Overarching sustainability objectives overcome incompatible directions in the Common Fisheries Policy

The lack of clarity in the objectives of the Common Fisheries Policy (CFP) must be addressed to create a more efficient balance across diverse ecological, economic and social dimensions. Particularly economic and social objectives present at an overarching level must be made explicit and addressed in lower level management measures, in order to link them to biological objectives and allow policy to build a balance across types of objectives. Selecting clear objectives is essential, particularly for policy impact assessment. The aim of this paper is to demonstrate how more specific high level objectives to managing fisheries can be derived from stakeholders. The paper first reviews the definition of objectives, from a historical and conceptual perspective. Secondly, it discusses the issues of manageability and acceptability, and finally describes an articulation of the high level objectives derived from extensive stakeholder consultations at European and regional level. The results from workshops at the European level to identify objectives were further examined at regional level for the Baltic and North Seas in additional individual consultations. The German case addresses two seas (Baltic and North Seas), has a complex governance structure (due to federalism) and significant roles for the three types of actors (industry, government and environmental NGOs). The analysis suggests that establishing higher level sustainability objectives within the CFP can help diverse interest groups to develop a consensus on management actions to meet complex social goals.

General information
State: Accepted/In press
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Thünen Institute of Sea Fisheries, Marine Institute, Thünen Institute of Baltic Sea Fisheries, National University of Ireland
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Publication date: 2018
Main Research Area: Technical/natural sciences
Achieving maximum sustainable yield in mixed fisheries: a management approach for the North Sea demersal fisheries

Achieving single species maximum sustainable yield (MSY) in complex and dynamic fisheries targeting multiple species (mixed fisheries) is challenging because achieving the objective for one species may mean missing the objective for another. The North Sea mixed fisheries are a representative example of an issue that is generic across most demersal fisheries worldwide, with the diversity of species and fisheries inducing numerous biological and technical interactions. Building on a rich knowledge base for the understanding and quantification of these interactions, new approaches have emerged. Recent paths towards operationalizing MSY at the regional scale have suggested the expansion of the concept into a desirable area of “pretty good yield”, implemented through a range around FMSY that would allow for more flexibility in management targets. This article investigates the potential of FMSY ranges to combine long-term single-stock targets with flexible, short-term, mixed-fisheries management requirements applied to the main North Sea demersal stocks. It is shown that sustained fishing at the upper bound of the range may lead to unacceptable risks when technical interactions occur. An objective method is suggested that provides an optimal set of fishing mortality within the range, minimizing the risk of total allowable catch mismatches among stocks captured within mixed fisheries, and addressing explicitly the trade-offs between the most and least productive stocks.
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.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Studiofuga
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Pages: 535-551
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Journal of Marine Science
Volume: 74
Issue number: 2
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
Fishing for MSY: using "pretty good yield" ranges without impairing recruitment

Pretty good yield (PGY) is a sustainable fish yield corresponding to obtaining no less than a specified large percentage of the maximum sustainable yield (MSY). We investigated 19 European fish stocks to test the hypothesis that the 95% PGY yield range is inherently precautionary with respect to impairing recruitment. An FMSY range was calculated for each stock as the range of fishing mortalities (F) that lead to an average catch of at least 95% of MSY in long-term simulations. Further, a precautionary reference point for each stock (FP.05) was defined as the F resulting in a 5% probability of the spawning-stock biomass falling below an agreed biomass limit below which recruitment is impaired (Blim) in long-term simulations. For the majority of the stocks analysed, the upper bound of the FMSY range exceeded the estimated FP.05. However, larger fish species had higher precautionary limits to fishing mortality, and species with larger asymptotic length were less likely to have FMSY ranges impairing recruitment. Our study shows that fishing at FMSY generally is precautionary with respect to impairing recruitment for highly exploited teleost species in northern European waters, whereas the upper part of the range providing 95% of MSY is not necessarily precautionary for small- and medium-sized teleosts.
Food for thought: pretty good multispecies yield

MSY principles for marine fisheries management reflect a focus on obtaining continued high catches to provide food and livelihoods for humanity, while not compromising ecosystems. However, maintaining healthy stocks to provide the maximum sustainable yield on a single-species basis does not ensure that broader ecosystem, economic, and social objectives are addressed. We investigate how the principles of a “pretty good yield” range of fishing mortalities assumed to provide >95% of the average yield for a single stock can be expanded to a pretty good multispecies yield (PGMY) space and further to pretty good multidimensional yield to accommodate situations where the yield from a stock affects the ecosystem, economic and social benefits, or sustainability. We demonstrate in a European example that PGMY is a practical concept. As PGMY provides a safe operating space for management that adheres to the principles of MSY, it allows the consideration of other aspects to be included in operational management advice in both data-rich and data-limited situations. PGMY furthermore provides a way to integrate advice across stocks, avoiding clearly infeasible management combinations, and thereby hopefully increasing confidence in scientific advice.

General information

State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, CSIRO Oceans and Atmosphere, National Oceanographic and Atmospheric Administration, Ministry for Primary Industries, AZTI-Tecnalia, University of Washington, University of New Brunswick, Marine Institute
Authors: Rindorf, A. (Intern), Dichmont, C. M. (Ekstern), Levin, P. (Ekstern), Mace, P. (Ekstern), Pascoe, S. (Ekstern), Prellezo, R. (Ekstern), Punt, A. (Ekstern), Reid, D. G. (Ekstern), Stephenson, R. (Ekstern), Ulrich, C. (Intern), Vinther, M. (Intern), Worsøe Clausen, L. (Intern)
Pages: 475-486
Publication date: 2017
Main Research Area: Technical/natural sciences
Inclusion of ecological, economic, social, and institutional considerations when setting targets and limits for multispecies fisheries: Introduction to the Symposium: ‘Targets and Limits for Long Term Fisheries Management’ Quo Vadimus

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, NOAA, Saint Mary's University, Aalborg University, AZTI Technalia, IMARES, Thünen Institute of Baltic Sea Fisheries, Ministry for Primary Industries, Hellenic Centre for Marine Research, Galway - Mayo Institute of Technology, Imperial College London, University of Washington, Marine Institute, University of St Andrews, IFREMER, University of Kiel
Pages: 453-463
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Journal of Marine Science
Volume: 74
Issue number: 2
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
Moving beyond the MSY concept to reflect multidimensional fisheries management objectives

Maximising the long term average catch of single stock fisheries as prescribed by the globally-legislated MSY objective is unlikely to ensure ecosystem, economic, social and governance sustainability unless an effort is made to explicitly include these considerations. We investigated how objectives to be maximised can be combined with sustainability constraints aiming specifically at one or more of these four sustainability pillars. The study was conducted as a three-year interactive process involving 290 participating science, industry, NGO and management representatives from six different European regions. Economic considerations and inclusive governance were generally preferred as the key objectives to be maximised in complex fisheries, recognising that ecosystem, social and governance constraints are also key aspects of sustainability in all regions. Relative preferences differed between regions and cases but were similar across a series of workshops, different levels of information provided and the form of elicitation methods used as long as major shifts in context or stakeholder composition did not occur. Maximising inclusiveness in governance, particularly the inclusiveness of affected stakeholders, was highly preferred by participants across the project. This suggests that advice incorporating flexibility in the interpretation of objectives to leave room for meaningful inclusiveness in decision-making processes is likely to be a prerequisite for stakeholder buy-in to management decisions.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Imperial College London, International Council for the Exploration of the Sea, AZTI Technalia, Ministry for Primary Industries, Scottish Pelagic Fishermen’s Association, Instituto Espanol de Oceanografia, Hellenic Centre for Marine Research,
Practical steps toward integrating economic, social and institutional elements in fisheries policy and management

While international agreements and legislation call for incorporation of four pillars of sustainability, the social (including cultural), economic and institutional aspects (the ‘human dimension’) have been relatively neglected to date. Three key impediments have been identified: a relative lack of explicit social, economic and institutional objectives; a general lack of process (frameworks, governance) for routine integration of all four pillars of sustainability; and a bias towards biological considerations. Practical integration requires a ‘systems’ approach with explicit consideration of strategic and operational aspects of management; multidisciplinary or transdisciplinary evaluations; practical objectives for the four pillars of sustainability; appropriate participation; and a governance system that is able to integrate these diverse considerations in management. We challenge all involved in fisheries to immediately take five practical steps toward integrating ecological, economic, social and institutional aspects: (1) Adopt the perspective of the fishery as a ‘system’ with interacting natural, human and management elements; (2) Be aware of both strategic and operational aspects of fisheries assessment and management; (3) Articulate overarching objectives that incorporate all four pillars of sustainability; (4) Encourage appropriate (and diverse) disciplinary participation in all aspects of research, evaluation and management; and (5) Encourage development of (or emulate) participatory governance.
Productivity and recovery of forage fish under climate change and fishing: North Sea sandeel as a case study

Forage fish occupy a central position in marine food-webs worldwide by mediating the transfer of energy and organic matter from lower to higher trophic levels. The lesser sandeel (Ammodytes marinus) is one of the ecologically and economically most important forage fish species in the North-east Atlantic, acting as a key prey for predatory fish and sea birds, as well as supporting a large commercial fishery. In this case study, we investigate the underlying factors affecting recruitment and how these in turn affect productivity of the North Sea sandeel using long-term data and modelling. Our results demonstrate how sandeel productivity in the central North Sea (Dogger Bank) depends on a combination of external and internal regulatory factors, including fishing and climate effects, as well as density dependence and food availability of the preferred zooplankton prey (Calanus finmarchicus and Temora longicornis). Furthermore, our model scenarios suggest that while fishing largely contributed to the abrupt stock decline during the late 1990s and the following period of low biomass, a complete recovery of the stock to the highly productive levels of the early 1980s would only be possible through changes in the surrounding ecosystem, involving lower temperatures and improved feeding conditions. To that end, we stress the need for ecosystem-based management accounting for multiple internal and external factors occurring within the broader context of the ecosystem in which forage fish species, such as sandeel, play an important and integral part.

General information
State: Accepted/In press
Organisations: National Institute of Aquatic Resources, Centre for Ocean Life, Section for Marine Living Resources, Section for Oceans and Arctic, Section for Ecosystem based Marine Management, International Council for the Exploration of the Sea
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Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Fisheries Oceanography
ISSN (Print): 1054-6006
Ratings:
Shifts in North Sea forage fish productivity and potential fisheries yield

1. Forage fish populations support large scale fisheries and are key components of marine ecosystems across the world, linking secondary production to higher trophic levels. While climate-induced changes in the North Sea zooplankton community are described and documented in literature, the associated bottom-up effects and consequences for fisheries remain largely unidentified.

2. We investigated the temporal development in forage fish productivity and the associated influence on fisheries yield of herring, sprat, Norway pout and sandeel in the North Sea. Using principal component analysis, we analysed 40 years of recruitment success and growth proxies to reveal changes in productivity and patterns of synchrony across stocks (i.e. functional complementarity). The relationship between forage fish production and Calanus finmarchicus (an indicator of climate change) was also analysed. We used a population model to demonstrate how observed shifts in productivity affected total forage fish biomass and fisheries yield.

3. The productivity of North Sea forage fish changed around 1993 from a higher average productivity to lower average productivity. During the higher productivity period, stocks displayed a covariance structure indicative of functional complementarity. Calanus finmarchicus was positively correlated to forage fish recruitment, however, for growth, the direction of the response differed between species and time periods. Maximum sustainable yield (MSY) and the
associated fishing mortality (Fmsy) decreased by 33%–68% and 26%–64%, respectively, between the higher and lower productivity periods.

4. Synthesis and applications. The results demonstrate that fisheries reference points for short-lived planktivorous species are highly dynamic and respond rapidly to changes in system productivity. Furthermore, from an ecosystem-based fisheries management perspective, a link between functional complementarity and productivity, indicates that ecosystem resilience may decline with productivity. Based on this, we advise that system productivity, perhaps monitored as forage fish growth, becomes an integral part of management reference points; in both single species and ecosystem contexts. However, to retain social license of biological advice when fish catch opportunities are reduced, it is crucial that shifts in productivity are thoroughly documented and made apparent to managers and stakeholders.

