Linking spawning ground extent to environmental factors - patterns and dispersal during the egg phase of four North Sea fishes

Previous studies have shown that four commercially important demersal species, namely cod (Gadus morhua), haddock (Melanogrammus aeglefinus), whiting (Merlangius merlangus) and plaice (Pleuronectes platessa) spawn in distinct areas across the North Sea. Based on two comprehensive ichthyoplankton surveys in 2004 and 2009, the present study uses Generalized Additive Mixed Models (GAMMs) to delimit these spawning grounds using the distribution of recently spawned eggs, investigates their relationship to specific environmental conditions and examines egg dispersal during their development. Results indicate that presence/absence of early stage eggs is more related to temporal and topographic variables, while egg densities are closely linked with hydrography. Egg distribution patterns were relatively consistent during development and only changed near hatching. Compared to historic observations, the location of the spawning grounds appeared stable on the broad scale but centres of egg abundance varied between the surveyed years. Potential effects of long-term climate change and anthropogenic short-term disturbances, such as seismic surveys, on fish reproduction are discussed, pointing out the demand for multi-species studies on these issues.
Differences in vertical and horizontal distribution of fish larvae and zooplankton, related to hydrography

Planktonic fish larvae have little influence on their horizontal distribution, while they are able to control their vertical position in the water column. While prey and light are among the factors with an apparent influence on the vertical distribution, the effects of other factors are less clear. Notably, distributional differences between larvae of different fish species are poorly understood. Information on the horizontal distribution of larvae of 27 species and the vertical distribution of seven species of Gadidae, two Pleuronectidae and one Scophthalmidae, was compiled from one survey in the northern North Sea. Horizontally, fish larvae aggregated near frontal structures, correlating with high densities of zooplankton. Increasing length and decreasing numbers indicated an origin in the western North Sea, followed by an eastward drift. Vertically, the different species exhibited similarities but also notable differences in their vertical distribution. Most gadoid species aggregated in the upper (B40 m) or middle water column (40 m) during the day with an increase in abundance at shallower depths during the night, while all flatfish were distributed at greater depths under all light conditions. Hence, larvae differed in their distributional patterns, but the relative depth distributions among the species in the larval community generally remained constant.
Spatial patterns and trends in abundance of larval sandeels in the North Sea: 1950–2005

Early recruitment indices based on larval fish data from the Continuous Plankton Recorder (CPR) have the potential to inform stock assessments of Ammodytes marinus in the North Sea. We evaluate whether the CPR data are reliable for sandeel larvae. Spatially, CPR larval data were comparable with catches by dedicated larval samplers (Gulf and bongo nets) during ICES coordinated surveys in 2004 and 2009. ICES data are also used to explore environmental influences on sandeel distributions. Temporally, CPR data correlate with larval data from plankton surveys off Stonehaven (1999–2005), with sandeel 0-group trawl data at the east Fair Isle ground (since 1984), and with recruitment data (since 1983) for the Dogger Banks stock assessment area. Therefore, CPR data may provide an early recruit index of relative abundance for the Dogger Banks assessment area, where the majority of the commercial catch of A. marinus is taken, and the Wee Bankie area that is particularly important for seabird foraging. While warm conditions may stimulate the production of sandeel larvae, their natural mortality is typically greater, in the Dogger Banks and Wadden Sea areas, when the larvae are hatched in warm years and/or with abundant 1-year-old sandeel that are likely to be cannibalistic.

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Authors: Lynam, C. P. (Ekstern), Halliday, N. C. (Ekstern), Höffle, H. (Intern), Wright, P. J. (Ekstern), van Damme, C. J. G. (Ekstern), Edwards, M. (Ekstern), Pitois, S. G. (Ekstern)
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Modelling the beginning and end of a planktonic life stage — the distribution of cod eggs and settled juveniles in the North Sea

The North Sea cod stock is close to the southern limit of the species’ range. Therefore, it might be vulnerable to future climate change. Direct as well as indirect effects of climate forcing may have the greatest effects on early life stages. Here we present a study on the distribution of cod (Gadus morhua) at the beginning and at the end of the planktonic life stage.

