition and to a large extent removed a strong size related bias in classification success. These results demonstrate the interplay of environmental, ontogenetic and genetic influences on otolith shape, which complicates the application of otolith shape for stock discrimination in mixed-stock scenarios. Rigorous genetic validation and further studies on the temporal dynamics of shape formation are necessary.

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Scopus rating (2011): SJR 1.154 SNIP 1.135 CiteScore 1.7
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.041 SNIP 1.1
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.022 SNIP 1.075
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.025 SNIP 1.274
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Scopus rating (2005): SJR 0.906 SNIP 1.134
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.944 SNIP 1.023
Web of Science (2004): Indexed yes
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Has eutrophication promoted forage fish production in the Baltic Sea?

Reducing anthropogenic nutrient inputs is a major policy goal for restoring good environmental status of coastal marine ecosystems. However, it is unclear to what extent reducing nutrients would also lower fish production and fisheries yields. Empirical examples of changes in nutrient loads and concurrent fish production can provide useful insights to this question. In this paper, we investigate to what extent a multi-fold increase in nutrient loads from the 1950s to 1980s enhanced forage fish production in the Baltic Sea. We use monitoring data on fish stock dynamics covering the period of the nutrient increase, combined with nutrient concentrations from a 3-dimensional coupled physical-biogeochemical ocean model. The results suggest that nutrient enrichment enhanced the biomass level of forage fish by up to 50 % in some years and areas due to increased body weight of fish. However, the trends in fish biomasses were generally decoupled from changes in nutrient concentrations.
Spatio-temporal trends in stock mixing of eastern and western Baltic cod in the Arkona Basin and the implications for recruitment

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Understanding the processes behind fish stock dynamics: Where are we?

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Authors: Köster, F. (Intern), Eero, M. (Intern), Sørensen, H. (Intern), Huwer, B. (Intern), Sørensen, S. R. (Intern)
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Using alternative biological information in stock assessment: condition-corrected natural mortality of Eastern Baltic cod
The inclusion of biological and ecological aspects in the assessment of fish population status is one of the bases for an ecosystem-based fisheries management. During the past two decades the Eastern Baltic cod has experienced a drastic reduction in growth and body condition that may have affected its survival. We used results from published experimental literature linking cod condition to starvation and mortality, to estimate the annual proportion of cod close to the lethal condition level in the Eastern Baltic cod stock. Thereafter we applied these results to adjust the natural mortality (M) assumed in the analytical stock assessment model. The results in terms of Spawning Stock Biomass (SSB), Fishing mortality (F) and Recruitment (R) in the final year from the stock assessment using M values adjusted for low condition were up to 40% different compared with the assessment assuming a constant M = 0.2. This method could be used for adjusting natural mortalities for other cod stocks where changes in condition are observed.
Does recreational catch impact the TAC for commercial fisheries?

The western Baltic cod is one of the first fish stocks in Europe that, since 2013, includes recreational catches in stock assessment and fisheries management advice. In this paper, we investigate the sensitivity of the calculated commercial total allowable catch (TAC) to including recreational catches in stock assessment. Our results show that the most crucial aspect in terms of the impact on commercial TAC is the assumption on recreational catch dynamics relative to that of commercial fisheries used in forecast. The results were less sensitive to the information on the historical amount and age structure of recreational catch. Our study is intended to inform potential debates related to resource allocation between the commercial and recreational sectors and contribute to developing a general framework for incorporating recreational catches in fisheries management advice in ICES.
Eastern Baltic cod in distress: biological changes and challenges for stock assessment

The eastern Baltic (EB) cod (Gadus morhua) stock was depleted and overexploited for decades until the mid-2000s, when fishing mortality rapidly declined and biomass started to increase, as shown by stock assessments. These positive developments were partly assigned to effective management measures, and the EB cod was considered one of the most successful stock recoveries in recent times. In contrast to this optimistic view, the analytical stock assessment failed in 2014, leaving the present stock status unclear. Deteriorated quality of some basic input data for stock assessment in combination with changes in environmental and ecological conditions has led to an unusual situation for cod in the Baltic Sea, which poses new challenges for stock assessment and management advice. A number of adverse developments such as low nutritional condition and disappearance of larger individuals indicate that the stock is in distress. In this study, we (i) summarize the knowledge of recent changes in cod biology and ecosystem conditions, (ii) describe the subsequent challenges for stock assessment, and (iii) highlight the key questions where answers are urgently needed to understand the present stock status and provide scientifically solid support for cod management in the Baltic Sea.

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Effects of recent changes in stock conditions and mixing on sustainability and economic viability of the fishery – The Danish fisheries for Baltic cod

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Has human-induced eutrophication promoted fish production in the Baltic Sea?

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Integration of fisheries in marine spatial planning: Quo vadis?

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Authors: Janssen, H. (Ekstern), Bartelings, H. (Ekstern), Bastardie, F. (Intern), Eero, M. (Intern), Girardin, R. (Ekstern), Hamon, K. (Intern), Hinrichsen, H. (Ekstern), Marchal, P. (Ekstern), Nielsen, J. R. (Intern), Le Pape, O. (Ekstern), Schulze, T. (Ekstern), Simons, S. (Ekstern), Teal, L. R. (Ekstern), Tidd, A. (Ekstern)
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Event:
Main Research Area: Technical/natural sciences
Optimal bæredygtig udnyttelse af tilgængelige torskebestande for dansk fiskeri

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, Section for Marine Ecology and Oceanography, Centre for Ocean Life
Authors: Eero, M. (Intern), Hansen, J. H. (Intern), Hüssy, K. (Intern), Huwer, B. (Intern), Berg, C. W. (Intern), Mariani, P. (Intern), Mosegaard, H. (Intern), Nielsen, A. (Intern), Eg Nielsen, E. (Intern), Rindorf, A. (Intern), Ulrich, C. (Intern), Vinther, M. (Intern), Worsøe Clausen, L. (Intern)
Number of pages: 52
Publication date: 2015

Processes controlling recruitment in Baltic cod

General information
State: Published
Organisations: National Institute of Aquatic Resources, Institute Management, Section for Marine Ecology and Oceanography, Section for Ecosystem based Marine Management, Leibniz Institute of Marine Sciences
Authors: Köster, F. (Intern), Huwer, B. (Intern), Hinrichsen, H. (Ekstern), Neumann, V. (Intern), Makarchouk, A. (Ekstern), Eero, M. (Intern), Hüssy, K. (Intern), Plikshs, M. (Ekstern)
Publication date: 2015
Event: Abstract from ICES Annual Science Conference 2015, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences

Stock mixing of eastern and western Baltic cod in SD 24

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Section for Marine Living Resources, Section for Ecosystem based Marine Management
Authors: Hüssy, K. (Intern), Mosegaard, H. (Intern), Albertsen, C. M. (Intern), Hansen, J. H. (Intern), Eero, M. (Intern)
Publication date: 2015
Event: Abstract from ICES Annual Science Conference 2015, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences

A demonstration of an integrated ecosystem assessment and advice for Baltic Sea fish stocks

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Centre for Ocean Life, Section for Marine Ecology and Oceanography, University of Kiel, University of Hamburg, Stockholm University, Lund University
Authors: Möllmann, C. (Ekstern), Bergström, L. (Ekstern), Blenckner, T. (Ekstern), Casini, M. (Ekstern), Dierking, J. (Ekstern), Eero, M. (Intern), Levin, P. (Ekstern), Lindegren, M. (Intern), Neuenfeldt, S. (Intern), Otto, S. (Ekstern), Schmidt, J. (Ekstern), Tomczak, M. (Ekstern), Voss, R. (Ekstern), Gårdmark, A. (Ekstern)
Publication date: 2014
Implications of stock recovery for a neighbouring management unit: experience from the Baltic cod

Cod in the Baltic Sea is assessed and managed as two separate stocks, i.e. eastern and western Baltic cod. The eastern Baltic cod has recently started to recover after several decades of severe depletion. In the present study, we suggest that the recovery of the eastern Baltic cod population has also substantially increased cod abundance in a specific area of the adjacent western Baltic management unit. This is investigated through long time-series of spatially resolved stock assessment data supplemented by genetic analyses of origin of the cod currently found in the transition area between the two populations. Due to immigrating cod from the east, there are currently large spatial differences in cod abundance and mean weight in the western Baltic management unit that raise new management concerns. First, the high abundance of cod of eastern origin found in the western Baltic management unit can mask the relatively poor state of the western Baltic cod population. Second, the current fishing mortality estimates for the entire western Baltic management unit, used as basis for fisheries management, are difficult to interpret as these are highly influenced by mixing of biological populations and the spatial distribution of fisheries.