**General information**

State: Accepted/In press
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Publication date: 2017

**Publication information**

Journal: Journal of Applied Ecology
ISSN (Print): 0021-8901
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 5.5 SJR 2.869 SNIP 2.008
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 3.242 SNIP 1.96 CiteScore 5.38
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 2.998 SNIP 2.171 CiteScore 5.25
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 3.031 SNIP 2.225 CiteScore 5.45
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 3.122 SNIP 2.089 CiteScore 5.18
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 3.665 SNIP 2.294 CiteScore 5.23
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 3.091 SNIP 2.014
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 3.22 SNIP 2.112
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 3.08 SNIP 2.252
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 3.494 SNIP 2.592
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 3.095 SNIP 2.385
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 3.124 SNIP 2.257
- Scopus rating (2004): SJR 2.709 SNIP 2.134
Towards ecosystem-based management: identifying operational food-web indicators for marine ecosystems

Modern approaches to Ecosystem-Based Management and sustainable use of marine resources must account for the myriad of pressures (interspecific, human and environmental) affecting marine ecosystems. The network of feeding interactions between co-existing species and populations (food webs) are an important aspect of all marine ecosystems and biodiversity. Here we describe and discuss a process to evaluate the selection of operational food-web indicators for use in evaluating marine ecosystem status. This process brought together experts in food-web ecology, marine ecology, and resource management, to identify available indicators that can be used to inform marine management. Standard evaluation criteria (availability and quality of data, conceptual basis, communicability, relevancy to management) were implemented to identify practical food-web indicators ready for operational use and indicators that hold promise for future use in policy and management. The major attributes of the final suite of operational food-web indicators were structure and functioning. Indicators that represent resilience of the marine ecosystem were less developed. Over 60 potential food-web indicators were evaluated and the final selection of operational food-web indicators includes: the primary production required to sustain a fishery, the productivity of seabirds (or charismatic megafauna), zooplankton indicators, primary productivity, integrated trophic indicators, and the biomass of trophic guilds. More efforts should be made to develop thresholds-based reference points for achieving Good Environmental Status. There is also a need for international collaborations to develop indicators that will facilitate management in marine ecosystems used by multiple countries.
Are FMSY ranges a promising or a dangerous option?

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Ulrich, C. (Intern), Rindorf, A. (Intern)
Publication date: 2016
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Journal article – Annual report year: 2017

A trans-Atlantic examination of haddock Melanogrammus aeglefinus food habits
The food habits of Melanogrammus aeglefinus were explored and contrasted across multiple north-eastern and north-western Atlantic Ocean ecosystems, using databases that span multiple decades. The results show that among all ecosystems, echinoderms are a consistent part of M. aeglefinus diet, but patterns emerge regarding where and when M. aeglefinus primarily eat fishes vs. echinoderms. Melanogrammus aeglefinus does not regularly exhibit the increase in piscivory with ontogeny that other gadoids often show, and in several ecosystems there is a lower occurrence of piscivory. There is an apparent inverse relationship between the consumption of fishes and echinoderms in M. aeglefinus over time, where certain years show high levels of one prey item and low levels of the other. This apparent binary choice can be viewed as part of a gradient of
prey options, contingent upon a suite of factors external to M. aeglefinus dynamics. The energetic consequences of this prey choice are discussed, noting that in some instances it may not be a choice at all.

**General information**

**State:** Published

**Organisations:** National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, National Oceanographic and Atmospheric Administration, PINRO, BioConsult Schuchardt & Scholle GbR, Institute of Marine Research, Bedford Institute of Oceanography, Thünen Institute of Sea Fisheries, Cefas, Johann Heinrich von Thünen-Institute

**Authors:** Tam, J. (Ekstern), Link, J. (Ekstern), Large, S. (Ekstern), Bogstad, B. (Ekstern), Bundy, A. (Ekstern), Cook, A. (Ekstern), Dingør, G. (Ekstern), Dolgov, A. (Ekstern), Howell, D. (Ekstern), Kempf, A. (Ekstern), Pinnegar, J. (Ekstern), Rindorf, A. (Intern), Schückel, S. (Ekstern), Sell, A. F. (Ekstern), Smith, B. (Ekstern)

**Pages:** 2203-2218

**Publication date:** 2016

**Main Research Area:** Technical/natural sciences

**Publication information**

**Journal:** Journal of Fish Biology

**Volume:** 88

**Issue number:** 6

**ISSN (Print):** 0022-1112

**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 1.57 SJR 0.741 SNIP 0.882
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.951 SNIP 0.935 CiteScore 1.64
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.944 SNIP 0.934 CiteScore 1.76
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 1.049 SNIP 1.118 CiteScore 1.98
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.93 SNIP 1.035 CiteScore 1.88
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 0.895 SNIP 0.946 CiteScore 1.66
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 0.774 SNIP 0.834
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 0.773 SNIP 0.891
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 0.883 SNIP 0.968
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 0.996 SNIP 1.06
Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes

The spatial distribution of marine fishes can change for many reasons, including density-dependent distributional shifts. Previous studies show mixed support for either the proportional-density model (PDM; no relationship between abundance and area occupied, supported by ideal-free distribution theory) or the basin model (BM; positive abundance–area relationship, supported by density-dependent habitat selection theory). The BM implies that fishes move towards preferred habitat as the population declines. We estimate the average relationship using bottom trawl data for 92 fish species from six marine regions, to determine whether the BM or PDM provides a better description for sea-bottom-associated fishes. We fit a spatio-temporal model and estimate changes in effective area occupied and abundance, and combine results to estimate the average abundance–area relationship as well as variability among taxa and regions. The average relationship is weak but significant (0.6% increase in area for a 10% increase in abundance), whereas only a small proportion of species–region combinations show a negative relationship (i.e. shrinking area when abundance increases). Approximately one-third of combinations (34.6%) are predicted to increase in area more than 1% for every 10% increase in abundance. We therefore infer that population density generally changes faster than effective area occupied during abundance changes. Gadiformes have the strongest estimated relationship (average 1.0% area increase for every 10% abundance increase) followed by Pleuronectiformes and Scorpaeniformes, and the Eastern Bering Sea shows a strong relationship between abundance and area occupied relative to other regions. We conclude that the BM explains a small but important portion of spatial dynamics for sea-bottom-associated fishes, and that many individual populations merit cautious management during population declines, because a compressed range may increase the efficiency of harvest.
Spatial differences in growth of lesser sandeel in the North Sea

Lesser sandeel, Ammodytes marinus, is a key prey to a variety of North Sea predators, including species such as single load seabirds which are highly sensitive to prey size and condition. Whilst differences in weight at age across the North Sea have been investigated previously, the scale and cause of this variation as well as the potential link to spatial differences in predator performance remains unknown. This study presents an analysis of spatial patterns in length and condition of the lesser sandeel in the North Sea and the relationship of these with physical and biological factors. Both mean length at age and condition was higher on warmer, deeper and central/northeastern fishing grounds. Sandeel in the water column exhibited large changes in condition over the season, having an initially low condition following spring emergence rising to a pronounced peak by June. Weight at age varied considerably both spatially and temporally, resulting in 4 fold and 1.9 fold variations in the number of sandeels required to obtain a specific weight, respectively. Hence, the value of sandeel as prey to single load predators varies considerably with values in central and northeastern North Sea being substantially higher than in northwestern and southern areas.
Aquatic Science, Ecology, Evolution, Behavior and Systematics, Condition, Length, Lesser sandeel, Spatial differences, Temperature, lesser sandeel, length, condition, temperature, spatial differences

Electronic versions:

Postprint

DOIs:

10.1016/j.jembe.2016.02.007
The MSY concept in a multi-objective fisheries environment – lessons learned from the North Sea

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Thünen Institute of Sea Fisheries, Imperial College London, University of Copenhagen, Wageningen IMARES, Wageningen University & Research, University of St Andrews
Authors: Kempf, A. (Ekstern), Mumford, J. (Ekstern), Levontin, P. (Ekstern), Leach, A. (Ekstern), Hoff, A. (Ekstern), Hamon, K. (Ekstern), Bartelings, H. (Ekstern), Vinther, M. (Intern), Staebler, M. (Ekstern), Poos, J. J. (Ekstern), Smout, S. (Ekstern), Frost, H. (Ekstern), van den Burg, S. (Ekstern), Ulrich, C. (Intern), Rindorf, A. (Intern)
Pages: 146-158
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Policy
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
Web of Science (2016): Indexed yes
Scopus rating (2016): CiteScore 2.7 SJR 1.335 SNIP 1.182
BFI (2015): BFI-level 2
Web of Science (2015): Indexed yes
Scopus rating (2015): SJR 1.591 SNIP 1.397 CiteScore 3.07
BFI (2014): BFI-level 2
Web of Science (2014): Indexed yes
Scopus rating (2014): SJR 1.438 SNIP 1.56 CiteScore 3.09
BFI (2013): BFI-level 1
Web of Science (2013): Indexed yes
Scopus rating (2013): SJR 1.472 SNIP 1.635 CiteScore 2.71
ISI indexed (2013): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.339 SNIP 1.495 CiteScore 2.54
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.406 SNIP 1.263 CiteScore 2.07
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.289 SNIP 1.483
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.947 SNIP 1.142
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.838 SNIP 1.417
Scopus rating (2007): SJR 0.927 SNIP 1.377
Web of Science (2007):Indexed yes
Scopus rating (2006): SJR 0.961 SNIP 2.043
Web of Science (2006): Indexed yes
Achieving Mixed-fisheries and multispecies MSY in the North Sea demersal fisheries

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Cefas, Marine Scotland Science
Authors: Ulrich, C. (Intern), Dolder, P. J. (Ekstern), Jardim, E. (Ekstern), Holmes, S. J. (Ekstern), Kempf, A. (Ekstern), Mortensen, L. O. (Intern), Poos, J. J. (Ekstern), Rindorf, A. (Intern), Vermard, Y. (Ekstern)
Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences
Links:
Publication: Research › Conference abstract for conference – Annual report year: 2015

A framework for managing fisheries with multiple economic, ecosystem and social objectives

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Wageningen IMARES, AquaMarine Advisers
Authors: Mumford, J. (Ekstern), Rindorf, A. (Intern), Reid, D. (Ekstern), Rossberg, A. (Ekstern), Röckmann, C. (Ekstern), Kempf, A. (Ekstern), Tserpes, G. (Ekstern), Maravelias, C. (Ekstern), Hopkins, C. C. (Ekstern), Hadjimichael, M. (Forskerdatabase)
Publication date: 2015
**Are 'pretty good yield' ranges precautionary?**

**General information**
- **State:** Published
- **Organisations:** National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Queen's University Belfast, Lund University
- **Publication date:** 2015
- **Event:** Abstract from ICES MYFISH Symposium, Athens, Greece.
- **Main Research Area:** Technical/natural sciences

**Beyond the Target Species: Future Consequences of MSY under different scenarios of change**

**General information**
- **State:** Published
- **Organisations:** National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, University of St Andrews, University of Copenhagen
- **Authors:** Smout, S. (Ekstern), Kempf, A. (Ekstern), Hoff, A. (Ekstern), Hamon, K. (Intern), Stabler, M. (Ekstern), Rindorf, A. (Intern), Northridge, S. (Ekstern)
- **Publication date:** 2015
- **Event:** Poster session presented at ICES MYFISH Symposium, Athens, Greece.
- **Main Research Area:** Technical/natural sciences

**Effect of spatial differences in growth on distribution of seasonally co-occurring herring Clupea harengus stocks**

The mechanisms most likely to determine the distribution of the two major herring Clupea harengus stocks in their common early summer feeding ground in the eastern North Sea, Skagerrak and Kattegat were investigated through analysis of acoustic survey data from six consecutive years. No change was detected in biomass of North Sea autumn spawning C. harengus (NSAS) over time, whereas the biomass of western Baltic spring spawning C. harengus (WBSS) declined severely. Analyses of centre of abundance by stock showed no change in NSAS distribution, whereas the WBSS changed to a more western distribution over time. Contrary to previous perception of the juvenile migration, NSAS were found to leave the study area at the age between 1 and 2 years and WBSS 1 year olds were encountered in the Skagerrak. The estimated parameters of von Bertalanffy growth equations showed marked differences between areas with fish in the eastern part of the area having the lowest size at age at all ages. Further, their growth conditions appeared to deteriorate progressively over the period studied. Both NSAS and WBSS showed the highest condition in the North Sea and Skagerrak while condition was substantially lower in age Kattegat. The westward movement of spring spawners over time suggests that growth rate and possibly density of conspecifics influence the migration pattern and distribution of C. harengus in the area. In contrast, there was no evidence to suggest that distribution was constant over time within stocks or that distribution reflected size-dependent limitations on migration distance.