The distribution of cod eggs was modelled with generalized additive models (GAMs) for the presence/absence and for the nonzero abundance, using environmental as well as spatial covariates. For comparison, we also examined the egg distribution of haddock (Melanogrammus aeglefinus), whiting (Merlangius merlangus), and plaice (Pleuronectes platessa). Findings indicated that in the egg stage, the environment is more important for the probability of occurrence, while abundance is more under the control of spatial dependency. Modelling the potential habitat of newly settled 0-group cod based on presence/absence alone, identified temperature, salinity, bottom depth, and geographic position as the core descriptors of settlement distribution. The habitat models had good predictive power on the subdecadal scale, but were found lacking on a longer time-scale. The results showed that the effects of the predicted climate change may be complex and may, even within the same species, be beneficial for one life stage and detrimental for another.
Spawning location of Norway pout (Trisopterus esmarkii Nilsson) in the North Sea

The northern region of the North Sea (56–62°N) was sampled in February/March 2009 for eggs and in May 2010 for larvae. To aid in the identification of Norway pout stage I eggs and distinguish them from other ‘cod-like’ eggs, a Taq-Man probe was designed for this species and used here. Stage I Norway pout egg diameters collected from the field were in the range 1.03–1.28 mm and largely overlapped with the size range determined for whiting (Merlangius merlangus). The distribution of Norway pout stage I eggs in 2009 revealed the distribution of spawning in the North Sea and showed that it was similar to the distribution of 2 + Norway pout taken during the International Bottom Trawl Surveys (IBTS) over the same period covering the whole North Sea. The larvae sampled in 2010 were largely in the same area; however, larger larvae occurred to the south-east of the survey area, suggesting advection of young stages from the principal spawning areas in the north-western North Sea to the south-east and toward the Skagerrak.

General information

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Authors: Nash, R. D. M. (Intern), Wright, P. J. (Ekstern), Matejusova, I. (Ekstern), Dimitrov, S. P. (Ekstern), O’Sullivan, M. (Ekstern), Augley, J. (Ekstern), Höffle, H. (Intern)
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High mortality of Zostera marina under high temperature regimes but minor effects of the invasive macroalgae Gracilaria vermiculophylla

The present study tested for density-dependent effects of the invasive drift macroalgae Gracilaria vermiculophylla (Ohmi) Papenfuss on growth and survival of the native eelgrass, Zostera marina L., under different temperature levels. Three weeks laboratory experiments were conducted in Odense, Denmark, combining three algae densities (control, low 1.9 kg WW m², high 4.5 kg WW m²) with typical Danish summer temperatures (18 °C) and elevated temperatures (21 °C and 27 °C). There was a significant effect of temperature on shoot survival with on average 68% mortality in the high temperature treatment but almost no mortality at the two lower temperatures. The higher mortality was probably caused by high
sulphide levels in the sediment pore water (0.6 mmol l\(^{-1}\) at 18 °C compared to 3.7 mmol l\(^{-1}\) at 27 °C). Above-ground growth of the surviving shoots was also significantly affected by temperature, with leaf elongation rates being negatively affected, while the leaf plastochrone interval increased. Relative growth rate was significantly higher at 21 °C than at 18 °C or 27 °C, whereas rhizome elongation was significantly lowest at 27 °C. Elemental sulphur content in the plant tissues increased significantly with temperature and was up to 34 times higher (S\(_0\) in rhizomes) at 27 °C compared to the lower temperatures. In contrast to the temperature effects, cover by G. vermiculophylla did not cause significant effects on any seagrass responses. However, there was a (non-significant) negative effect of algal cover at the highest temperature, where the seagrass is already stressed. The latter results suggest that more studies should test for interaction effects between temperature and other anthropogenic stressors given that temperature is predicted to increase in the near future.

**General information**

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Vertical distribution and diurnal patterns of fish larvae in a species rich environment

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Impacts of invasive species on seagrass health under present and future temperature

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Linkages between hydrography and fish spawning sites in the southern North Sea—observations 2004 and 2009

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Number of participants: 6
Phd Student:
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Supervisor:
MacKenzie, Brian (Intern)
Scaling from individuals to populations (SLIP) (38728)
The research school SLIP (Scaling from Individuals to Populations) focuses on how individual behavior and mutual interactions generate the dynamics observed at the population level. This topic forms the link between the basic and applied marine ecological research environments in Denmark and requires input from biology, mathematics and statistics. SLIP is one of the five research networks and research schools under the Danish Network for Aquaculture and Fisheries Research (Fishnet). SLIP has arranged a number of national and international PhD courses and workshops and has served to focus the interest on size and trait-based modeling, as well as on improved understanding of the physiology, genetics and behavior of marine organisms, in particular fish.

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Project participant:
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Eg Nielsen, Einar (Intern)
Project