General information

State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, Section for Marine Ecology and Oceanography
Authors: Eero, M. (Intern), Hansen, J. H. (Intern), Hüssy, K. (Intern)
Pages: 1458-1466
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information

Journal: ICES Journal of Marine Science
Volume: 71
Issue number: 6
ISSN (Print): 1054-3139
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.63
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.18
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.32
ISI indexed (2011): ISI indexed yes
Recovery in eastern Baltic cod: is increased recruitment caused by decreased predation on early life stages?
Cod (Gadus morhua) recruitment in the eastern Baltic Sea is influenced by predation on early life stages by sprat (Sprattus sprattus) and herring (Clupea harengus), which is considered as one of the mechanisms preventing cod recovery in the 1990s. In the light of improved cod recruitment in the second half of the 2000s, new analyses of stomach content of sprat and herring were conducted, to elucidate the contribution of changes in predation pressure on cod recruitment. Comparison of stomach contents of sprat and herring in 2004–2008 with data from the 1990s showed a similar diet composition in the two periods; however, changes were found in the ichthyoplankton abundance and composition in the diet, indicating reduced predation pressure on cod eggs in the most recent period. The abundance of cod eggs in the field, availability of other prey, and horizontal and vertical overlap between predator and prey were investigated as potential factors influencing cod egg predation.
The Baltic cod: A case study for testing stock discrimination based on otolith shape analysis in a mixed stock fishery

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Section for Marine Living Resources, Section for Ecosystem based Marine Management
Authors: Hüssy, K. (Intern), Mosegaard, H. (Intern), Hansen, J. H. (Intern), Eero, M. (Intern)
Publication date: 2014
Event: Abstract from 5th International Otolith Symposium, Mallorca, Spain.
Main Research Area: Technical/natural sciences
Links:

Cod recovery as a new challenge for fisheries management: experience from the Baltic Sea

General information
State: Published
Improved management based on stock identification of eastern and western Baltic cod

The objective of this project was to establish an empirically founded knowledge base for the sustainable exploitation of the western Baltic cod stock by including the complex stock structure and migration patterns.

Stock mapping: Extensive immigration of “Eastern” cod into the Arkona Basin (SD 24) within the “Western” cod’s management unit was documented using high-powered genetic tools. The majority (91%) of all spawning fish caught in SD 24 in 2011 were “Eastern” cod and only 9% were from the “Western” stock. The results suggest that the stock structure in the Arkona Basin is highly influenced by mixing of genetically separate stocks.

Trends in mixing: Since the 1980’s where cod in SD 24 consisted primarily of “Western” type, the proportion of “Eastern” cod has increased, particularly since 2005. Throughout that period, the immigration of “Eastern” cod into SD 24 consisted primarily of adult, older fish. The changes in biological characteristics (mean size at age, condition and maturity) observed in that area since 2005 are thus a direct consequence of the extensive immigration of “Eastern” cod. As no seasonal signals in stock mixing were observed, the immigration is not associated with a change in “Eastern” cod’s spawning behaviour.

Management: The stock mixing proportions were successfully implemented in DTU Aqua’s modeling framework for management scenarios. ‘Eastern’ immigrants into SD 24 lead the management procedure to advice for higher TACs that enhance the pressure on the fishing mortality level in SD 22. The fishing mortality level in SD 22 in this situation will need to be lowered i.e. by allocating more effort and catch from SD 22 to SD 24. Higher landings are expected if effort is re-directed/re-allocated to SD 24, profiting from the “Eastern” immigrants. By lowering the fishing mortality in SD 22, the SSB in SD 22 is also preserved, which is assumed to be the main source of recruits for the whole “western” stock (i.e. SD 22 + SD 24). In conclusion: Within the frame of this project we showed that substantial immigration “Eastern” cod into SD 24 has occurred and that these stock dynamics should be incorporated in evaluations of future management plans.
Lessons for fisheries management from the EU cod recovery plan

The performance of the EU long-term management plan for cod stocks, in force since 2009, is analysed focusing on the human and institutional factors. The plan operates through landings quotas (TACs) and effort restrictions following a Harvest Control Rule, and deploys a novel instrument allowing Member States to 'buy back' or increase fishing effort for fleet segments engaged in cod-avoidance measures. The stipulated fishing mortality reductions have not been achieved. On the positive side, the 'buy-back' instrument has led to increased uptake of selective gear and implementation of permanent and real-time temporary closures. On the negative side, ignoring the dimension of fishers as reactive agents in the design, the impact assessment, and the annual implementation of the measures has contributed to the failure to adequately implement the plan and achieve its objectives. The main problem is that the landings quotas taken in a mixed fishery did not limit catches because fishers were incentivised to continue fishing and discard overquota catch while quota for other species was available. The effort limitations intended to reduce this effect were insufficient to adequately limit fishing mortality in targeted fisheries, although fishers experienced them as prohibiting the full uptake of other quotas. Recommendations for future plans include (i) management through catch rather than landings quotas, (ii) the internalisation of the costs of exceeding quotas, (iii) use of more selective gear types, (iv) the development of appropriate metrics as a basis for regulatory measures and for evaluations, (v) participatory governance, (vi) fishery-based management, (vii) flexibility in fishing strategy at vessel level.

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources, Institute Management, Section for Public Sector Consultancy
Pages: 200-213
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
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Volume: 37
ISSN (Print): 0308-597X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.7 SJR 1.335 SNIP 1.182
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.591 SNIP 1.397 CiteScore 3.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.438 SNIP 1.56 CiteScore 3.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.472 SNIP 1.635 CiteScore 2.71
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Quantifying relative fishing impact on fish populations based on spatio-temporal overlap of fishing effort and stock density

Evaluations of the effects of management measures on fish populations are usually based on the analyses of population dynamics and estimates of fishing mortality from stock assessments. However, this approach may not be applicable in all cases, in particular for data-limited stocks, which may suffer from uncertain catch information and consequently lack reliable estimates of fishing mortality. In this study we develop an approach to obtain proxies for changes in fishing mortality based on effort information and predicted stock distribution. Cod in the Kattegat is used as an example. We use GAM analyses to predict local cod densities and combine this with spatio-temporal data of fishing effort based on VMS (Vessel Monitoring System). To quantify local fishing impact on the stock, retention probability of the gears is taken into account. The results indicate a substantial decline in the impact of the Danish demersal trawl fleet on cod in the Kattegat in recent years, due to a combination of closed areas, introduction of selective gears and changes in overall effort.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Vinther, M. (Intern), Eero, M. (Intern)
Pages: 618-627
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Journal of Marine Science
Volume: 70
Issue number: 3
Rapport om konsekvenser for fiskeriet ved udpegning af lukkede områder i Kattegat til beskyttelse af den bløde bund

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Monitoring and Data, Public Sector Consultancy
Rekreativt fiskeri påvirker ikke kvoten i den vestlige Østersø

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Eero, M. (Intern), Vinther, M. (Intern)
Pages: 4
Publication date: 2013

Threshold-dependent climate effects and high mortality limit recruitment and recovery of the Kattegat cod

Cod in the Kattegat is one of the most dramatic examples of stock collapse, where despite large management efforts, almost no signs of recovery have been observed. We investigate how multiple physical and biological factors could potentially influence recruitment and recovery of Kattegat cod, using non-additive threshold models. In contrast to previous studies on recruitment dynamics of Kattegat cod Gadus morhua, we found that recruitment variability may be explained by a combination of the size of the spawning stock and external conditions (i.e. sea surface temperature and oxygen concentrations), but only during periods of low stock size. Our results indicate that the long-term decrease and the present poor state of the Kattegat cod stock is likely caused by high total mortality rates and stock-size dependent effects of climate which together are currently preventing recovery. In addition, we illustrate how only a drastic reduction in total mortalities, primarily by limiting unintended bycatch and discards, may promote a recovery of the stock. This knowledge is important for evaluating the success or failure of various management measures which have been employed to recover the stock and for developing future management strategies which can take the environmental and/or ecosystem impacts into account