**General information**
- **State:** Published
- **Organisations:** National Institute of Aquatic Resources, Section for Marine Living Resources, Section for Monitoring and Data, Section for Ecosystem based Marine Management
- **Authors:** Worsøe Clausen, L. (Intern), Stæhr, K. (Intern), Rindorf, A. (Intern), Mosegaard, H. (Intern)
- **Pages:** 228–247
- **Publication date:** 2015
- **Main Research Area:** Technical/natural sciences

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

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Bastardie, F. (Intern), Nielsen, J. R. (Intern), Rindorf, A. (Intern), Eero, M. (Intern)
Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences

Empowering fishermen towards the landing obligations, with their own technical solutions

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Monitoring and Data
Authors: Mortensen, L. O. (Intern), Olesen, H. J. (Intern), Egekvist, J. (Intern), Rindorf, A. (Intern), Ulrich, C. (Intern)
Publication date: 2015
Event: Abstract from Conference of the European Association of Fisheries Economists, Salerno, Italy.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

Estimering af zooplankton dødelighed i en 3D økosystemmodel ved at anvende en rumlig- og tidslig varierende fiskeprædation

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, Aarhus University, Danish Meteorological Institute
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Publication date: 2015
Event: Abstract from 18. Danske Havforskermøde, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

Identifying marine pelagic ecosystem management objectives and indicators
International policy frameworks such as the Common Fisheries Policy and the European Marine Strategy Framework Directive define high-level strategic goals for marine ecosystems. Strategic goals are addressed via general and operational management objectives. To add credibility and legitimacy to the development of objectives, for this study stakeholders explored intermediate level ecological, economic and social management objectives for Northeast Atlantic pelagic ecosystems. Stakeholder workshops were undertaken with participants being free to identify objectives based on their own insights and needs. Overall 26 objectives were proposed, with 58% agreement in proposed objectives between two workshops. Based on published evidence for pressure-state links, examples of operational objectives and suitable indicators for each of the 26 objectives were then selected. It is argued that given the strong species-specific links of pelagic species with the environment and the large geographic scale of their life cycles, which contrast to demersal systems, pelagic indicators are needed at the level of species (or stocks) independent of legislative region. Pelagic community indicators may be set at regional scale in some cases. In the evidence-based approach used in this study, the selection of species or region specific operational objectives and indicators was based on demonstrated pressure-state links. Hence observed changes in indicators can reliably inform on appropriate management measures. (C) 2015 Elsevier
Larval grazing on zooplankton from a spatial model of the North Sea larval community

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources, Section for Ecosystem based Marine Management, Aarhus University, Danish Meteorological Institute
Authors: Christensen, A. (Intern), Maar, M. (Ekstern), Rindorf, A. (Intern), Møller, E. F. (Ekstern), Madsen, K. S. (Ekstern), Deurs, M. V. (Intern)
Publication date: 2015
Event: Abstract from 18. Danske Havforskermøde, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

Lost in translation: Increased complexity in management results in lost pelagic catch opportunities

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Living Resources, Wageningen IMARES
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Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

MSY ranges in a multispecies stochastic model environment

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Vinther, M. (Intern), Rindorf, A. (Intern), Kempf, A. (Ekstern)
Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

Optimal bæredygtig udnyttelse af tilgængelige torskebestande for dansk fiskeri
Relaxing technical regulations under the Landings Obligation – effects on the discard ratio

The landings obligation (LO), currently being implemented in the new CFP, puts major constraints on fishers, by making the landing of unwanted catch mandatory. Less restrictive technical rules (TR) in a results-based management frame have been suggested as a mechanism to release some of these constraints. To investigate the effects of the existing TR, some fishers were relaxed from TR during the trial and could freely choose and develop alternative gears, aiming to optimize annual catch value, while reducing discards. The study included 14 demersal fishing vessels, operating in the North Sea, Skagerrak and the Baltic Sea. Fishers used test and control gears interchangeably or in pairs and were required to sort and weight all discard of seven common target species on a haul by haul basis. All vessels were equipped for Fully Documented Fisheries, including cameras. Collected data were analyzed to investigate differences in landings, discards, discard ratio, CPUE, VPUE and DPUE, between conventional (control) and new gears (test). The results showed a varying degree of success, depending both on area and on choices made by the individual fisher. The best results were observed in the Baltic Sea, where relaxing technical rules led to major improvements in fishing patterns. But gear changes did not contribute much in fisheries where initial discards rates were already low.

Surveillance indicators and their use in implementation of the Marine Strategy Framework Directive

The European Union Marine Strategy Framework Directive (MSFD) uses indicators to track ecosystem state in relation to Good Environmental Status (GES). These indicators were initially expected to be “operational”, i.e. to have well-understood relationships between state and specified anthropogenic pressure(s), and to have defined targets. Recent discussion on MSFD implementation has highlighted an additional class of “surveillance” indicators. Surveillance indicators monitor key aspects of the ecosystem for which there is: first, insufficient evidence to define targets and support formal state assessment; and/or second, where links to anthropogenic pressures are either weak or not sufficiently well understood to underpin specific management advice. Surveillance indicators are not only expected to directly track state in relation to GES, but also to provide complementary information (including warning signals) that presents a broader and more holistic picture of state, and inform and support science, policy, and management. In this study, we (i) present a framework for including surveillance indicators into the Activity–Pressure–State–Response process, (ii) consider a range of possible indicators that could perform this surveillance role, and (iii) suggest
criteria for assessing the
derformance of candidate surveillance indicators, which might guide selection of the most effective indicators to perform
this function

**General information**

*State:* Published  
*Organisations:* National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Marine Scotland Science, Wageningen IMARES, International Council for the Exploration of the Sea, Queen's University Belfast  
*Authors:* Shephard, S. (Ekstern), Greenstreet, S. P. R. (Ekstern), Piet, G. J. (Ekstern), Rindorf, A. (Intern), Dickey-Collas, M. (Intern)  
*Pages:* 2269-2277  
*Publication date:* 2015  
*Main Research Area:* Technical/natural sciences

**Publication information**

*Journal:* ICES Journal of Marine Science  
*Volume:* 72  
*Issue number:* 8  
*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  
  - Web of Science (2008): Indexed yes  
  - Web of Science (2007): Indexed yes  
  - Web of Science (2006): Indexed yes  
  - Web of Science (2005): Indexed yes  
  - Web of Science (2004): Indexed yes  
  - Web of Science (2003): Indexed yes  
  - Web of Science (2002): Indexed yes
Surveillance indicators and their use in implementation of the Marine Strategy Framework Directive

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Marine Scotland Science, Wageningen IMARES, International Council for the Exploration of the Sea, Queen's University Belfast
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Number of pages: 1
Publication date: 2015
Event: Abstract from ICES Annual Science Conference 2015, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences

The MSY concept in a multi-objective fisheries environment – lessons learned from the North Sea

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Wageningen IMARES, University of St Andrews, University of Copenhagen
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Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences

Ups and downs in the cooperation between Danish fishers and scientists

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Danish Fishermen's Producers' Organization
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Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences

What is it we want to maximise and sustain in Maximum Sustainable Yield?

General information
State: Published
What is MSY when stock productivity shifts? A worked example from the North Sea

General information
State: Published
Authors: Worsøe Clausen, L. (Intern), Rindorf, A. (Intern), Deurs, M. V. (Intern), Vinther, M. (Intern), Dickey-Collas, M. (Ekstern), Hintzen, N. (Ekstern)
Publication date: 2015
Event: Abstract from ICES MYFISH Symposium, Athens, Greece.
Main Research Area: Technical/natural sciences
Links:
Publication: Research › Conference abstract for conference – Annual report year: 2015

Achieving MSY and minimising conflicts in mixed-fisheries management

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Cefas, University of Copenhagen
Authors: Ulrich, C. (Intern), Dolder, P. J. (Ekstern), Hoff, A. (Ekstern), Kempf, A. (Ekstern), Poos, J. (Ekstern), Rindorf, A. (Intern), Vermard, Y. (Ekstern)
Number of pages: 15
Publication date: 2014
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2015

Assessing the state of pelagic fish communities within an ecosystem approach and the European Marine Strategy Framework Directive

Pelagic fish are key elements in marine foodwebs and thus comprise an important part of overall ecosystem health. We develop a suite of ecological indicators that track pelagic fish community state and evaluate state of specific objectives against Good Environmental Status (GES) criteria. Indicator time-series are calculated for the EU Marine Strategy Framework Directive “Celtic Seas” (CS) and “Greater North Sea” subregions. Precautionary reference points are proposed for each indicator and a simple decision process is then used to aggregate indicators into a GES assessment for each subregion. The pelagic fish communities of both subregions currently appear to be close to GES, but each remains vulnerable. In the CS subregion, fishing mortality is close to the precautionary reference point, although the unknown dynamics of sandeel, sprat, and sardine in the subregion may reduce the robustness of this evaluation. In the North Sea, sandeel stocks have been in poor state until very recently. Pelagic fish community biomass is slightly below the precautionary reference point in both subregions

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Queen's University Belfast, International Council for the Exploration of the Sea, Wageningen IMARES, Marine Institute
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Pages: 1572-1585
Publication date: 2014
Does copepod size determine food consumption of particulate feeding fish?

The climate-induced reduction in the mean copepod size, mainly driven by a decrease in the abundance of the large Calanus finmarchicus around 1987, has been linked to the low survival of fish larvae in the North Sea. However, to what extent this sort of reduction in copepod size has any influence on adult particulate feeding fish is unknown. In the present study, we investigated the hypothesis that the availability of the large copepods determines food consumption and growth
conditions of lesser sandeel (Ammodytes marinus) in the North Sea. Analysis of stomach content suggested that food consumption is higher for fish feeding on large copepods, and additional calculations revealed how handling time limitation may provide part of the explanation for this relationship. Comparing stomach data and zooplankton samples indicated that lesser sandeel actively target large copepods when these are available. Finally, we observed that the length of lesser sandeel began to decrease in the late 1980s, simultaneously with the C. finmarchicus decline.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources, Centre for Ocean Life, Section for Ecosystem based Marine Management
Authors: Deurs, M. V. (Intern), Koski, M. (Intern), Rindorf, A. (Intern)
Pages: 35-43
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES Journal of Marine Science
Volume: 71
Issue number: 1
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
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Ecosystem-based management objectives for the North Sea: riding the forage fish rollercoaster

The North Sea provides a useful model for considering forage fish (FF) within ecosystem-based management as it has a complex assemblage of FF species. This paper is designed to encourage further debate and dialogue between stakeholders about management objectives. Changing the management of fisheries on FF will have economic consequences for all fleets in the North Sea. The predators that are vulnerable to the depletion of FF are Sandwich terns, great skua and common guillemots, and to a lesser extent, marine mammals. Comparative evaluations of management strategies are required to consider whether maintaining the reserves of prey biomass or a more integral approach of monitoring mortality rates across the trophic system is more robust under the ecosystem approach. In terms of trophic energy transfer, stability, and resilience of the ecosystem, FF should be considered as both a sized-based pool of biomass and as species components of the system by managers and modellers. Policy developers should not consider the knowledge base robust enough to embark on major projects of ecosystem engineering. Management plans appear able to maintain sustainable exploitation in the short term. Changes in the productivity of FF populations are inevitable so management should remain responsive and adaptive.
Forage fish, their fisheries, and their predators: who drives whom?
The North Sea has a diverse forage fish assemblage, including herring, targeted for human consumption; sandeel, sprat, and Norway pout, exploited by industrial fisheries; and some sardine and anchovy, supporting small-scale fisheries. All show large abundance fluctuations, impacting on fisheries and predators. We review field, laboratory, and modelling studies to investigate the drivers of this complex system of forage fish. Climate clearly influences forage fish productivity; however, any single-species considerations of the influence of climate might fail if strong interactions between forage fish exist, as in the North Sea. Sandeel appears to be the most important prey forage fish. Seabirds are most dependent on forage fish, due to specialized diet and distributional constraints (breeding colonies). Other than fisheries, key predators of forage fish are a few piscivorous fish species including saithe, whiting, mackerel, and horse-mackerel, exploited in turn by fisheries; seabirds and seals have a more modest impact. Size-based foodweb modelling suggests that reducing fishing mortality may not necessarily lead to larger stocks of piscivorous fish, especially if their early life stages compete with forage fish for zooplankton resources. In complex systems, changes in the impact of fisheries on forage fish may have potentially complex (and perhaps unanticipated) consequences on other commercially and/or ecologically important species.
Integrated assessment of marine biodiversity status using a prototype indicator-based assessment tool

Integrated assessment of the status of marine biodiversity is and has been problematic compared to, for example, assessments of eutrophication and contamination status, mostly as a consequence of the fact that monitoring of marine habitats, communities and species is expensive, often collected at an incorrect spatial scale and/or poorly integrated with existing marine environmental monitoring efforts. The objective of this Method Paper is to introduce and describe a simple tool for integrated assessment of biodiversity status based on the HELCOM Biodiversity Assessment Tool (BEAT), where interim biodiversity indicators are grouped by themes: broad-scale habitats, communities, and species as well as supporting non-biodiversity indicators. Further, we report the application of an initial indicator-based assessment of biodiversity status of Danish marine waters where we have tentatively classified the biodiversity status of Danish marine waters. The biodiversity status was in no areas classified as “unaffected by human activities.” In all the 22 assessment areas, the status was classified as either “moderately affected by human activities” or “significantly affected by human activities.” Spatial variations in the biodiversity status were in general related to the eutrophication status as well as fishing pressure.
Minimising conflicts in mixed-fisheries management using flexible Harvest Control Rules

