

Where to spawn and where to hatch – a comparison of early and late stage fish eggs in the North Sea

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Abstract: The present study compares the distribution of early and late stage fish eggs of four species in the North Sea during the spawning seasons 2004 and 2009. The aim is to determine relationships between the hydrographic conditions and the distribution of fish eggs and also to determine any differences between stages of the same species. Present results indicate reduced areas where late egg stages can be found compared to early stages. The correlation between occurrence probabilities and abundances was shown to be weak.

Introduction and Methods

This study serves to support the process of building new models for fisheries management, taking the influence of climate variations into account. It builds on the earlier studies by Fox et al. (2008) and Munk et al. (2009) who both considered the data from the 2004 survey. Our hypothesis is that late egg stages may have more of an advantage and thus be more common at frontal hydrographic structures than early stages.

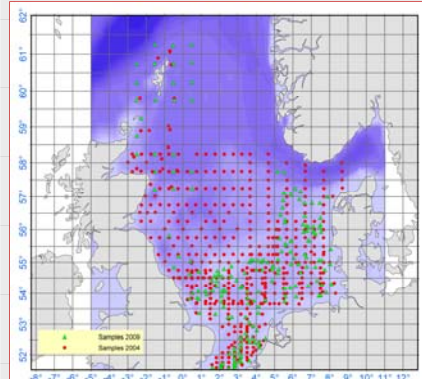


Figure 1: Study area and samples 2004 and 2009. The underlying map is a topographic representation of the North Sea, with the shallow areas represented in layers of 10 m. The squares correspond to the ICES rectangles (1° Longitude X 0.5° Latitude). Only samples no more than 10 miles and 3 days from the nearest CTD station were included.

Samples and concurrent CTD-hauls were taken in surveys coordinated by the PGEES group of ICES. Sampled fish eggs were then staged, measured and the species determined, for the Gadoids the proportion of species was established with genetic methods (Fox et al. 2008). The abundance was grouped into early (1, 2, 3) and late (4, 5) egg stages and then analyzed in two ways.

First as binary presence/absence data and plotted on a 0.25 X 0.25 decimal degree grid using Indicator Kriging with a Gaussian variogram, yielding probability maps.

Then the abundance was plotted on the same grid as the probability but using non-linear Disjunctive Kriging to cope with the sharp transitions from patches of zero abundance to patches of high abundance. The output of both Kriging procedures was then averaged over both years and used to establish correlations (Fig. 3). Additionally the abundance data is used to analyze the relationship between egg abundance for the two groups and the hydrographic conditions in each year, using advanced statistical methods like Geographically Weighted Regression (GWR).

Results

The major difference in hydrography between 2004 and 2009 was in the South. While in 2004 cold, low saline water (30 psu and lower) formed a strong front along the offshore side of the German Bight, in 2009 the water in the German Bight was more saline (ca. 33 psu) and the front extended into the English Channel, with a similar pattern for density gradients. The correlations between probability and abundance were significant for plaice and whiting for both groups and for cod only for early stages. The R^2 ranged between 0.14 and 0.48 indicating a rather weak relation.

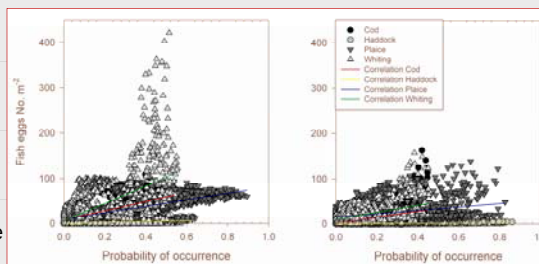


Figure 3: Correlation of density of early (left) and late (right) egg stages with their probability of occurrence. The relation was never significant for haddock (*Melanogrammus aeglefinus*), only significant for early stage cod (*Gadus morhua*) and always significant for plaice (*Pleuronectes platessa*) and Whiting (*Merlangius merlangus*), but with a low R^2 . The low R^2 is probably due to the short time series. Over longer time significant correlations of high probability and high abundance can indicate preferred spawning and hatching areas.

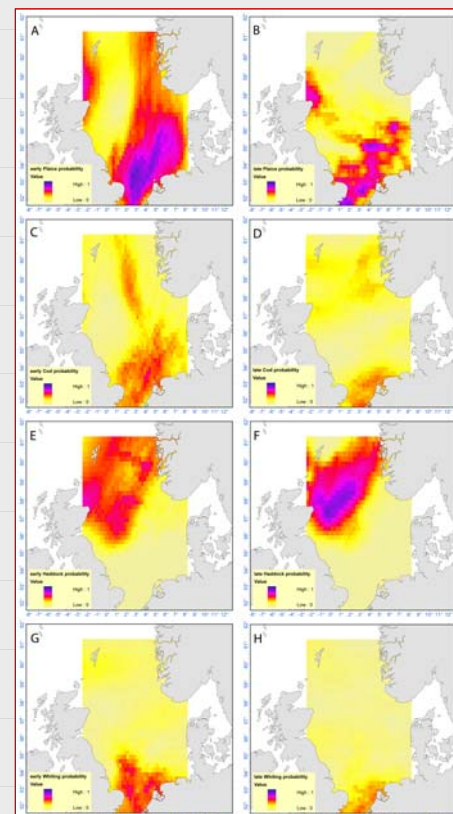


Figure 2: Probabilities of occurrence for early (left panels) and late (right panels) stages of fish eggs, averaged for 2004 and 2009. Except for haddock the highest probability to find eggs was in the southern North Sea. Overall the area with a high probability to find early stages of eggs was much larger, especially for plaice (A, B) and to some extent also for cod (C, D). In comparison the reduction in area of high probability was not that high for haddock (E, F) and whiting (G, H).

Discussion and Outlook

Preferred spawning and hatching areas can be indicated by strong correlations between occurrence probability and high abundance, the longer the time series the better (Bellier et al. 2007). When planning future surveys, it can help to account for differences in the progress of spawning seasons in different areas. Combination with identified beneficial hydrographic conditions allows to establish maps of suitable habitats for spawning fish and their offspring.

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References

- Bellier, E., Planque, B., Pettigrew, P., 2007. Historical fluctuations in spawning location of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) in the Bay of Biscay during 1967-73 and 2000-2004. *Fisheries Oceanography* 16, 1-15.
- Fox, C.J., Taylor, M., Dickey-Collas, M., Fossum, P., Kraus, G., Rohlf, N., Munk, P., van Damme, C.J.G., Bolle, L.J., Maxwell, D.L., Wright, P.J., 2008. Mapping the spawning grounds of North Sea cod (*Gadus morhua*) by direct and indirect means. *Proceedings of the Royal Society B-Biological Sciences* 275, 1543-1548.
- Munk, P., Fox, C.J., Bolle, L.J., van Damme, C.J.G., Fossum, P., Kraus, G., 2009. Spawning of North Sea fishes linked to hydrographic features. *Fisheries Oceanography* 18, 458-469.