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Scripps Institution of Oceanography
Authors: Lindegren, M. (Intern), Eero, M. (Intern)
Pages: 223-232
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Ecology - Progress Series
Volume: 490
ISSN (Print): 0171-8630
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Identification of potential target levels for Central Baltic Sea fishing mortalities, taking multispecies interactions into account: Extended abstract

The main biological interactions between Baltic cod, herring and sprat have been modelled in a stochastic multispecies (SMS) model. Based on this, a simple approach has been developed to quantify candidates for FMSY proxies (fishing mortality that produces the maximum sustainable yield) in a multispecies context. Multispecies FMSY is higher for cod than single-species FMSY values, due to cannibalism. The actual FMSY for herring and sprat, and cod's influence on prey yield, depend on assumptions about density-dependent growth and spatial overlap between predator and prey. The results are ready for implementation in management, however, the multispecies aspects depend on predation data mainly from the 1980s and there is an urgent need to update the information base. The current productivity regime and spatial distribution of fish stocks in the Baltic is different from the earlier period when predation data was collected. Also, prey-to-predator feedback mechanisms should be more
understood before implementation in management

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Section for Public Sector Consultancy, Section for Population Ecology and Genetics, Section for Management Systems
Authors: Vinther, M. (Intern), Neuenfeldt, S. (Intern), Eero, M. (Intern), Casini, M. (Ekstern), Sparholt, H. (Ekstern)
Publication date: 2012
Event:
Main Research Area: Technical/natural sciences
Electronic versions:
K2212.pdf
Links:
http://ices.dk/products/CMdocs/CM-2012/K/K2212.pdf
Publication: Research › Conference abstract for conference – Annual report year: 2012

**Impact of climate change on fish population dynamics in the Baltic Sea: a dynamical downscaling investigation**
Understanding how climate change, exploitation and eutrophication will affect populations and ecosystems of the Baltic Sea can be facilitated with models which realistically combine these forcings into common frameworks. Here, we evaluate sensitivity of fish recruitment and population dynamics to past and future environmental forcings provided by three ocean-biogeochemical models of the Baltic Sea. Modeled temperature explained nearly as much variability in reproductive success of sprat (Sprattus sprattus; Clupeidae) as measured temperatures during 1973-2005, and both the spawner biomass and the temperature have influenced recruitment for at least 50 years. The three Baltic Sea models estimate relatively similar developments (increases) in biomass and fishery yield during twenty-first century climate change (ca. 28 % range among models). However, this uncertainty is exceeded by the one associated with the fish population model, and by the source of global climate data used by regional models. Knowledge of processes and biases could reduce these uncertainties

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ocean Ecology and Climate, Section for Management Systems, Section for Population Ecology and Genetics
Authors: Mackenzie, B. R. (Intern), Meier, H. E. M. (Ekstern), Lindegren, M. (Intern), Neuenfeldt, S. (Intern), Eero, M. (Intern), Blenckner, T. (Ekstern), Tomczak, M. T. (Intern), Niiranen, S. (Ekstern)
Pages: 626-636
Publication date: 2012
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Ambio
Volume: 41
Issue number: 6
ISSN (Print): 0044-7447
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.19 SJR 1.221 SNIP 1.194
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.114 SNIP 1.089 CiteScore 2.6
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.23 SNIP 1.308 CiteScore 2.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.203 SNIP 1.278 CiteScore 2.56
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.953 SNIP 0.907 CiteScore 1.88
ISI indexed (2012): ISI indexed yes
Reconstructing the population dynamics of sprat (Sprattus sprattus balticus) in the Baltic Sea in the 20th century

Long time-series of population dynamics are increasingly needed in order to understand human impacts on marine ecosystems and support their sustainable management. In this study, the estimates of sprat (Sprattus sprattus balticus) biomass in the Baltic Sea were extended back from the beginning of ICES stock assessments in 1974 to the early 1900s. The analyses identified peaks in sprat spawner biomass in the beginning of the 1930s, 1960s, and 1970s at ~900 kt. Only a half of that biomass was estimated for the late 1930s, for the period from the late 1940s to the mid-1950s, and for the mid-1960s. For the 1900s, fisheries landings suggest a relatively high biomass, similar to the early 1930s. The exploitation rate of sprat was low until the development of pelagic fisheries in the 1960s. Spatially resolved analyses from the 1960s onwards demonstrate changes in the distribution of sprat biomass over time. The average body weight of sprat by age in the 1950s to 1970s was higher than at present, but lower than during the 1980s to 1990s. The results of this study facilitate new analyses of the effects of climate, predation, and anthropogenic drivers on sprat, and contribute to setting long-term management strategies for the Baltic Sea.
Spatial management of marine resources can enhance the recovery of predators and avoid local depletion of forage fish

The eastern Baltic cod stock has recently started to recover, after two decades of severe depletion, however with unexpected side effects. The stock has not re-occupied its former wide distribution range, but remains concentrated in a limited area in the southern Baltic Sea. The biomass of forage fish, i.e., sprat and herring, is historic low in this area, which in combination with increasing cod stock results in locally high predation mortality of forage fish and cannibalism of cod. In line with low prey availability, body weight and nutritional condition of cod drastically declined. In the southern Baltic Sea, cod competes with pelagic fisheries for the limited resources of sprat and herring, while the largest biomass of these species is currently found outside the distribution range of cod. Accounting for spatial overlap between species is crucial in developing ecosystem based fisheries management to enhance the recovery of predator stocks.
The state and relative importance of drivers of fish population dynamics: An indicator-based approach

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources, Institute Management
Authors: Eero, M. (Intern), Lindegren, M. (Intern), Köster, F. (Intern)
Pages: 248-252
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Ecological Indicators
Volume: 15
Issue number: 1
ISSN (Print): 1470-160X
Ratings:
Tynde torsk giver lavere kvoter

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Management Systems, Section for Monitoring
Authors: Eero, M. (Intern), Storr-Paulsen, M. (Intern)
Pages: 4
Publication date: 2012

Publication information
Pages (from-to): 4
Newspaper: Fiskeritidende
Volume: 19
No.: 23
Ratings:
ISI indexed (2013): ISI indexed no
Why is the Eastern Baltic cod recovering?

**General information**

State: Published  
Organisations: Section for Management Systems, National Institute of Aquatic Resources, Section for Public Sector Consultancy  
Authors: Eero, M. (Intern), Köster, F. (Intern), Vinther, M. (Intern)  
Pages: 235-240  
Publication date: 2012  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Marine Policy  
Volume: 36  
Issue number: 1  
ISSN (Print): 0308-597X

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Could seals prevent cod recovery in the Baltic Sea?

Fish populations are increasingly affected by multiple human and natural impacts including exploitation, eutrophication, habitat alteration and climate change. As a result many collapsed populations may have to recover in ecosystems whose structure and functioning differ from those in which they were formerly productive and supported sustainable fisheries. Here we investigate how a cod (Gadus morhua) population in the Baltic Sea whose biomass was reduced due to a combination of high exploitation and deteriorating environmental conditions might recover and develop in the 21st century in an ecosystem that likely will change due to both the already started recovery of a cod predator, the grey seal Halichoerus grypus, and projected climate impacts. Simulation modelling, assuming increased seal predation, fishing levels consistent with management plan targets and stable salinity, shows that the cod population could reach high levels well above the long-term average. Scenarios with similar seal and fishing levels but with 15% lower salinity suggest that the Baltic will still be able to support a cod population which can sustain a fishery, but biomass and yields will be lower. At present knowledge of cod and seal interactions, seal predation was found to have much lower impact on cod recovery, compared to the effects of exploitation and salinity. These results suggest that dual management objectives (recovery of both seal and cod populations) are realistic but success in achieving these goals will also depend on how climate change affects cod recruitment.