Grey seals (Halichoerus grypus) are adaptable generalist predators whose diet includes commercial fish species such as cod. Consumption by the seals may reduce the size of some fish stocks or have an adverse effect on stock recovery programmes, especially because predation may trap sparse prey populations in a “predator pit”. To assess the likely impact of such effects, it is important to know how consumption and consequent predation mortality respond to the changing availability of prey. We present a model of grey seal consumption as a function of the availability of multiple prey types [a Multi-Species Functional Response (MSFR)]. We fit this MSFR to data on seal diet and prey availability (based on the overlap between the distributions of predators and prey). Bayesian methodology was employed to account for uncertainties in both dependent and independent variables, improve estimation convergence by the use of informative priors, and allow the estimation of missing data on prey availability. Both hyperbolic (Type 2) and sigmoidal (Type 3) functional response models were fitted to the data and the Type 3 model was clearly favoured during model selection, supporting the conclusion that seal–prey encounter rates change with prey abundance (sometimes referred to as “switching”). This suggests that some prey species may be vulnerable to predator pit effects. The fitted model reproduced contrasts in diet observed between different regions/years and, importantly, added information to the prior distributions of prey abundance in areas where the availability of some prey species (such as sandeels) was not known. This suggests that the diet of predators such as seals could provide information about the abundance and distribution of prey in areas that are not covered by fisheries and research surveys.
Zooplankton mortality in 3D ecosystem modelling considering variable spatial–temporal fish consumptions in the North Sea

We tested the feasibility of imposing mesozooplankton mortality into a 3D model based on estimated consumption rates of the dominant planktivorous fish in the North Sea-Kattegat area. The spatial biomass distribution of Atlantic herring (Clupea harengus), horse mackerel (Trachurus trachurus), Atlantic mackerel (Scomber scombrus), sandeel (Ammodytidae) and European sprat (Sprattus sprattus) was derived from quarterly scientific trawl surveys and Danish commercial catches. Spatio-temporal indices of mortality were created based on the estimated biomasses and ingestion rates from the literature. The fish larvae grazing pressure was obtained from a spatial, size-based larval community model. In this model, larvae, herring and sandeel were the most important fish predators on mesozooplankton, but these groups had different spatial and temporal (seasonal) distributions. Fish larvae were particularly dominant in the eastern and southern areas in early summer. Herring and sandeel had the highest consumption in the central and north-western areas and were more important in late summer. The fish index changed the perceived annual, seasonal and spatial patterns in modelled mesozooplankton biomass, production and mortality. In the present study, the index was kept relatively simple and can be further developed with respect to the description of fish as well carnivorous zooplankton ingestion rates. The data input required to create the fish index is i) planktivorous fish stock biomasses and ii) relative fish spawning distribution information and iii) physics (ocean currents and temperatures) for the region and situation of interest. The fish index seems promising as a realistic mortality term for lower trophic levels in 3D ecosystem models in areas with available data on fish stocks to improve management of marine resources.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Maar, M. (Ekstern), Rindorf, A. (Intern), Møller, E. F. (Ekstern), Christensen, A. (Intern), Madsen, K. S. (Ekstern), Deurs, M. V. (Intern)
Pages: 78-91
Publication date: 2014
Main Research Area: Technical/natural sciences
Publication information
Journal: Progress in Oceanography
Volume: 124
ISSN (Print): 0079-6611
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 3.4 SJR 1.922 SNIP 1.278
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.703 SNIP 1.348 CiteScore 3.34
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.909 SNIP 1.461 CiteScore 3.65
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.397 SNIP 1.595 CiteScore 3.87
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.741 SNIP 1.794 CiteScore 4.17
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.279 SNIP 1.341 CiteScore 3.41
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.643 SNIP 1.586
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.669 SNIP 1.829
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.065 SNIP 1.422
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.859 SNIP 1.503
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.551 SNIP 1.175
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.619 SNIP 1.839
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.526 SNIP 1.571
Scopus rating (2003): SJR 2.523 SNIP 1.658
Scopus rating (2002): SJR 2.168 SNIP 1.807
Scopus rating (2001): SJR 2.389 SNIP 1.732
Scopus rating (2000): SJR 1.924 SNIP 1.245
Scopus rating (1999): SJR 2.094 SNIP 1.268
Original language: English
DOIs:
10.1016/j.pocean.2014.03.002
Publication: Research - peer-review » Journal article – Annual report year: 2014
Identifying pelagic ecosystem indicators for management
When exploiting fish populations under the ecosystem approach, aiming for MSY is not necessarily sufficient to ensure wider ecosystem sustainability. All of the large stocks of pelagic fish are managed through harvest control rules based on an MSY approach. Ensuring good environmental status will probably require further constraints to be imposed by management. Most of the current paradigm with regards to GES for fisheries has been based on demersal fish. Pelagic fisheries and fish are operationally and biologically respectively different. We use the example of applying the ecosystem approach to pelagic fisheries to further explore the setting of management objectives. The objectives were identified through a participatory process including industry, management, scientist and NGO representatives. These objectives were used to identify appropriate driver, pressure and state indicators. The links between objectives and indicators were explored for a range of examples highlighting the importance of the biology and the interaction between the pelagic ecosystem and humans. Considering MSY targets alone will not fulfill GES objectives with regards to e.g. genetic, phenotypic, and behavioural dimensions. The MSY approach also does not consider specifically habitat and bycatch concerns.
Patchy zooplankton grazing and high energy conversion efficiency: ecological implications of sandeel behavior and strategy

Sandeel display strong site-fidelity, and spend most of their life buried in the seabed. This strategy carries important ecological implications. Sandeels save energy when they are not foraging but in return are unable to move substantially and therefore possibly are sensitive to local depletion of prey. Here we studied zooplankton consumption and energy conversion efficiency of lesser sandeel (Ammodytes marinus) in the central North Sea, using stomach data, length and weight-at-age data, bioenergetics, and hydrodynamic modeling. The results suggested: (i) Lesser sandeel in the Dogger area depend largely on relatively large copepods in early spring. (ii) Lesser sandeel is an efficient converter making secondary production into fish tissue available for higher trophic levels. Hence, changes in species composition towards a more herring dominated system, as seen in recent times, may lead to a decrease in system transfer efficiency. (iii) Sandeels leave footprints in the standing copepod biomass as far as 100 km from the edge of their habitat, but smaller and more isolated sandeel habitat patches have a much lower impact than larger patches, suggesting that smaller habitats can sustain higher sandeel densities and growth rates per area than larger habitats.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources, Section for Ecosystem based Marine Management
Authors: Deurs, M. V. (Intern), Christensen, A. (Intern), Rindorf, A. (Intern)
Pages: 123-133
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Ecology - Progress Series
Volume: 487
ISSN (Print): 0171-8630
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 2.4
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.56
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.9
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
Seabirds maintain offspring provisioning rate despite fluctuations in prey abundance: A multi-species functional response for guillemots in the North Sea

1. Seabirds that consume more than one prey type may adjust their foraging to maintain provisioning rates for their chicks. How energetically effective are these strategies, and what are the implications for the management of seabirds and their marine habitat? 2. A multi-species functional response links consumption rates to the availability of multiple prey types, but fitting multi-species functional responses to field data can be difficult, requiring consumption measurements over a range of different prey abundances. Such detailed data may be especially difficult to obtain in marine ecosystems. 3. We used annual time-series data on chick provisioning for the common guillemot Uria aalge together with abundance indices for its two main prey (lesser sandeel Ammodytes marinus and sprat Sprattus sprattus) to parameterize a multi-species functional response for parents provisioning chicks at a major North Sea colony from 1992 to 2005.
4. The fitted model reproduced changes in diet and consumption rate which were consistent with changes in local prey abundance including a long-term decline in sandeels. The model predicted that energy intake by chicks would be more sensitive to changes in sprat abundance than sandeel abundance. Guillemots appeared able to adjust their foraging tactics over a wide range of prey abundances to maintain a consistent energetic intake rate for chicks.
5. Synthesis and applications. Our results suggest guillemot chicks obtain adequate calorific intake from their parents despite fluctuating prey abundances, conferring some resilience in the face of environmental variation. The parameterized multi-species functional response model can be used to estimate levels of severe prey shortage that compromise provisioning. It also enables us to interpret predator consumption rates so that these can be used as a metric of prey availability. Further, quantifying trophic links between marine prey and apex predators is needed to support the development of multi-species models in which the predators can be included. Such models are needed as tools to effectively manage the marine ecosystem, taking into account the objectives of fishing, conservation and the need to maintain Good Environmental Status.
The future of sustainable harvesting strategies

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Authors: Döring, R. (Ekstern), Fernández, C. (Ekstern), Hjørleifsson, E. (Ekstern), Rindorf, A. (Intern)

DOI: 10.1111/1365-2664.12095
Publication: Research - peer-review › Journal article – Annual report year: 2013
To eat glass or fish, that is the question: A Trans-Atlantic examination of haddock (Melanogrammus aeglefinus) food habits

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, National Oceanographic and Atmospheric Administration, Institute of Marine Research, Bedford Institute of Oceanography, Thünen Institute of Sea Fisheries, Cefas, Senckenberg am Meer, Dept. Marine Science
Authors: Link, J. (Ekstern), Bogstad, B. (Ekstern), Bundy, A. (Ekstern), Cook, A. (Ekstern), Dingser, G. (Ekstern), Howell, D. (Ekstern), Lucey, S. (Ekstern), Kempf, A. (Ekstern), Pinnegar, J. (Ekstern), Rindorf, A. (Intern), Schückel, S. (Ekstern), Smith, B. (Ekstern)
Publication date: 2013
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2013

Estimating the relationship between abundance and distribution
Numerous studies investigate the relationship between abundance and distribution using indices reflecting one of the three aspects of distribution: proportion of area occupied, aggregation, and geographical range. Using simulations and analytical derivations, we examine whether these indices provide unbiased estimates of the relationship when estimated from count data. The indices investigated include the proportion of empty samples, the proportion of structurally empty samples, Lloyds index of patchiness, measures derived from Lorenz curves (such as D95 and the Gini index), and measures based on Euclidean distance to the centre of gravity of the spatial distribution. Only the proportion of structurally empty areas, Lloyds index, and indices of the distance to the centre of gravity of the spatial distribution are unbiased at all levels of abundance. The remaining indices generate relationships between abundance and distribution even in cases where no underlying relationships exists, although the problem decreases for measures derived from Lorenz curves when samples contain more than four individuals on average. To illustrate the problem, the indices are applied to juvenile North Sea cod, Gadus morhua.
Explaining growth variation over large spatial scales: Effects of temperature and food on walleye growth

Most fishes exhibit strong spatial variation in growth. Because fish growth and production are tightly linked, quantifying and explaining variation in growth can mean the difference between successful management and unforeseen collapse. However, disentangling the factors that are responsible for among-lake variation in growth (e.g., food and temperature) has proved very difficult. Here, we use length at age and temperature data from hundreds of water bodies between 44⁰N to 53⁰N latitude to explain variation in immature growth of walleye (Sander vitreus), one of the most economically valuable freshwater fish species in North America. We then use length at age data from yellow perch (Perca flavescens) to identify the mechanisms behind the remaining variation in the length at age – temperature relationship for walleye. A positive perch – walleye relationship indicates that the mechanism behind the variation is productivity and a negative relationship indicates density-dependence. We found that variation in walleye growth among water bodies is largely explained by food productivity - not density-dependence. These results suggest that we can’t detect density-dependence among lakes when density-dependent effects are swamped by differences in productivity.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Population Ecology and Genetics, University of Minnesota, Ontario Ministry of Natural Resources
Authors: Mosgaard, T. (Intern), Venturelli, P. (Ekstern), Lester, N. P. (Ekstern), Gislason, H. (Intern), Rindorf, A. (Intern)
Publication date: 2012

Setting maximum sustainable yield targets when yield of one species affects that of other species

The exploitation of interacting stocks requires management targets beyond and more complex than the usual single-species versions. As the yield of one species can affect that of another, stocks can no longer be managed independently and the yield of one species must be weighed against that of other species. But how should we prioritize and identify most appropriate targets? Do we prefer to maximize by focusing on total yield in biomass across species, or are other measures targeting maximization of profits or preserving high living qualities more relevant? And how do we ensure that targets remain not only relevant but also consistent with ecosystem, economic, and social dimensions of sustainability and that they will gain a wide acceptance with scientists, the fishing industry, managers, and other stakeholders? Here, we present results of a MYFISH workshop bringing together a total of 70 scientists, industry, managers, and NGO representatives. The workshop was designed to identify variants of maximum sustainable yield (MSY) which account for the necessary trade-offs and estimate the preferences of the workshop participants for each of these variants across five regional groups: the Baltic Sea, Mediterranean, North Sea, western European waters, and widely ranging pelagic stocks in European waters. During a well-prepared process designed in this workshop, the participants contributed with a broad variety of knowledge and perceptions, and in our view allowed an understanding of MSY in a much broader and consensual way than is
Tobis skrabetog viser lave forekomster af tobis

Torsk og klima: Hvordan påvirker klimaændringerne torskken i Nordsøen?

Consumption of fish by top predators in the North Sea
How does prey availability affect the provisioning of chicks by parent birds? A functional response for guillemots in the North Sea

Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery
Spatial selection of sandeel (Ammodytes marinus) by grey seals (Halichoerus grypus)

General information
State: Published
Organisations: Section for Population Ecology and Genetics, National Institute of Aquatic Resources
Authors: Aarts, G. (Ekstern), Brasseur, S. (Ekstern), Rindorf, A. (Intern), Smout, S. (Ekstern), Dickey-Collas, M. (Ekstern), Matthiopoulus, J. (Ekstern)
Publication date: 2011
Event: Abstract from ICES Council Meeting 2011, Gdansk, Poland.
Main Research Area: Technical/natural sciences
Source-ID: 314462
Publication: Research › Conference abstract for conference – Annual report year: 2011

Comparative analysis of marine ecosystems: workshop on predator-prey interactions
Climate and human influences on marine ecosystems are largely manifested by changes in predator–prey interactions. It follows that ecosystem-based management of the world's oceans requires a better understanding of food web relationships. An international workshop on predator–prey interactions in marine ecosystems was held at the Oregon State University, Corvallis, OR, USA on 16–18 March 2010. The meeting brought together scientists from diverse fields of expertise including theoretical ecology, animal behaviour, fish and seabird ecology, statistics, fisheries science and ecosystem modelling. The goals of the workshop were to critically examine the methods of scaling-up predator–prey interactions from local observations to systems, the role of shifting ecological processes with scale changes, and the complexity and organizational structure in trophic interactions.

General information
State: Published
Organisations: Section for Population Ecology and Genetics, National Institute of Aquatic Resources
Authors: Bailey, K. M. (Ekstern), Ciannelli, L. (Ekstern), Hunsicker, M. (Ekstern), Rindorf, A. (Intern), Neuenfeldt, S. (Intern), Möllmann, C. (Ekstern), Guichard, F. (Ekstern), Huse, G. (Ekstern)
Spatial differences in natural mortality of North Sea gadoids

General information
Do North Sea cod (Gadus morhua) fisheries maintain high catch rates at low stock size?

This study presents all investigation of the relationship between stock size of North Sea cod (Gadus morhua) and catch rates in seven commercial fishing fleets. The shape of the relationship was estimated using a model allowing both density-dependent changes in catchability and bias in the assessment biomass estimates. Catchability in fisheries targeting a mixed species composition either remained constant or decreased with decreasing stock size, whereas catchability in targeted cod fisheries increased with decreasing stock size. However, even in the cases where catchability increased, the change was insufficient to compensate for the decrease in stock size, and catch rates of all fleets decreased. Two factors that could lead to nonconstant catchability were investigated: (i) the presence of decoupling between stock size and density ill high-density areas and (ii) the presence of concurrent shifts in the spatial distribution of the cod stock and the cod fishery. No evidence of the former was found but there was a northern shift in the spatial distribution of both effort and the cod stock.
ISSN (Print): 0706-652X

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 2.56 SJR 1.322 SNIP 1.163
Web of Science (2016): Indexed yes

BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.256 SNIP 1.051 CiteScore 2.22
Web of Science (2015): Indexed yes

BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.443 SNIP 1.379 CiteScore 2.6
Web of Science (2014): Indexed yes

BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.421 SNIP 1.081 CiteScore 2.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes

BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.324 SNIP 1.196 CiteScore 2.29
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes

BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.423 SNIP 1.09 CiteScore 2.13
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes

BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.425 SNIP 1.118
Web of Science (2010): Indexed yes

BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.451 SNIP 1.196
Web of Science (2009): Indexed yes

BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.589 SNIP 1.379
Web of Science (2008): Indexed yes

Scopus rating (2007): SJR 1.621 SNIP 1.236
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

Scopus rating (2003): SJR 2.097 SNIP 1.622
Scopus rating (2002): SJR 1.909 SNIP 1.457
Web of Science (2002): Indexed yes

Scopus rating (2001): SJR 1.769 SNIP 1.46
Web of Science (2001): Indexed yes

Scopus rating (2000): SJR 1.5 SNIP 1.464
Web of Science (2000): Indexed yes

Scopus rating (1999): SJR 1.928 SNIP 1.436
Growth, temperature and density relationships of North Sea cod (Gadus morhua)

This study presents an analysis of the relationship between ambient temperature, cod density, fishing mortality, prey fish biomass, and growth of North Sea cod (Gadus morhua) as estimated from survey catches during the period from 1983 to 2006. Growth of young cod was positively related to temperature; however, although temperature increased, distribution of 1-year-olds changed concurrently and no increase in length at age 1 occurred. Growth from age 1 to age 2 decreased as ambient biomass of sandeel and density of cod decreased, whereas growth of cod older than 2 years decreased with increasing density of cod and increased with increasing biomass of demersal fish prey. Though growth of juveniles was strongly positively correlated to ambient temperature, no indication of direct temperature limitation of growth of older North Sea cod was found.
Prey switching of cod and whiting in the North Sea

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern), Gislason, H. (Intern), Lewy, P. (Intern)
Pages: 243-253
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Ecology - Progress Series
Volume: 325
ISSN (Print): 0171-8630
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 2.4
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Warm, windy winters drive cod north and homing of spawners keeps them there

1. Climatic and anthropogenic effects often interact leading to unexpected results. For example, climate may lead to a change in the spatial distribution of a fish stock and thereby its vulnerability to exploitation. The North Sea cod stock is currently under pressure from both environmental change and human exploitation. This stock has experienced a series of poor recruitments since the late 1990s and, concomitant with the decrease in abundance, the distribution of cod has changed. While it has been suggested that the change in distribution can be linked to increasing temperatures and fishing pressure, there is little evidence for this hypothesis. 2. Using winter and summer survey catches, we investigated whether a directional shift in the distribution of cod has taken place over the years 1983-2003. We then examined whether the change could be linked to climatic conditions, fishing mortality, stock size or limited directional movement of cod. Using the derived models, we investigated whether fishing has increased the sensitivity of the cod population to climate-induced distribution changes. 3. A series of winters characterized by high temperatures and southerly winds during the egg and larval phases of cod led to a northward shift in the distribution of recently settled cod. A concomitant northern shift of mature fish around the time of spawning was linked directly to a tendency for northerly distributed juveniles to remain northerly throughout their life. This shift of the spawners further augmented that of the new recruits. 4. Although fishing mortality on a North Sea scale was not directly correlated with the displacement of any of the age groups, fishing has severely decreased the number of fish in older age groups. This increased the sensitivity of the distribution of the cod stock to climatic changes. 5. Synthesis and applications. The centre of gravity of North Sea cod has moved north as a result of the effect of a series of warm, windy winters on the distribution of recently settled cod. The shift was followed by a northwards shift in the distribution of older age groups. Unless a series of cold and calm years combined with a reduced mortality in the southern areas allows a southern spawning population to rebuild, the cod stock is unlikely to return to its previous area of distribution. Furthermore, protecting adult cod mainly in northern areas is unlikely to result in
improved recruitment to the southern North Sea.

**General information**

State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern), Lewy, P. (Intern)
Pages: 445-453
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Applied Ecology
Volume: 43
Issue number: 3
ISSN (Print): 0021-8901

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 5.5 SJR 2.869 SNIP 2.008
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.242 SNIP 1.96 CiteScore 5.38
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.998 SNIP 2.171 CiteScore 5.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.031 SNIP 2.225 CiteScore 5.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.122 SNIP 2.089 CiteScore 5.18
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.665 SNIP 2.294 CiteScore 5.23
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.091 SNIP 2.014
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.22 SNIP 2.112
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.08 SNIP 2.252
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.494 SNIP 2.592
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.095 SNIP 2.385
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.124 SNIP 2.257
Scopus rating (2004): SJR 2.709 SNIP 2.134
Scopus rating (2003): SJR 3.09 SNIP 2.121
Scopus rating (2002): SJR 2.682 SNIP 1.744
Scopus rating (2001): SJR 2.128 SNIP 1.69
Scopus rating (2000): SJR 1.935 SNIP 1.523
Scopus rating (1999): SJR 1.663 SNIP 1.56
Functional and aggregative response of North Sea whiting

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern), Gislason, H. (Intern)
Pages: 1-19
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Experimental Marine Biology and Ecology
Volume: 324
Issue number: 1
ISSN (Print): 0022-0981
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 2.03 SJR 0.937 SNIP 0.914
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.043 SNIP 0.823 CiteScore 1.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.145 SNIP 1.045 CiteScore 2.41
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.294 SNIP 1.08 CiteScore 2.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.186 SNIP 1.021 CiteScore 2.27
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.067 SNIP 1.007 CiteScore 2.14
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.239 SNIP 1.017
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.299 SNIP 1.208
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Bias in estimating food consumption of fish from stomach-content analysis

This study presents an analysis of the bias introduced by using simplified methods to calculate food intake of fish from stomach contents. Three sources of bias were considered: (1) the effect of estimating consumption based on a limited number of stomach samples, (2) the effect of using average contents derived from pooled stomach samples rather than individual stomachs, and (3) the effect of ignoring biological factors that affect the evacuation of prey. Estimating consumption from only two stomach samples yielded results close to the actual intake rate in a simulation study. In contrast to this, a serious positive bias was introduced by estimating food intake from the contents of pooled stomach
samples. An expression is given that can be used to correct analytically for this bias. A new method, which takes into account the distribution and evacuation of individual prey types as well as the effect of other food in the stomach on evacuation, is suggested for estimating the intake of separate prey types. Simplifying the estimation by ignoring these factors biased estimates of consumption of individual prey types by up to 150% in a data example.

**General information**

State: Published  
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources  
Authors: Rindorf, A. (Intern), Lewy, P. (Intern)  
Pages: 2487-2498  
Publication date: 2004  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Canadian Journal of Fisheries and Aquatic Sciences  
Volume: 61  
Issue number: 12  
ISSN (Print): 0706-652X  
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  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2016): CiteScore 2.56 SJR 1.322 SNIP 1.163  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 1.256 SNIP 1.051 CiteScore 2.22  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 1.443 SNIP 1.379 CiteScore 2.6  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 2  
Scopus rating (2013): SJR 1.421 SNIP 1.081 CiteScore 2.25  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): SJR 1.324 SNIP 1.196 CiteScore 2.29  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): SJR 1.423 SNIP 1.09 CiteScore 2.13  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 1.425 SNIP 1.118  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 1.451 SNIP 1.196  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 1.589 SNIP 1.379  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.621 SNIP 1.236  
Web of Science (2007): Indexed yes  
Scopus rating (2006): SJR 1.354 SNIP 1.267  
Web of Science (2006): Indexed yes
Estimation of evacuation rates in the field

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern)
Pages: 262-281
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Fish Biology
Volume: 65
Issue number: 1
ISSN (Print): 0022-1112
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 1.57 SJR 0.741 SNIP 0.882
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.951 SNIP 0.935 CiteScore 1.64
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.944 SNIP 0.934 CiteScore 1.76
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.049 SNIP 1.118 CiteScore 1.98
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.93 SNIP 1.035 CiteScore 1.88
ISI indexed (2012): ISI indexed yes
Diel feeding pattern of whiting in the North Sea

Though numerous studies have analysed the feeding periodicity of North Sea gadoids, no general diel pattern has been found. The lack of agreement between studies may be related to differences, in prey composition and behaviour, but it has not been attempted to link the diel intake pattern directly to intake of individual prey. This study presents an analysis of the round the clock occurrence of several prey types in the stomachs of whiting Merlangius merlangus, a major predator on fish and crustaceans in the North Sea. Generalised linear models were used to determine if the occurrence of different prey varied significantly with time of day and whether this diel pattern differed between locations and predator size groups. The results show that the occurrence of bottom dwelling prey increased significantly during the night at 4 of 5 locations. In contrast, free swimming prey and prey migrating towards the demersal layer during the day were eaten mainly in the daylight hours. No diel pattern in the presence of larger fish prey could be found, presumably due to their longer digestion time. A general diel pattern in catch rates of the predator could not be detected and the analyses did not appear to be biased by vertical migration of the predator. The results have important implications for the understanding of prey selection by wild predators, as this is, in effect, a choice between temporally co-occurring prey.
The effect of stomach fullness on food intake of whiting in the North Sea

The probability of a North Sea whiting Merlangius merlangus stomach containing fresh food was depressed when partially digested food was already present in the stomach. The lowered probability was detected even at levels where the fish was physiologically able to ingest an average meal. The feeding probability of c. 15% of the fish caught was predicted to be severely decreased at the level of partially digested food found in the stomachs. No effect of stomach fullness on meal size was found, indicating that the saturation is affecting search activity rather than prey or meal size selection. The diurnal pattern in food intake varied between the five sampling locations, presumably Lis a result of differences in prey availability.

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Analyses of length and age distributions using continuation-ratio logits

Sampling of length and age distributions of catches is important for the assessment of commercially fished stocks. This paper presents a new method for statistical analyses and comparisons of length and age distributions based on generalised linear models of continuation-ratio logits. The method allows statistical testing of the effects of both continuous and discrete variables. Further, by utilising the smoothness of length and age distributions as a function of length, the method provides more accurate estimates of these distributions than traditional methods. The observations are assumed to be multinomially distributed, but cases in which the variance exceeds that of this distribution may also be analysed. The implementation of the method in existing statistical analysis software is straightforward and is demonstrated using length and age distributions of the lesser sandeel, Ammodytes marinus Raitt.
Modelling the population dynamics of sandeel (Ammodytes marinus) populations in the North Sea on a spatial resolved level: Final report

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources, Section for Monitoring
Authors: Jensen, H. (Intern), Rindorf, A. (Intern), Horsten, M. (Ekstern), Mosegaard, H. (Intern), Brogaard, P. (Intern), Lewy, P. (Intern), Wright, P. (Ekstern), Kennedy, F. (Ekstern), Gibb, I. (Ekstern), Ruxton, G. (Ekstern), Arnott, S. (Ekstern), Leth, J. (Ekstern)
Number of pages: 102
Publication date: 2001

Publication information
Place of publication: Charlottenlund
Publisher: DIFRES
Original language: English

Series: Report for the Commission
Number: 98/025
Main Research Area: Technical/natural sciences
Effects of changes in sandeel availability on the reproductive output of seabirds

The lesser sandeel Ammodytes marinus is a key prey species for many marine birds in the North Sea. This fish is currently the target of the largest single species fishery in the area, and this has led to concern about the potential impact of the fishery on seabirds. There are 2 critical issues: does the breeding success of seabirds depend on sandeel availability and does the fishery reduce sandeel availability to a level at which avian reproductive output is affected? This paper investigates the first question in detail and briefly touches on the second by testing for correlations between productivity, breeding effort and diet in 3 species of seabird with contrasting foraging and dietary characteristics (common guillemot Uria aalge, black-legged kittiwake Rissa tridactyla, and European shag Phalacrocorax aristotelis) and an index of availability of 1 group and older sandeels derived from catch per unit effort statistics from the Danish sandeel fishery. Breeding success in all 3 species was significantly reduced when sandeel availability to the fishery in June was low. There was also evidence that the timing of peak sandeel availability influenced reproductive output such that success was lower when availability peaked early. We speculate that these effects are linked to annual variations in sandeel Life history events and, in particular, to the onset of burying behaviour of 1+ group fish and the arrival of 0 group sandeels on the seabirds’ feeding grounds. Although the timing of these events is unlikely to be directly influenced by the sandeel fishery, since most catches are taken in June, it is possible that the fishery could exacerbate a difficult situation for seabirds by further reducing the biomass of available 1+ group fish. We suggest that this may have occurred in one of the years of the study.
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.4
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.56
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.9
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes
Original language: English
Electronic versions:
Rindorf.pdf
DOIs:
10.3354/meps202241
Links:
Source: orbit
Source-ID: 227288
Publication: Research - peer-review › Journal article – Annual report year: 2000

**Does the diet of cod and whiting reflect the species composition estimated from trawl surveys?**

**General information**
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern), Gislason, H. (Intern), Lewy, P. (Intern)
Pages: 1-23
Publication date: 1998
Prey switching and the Implications for the use of predatory fish as bioindicators

General information
State: Published
Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Authors: Rindorf, A. (Intern)
Number of pages: 125
Publication date: 1998

Projects:
Bycatch of marine mammals and seabirds - Assessment and mitigation (39337)
The aim of the project is to develop innovative mitigation methods to reduce the unintended bycatch of marine mammals and seabirds in Danish gillnet fisheries.

The project includes the following components:
- determine the distribution in time and space of the bycatches;
- identify the factors that determine the occurrence of the bycatch and its distribution;
- identify behaviour that are correlated with bycatch;
- conduct pilot trials of mitigation methods;
- propose further mitigation methods to test in a continuation of the project.

The results of the project will contribute to a better management of protected species of marine mammals and seabirds, as well as placing Denmark in a better position with respect to its obligations in relation to the EU Habitats Directive, the EU Bird Directive, the EU Marine Strategy Framework Directive, the EU Council Resolution 812/2004 and the EU Action Plan for reduction of seabird bycatch.

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
Kolmården Wildlife Park
Period: 01/03/2016 → 28/02/2018
Number of participants: 5
Research areas: Ecosystem based Marine Management & Coastal Ecology
Forward management of sandeel in the North Sea (39316)
The project will define and align the management of sandeel considering the goals and desires of the fishing industry, administration and science while taking the biology and importance of the sandeel in the ecosystem into account.

The project is structured by several work-packages, each dealing with specific aspects of sandeel biology and/or fishery relevant for management. Among these will the sandeel population structure and its influence on stock assessment, CPUE and counselling be discussed. Analyses of fisheries development and sandeel availability over the fishing season will enable a more accurate calculation of fishing mortality. Furthermore, it is examined whether the increasing concentration of fishing effort on certain banks potentially causes an error in the stock assessment in relation to recruitment from unfished banks. The project will perform a statistical evaluation of fisheries-independent data for sandeel in the North Sea and evaluate existing and alternative methods of stock assessment for sandeel in the North Sea with current and alternative management areas, including implementing an analytical stock assessment of sandeel in sandeel area 4. Finally the project will evaluate existing biological and management reference points, and discuss these in relation to ecosystem reference points.

Throughout the project period, a series of workshops and meetings will be held in order to discuss possible management strategies for sandeel in the North Sea. These discussions will imply a number of fundamental prerequisites defined in collaboration between management, fisheries and science in order to form the basis for an optimal management of sandeel.

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).

Supporting the national monitoring of Marine Strategy Framework Indicators (39304)
In support of the national implementation of EU’s Marine Framework Strategy Directive, the project assembles a one-off monitoring of indicators of the following aspects:
- Quality of sandeel habitat
- Proportion of large top predatory fish
- Biomass of planktonic secondary producers
- Pressure on the sea bed from towed fishing gear
- Marine macro-litter
- Marine micro-litter in the food chain

The quality of sandeel habitat is measured as the fraction of sampling sites in known sandeel habitat which are unsuitable for sandeel due to excessive silt content. The proportion of large top predatory fish describes the proportion of large cod and saithe in Danish waters, and biomass of secondary producers is measured as the annual average biomass of zooplankton of three size categories in Skagerrak/Kattegat in summer.

Pressure on the seabed is measured from VMS data and the minimum area which sustains 90 % of all pressure estimated together with the effectively unfished area. Macro-litter is measured as the average catch of litter in fish trawl surveys, whereas micro-litter in the food chain is monitored as the amount and occurrence of microplastic particles in stomachs from pelagic and demersal fish.

This project was coordinated by DTU Aqua.

The project was funded by the Danish Nature Agency.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management

Danish Fishermen's Association
Period: 15/05/2015 → 31/12/2015
Number of participants: 4
Research areas: Ecosystem based Marine Management & Oceanography
Project participant:
Stedmon, Colin (Intern)
Mortensen, Lars O. (Intern)
Egekvist, Josefine (Intern)
Project Coordinator:
Rindorf, Anna (Intern)

Strategies for the gradual elimination of discards in European fisheries (DiscardLess) (39238)
DiscardLess will help provide the knowledge, tools and technologies as well as the involvement of the stakeholders to achieve the gradual elimination of discarding. These will be integrated into Discard Mitigation Strategies (DMS) proposing cost-effective solutions at all stages of the seafood supply chain.

This project is coordinated by DTU Aqua.

The project is funded by EU, Horizon2020.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management

IFREMER
Instituto Español de Oceanografía
University of Bergen
Strathclyde University
University of Copenhagen
Université de Bretagne Occidentale
Sea Fish Industry Authority
Marine Scotland Science
FAO
Simrad Spain SLU
Study on stomach content of fish to support the assessment of good environmental status of marine food webs and the prediction of MSY after stock restoration (Open call for tenders No MARE/2012/02) (39036)

In support of policies for sustainable management strategies of living marine resources, demands for integrated ecosystem advice are growing and more extensive use of long-term management plans, which are consistent with the ecosystem approach to fisheries management, is anticipated. However, long-term management plan evaluations of fish are particularly sensitive to changes in the proportion of fish removed by natural predators (natural mortality). A prerequisite for estimating this correctly is accurate knowledge of species interactions: Who is eating whom when, where and in which quantity?
Existing stomach content data are currently used in multispecies models using historic stomach content data from before 1995. Since this period, there have been considerable changes in the predator and prey stocks of both the Baltic and the North Sea. Thus, updated information on stomach contents of the essential predators in these two areas is urgently needed.

In order to update and improve the quality and quantity of the available background data for the above mentioned multispecies models and management plans, the aim of this project is to:

- conduct new stomach content analyses of Baltic cod to support our knowledge of the spatial and temporal stability of cod preferences
- conduct new stomach content analyses of Baltic whiting as well as grey gurnard, mackerel and hake collected in the North Sea to support our knowledge of potentially important predators for which the diet is presently poorly known or is expected to have changed significantly since the last sampling efforts
- compile historical data, which are existing in several institutes around the Baltic and North Sea, and convert them from paper or outdated electronic format into the necessary standard format
- incorporate the new as well as all appropriate historical stomach content information into the Baltic and North Sea stomach content databases

The end product will be updated stomach content databases for the Baltic and North Sea, which include all available information up to 2013. In the Baltic, the project will increase the number of stomachs available for modeling by more than 170%. In the North Sea, the project will increase the number of years where data are available for grey gurnard from 2 to 8, for mackerel from 2 to 6 and for hake from 0 to 1, hence substantially increasing the confidence in the temporal stability of the modeling results.

The databases will be made freely available to the scientific community and will form the basis for new estimates of natural mortality and improved long-term management plans in the Baltic and North Sea.

The project is coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Marine Ecology and Oceanography
Johann Heinrich von Thünen-Institute
National Marine Fisheries Research Institute
Lund University
Institute of Food Safety, Animal Health and Environment
University of Hamburg
Wageningen IMARES
Cefas
Period: 27/11/2012 → 27/11/2014
Number of participants: 7
Research area: Marine Populations and Ecosystem Dynamics
Project participant:
Andreasen, Heidi (Intern)
Neuenfeldt, Stefan (Intern)
Rindorf, Anna (Intern)
Storr-Paulsen, Marie (Intern)
Andersen, Niels Gerner (Intern)
Project Manager, organisational:
Haslund, Ole Henrik (Intern)
Project Coordinator:
Huwer, Bastian (Intern)
Project

Analysis of measures for increased stability in the industrial fisheries (39027)

The objective of the project "Analysis of measures for increased stability in the industrial fisheries" has been to improve fisheries advice to ensure more stable quotas for the three main industrial species in the North Sea; sandeel, sprat and Norway pout. The means to get there was to improve data, calculation procedure and management plans by taking into account the special conditions that exist for each species.

Through an industry-scientist-manager collaboration platform initiatives were taken to a theoretically and practical cooperation, where collection and analysis of biological and fishery-based data and knowledge sharing between fisheries,
bio-economy, management and research has supported development of robust management strategies that may increase economic stability in the industry if implemented in the future.

The project is 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 Marine Living Resources
Danish Fishermen's Association
Cefas
Association of Danish Fish Meal and Fish Oil Manufacturers
Danmarks Pelagiske Producentorganisation

Period: 10/07/2012 → 22/05/2014
Number of participants: 6
Research areas: Marine Living Resources & Ecosystem based Marine Management

Project participant:
van Deurs, Mikael (Intern)
Worsøe Clausen, Lotte (Intern)
Rindorf, Anna (Intern)
Christensen, Asbjørn (Intern)

Project Manager, organisational:
Pedersen, Eva Maria (Intern)

Project Coordinator:
Mosegaard, Henrik (Intern)

Maximizing yield of fisheries while balancing ecosystem, economic and social concerns (MYFISH) (38850)

The European Common Fisheries Policy has made a commitment to direct management of fish stocks towards achieving Maximum Sustainable Yield (MSY) by 2015 (or no later than 2020 in special cases). Attaining this goal is complicated by lack of common agreement on the interpretation of both 'sustainability' and 'yield', and because achieving MSY for one stock may affect the possibility of achieving MSY for other stocks and compromise ecological, environmental, economic, or social aims.

The objective of MYFISH was to face these difficulties and provide definitions of MSY variants, evaluations of the effect on ecosystems, economy and social aspects of attaining these variants, their social desirability and an operational framework for their implementation.

This was achieved through cases addressing a range of fisheries in all European regional areas. The cases cover situations ranging from data-poor to the most studied and well-understood marine ecosystems in EU waters. The suggested implementation of MSY builds on the existing ecosystem and fisheries models in the cases, modified to perform the maximization of the relevant yield measure operationally. Social aspects were integrated throughout the project by active involvement of stakeholders in the definition and evaluation of MSY variants. Global experience was engaged through associated partners and communication of results was enhanced through two major events, a dedicated MYFISH/ICES symposium in 2015 and a targeted policy meeting in 2016. More details can be found at www.myfishproject.eu.

The project was coordinated by DTU Aqua.

The project was funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management

Period: 01/01/2012 → 29/02/2016
Number of participants: 10
Research areas: Ecosystem based Marine Management & Fisheries Management & Marine Living Resources

Project participant:
Ulrich, Clara (Intern)
Eigaard, Ole Ritzau (Intern)
Mortensen, Lars O. (Intern)
Optimal sustainable exploitation of Nephrops norvegicus in Kattegat and Skagerrak (38909)

The scientific advice on management of fisheries is primarily aiming at avoiding overfishing of the fish and shellfish stocks and only to a very limited extend addresses how the utilisation of the resources can be optimised within a sustainable ecosystem framework. An example is the regulation of the demersal trawl fisheries in the Skagerrak and the Kattegat which to protect the cod stock is sub-optimal in relation to the utilisation of the Norway lobster (Nephrops) stocks. The project takes a new approach to the management and aims at optimising the utilisation of Nephrops stocks without compromising the protection of cod.

The Nephrops fishery is one of the economically most important fisheries in Denmark. In the Kattegat and Skagerrak, Nephrops catches accounted in 2010 for 53% and 25% of the total value of fish and shellfish, respectively, landed by Danish fishermen. Cod is taken as by-catch in the Nephrops fishery and it has been necessary to introduce measures to limit the by-catches of cod, which is currently below agreed reference points for stock size. These measures have had a negative impact on Nephrops catches.

The project addressed four objectives: (i) development of advice on the fishing mortality for the Nephrops stocks, which is consistent with maximum sustainable yield; (ii) mapping of the distribution of Nephrops in Skagerrak and Kattegat; (iii) development of a new trawl concept optimising the catchability on Nephrops while limiting the by-catches of cod and impact on the sea bed; and (iv) evaluating alternative fishing methods for Nephrops including fishing with pots.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management

Statistical aspects of heterogeneous population dynamics (38102)

A variety of 'indices' of distribution are often considered: occurrence, aggregation and geographical range. However, the estimators of these indices are frequently biased and the results often do not reflect changes in distribution, often due to effects of non-random sampling in space and time. Another type of bias in many existing methods results from the assumption that the individual observations of abundance in an area are all independent and spatial correlation is ignored.
Methods that do take spatial correlation into account, such as kriging, are often inappropriate because they do not handle the high frequency of zero observations, which are typical of survey data. During this task we will develop new types of models using the so-called “Log Gaussian Cox Process” (e.g. Lewy and Kristensen 2009; Kristensen 2008), which account for spatial correlation and better involve the information from zero observations. These models will further strengthen our ability to detect changes in distribution and provide useful indices of biological aggregation or ‘clumping’ based on the degree of spatial correlation.

24 research institutes and 14 universities are partners in the project.

The project is coordinated by Plymouth Marine Laboratory, UK.

National Institute of Aquatic Resources

Section for Marine Living Resources
Period: 01/01/2011 → 31/12/2011
Number of participants: 3
Research area: Marine Living Resources
Project participant:
Rindorf, Anna (Intern)
Project Manager, organisational:
Lewy, Peter (Intern)
Project Manager, academic:
Gislason, Henrik (Intern)

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)
Life history adaptation in marine fishes

National Institute of Aquatic Resources
Period: 15/12/2010 → 15/08/2013
Number of participants: 3
Phd Student: Mosgaard, Thomas (Intern)
Supervisor: Rindorf, Anna (Intern)
Main Supervisor: Gislason, Henrik (Intern)

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

Development and demonstration of Marine Strategy Framework Directive (MSFD) tools for harmonization of the initial assessment in the eastern parts of the Greater North Sea sub-region (HARMONY) (38894)

The HARMONY project has developed and made available a toolbox supporting national MSFD implementation with special focus on issues of a transnational relevance and importance. It builds on cooperation among member states sharing the Greater North Sea sub-region through active involvement in several OSPAR groups. The tools are based on respecting the needs for national flexibility, while ensuring the necessary regional harmonization of key elements under the marine strategies.

The project partnership met these challenges through four development/harmonization activities and a coordination and information activity:
1) To develop and demonstrate a tool supporting an analysis of essential features and characteristics leading towards an integrated assessment building upon the criteria identified in the Commission Decision, while ensuring the necessary linkage to existing work under the Regional Sea Conventions as well as existing EU legislation (WFD, Natura 2000).
2) To develop and demonstrate a tool (a pressure and an impact index) supporting an analysis of the predominant pressures and impacts on the ecosystems, including those impacts of human activities for the Greater North Sea Marine sub-region.
3) Provide examples on the linkage of effects and human pressures to informed ecosystem-based marine strategies (based on activities 1 and 2).
4) To establish and support the active cooperation among member states sharing the Greater North Sea sub-region enabling comparisons and harmonization, where relevant and possible, between national efforts in preparing the initial assessment, elaborate the criteria including identification of indicators and target setting, and further on, the preparation of the monitoring program and the program of measures within the Greater North Sea sub-region.

DTU Aqua has focused on biodiversity of fish and fish populations, mapping fishing pressures and ecosystem components of the project working area (North Sea).

The project was coordinated by Department of Bioscience, Aarhus University, Denmark.

The project was funded by the Danish Ministry of Environment.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Aarhus University
Forage fish interactions (FACTS) (38781)
Removal of a forage fish has consequences for both predators and prey of forage fish. As everything is connected, every management action has a price which goes beyond the apparent, direct effect on the target species. The fishery on forage fish can therefore not be seen in isolation, as the immediate gain in profit from the fishery has to be discounted by the lowered potential for production of large piscivorous fish. Management actions on other species also influences forage fish, i.e. conservation efforts on marine mammals or sea birds have direct consequences for the predation pressure on forage fish.

The objective of the project was to provide insight and quantitative advice on the ecosystem wide consequences of management actions directly or indirectly related to forage fish.

The two overarching questions were:
- What are the consequences of forage fish fisheries on (a) predator growth and abundance, (b) economic output of fisheries on piscivorous species, and (c) ecosystem stability and the risk for regime shifts?
- What are the consequences of changes in predator populations on forage fish populations and fisheries?

The method was a combination of ecosystem models, of process studies aimed at feeding into the models, of economic models, and of data-analysis of existing data sources.

The project covered four ecosystems in detail: Norwegian-Barents Sea, Baltic Sea, North Sea and Bay of Biscay.

FACTS brought together leading European fisheries and university institutes working on creating the tools for ecosystem based management. The active involvement of the institutes in the current management has provided a means for the results of the project to feed into management. The project furthermore included a network component which has ensured a wider dissemination of methods and results within the marine scientific community.

The project was coordinated by DTU Aqua.

The project was funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Marine Ecology and Oceanography
Wageningen IMARES
Cefas
Marine and Food Technological Centre
IFREMER
University of Hamburg

DHI Denmark
Climate and Pollution Agency
Norwegian Institute for Water Research
Institute of Marine Research
Havs- och Vattenmyndigheten
Swedish Meteorological and Hydrological Institute
German Federal Environment Agency

Period: 01/01/2010 → 01/01/2012
Number of participants: 4
Research area: Ecosystem based Marine Management
Contact person:
Sørensen, Thomas Kirk (Intern)
Project participant:
Rindorf, Anna (Intern)
Hartvig, Martin (Intern)
Project Manager, organisational:
Vinther, Morten (Intern)
Project
Institute of Marine Research
University of Southern Denmark
Christian-Albrechts-Universität zu Kiel
Finnish Game and Fisheries Research Institute
Centre National de la Recherche Scientifique
University of Copenhagen
Leibniz-Institute for Baltic Sea Research
University of St Andrews
Spanish Institute of Oceanography

Period: 01/01/2010 → 31/12/2012
Number of participants: 4
Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Ecosystem based Marine Management

Project participant:
Andersen, Ken Haste (Intern)
Rindorf, Anna (Intern)

Project Manager, organisational:
Haslund, Ole Henrik (Intern)

Project Manager, academic:
Neuenfeldt, Stefan (Intern)

Project

Modellering af fiskesamfund ved hjælp af livshistorietræk og størrelse

National Institute of Aquatic Resources
Period: 15/09/2009 → 31/07/2011
Number of participants: 3
Phd Student:
Schrøter, Marie Louise (Intern)
Supervisor:
Rindorf, Anna (Intern)
Main Supervisor:
Gislason, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Developing fisheries management indicators and targets (DEFINEIT) (38763)
DEFINEIT constructed operational models of fish stock dynamics explicitly taking into account exploitation and climatic conditions and combine these models with basic economic models. To ensure an outstanding scientific level in each of these areas, the project brought together key competences in operational multispecies modelling, stock recruitment relationships, population dynamics of non-target fish species and economic modelling of fisheries from a wide geographic area ranging from the Barents Sea to the North Sea. The project used multispecies models to investigate changes in predation induced by differences in the distribution and the amount of alternative food. Effects of technical interactions in the fishing process were considered to avoid delivering management advice for different stocks which is mutually inconsistent. Integrating the knowledge gained, the project suggested methods for estimating reference points. The project identified the main causes of variation in recruitment patterns between stocks as well as the key processes from spawning to recruitment of selected stocks. The consequences of using proxies to describe stock reproductive potential were determined and survival during early life stages was investigated in order to identify the role of the physical and biological environment. The improved understanding of recruitment variability was used in individual stock assessment and included in multispecies models to provide reliable predictions. The maximum level of fishing effort consistent with sustainment of susceptible species was estimated along with the effect of discard of by-catch on economic yield. The project developed resource indicators that combine economic, social and biological indicators and relate directly to the benefit for the society. Future stock dynamics limits to sustainable ecosystem exploitation and the fishing levels delivering maximum sustainable economic yield under selected climatic scenarios were analyzed in unison to ensure the delivery of mutually consistent management advice. General properties of the ecosystems were used to suggest rules of thumb for management in areas where the amount of data available is insufficient to construct similar models.
Establishment and testing of area-based management models for North Sea sandeel fisheries (ETOMTOBIS) (38588)

The goal of this project is to investigate the effects of area-based management for sandeel stocks and the fisheries. Objectives include developing for optimal area-based management of sandeel fisheries in the North Sea. The tools will first be tested through computer simulations and the experience gained will be used to develop a revised management model at the end of the project.

The project will also help fisheries managers to act proactively to other marine management initiatives. In connection with the implementation of the EU Habitat Directive in the North Sea, EU coastal states appoint Natura 2000 areas by 2010. Area based analysis of population dynamics is therefore necessary to quantify the effect of fishing at the local level, and subsequently assess whether fisheries are affecting the habitat. Additional field-based analysis will be valuable in assessing interaction of the sandeel fishery with potential Natura 2000 areas. Spatial management is not only intended to restrict fishing. A description of the consequences for fisheries and sandeel population dynamics are important in assessing the benefits and drawbacks of introducing area-based management of sandeel fisheries in the North Sea.

Currently the sandeel fishery is managed under the assumption that there is one population of the sandeel (Ammodytes marinus) in the North Sea, in spite of this, the North Sea sandeel stock can be divided into several sub-populations. Based on recent research there is now a strong wish from ICES (see eg. ICES 2007 and 2008) and from the EU (see eg. STECF 2005), to introduce area based management of the sandeel fisheries, in order to adjust fishing to a level defined as sustainable for each of the local sub-populations.

Sandeel stocks in the North Sea will be divided into separate management units, each of which can be regarded as sub-populations who have little or no mutual exchange of both sand eel fry and adult sandeels, as presented in the final report of the project TORTN (project 38128). An assessment model will be developed to analyze sandeel population dynamics for each of the identified management units. A forecast model based on the relevant scientific surveys will predict the actual size of the sandeel recruitment in each of the management areas. Finally a tool will be developed that calculates the catch of sandeels in each of the management areas in a number of scenarios that include output of maximum sustainable yield, the most stable catches, and optimal fisheries management.
The project also includes a field sampling module, using two different methods, pelagic larval and demersal 0-group sampling, associated with a tool technological module for this collection to measure the size of the sandeel recruitment. The purpose of the field collection is to continue and analyze existing time series of field data to further develop area based recruitment indices. Field data should also be used as a fishery independent index of the sandeel stock size in the developed assessment model. The project is coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Marine Living Resources
Danish Fishermen's Association
Period: 01/01/2008 → 31/12/2010
Number of participants: 5
Research area: Marine Living Resources
Project Manager, academic:
Mosegaard, Henrik (Intern)
Vinther, Morten (Intern)
Rindorf, Anna (Intern)
Christensen, Asbjørn (Intern)
Jensen, Henrik (Ekstern)

Sustainable fisheries, climate change and the North Sea ecosystem (SUNFISH) (38135)
Global climate changes will seriously challenge the governance of fisheries in the North Sea and elsewhere. Changes in temperature, wind conditions, river runoff and currents will affect primary and secondary production, the distribution, feeding, growth and survival of commercially exploited fish at all stages of life. Without improved knowledge about the effect of climate on the basic biological processes involved in fish production, it will be increasingly difficult to separate the effects of fishing from those of environmental fluctuations and change, identify biological reference points, and to develop management strategies for sustainable fisheries. By combining models of the effects of climate on the hydrographical and biological processes important for fish production with models of fish stock dynamics and fishing, the project provided a basis for improved predictions of the effects of climate change on the sustainable exploitation and maximum yield of North Sea fish stocks. The dynamics of cod (a top predator), herring and sandeel (two important prey for fish), seabirds and marine mammals were studied in detail. Their spawning, egg and larval drift, juvenile and adult distribution, growth and survival were investigated through experiments, statistical analyses of collected data and advanced bio-oceanographic models. The sustainability of exploitation under changing climate conditions were examined by modifying an existing stochastic multispecies fisheries model to make it account for climate effects on fish ecology. The project provided an integrated modelling framework for developing sustainable fisheries management strategies superior to using simple extrapolations of observed historical trends to predict the likely outcome of climate change on the North Sea ecosystem.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Council for Strategic Research.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
University of Copenhagen
Aarhus University
Danish Meteorological Institute
Marine Scotland
University of Hamburg
Period: 01/01/2008 → 01/09/2012
Number of participants: 6
Research areas: Ecosystem Based Marine Management & Marine Living Resources
Project participant:
Munk, Peter (Intern)
Lewy, Peter (Intern)
Christensen, Asbjørn (Intern)
Mosegaard, Henrik (Intern)
Project Manager, academic:
Development and performance test of method for establishing an area based recruitment index for North Sea sandeels (TORTN) (38128)

The project's overall objective is to establish a recruitment index for sandeel in the North Sea, for use in preparation of the scientific advice for North Sea sandeel fisheries. It is also an objective that this index should be developed in collaboration with the fishing industry. This is partly to increase the transparency and credibility of the scientific work but also to reduce the cost of setting up the necessary information to as low as possible.

It is of significant interest to be able to subdivide North Sea sandeel habitats based on well-founded biological and physical principles in order to provide spatial explicit stock assessment and advice on local fishing potential. Using hydrographic modeling and field sampling during the fishing season the coupled larval drift and population model (SPAM) will be validated.

The North Sea wide collection of winter hibernating sandeels from the seabed with the modified scallop dredges will be continued and the time series of abundance data will be analyzed. The project will further create a database of VMS, data corresponding to Danish vessels fishing for sand eels (defined by logbook database). From this data fishing effort, a fishing ground level will be estimated through the use of VMS and log book data. Using sandeel samples from the fishery area-based age-length keys will be developed using a continuation logit statistical approach. Combining recruitment data from population analysis and fisheries independent data on 0-group, the project will further develop, test and optimize a method for calculating the recruitment of 0-year-old sandeels to the North Sea stock. Real-time Monitoring of the sandeel fishery, which is the present basis for in season advice on fishing opportunities (applied 2004-2009), earliest establish the same basis by May i.e. in the middle of the fishing season. The new procedure developed in the project makes it possible to provide the scientific advice used in fisheries management in January, more than 2 months before the start of fishing season. Thus the procedure will allow the development of area based recruitment indices to manage the sandeel fishery in accordance with principles that ensure a more optimal utilization of sandeel stock and also reduces the risk of local overfishing.

The project is coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Marine Living Resources
Danish Fishermen's Association

Period: 01/01/2007 → 31/12/2008
Number of participants: 4
Research area: Marine Living Resources
Project Manager, academic:
Mosegaard, Henrik (Intern)
Christensen, Asbjørn (Intern)
Rindorf, Anna (Intern)
Jensen, Henrik (Ekstern)

Critical interactions between species and their implications for a precautionary fisheries management in a variable environment – a modeling approach (BECAUSE) (38613)

Across Europe, the population of predatory fish has fallen dramatically in recent years. This has reduced the predation rate and the prey species has remained fairly stable. Therefore the balance between predators and prey species has been radically changed. No accurate scientific picture of the exact interactions between these species and their effects on non-commercial top predators is available. To maintain biodiversity and make recovery plans more effective, such an understanding is vital.

The sustainable management of European fisheries requires an adaptive approach that takes into account the long term dynamics of the entire marine ecosystem so as to protect the biodiversity of our seas. BECAUSE investigated the interaction between predator and prey, and the shifts in their relative populations and looked into how fishing affects the balance of the marine food chain. The interactions targeted for investigation included sandeel/predator fish, predators and prey of cod, and hake/prey fish.

Contributions to the policy development aimed at integrating a sustainable ecosystem approach into the EU’s Common Fisheries Policy (CFP) thereby helping the EU to meet its global fishing commitments and underwrite the sustainability of ecosystem services. Multi-species fisheries assessment were improved and enhanced policy and management measures to replenish fish stocks and ensure high yields were proposed.
Analysis of biological key parameters, population structure and population dynamics of the lesser sandeel (Ammodytes marinus) in the North Sea, based on detailed information about the sandeel fishery (AHA.DOT) (2167)

The overall goal is to establish the scientific basis for a management system for the North Sea sandeel fishery that will prevent local depletion of sandeels due to fishing and improve the yield of the fishery.

Stock assessment of sandeels in the North Sea is based on the assumption that there is one stock of sandeels in the North Sea and one stock in the Shetland area. However, recent investigations suggest that sandeels in the North Sea can be divided into several stock components or sub-stocks. Further, growth and fecundity seem to vary significantly between the different stock components. This project will analyse spatial trends in key biological parameters (emergence behaviour, growth and fecundity) and the distribution of the lesser sandeel Ammodytes marinus in the North Sea. Additionally the drift pattern of sandeels larvae between the spawning areas will be analysed by use of a hydrographical model. Information about distribution, biological parameters and the drift of larvae will be used to define the stock components of sandeels to be assessed as separate population units.

Besides the lack of information about the spatial heterogeneity on the biology of sandeels, the possibility to carry out regional assessments is hindered by a lack of information about the sandeel fishery and the catches of sandeels, where the main problem being the level of aggregation of the data. To carry out assessments for each of the stock components separately, more detailed information about the fishery and the catches of sandeels is needed. The data available about the fishery can only be allocated to ICES rectangles. However, data will have to be allocated to fishing grounds. Effort and catch data as well as biological samples has since 1999 been collected on a by haul basis for 15-20 Danish vessels representing the existing vessel categories and fishing pattern in the Danish North Sea sandeel fishery. During this project
satellite data for all Danish vessels fishing sandeels in the North Sea will together with the detailed data from the 15-20 vessels, be used to disaggregate data on effort and catches of sandeels, from being on a trip and ICES rectangle level to being on a haul and fishing ground level. The information about the biology and population structure of sandeels and the detailed data about catches and effort will be used to carry out separate assessments of each of the stock components of sandeels. Furthermore, a model that was developed at DTU Aqua (THEMAS) will be used to simulate the effect of different management scenarios on the fishing fleet and the sandeel populations.

The project was coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Marine Living Resources
Danish Fishermen's Association
Krog Consult ApS
University of Hamburg
Marine Scotland Science
Period: 01/01/2003 → 31/12/2007
Number of participants: 4
Research area: Marine Living Resources
Project Manager, academic:
Mosegaard, Henrik (Intern)
Rindorf, Anna (Intern)
Christensen, Asbjørn (Intern)
Jensen, Henrik (Ekstern)

Danish Network for Aquaculture and Fisheries Research (FISHNET) (38082)
FISHNET is a network of Danish Fisheries and Aquaculture scientists. It was established to foster cooperation in aquaculture and fisheries research and research education in Denmark.

From the start it functioned as an umbrella over four independent thematic research schools and networks in fisheries biology (SLIP), Fisheries and Aquaculture Management and Economics (FAME), Fish Food, Biochemistry and Physiology (FIBP) and Sustainable Control of Fish Diseases in Aquaculture (SCOFDA). In 2001 a research school in Maritime History and Marine Environmental Research (MARINERS) was added to the network.

FISHNET aims to enhance the visibility and quality of Danish fisheries and aquaculture research through improved collaboration and communication, improving the recruitment and training of PhD students through networks and research schools, thus providing high quality courses, seminars and workshops.

FISHNET has organised a large number of joint courses, seminars, workshops and conferences connecting more than 100 fisheries and aquaculture scientists from Danish universities and sectoral research institutions.

In 2004 Fishnet received funds to embed the network through a number of postdoc grants and co-funded professorships in Fisheries Oceanography, Fisheries Management and Fish Physiology.

The merger of the Danish Universities and Sectoral Research Institutions and various changes in Danish marine research made it necessary to extend the second phase of the project from 2008 to the end of 2012.

The project is coordinated by DTU Aqua.

National Institute of Aquatic Resources
University of Copenhagen
Aarhus University
University of Southern Denmark
Period: 01/01/2000 → 31/12/2012
Number of participants: 4
Research area: Marine Populations and Ecosystem Dynamics
Project participant:
Rindorf, Anna (Intern)
van Deurs, Mikael (Intern)
Activities:

**ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS** (External organisation)
Period: 2015
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG** (External organisation)
Period: 2015
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO** (External organisation)
Period: 2015
Anna Rindorf (Chairman)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Workshop on guidance for the review of MSFD Decision Descriptor 4 - foodwebs II - WKGMSFDD4-II** (External organisation)
Period: 2015
Anna Rindorf (Chairman)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

**Related external organisation**

**ICES - Workshop on guidance for the review of MSFD Decision Descriptor 4 - foodwebs II - WKGMSFDD4-II**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS (External organisation)
Period: 2014
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Benchmark Workshop on Pelagic Stocks - WKPELA (External organisation)
Period: 2014
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG (External organisation)
Period: 2014
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Joint ICES-MYFISH Workshop to consider the basis for Fmsy ranges for all stocks - WKMSYREF3 (External organisation)
Period: 2014
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - The ACOM Workshop to develop recommendations for potentially useful Food Web Indicators - WKFOOWI (External organisation)
Period: 2014
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - The ACOM Workshop to develop recommendations for potentially useful Food Web Indicators - WKFOOWI
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO (External organisation)
Period: 2014 → …
Anna Rindorf (Chairman)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS (External organisation)
Period: 2013 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Benchmark Workshop on Baltic Multispecies Assessments - WKBALT (External organisation)
Period: 2013 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Benchmark Workshop on Baltic Multispecies Assessments - WKBALT
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Benchmark Workshop on Sprat Stocks - WKSPRAT (External organisation)
Period: 2013 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Benchmark Workshop on Sprat Stocks - WKSPRAT
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG (External organisation)
Period: 2013 → …
Anna Rindorf (Participant)

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Working Group on Multispecies Assessment Methods - WGSAM (External organisation)
Period: 2013 → …
Anna Rindorf (Chairman)

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Working Group on Multispecies Assessment Methods - WGSAM
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO (External organisation)
Period: 2013 → …
Anna Rindorf (Participant)

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
Degree of recognition: International

Related external organisation

ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - 6th World Fisheries Congress (WFC 2012) "Sustainable Fisheries in a Changing World" (External organisation)
Period: 2012 → …
Anna Rindorf (Participant)

National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation

ICES - 6th World Fisheries Congress (WFC 2012) "Sustainable Fisheries in a Changing World"
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS (External organisation)
Period: 2012 → …
Anna Rindorf (Participant)

National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Related external organisation

**ICES - Annual Meeting of Advisory Working Group Chairs - WGCHAIRS**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG (External organisation)**
Period: 2012 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation

**ICES - Herring Assessment Working Group for the Area South of 62ºN - HAWG**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Working Group on Fish Ecology - WGFE (External organisation)**
Period: 2012 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation

**ICES - Working Group on Fish Ecology - WGFE**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Working Group on Maritime Systems - WGMARS (External organisation)**
Period: 2012 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation

**ICES - Working Group on Maritime Systems - WGMARS**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**ICES - Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - WGNSSK (External organisation)**
Period: 2012 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation

**ICES - Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - WGNSSK**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO (External organisation)
Period: 2012 → …
Anna Rindorf (Participant)
National Institute of Aquatic Resources
Section for Population Ecology and Genetics
Degree of recognition: International

Related external organisation
ICES - Working Group on the Ecosystem Effects of Fishing Activities - WGECO
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar