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Connectivity, growth and survival in a spatially structured fish population, which is currently managed as seven separate stock units


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Introduction

> Predicting stock recruitment for short lived industrial species can be challenging as they normally enter the fishery stock early in life, thereby limiting the chance to collect biological data before hand.
> Nevertheless, predictions of stock recruitment in the industrial fisheries are of major importance since significant proportions of the catches are made up of newly recruited fish.
> It is generally acknowledged that growth affects the survival of early life stages. For instance, growth determines predation risk and overwinter survival.
> However, in spatially structured fish stocks (resident behaviour and habitat attachment), hydrographic dynamic forcing may complicate things considerably, as it affects retention and advection processes and influences the growth conditions experienced by the drifting larvae.

Pressent study

> In the present study we have focused on the short lived lesser sandeel (Ammodites marinus) population in the North Sea. This stock is spatially structured (currently managed as a cluster of sub stocks) with strong affinity to distinct habitats distributed patchily in the North Sea.
> On the Dogger Bank in the North Sea, weights measured during a juvenile-survey and recruitment estimates from stock assessment models indicate that growth and recruitment success are interlinked (see Graph to the Right).
> We investigated [A] spatial variation in hydrodynamically influenced drift patterns of sandeel larvae, [B] the role of hatch date on growth, and [C] possible linkages between growth in early life and the probability of surviving the first winter.

Results

[A] Spatial variation in larval drift

Objective: To investigate spatial variation in drift patterns

- Drift patterns are dynamic between areas and years
- Dogger Bank is a self-supplying area with a high degree of retention in all study years
- Central and North-eastern Banks show higher connectivity with spawning grounds further south and are to a higher degree susceptible to changes in drift patterns
- Intermittency in drift distance and direction is increasing from Dogger Bank to North-eastern banks

Modeled drift pattern of larvae in 2008. Dogger Bank is well supplied, while recruitment to the central and North-eastern Banks is limited, especially from southern and possibly coastal areas. The dashed area covers approximately 70% of possible hatch sites. Red dots: sample positions. Blue shaded areas: sandeel habitat.

[B] Larval growth and hatch date

Objective: To test whether otolith growth rate is a proxy for larval somatic growth or for hatch date

- Otolith growth showed a significant correlation with somatic growth rate proxy (residuals of the larval size–otolith size relationship), explaining only 3% of the variance (p < 0.003, r² = 0.03) (Not shown).
- Otolith growth was significantly correlated with hatch date, with late-hatching larvae showing faster increase in daily increment width, indicating faster growth (p = 0.001, r² = 0.18) (Graph below).

Yearly model predictions of the origin (hatch area) of larvae settling at two sites in the North Sea (Dogger Bank (left map) and North Eastern North Sea (right map). The sites are indicated with “+” on the maps. Bubble size indicate contribution from a given location relative to other locations. The predictions assume homogenous distribution of spawning biomass across suitable sandeel habitat and spatially variable larval mortality.

[C] Overwintering survival

Objective: To test whether individuals with faster otolith growth rates have higher overwinter survival on Dogger Bank

- Considerable somatic growth (ca. 4cm) occurred during the period from before to after winter
- Linear mixed effects model comparison and estimation of otolith growth, showed significant higher mean increments for survivors of the winter 2003/2004 caught at the commence of fishery April/May compared to juveniles caught before winter in Nov/Dec. No such difference was found for the winter 2008/2009.

Conclusions

[A] Results indicate that Dogger Bank is a self-contained reproductive system while central and northern sandeel habitats received more recruitment from more distant regions, suggesting a source-sink approach to the stock may be appropriate. Improved understanding of link between inter-annual variation in hydrodynamics and stock recruitment may prove useful in future attempts to develop spatial explicit forecasts of the recruitment success of this stock.

[B] Larvae hatching late in the season appeared to be growing faster. This advocates for research dealing with the link between stock recruitment and inter-annual variation in timing of primary and secondary production in spring.

[C] There were some indications that growth in early life affected overwinter-survival. However, the results were inconsistent. Altogether the considerable difference between the size of juveniles in December (from scientific sandeel survey) and the size of age-1 sandeel caught in the fishery in April (overwintering lasts until late March—early April) indicates increased overwinter-mortality of the smallest individuals.