General information
State: Published
Organisations: Section for Ocean Ecology and Climate, National Institute of Aquatic Resources, Section for Management Systems, University of Tartu
Authors: MacKenzie, B. (Intern), Eero, M. (Intern), Ojaveer, H. (Ekstern)
Pages: e18998
Publication date: 9 May 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: PLoS ONE
Volume: 6
Issue number: 5
ISSN (Print): 1932-6203
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.11 SJR 1.201 SNIP 1.092
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.414 SNIP 1.131 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.545 SNIP 1.141 CiteScore 3.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Could seals prevent cod recovery in the Baltic Sea?

General information
State: Published
Organisations: Section for Ocean Ecology and Climate, National Institute of Aquatic Resources, Section for Management Systems
Authors: MacKenzie, B. (Intern), Eero, M. (Intern), Ojaveer, H. (Ekstern)
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Council Meeting
Volume: 1:24
ISSN (Print): 1015-4744
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Web of Science (2003): Indexed yes
Original language: English
Source: orbit
Source-ID: 286881
Publication: Research › Conference article – Annual report year: 2011

Den østlige Østersøtorsks fremgang - held eller forstand?
Evaluation of effort and TAC quota uptake and capacity use by country as well as efficiency of effort measures according to fishing mortality and fishing power in the Western and Eastern Baltic cod fishery during 2005-2010 in relation to the multi-annual cod management plan

Extending time-series of fish biomasses using a simple surplus production based approach
Cod (Gadus morhua L.) recruitment success in the central Baltic Sea is influenced by various abiotic and biotic factors, which include ambient salinity and oxygen conditions as well as predation pressure on early life stages by planktivore clupeids, such as sprat (Sprattus sprattus) and herring (Clupea harengus). After a period of very low recruitment and stock size during the 1990s–early 2000s, the eastern Baltic cod stock exhibits signs of recovery, at least partly owing to several stronger year classes formed in recent years. In this paper we investigate whether or not changes in predation pressure by clupeids on the early life stages of cod could have enhanced cod recruitment in recent years. The analyses are based on a large dataset of stomach content of clupeids, cod egg abundances from ichthyoplankton surveys, and hydrographic measurements. We investigate temporal and spatial variability in predation pressure on cod eggs, both within and between years, and relate this to variability in hydrographic conditions. Preliminary results indicate lower predation pressure on cod eggs in the recent period compared with some earlier years.
Four regional marine biodiversity studies: Approaches and contributions to ecosystem-based management

General information
State: Published
Organisations: Section for Ocean Ecology and Climate, National Institute of Aquatic Resources, Section for Management Systems
Authors: Ellis, S. L. (Ekstern), Incze, L. S. (Ekstern), Lawton, P. (Ekstern), Ojaveer, H. (Ekstern), MacKenzie, B. (Intern), Pitcher, R. C. (Ekstern), Shirley, T. C. (Ekstern), Eero, M. (Intern), Tunnell, J. W. J. (Ekstern), Doherty, P. J. (Ekstern), Zeller, B. M. (Ekstern)
Pages: e18997
Publication date: 2011
Main Research Area: Technical/natural sciences
Publication information
Journal: PLoS ONE
Volume: 6
Issue number: 4
ISSN (Print): 1932-6203
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.11 SJR 1.201 SNIP 1.092
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.414 SNIP 1.131 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.545 SNIP 1.141 CiteScore 3.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.74 SNIP 1.147 CiteScore 3.94
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.945 SNIP 1.142 CiteScore 4.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.369 SNIP 1.23 CiteScore 4.58
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Historical ecology provides new insights for ecosystem management: Eastern Baltic cod case study

A recent historical marine ecological case study (cod in the eastern Baltic Sea) is used to show how long-term data and knowledge of fluctuations can contribute to revisions of fishery management policy. The case study first developed new longer analytical time series of spawner biomass and recruitment back to the 1920s, which extended knowledge of population dynamics into a time period when ecosystem state was characterized by temporally varying combinations of exploitation, climate-hydrographic conditions, marine mammal predation and eutrophication. Recovery of spatially resolved historical catch data from the late 1500s to early 1600s also contributed new perspectives to cod population dynamics under alternative ecosystem forcings. These new perspectives have contributed, and will likely continue to contribute to new management policies (e.g., revision of fishery management reference points), which should lead to higher sustainability of the population and fishery yields, and improved overall ecosystem health. These perspectives will likely continue to provide baseline information as ICES and the EU develop new policies based on maximum sustainable yield concepts.
Methodological challenges in assessing the environmental status of a marine ecosystem: Case study of the Baltic Sea

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources
Authors: Ojaveer, H. (Ekstern), Eero, M. (Intern)
Pages: e19231
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: PLoS ONE
Volume: 6
Issue number: 4
ISSN (Print): 1932-6203
Ratings:
BFI (2018): BFI-level 1
Multi-decadal responses of a cod (Gadus morhua) population to human-induced trophic changes, fishing, and climate

Understanding how human impacts have interacted with natural variability to affect populations and ecosystems is required for sustainable management and conservation. The Baltic Sea is one of the few large marine ecosystems worldwide where the relative contribution of several key forcings to changes in fish populations can be analyzed with empirical data. In this study we investigate how climate variability and multiple human impacts (fishing, marine mammal hunting, eutrophication) have affected multi-decadal scale dynamics of cod in the Baltic Sea during the 20th century. We document significant climate-driven variations in cod recruitment production at multi-annual timescales, which had major impacts on population dynamics and the yields to commercial fisheries. We also quantify the roles of marine mammal predation, eutrophication, and exploitation on the development of the cod population using simulation analyses, and show...
how the intensity of these forcings differed over time. In the early decades of the 20th century, marine mammal predation and nutrient availability were the main limiting factors; exploitation of cod was still relatively low. During the 1940s and subsequent decades, exploitation increased and became a dominant forcing on the population. Eutrophication had a relatively minor positive influence on cod biomass until the 1980s. The largest increase in cod biomass occurred during the late 1970s, following a long period of hydrographically related above-average cod productivity coupled to a temporary reduction in fishing pressure. The Baltic cod example demonstrates how combinations of different forcings can have synergistic effects and consequently dramatic impacts on population dynamics. Our results highlight the potential and limitations of human manipulations to influence predator species and show that sustainable management can only be achieved by considering both anthropogenic and naturally varying processes in a common framework.

**General information**
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources, Section for Ocean Ecology and Climate, Institute Management, Section for Population Ecology and Genetics
Authors: Eero, M. (Intern), MacKenzie, B. (Intern), Köster, F. (Intern), Gislason, H. (Intern)
Pages: 214-226
Publication date: 2011
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Ecological Applications
Volume: 21
Issue number: 1
ISSN (Print): 1051-0761
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.4 SJR 2.265 SNIP 1.576
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.76 SNIP 1.759 CiteScore 4.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.593 SNIP 1.842 CiteScore 4.59
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.676 SNIP 1.863 CiteScore 4.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.965 SNIP 1.937 CiteScore 4.55
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.286 SNIP 1.975 CiteScore 4.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.784 SNIP 1.675
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.664 SNIP 1.759
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.869 SNIP 1.749
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.805 SNIP 1.876
The recovery of cod in the Baltic Sea, a success against all odds

General information
State: Published
Organisations: National Institute of Aquatic Resources, Institute Management, Section for Ecosystem based Marine Management, Section for Marine Ecology and Oceanography
Authors: Köster, F. (Intern), Eero, M. (Intern), Huwer, B. (Intern)
Publication date: 2011
Main Research Area: Technical/natural sciences
Electronic versions:
AIPCE CEP Baltic cod recovery
Publication: Research › Paper – Annual report year: 2011

The relative roles of fishing and biological productivity in fish stock dynamics: history can help to understand the present and design the future

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources
Authors: Eero, M. (Intern)
Publication date: 2011
Event: Abstract from ICES Council Meeting 2011, Gdansk, Poland.
Main Research Area: Technical/natural sciences
Source-ID: 314497
Publication: Research › Conference abstract for conference – Annual report year: 2011

Challenges and landmarks in assessing the environmental status of a marine ecosystem: case study of the Baltic Sea

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources
Authors: Ojaveer, H. (Ekstern), Eero, M. (Intern)
Number of pages: 346
Publication date: 2010
Main Research Area: Technical/natural sciences
Bibliographical note
ICES CM 2010/Q:02
Source-ID: 267855
Publication: Research › Conference abstract for conference – Annual report year: 2010
An ecosystem-based framework for tracking performance of fish stocks and related forcings using fuzzy-logic approach

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources, Institute Management
Authors: Eero, M. (Intern), Jarre, A. (Intern), Ojaveer, H. (Ekstern), Tomczak, M. (Intern), Lindegren, M. (Intern), Köster, F. (Intern)
Publication date: 2009
Event: Abstract from ICES/PICES/UNCOVER Symposium 2009 on Rebuilding Depleted Fish Stocks, Warnemünde/Rostock, Germany.
Main Research Area: Technical/natural sciences
Links:
http://www.academia.edu/3478438/Stock-based_vs._fleet-based_evaluation_of_the_multi-annual_management_plan_for_the_cod_stocks_in_the_Baltic_Sea
Source: orbit
Source-ID: 284726
Publication: Research › Conference abstract for conference – Annual report year: 2009

Environmental effects on recruitment and implications for biological reference points of Eastern Baltic cod (Gadus morhua)
The decline of the Eastern Baltic cod (Gadus morhua) stock from highest to lowest stock levels on record throughout the 1980s and early 1990s was caused by a combination of recruitment failure and increasing fishing pressure at declining stock sizes. The processes driving the reproductive success are largely understood, but the consequences of these changes for fisheries management are far less evident. This includes doubts about the adequacy of the biological reference points presently used to advise on the stock status, and the need of their revision given that environmental changes have affected stock productivity. Long-term projections suggest that under adverse environmental conditions for reproduction, harvesting at fishing mortality determined as precautionary may not lead to a recovery of the stock to a biomass level considered precautionary. Thus, a revision of either the limit fishing mortality or the limit biomass reference point is indicated. However, an accepted methodology to determine these reference points in situations of changing stock productivity or system carrying capacity does not exist. Environmental conditions affecting recruitment matter not only for the determination of limit reference points, but according to long-term simulations also for target fishing mortalities, being central parts of harvest control rules in several management plans.

General information
State: Published

Dynamics of the eastern Baltic cod (Gadus morhua) stock in the 20th century under variable climate and anthropogenic forcing

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Eero, M. (Intern)
Publication date: 2008

Publication information
Publisher: University of Southern Denmark. Faculty of Humanities and Technical University of Denmark. National Institute of Aquatic Resources
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Thesis_MEero.pdf

Bibliographical note
University of Southern Denmark, Faculty of Humanities and Technical University of Denmark, National Institute of Aquatic Resources
Source: orbit
Source-ID: 225359
Publication: Research › Ph.D. thesis – Annual report year: 2008

Long-term dynamic in eastern Baltic cod spawning time: from small scale reversible

General information
State: Published
Organisations: Section for Management Systems, National Institute of Aquatic Resources
Authors: Karasiova, E. M. (Ekstern), Voss, R. (Ekstern), Eero, M. (Intern)
Pages: 20
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES C.M.
Volume: J:03
Original language: English
Links:
Source: orbit
Source-ID: 284623
Publication: Research › Conference article – Annual report year: 2008

Reconstructing historical stock development of Atlantic cod (Gadus morhua) in the eastern Baltic Sea before the beginning of intensive exploitation

The landings of Atlantic cod (Gadus morhua) in the eastern Baltic Sea in the early decades of the 20th century were below 50 thousand tonnes and therefore lower than in recent years at very low stock size. These low landings have largely contributed to a perception that the stock size was also low before the 1950s. In this investigation, we demonstrate that cod spawning stock biomass in the years 1925-1944 fluctuated in a similar range as in the periods from the 1950s to the mid-1970s and from the late 1980s onwards and was in most of these years at least twice as high as at present. Fishing mortality before the 1940s was below 0.2, but reached moderate levels during the Second World War. The stock size before the war may be considered as a reference level of biomass at low fishing impact, providing important information for the management of fisheries and the Baltic ecosystem.

General information
The Eastern Baltic cod stock in the 20th century: Resolving impacts of fishing, human-induced trophic changes and climate

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources, Institute Management
Authors: Eero, M. (Intern), MacKenzie, B. (Intern), Köster, F. (Intern), Gislason, H. (Intern)
Pages: 1-22
Publication date: 2008
Main Research Area: Technical/natural sciences

Development of international fisheries for the eastern Baltic cod (Gadus morhua) from the late 1880s until 1938
The paper provides an overview of eastern Baltic cod (Gadus morhua) fisheries from the end of the 1880s until 1938, in order to improve the knowledge of long-term stock dynamics. The data compiled and included in the study comprise catches and economic values of exploited fish species, time series of indicators of fishing effort and qualitative information on developments in fishing technology. This information has been assembled for different countries and locations in the Baltic Sea. We first summarize the multi-decadal development of national cod fisheries and their relative importance during the first decades of the 20th century. We then assess whether these data can be used to estimate the relative roles of fishing and ecosystem changes on variations in catches. We conclude that the assembled data reveal biologically meaningful variations in the state of the cod stock and that some of the variations in the catches of different countries (e.g. decline in the late 1920s; increase in the late 1930s) were caused by factors other than fishery developments. These factors probably include ecosystem-induced variations in cod population dynamics and need further investigation. (c) 2007 Elsevier B.V. All rights reserved.
Eastern Baltic cod (Gadus morhua callarias) stock dynamics: extending the analytical assessment back to the mid-1940s

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources, Institute Management
Authors: Eero, M. (Intern), Köster, F. (Intern), Plikshs, M. (Ekstern), Thurow, F. (Ekstern)
Pages: 1257-1271
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Journal of Marine Science
Volume: 64
Issue number: 6
ISSN (Print): 1054-3139
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.63
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.18
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.32
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Annual and seasonal dynamics of fish in the brackish-water Matsalu Bay, Estonia

General information
State: Published
Organisations: University of Tartu
Authors: Vetemaa, M. (Ekstern), Eschbaum, R. (Ekstern), Verliin, A. (Ekstern), Albert, A. (Ekstern), Eero, M. (Intern), Lillemagi, R. (Ekstern), Pihlak, M. (Ekstern), Saat, T. (Ekstern)
Pages: 211-220
Publication date: 2006
Conference: Conference on Behaviour and Ecology of Freshwater Fish - Linking Ecology and Individual Behaviour, Silkeborg, Denmark, 01/01/2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Ecology of Freshwater Fish
Volume: 15
Issue number: 2
ISSN (Print): 0906-6691
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.66 SJR 0.804 SNIP 0.885
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.022 SNIP 1.192 CiteScore 1.92
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.866 SNIP 0.994 CiteScore 1.58
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.971 SNIP 1.072 CiteScore 1.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.061 SNIP 1.247 CiteScore 2.05
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.979 SNIP 0.887 CiteScore 1.65
Some considerations in the use of early life stages of Baltic sprat (Sprattus sprattus) in recruitment predictions: the importance of hatching date

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources, Section for Management Systems
Authors: Reglero Baron, P. (Ekstern), Mosegaard, H. (Intern), Eero, M. (Intern)
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES C.M. 2001/
Volume: P:19
Original language: English
Source: orbit
Source-ID: 276896
Publication: Research - peer-review › Conference article – Annual report year: 2006

Projects:

Eastern Baltic cod - New knowledge of growth and mortality is the way to improved management advice (39366)
The aim of the project is to improve the knowledge and data basis for stock assessment and management for cod in the eastern Baltic Sea.
In later years, changes in growth and natural mortality of cod have presumably taken place and new knowledge on these parameters is essential for restoring analytical stock assessment for Eastern Baltic cod that is currently lacking. Improved knowledge on cod growth and mortality is therefore a prerequisite for being able to evaluate the stock status in relation to management targets and implement management plans that are built on quantitative stock assessment.

Ecological situation in the Baltic Sea has changed in later years, which requires updated biological information. This is done in the project using different approaches, bringing together expertise of different research areas. The approaches applied include molecular-genetic analyses of cod growth, bioenergetic modelling, and analyses of monitoring data on predation and condition/growth of cod. An important component of the project is cooperation with fishing industry to support tagging experiments of Baltic cod, to obtain updated estimates of cod growth.

Finally, the project combines the new knowledge on cod that becomes available from this and other relevant projects to ensure that the assessment of stocks status and management advice is based on best available scientific information.

This project is coordinated by DTU Aqua.

The project is funded by the Ministry of Environment and Food of Denmark and the European Maritime and Fisheries Fund (EMFF).

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Danish Fishermen's Association
University of Copenhagen
Period: 15/08/2016 → 15/08/2018
Number of participants: 8
Research areas: Ecosystem based Marine Management & Fish Biology & Marine Populations and Ecosystem Dynamics & Population Genetics & Marine Living Resources & Fisheries Management
Project participant:
Storr-Paulsen, Marie (Intern)
Tomkiewicz, Jonna (Intern)
Hansen, Jakob Hemmer (Intern)
Neuenfeldt, Stefan (Intern)
Christensen, Asbjørn (Intern)
Kindt-Larsen, Lotte (Intern)
Berg, Casper Willestofte (Intern)
Project Coordinator:
Eero, Margit (Intern)

Sustainable management of Kattegat cod; Improved knowledge about stock components and migration (39346)

The Kattegat cod has been categorized as a data limited stock, mainly due to a large unallocated mortality, which may be caused by migration between Kattegat and neighbouring areas. In this project, we aim to improve our understanding of migration patterns and mixing of different stock components within the Kattegat through a novel combination of genetic and micro-chemical signatures for individual fish. Results from the project will feed directly into the ICES advisory process, including a scheduled benchmark meeting in early 2017 where new procedures for stock assessment will be discussed. As cod are also caught as bycatch in other fisheries, a more robust stock assessment for cod will also be important to fisheries for other species under the landing obligation, which is scheduled for implementation in the Kattegat in 2017.

This project is coordinated by DTU Aqua.

The project is funded by the Ministry of Environment and Food of Denmark and the European Maritime and Fisheries Fund (EMFF).

National Institute of Aquatic Resources
Section for Marine Living Resources
Danish Fishermen's Association
University of Copenhagen
Period: 01/03/2016 → 28/02/2018
Number of participants: 7
Research areas: Population Genetics & Marine Living Resources & Fisheries Management
Project participant:
Hüssy, Karin (Intern)
The overall aim of this project is to examine the current data collection, observation, surveying, sampling and data assembly programs in the Baltic Sea basin, assess and demonstrate how they can fit into purpose in the 11 challenge areas in terms of data uncertainty, availability, accessibility and adequacy, and deliver the findings to stakeholders through an internet portal with dynamic mapping features and a stakeholder workshop. The Baltic Sea region is as defined by the Marine Strategy Framework Directive, i.e., the semi-enclose sea bounded by the parallel of the Skaw in the Skagerrak at 57°44.43' This project is coordinated by the Danish Meteorological Institute. The project is funded by the EU Executive Agency for Small and Medium-sized Enterprises (EASME) & the Ministry of Environment and Food of Denmark and the European Maritime and Fisheries Fund (EMFF).

National Institute of Aquatic Resources
Section for Marine Living Resources
Danish Meteorological Institute
Klaipeda University
European Global Ocean Observing System
Finnish Meteorological Institute
ETT S.p.A
Swedish Maritime Administration
Tshwane University of Technology
Grontmij A/S
Period: 17/09/2015 → 16/06/2018
Number of participants: 3
Research areas: Marine Living Resources & Coastal Ecology & Ecosystem based Marine Management
Project participant:
Dinesen, Grete E. (Intern)
Eero, Margit (Intern)
Project Coordinator:
Christensen, Asbjørn (Intern)
Project

Biodiversity changes - causes, consequences and management implications (BIO-C3) (39117)
BIO-C3 will investigate the dynamics of biodiversity in the Baltic Sea, their causes and the consequences for the function of food webs, including biodiversity management policies.

Baltic biodiversity is historically dynamic responding to various drivers operating at different time and space scales. Species diversity is generally low and contains many recent immigrants and glacial relict species because of low salinity and relatively young age. Nevertheless, Baltic food webs sustain many goods and services valued by society.

We focus on functional consequences of ongoing and projected distribational and compositional changes of benthic and pelagic communities with a focus on invasive and resident key species. Using spatial and temporal projections of abiotic/biotic drivers including their interaction (climate change, eutrophication, species invasions, fisheries), we will assess how biodiversity (e. g., of species, traits, habitats) responds in time, space and along gradients of human impact and hydrography. We will investigate the potential and genetic basis for colonisation, acclimation and adaptation of species and populations to the Baltic Sea, and how compositional and adaptive changes of Baltic biodiversity affect ecosystem functions with an emphasis on trophic linkage and food web dynamics.

Results will feed into impact assessments that guide management policies including improved operationalization of status indicators, and guidelines for MPAs.
The project is coordinated by Helmholtz Centre for Ocean Research, Kiel (GEOMAR). DTU Aqua is co-coordinator. The project is funded equally by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.

National Institute of Aquatic Resources
Section for Marine Ecology and Oceanography
GEOMAR - Helmholtz Centre for Ocean Research Kiel
University of Hamburg
Stockholm University
National Marine Fisheries Research Institute
University of Tartu
Finnish Environment Institute
Klaipeda University
DHI Denmark
University of Gothenburg
Johann Heinrich von Thünen-Institute
Swedish Meteorological and Hydrological Institute
Åbo Academy University
Period: 01/03/2014 → 28/02/2018
Number of participants: 10
Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Population Genetics & Ecosystem based Marine Management

Project participant:
Tomkiewicz, Jonna (Intern)
MacKenzie, Brian (Intern)
Eero, Margit (Intern)
Bekkevold, Dorte (Intern)
Dutz, Jörg (Intern)
Behrens, Jane (Intern)
Huwer, Bastian (Intern)
Neuenfeldt, Stefan (Intern)
Jaspers, Cornelia (Intern)
Köster, Fritz (Intern)

Integrating spatial processes into ecosystem models for sustainable utilization of fish resources (INSPIRE) (39118)
The BONUS INSPIRE Project conducts pilot ecosystem field surveys that help resolving the habitat requirements of different life-stages of the focal species by combined use of traditional methods and application of modern advanced analysis and modelling techniques.

The research is conducted in a matrix approach with four species specific case (cod, herring, sprat and flounder) and five research work-packages. The work packages deal with (i) habitat requirements and survival probability for different life stages, (ii) connectivity between habitat occupied in successive life stages, (iii) spatial scaling from local events to regional population dynamics, (iv) spatially explicit analytical stock assessments (including a comprehensive flatfish programme), and (v) ecosystem-based management and Marine Strategy Framework Directive indicators.

The overarching questions of the BONUS INSPIRE Project are:
- What habitat (both pelagic and benthic) conditions characterize the spatial distributions of cod, herring, sprat and flounder?
- To what extent do fishing and species interaction affect the local and basin-scale distribution of exploited stocks?
- What drives spatial connectivity and migrations of different fish species/populations?
- How does stock structure and separation of natural populations impact stock assessment outcomes?
This project is coordinated by University of Tartu, Estonia.

The project is funded by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.

**National Institute of Aquatic Resources**
Section for Oceans and Arctic
University of Tartu
National Marine Fisheries Research Institute
Stockholm University
Swedish University of Agricultural Sciences
Institute of Food Safety, Animal Health and Environment
Thünen Institut für Ostseefischerei
University of Hamburg
National Resources Institute Finland
GEOMAR - Helmholtz Centre for Ocean Research Kiel
Lund University
Uppsala University

**Period:** 01/02/2014 → 30/08/2017

**Number of participants:** 4

**Research areas:** Marine Populations and Ecosystem Dynamics & Fish Biology & Ecosystem based Marine Management

**Project participant:**

Hüssy, Karin (Intern)
Andersen, Niels Gerner (Intern)
Eero, Margit (Intern)

**Project Manager, academic:**
Neuenfeldt, Stefan (Intern)

**Optimal sustainable use of cod stocks accessible for Danish fisheries (DEL-TORSK) (39147)**

Optimal sustainable utilization of cod stocks that contain several biological sub-populations requires taking population structure into account in stock assessment and management. The aim of this project was to develop scientific basis for cod management decisions in the North Sea and the Baltic that takes biological units of cod and their dynamics into account.

Methodological challenges concerning advising on stocks that contain sub-populations with differences in dynamics and biological parameters are common for North Sea and the Baltic. Therefore, the project considered both seas, in terms of developing methodological basis for addressing population structure in management advice. The results were presented at ICES benchmarks for North Sea and Baltic Sea cod in 2015, and used to developing further the management basis for optimal use of cod stocks.

The project included mapping of distribution of sub-populations using genetic analyses and modelling of transport of early life stages. These results were combined with existing knowledge on cod population structure both in the Baltic and North Sea, to identify distribution areas of sub populations. This information was then incorporated in area-specific stock assessment analyses.

This project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

**National Institute of Aquatic Resources**
Section for Ecosystem based Marine Management

**Period:** 17/07/2013 → 30/04/2015

**Number of participants:** 8

**Research areas:** Ecosystem based Marine Management & Marine Populations and Ecosystem Dynamics & Population Genetics & Fish Biology & Marine Living Resources & Fisheries Management

**Project participant:**
The aim of this project was to improve the management of western Baltic cod by incorporating stock identification routines in order to discriminate between eastern and western Baltic cod stocks. In recent years evidence from fishery patterns and otolith structures have indicated an increasing degree of mixing between the two cod stocks which up until 2013 were managed as two separate stocks. Changes in fishing pressure and patterns would therefore result in a risk for local depletion of the smaller western stock.

Stock identification methods were based on established approaches using genetic discrimination and otolith shape analysis, and improved by linking these methods. This method provides a tool to estimate the degree of stock mixing using the existing otolith archives. This approach documented an increase of eastern Baltic cod from 30% to > 80% in the eastern part of the western Baltic Sea management area. As a consequence of this stock mixing, a new procedure incorporating stock mixing on an annual basis was set in place, with the aim to improve stock exploitation and reduce the risk of local depletion. The knowledge gained also influenced recent management regulations, particularly a prolongation of spawning closer of the fishery in 2016.

The project was coordinated by Centre for Environment, Fisheries & Aquaculture Science, UK. The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

National Institute of Aquatic Resources
Section for Marine Ecology and Oceanography
Cefas
Period: 27/06/2011 → 29/03/2013
Number of participants: 18
Research areas: Marine Populations and Ecosystem Dynamics & Marine Living Resources & Population Genetics & Fisheries Management
Project participant:
Hansen, Jakob Hemmer (Intern)
Huwer, Bastian (Intern)
Bastardie, Francois (Intern)
Eero, Margit (Intern)
Nielsen, J. Rasmus (Intern)
Worsøe Clausen, Lotte (Intern)
Mosegaard, Henrik (Intern)
Storr-Paulsen, Marie (Intern)
Olesen, Hans Jakob (Intern)
Kirkegaard, Eskild (Intern)
Larsen, Peter Vingaard (Intern)
Hansen, Frank Ivan (Intern)
Lundgaard, Louise Scherffenberg (Intern)
Willandsen, Maj-Britt (Intern)
de Jong, Noortje (Intern)
Mensberg, Karen-Lise Dons (Intern)
Meldrup, Dorte (Intern)
Project Coordinator:
Externally driven mortality of Eastern Baltic cod early life stages: Impact of predation and hydrography

National Institute of Aquatic Resources
Period: 01/02/2011 → 30/08/2017
Number of participants: 6
PhD Student:
Neumann, Viola (Intern)
Supervisor:
Eero, Margit (Intern)
Main Supervisor:
Köster, Fritz (Intern)
Examiner:
MacKenzie, Brian (Intern)
Grønkjær, Peter (Ekstern)
Kraus, Gerd (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

History of marine animal populations (HMAP) (38156)
The History of Marine Animal Populations (HMAP) is the historical component of the Census of Marine Life program (CoML), which is an international, multi-disciplinary project which will investigate biodiversity in the world’s oceans. HMAP’s long-term aim is to improve our historical understanding of ecosystem change and our ecological understanding of man’s role in changing marine ecosystems.

The long data series and time-specific snapshots of marine ecological conditions that are being generated are being used to provide input to contemporary ecological modelling in order to characterize and visualize variations in past ecosystems. Such visualizations and testing of ecological hypotheses will enhance the disciplines of history and ecology in seeking to explain long-term changes in marine animal populations and their ecosystems, especially those changes resulting from man’s activities.

Some key results from our earlier historical ecology work include reconstructions of extended time series of cod and sprat biomasses in the Baltic Sea which have enabled us to document how the relative importance of different ecosystem drivers (e.g., fishing, hydrographic variability, mammal predation, eutrophication) of biomass dynamics change and interact over time, and how eutrophication has affected forage fish production in the Baltic Sea. Ongoing work is evaluating and documenting the causes of long-term declines of a local herring population in the Baltic Sea and swordfish fisheries in coastal New England, Nova Scotia and Italy. Another key result is a recent consensus article by an ICES expert group on how historical ecology can contribute to fisheries and ecosystem management.

Because HMAP and CoML have ended, DTU Aqua’s work in this area continues with support from other projects and as contributions to new successor fora established in 2013-2015. These include the Oceans Past Initiative, ICES Study Group on the History of Fish and Fisheries and the EU COST program Oceans Past Platform (2015). DTU Aqua’s work will contribute to the development of new management and conservation policies by demonstrating the species compositions, sizes and distributions of animals that lived in the ocean during periods with less human impact than today, and how these biological properties have changed over time.

The project was coordinated by Trinity College, Ireland.

The project was funded by Trinity College, Dublin, Ireland.

National Institute of Aquatic Resources
Section for Marine Ecology and Oceanography
University of Copenhagen
University of Tartu
Trinity College Dublin
University of Cambridge
Period: 01/01/2011 → 01/03/2012
Number of participants: 2
Research areas: Oceanography & Marine Populations and Ecosystem Dynamics
Contact person:
MacKenzie, Brian (Intern)
Project Manager, academic:
Eero, Margit (Intern)
 Project

**Vectors of change (VECTORS) (38907)**
Marine life makes a substantial contribution to the economy and society of Europe. VECTORS aimed at elucidating the drivers, pressures and vectors that cause change in marine life, the mechanisms by which they do so, the impacts that they have on ecosystem structures and functioning, and on the economics of associated marine sectors and society. VECTORS particularly focused on causes and consequences of invasive alien species, outbreak forming species, and changes in fish distribution and productivity. New and existing knowledge and insight was synthesized and integrated to project changes in marine life, ecosystems and economies under future scenarios for adaptation and mitigation in the light of new technologies, fishing strategies and policy needs. VECTORS also evaluated current forms and mechanisms of marine governance in relation to the vectors of change. Based on its findings, VECTORS outlined solutions and tools for relevant stakeholders and policymakers during the lifetime of the project. The VECTORS consortium included a mixture of natural scientists with knowledge of socio-economic aspects, and social scientists (environmental economists, policy and governance analysts and environmental law specialists) with interests in natural system functioning.

DTU Aqua contributed to VECTORS by developing new statistical models of fish species distributions, by further developing spatially resolved bio-economic models of fishing, and by analyzing fish species richness and distribution in the north Atlantic and the general relationship between changes in fish stock abundance and distribution area. We coordinated the Baltic WP where we implemented the ATLANTIS end-to-end model and performed initial scenario testing. We also analyzed the most important drivers of fish population dynamics in the Baltic, and contributed to the study of invasive species.

VECTORS comprised a total of 37 European Universities, research institutions and professional associations dealing with applied maritime and marine research.

The project included marine environmental scientists, fisheries scientists, conservation biologists, sociologists and economists from across the European scientific community providing expertise in marine ecosystems, management, fisheries, maritime transport, tourism and coastal development.

The project was coordinated by Plymouth Marine Laboratory, UK.

The project was funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Period: 01/01/2011 → 31/01/2015
Number of participants: 9
Research areas: Ecosystem based Marine Management & Fisheries Management & Marine Living Resources
Contact person:
Köster, Fritz (Intern)
Project participant:
Nielsen, J. Rasmus (Intern)
Lewy, Peter (Intern)
Rindorf, Anna (Intern)
Bastardie, Francois (Intern)
Kristensen, Kasper (Intern)
Huwcr, Bastian (Intern)
Project Manager, academic:
Gislsason, Henrik (Intern)
Eero, Margit (Intern)
Project
Advanced modelling tool for scenarios of the Baltic Sea ecosystem to support decision making (ECOSUPPORT) (38733)

The Baltic Sea is subject to several major human impacts, and three of the most important are fishing, eutrophication and climate change. Understanding and projecting how these impacts will affect the food web and its fish populations in future is therefore challenging, and requires modelling approaches which include climatic-hydrographic forcing, nutrient loading scenarios and likely fishing intensities.

ECOSUPPORT was a project whose objective was to develop an advanced modelling tool for conducting scenario simulations of how these human impacts affect the marine ecosystem and fish populations. The project coupled several different types of models so that end-to-end ecosystem models were developed which to understand how human impacts could influence the Baltic food web and fish populations. The models to be linked included regional climate models, oceanographic-lower trophic level ecosystem models (Nutrient-Phytoplankton-Zooplankton-Detritus) and fish population models. Key project results included new scenario simulations how regionally downscaled global climate model outputs would affect the development of Baltic cod populations under scenarios of climate change and seal (predator) population growth, and under different combinations of eutrophication, exploitation and climate change. These simulations included all key elements of the foodweb via an Ecopath model which included competitive and predatory interactions between the major fish species in the Baltic. The results demonstrated the vulnerability of the cod population to successful implementation of key ecosystem management policies for the Baltic Sea, including those related to exploitation and nutrient loading. Additional model scenarios focused on the sprat population which is a key intermediary link in the Baltic foodweb as prey and predator for cod and of zooplankton. These scenarios illustrated the range of future biomass and yields under assumed ranges of climate change and natural mortality.

One of the major novelties of the project was the availability of 3 different NPZD models, which enable estimation of output uncertainties to different model parameterizations and assumptions in the lower trophic levels and physical oceanographic processes, and to compare these with uncertainties due to fish population dynamics (e.g., recruitment variability). These comparisons suggest that the biological uncertainty associated with fish population dynamics was larger than that associated with the choice of the oceanographic NPZD model.

Partners in the project are the above mentioned and five other marine research institutes around the Baltic Sea.

The project is coordinated by Swedish Meteorological and Hydrographic Institute, Sweden.

The project was funded by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.

National Institute of Aquatic Resources
Centre for Ocean Life
Swedish Meteorological and Hydrographic Institute (SMHI)
Leibniz-Institute for Baltic Sea Research
GKSS-Research Centre
University of Gothenburg
Stockholm University

Period: 01/01/2009 → 31/12/2011
Number of participants: 4
Research areas: Oceanography & Marine Populations and Ecosystem Dynamics & Ecosystem based Marine Management

Contact person:
MacKenzie, Brian (Intern)
Eero, Margit (Intern)
Lindegren, Martin (Intern)
Neuenfeldt, Stefan (Intern)

Marine ecosystem evolution in a changing environment (MEECE) (38131)

In order to advance our understanding and the predictive capacities necessary to resolve how marine ecosystems will respond to global change MEECE employed a combination of data synthesis, numerical simulation and targeted experimentation to further our knowledge of how marine ecosystems will respond to combinations of these climate change and anthropogenic drivers.

A key objective of MEECE was to advance model coupling across trophic levels and create concepts and infrastructure to enable end-to-end modeling, from physics to fish, which has empirically been difficult due to different space and time scales involved, as well as relative emphasis of statistical and mechanistic aspects. Finally MEECE integrated modeling advancements with fishery management perspectives.
The project was coordinated by Plymouth Marine Laboratory, UK, and had 21 partners from the EU.

The project was funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Marine Living Resources
Period: 01/01/2008 → 15/10/2012
Number of participants: 11
Research areas: Marine Living Resources & Marine Populations and Ecosystem Dynamics & Fisheries Management
Acronym: MEECE
Contact person:
Christensen, Asbjørn (Intern)
Project participant:
Vinther, Morten (Intern)
Neuenfeldt, Stefan (Intern)
MacKenzie, Brian (Intern)
Nielsen, J. Rasmus (Intern)
Eero, Margit (Intern)
Andersen, Ken Haste (Intern)
Bastardie, Francois (Intern)
Neumann, Viola (Intern)
Grigorov, Ivo (Intern)
Project Manager, academic:
Köster, Fritz (Intern)

Relations
Publications:
Should “Citizen Scientists” play with climate & ecosystem models?

Project

Indicators for fisheries management in Europe (IMAGE) (38225)
The Common Fisheries Policy (CFP) requires the progressive implementation of an ecosystem-based approach to fisheries management (EBFM). To implement effective management, it is essential to develop a framework that allows for the evaluation of different management strategies based on indicators. Indicators can support the decision-making process by (i) describing the pressures affecting the ecosystem, the state of the ecosystem and the response of managers, (ii) tracking progress towards meeting management objectives and (iii) communicating trends in complex impacts and management processes to a non-specialist audience. The aim of this project was to develop an indicator-based operational framework that can support ecosystem-based management, and also show how this can be applied to test and evaluate different management strategies or sampling programs.

The principal objectives of IMAGE were:-To develop an operational framework of candidate indicators (ecological, economic, social) that can support ecosystem-based fisheries management at the regional and pan-European scale-To elaborate these indicators in comprehensive dashboards (e.g. current values, trends, reference levels)-To develop methodology to integrate this information into tools supporting the decision-making process-To develop a framework that can evaluate management strategies based on indicators-To advise on how indicators can be used to support EBFM in selected regional case studies based on the RAC areas.

The project consisted of a conceptual phase where the operational framework was designed. This was followed by a phase of methodology development, an implementation phase consisting of regional case studies linked to the RACs and finally a pan-European evaluation and synthesis of the projects results. The results of this project contribute to the development of an effective EBFM in the context of the CFP, while also contributing to the applied science needed to support the emerging European Marine Strategy and Maritime Policy.

The project was coordinated by Institute for Marine Resources and Ecosystem Studies (IMARES), The Netherlands.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Wageningen IMARES
Cefas
Activities:

**ICES - Baltic Fisheries Assessment Working Group - WGBFAS (External organisation)**
Period: 2015
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Baltic Fisheries Assessment Working Group - WGBFAS**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Benchmark Workshop for North Sea Stocks - WKNSEA (External organisation)**
Period: 2015
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Benchmark Workshop for North Sea Stocks - WKNSEA**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Benchmark Workshop on Baltic Cod Stocks - WKBALTCOD (External organisation)**
Period: 2015
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Benchmark Workshop on Baltic Cod Stocks - WKBALTCOD
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - A Benchmark Workshop on Baltic Flatfish Stocks - WKBALFLAT (External organisation)
Period: 2014
Margit Eero (Chairman)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - A Benchmark Workshop on Baltic Flatfish Stocks - WKBALFLAT
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Baltic Fisheries Assessment Working Group - WGBFAS (External organisation)
Period: 2014
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Baltic Fisheries Assessment Working Group - WGBFAS
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Data Compilation for Benchmark Workshop on North Sea stocks - DCWKNSEA (External organisation)
Period: 2014
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Data Compilation for Benchmark Workshop on North Sea stocks - DCWKNSEA
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea - WGIAB (External organisation)
Period: 2014
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea - WGIAB
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
ICES - The Workshop on Scoping for Integrated Baltic Cod Assessment - WKSIBCA (External organisation)
Period: 2014
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation
ICES - The Workshop on Scoping for Integrated Baltic Cod Assessment - WKSIBCA
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - The Workshop to draft recommendations for the assessment of Descriptor D3 - WKD3R (External organisation)
Period: 2014
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation
ICES - The Workshop to draft recommendations for the assessment of Descriptor D3 - WKD3R
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Baltic Fisheries Assessment Working Group - WGBFAS (External organisation)
Period: 2012 → …
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Management Systems
Degree of recognition: International

Related external organisation
ICES - Baltic Fisheries Assessment Working Group - WGBFAS
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Study Group on Spatial Analyses for the Baltic Sea - SGSPATIAL (External organisation)
Period: 2012 → …
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Management Systems
Degree of recognition: International

Related external organisation
ICES - Study Group on Spatial Analyses for the Baltic Sea - SGSPATIAL
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Workshop on Regional Database (External organisation)
Period: 2012 → …
Margit Eero (Participant)
National Institute of Aquatic Resources
Section for Management Systems
Degree of recognition: International

Related external organisation

ICES - Workshop on Regional Database
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar