Fine-Scale Spatial Variation of Pelagic Fish Eggs in Relation to Ontogenetic Variation over the Western Agulhas Bank, South Africa

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Understanding the spatial distribution of fish eggs is important in fisheries science (Haug *et al*., 1986), because it: (i) affects the transport of eggs from spawning to nursery grounds, (ii) provides insights into the of reproductive strategies of fish, and (iii) allows one to design optimal sampling. However, because pelagic fish eggs are highly aggregated, it is difficult to infer distributions from studies conducted using coarse-scale data. Fine-scale quantitative studies to examine the spatial distribution of fish eggs have been lacking in the southern Benguela upwelling ecosystem and are scarce in many other ecosystems.

To address this, ichthyoplankton samples collected over 1 nautical mile intervals in an area of high egg densities (Fig. 1) were analyzed for anchovy, *Engraulis encrasicolus* (formerly known as *E. capensis*), sardine, *Sardinops sagax* and round herring (red-eye), *Etrumeus whiteheadi*. Samples were collected using a continuous, underway fish egg sampler (CUFES, Checkley *et al*., 1997) aboard the FRS Algoa in September 2000 over the western Agulhas Bank, South Africa (Fig. 1). In the laboratory, eggs were identified, grouped into three stage categories: (i) early-stage (*i.e.* no embryo- stages 1-3), (ii) middle-stage (early embryo, *i.e.* tail is still attached to the yolk- stages 4-7) and (iii) late-stage (*i.e.* tail has detached from the yolk- stages 8-11), and concentrations were standardized to numbers per cubic meter. Directional (anisotropic) variograms were computed for each category for each species using the EVA computer software package to quantitatively describe the spatial variation or correlation of the eggs in terms of distance and direction of each category for the three species.

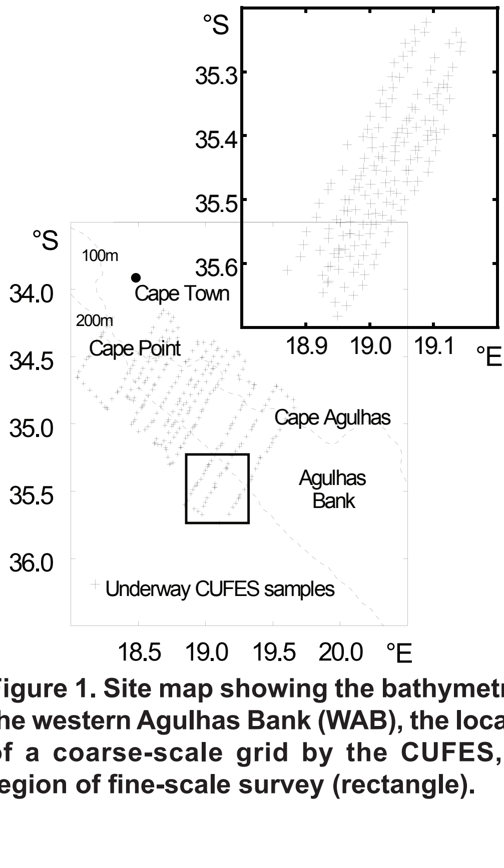

Figure 1. Site map showing the bathymetry of the western Agulhas Bank (WAB), the location of a coarse-scale grid by the CUFES, the region of fine-scale survey (rectangle).

The variogram results illustrate the spatial structure of the egg patches of the three species following spawning (Fig. 2; Plate 8, page xiii). Theoretically, stations that are far apart were expected to be less correlated, and to have large variances. Late-stage anchovy eggs showed no spatial structure in the inshore/offshore direction, but were spatially structured alongshore (Fig. 2). Early and middle-stage eggs were not collected from the CUFES samples, but were collected from the WP2 net hauled at vertical stations in the same area. Therefore, these results highlight the drawback of the CUFES sampler. It damaged about 68% of anchovy eggs beyond recognizable developmental stage, but the extent of damage was less pronounced for sardine (14%) and round herring (16%). Sardine early-stage eggs were patchily distributed with a nugget effect (the distance between the origin and the value of the variance at an extremely small distance apart) generally large (Fig. 2). Middle-stage eggs were spatially structured, samples at close distances being spatially correlated and those at large distances apart less correlated with an influence range of about 5-6 nautical miles, whereas late-stage eggs had no spatial cohesion. Unlike for sardine, round herring early-stage eggs were relatively spatially structured with an influence range of about 3 nautical miles, whereas middle- and late-stage eggs had similar spatial structure to those of sardine.

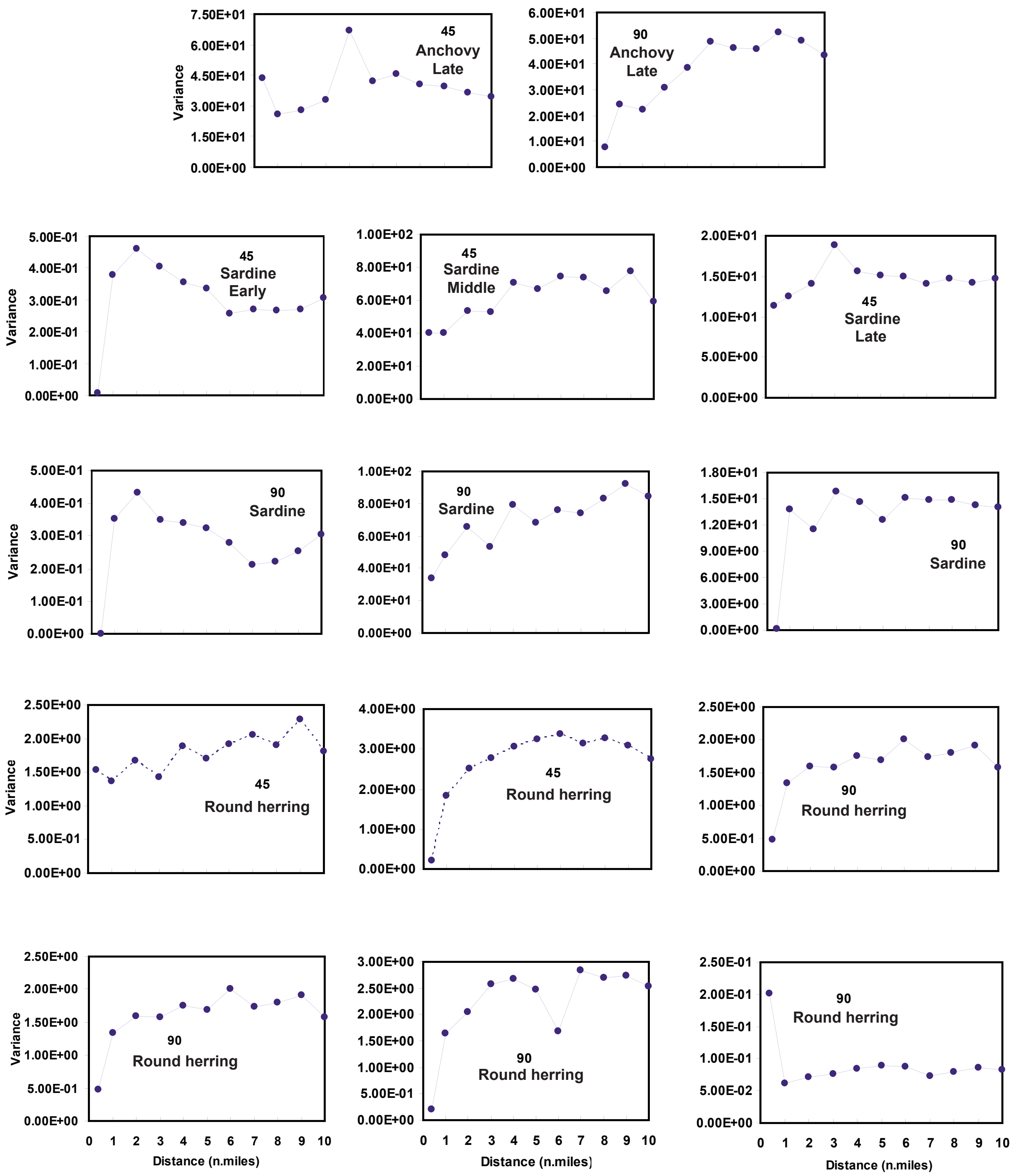

Figure 2. Variograms of anchovy, sardine and round herring, eggs by stage category. The degrees indicate the directions that were given greatest weighting in constricting the variogram; degree 45 is inshore/offshore direction, and degree 90 is the alongshore direction.

These results suggest that the sardine spawning strategy is that of several dense spawning shoals over the spawning area, unlike round herring, which appears to be that of less dense spawning shoals. Similar results have been reported for the Australian sardine *S. sagax* (Fletcher and Sumner, 1999) using a similar sampling distance, but using vertically towed nets. Furthermore, these results indicate that the size of the egg patches (5-6 nautical miles) for all three species is smaller than the current sampling interval of 10 nautical miles between stations in the southern Benguela. These data are currently used to make inferences about the spawning strategies of the species, therefore this study suggest that such inferences could be inappropriate. In conclusion, the results obtained from this study suggest that these spatial properties would have serious implications for individual based modelling (IBM) studies, and would need to be incorporated.

Acknowledgements

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Plate 7

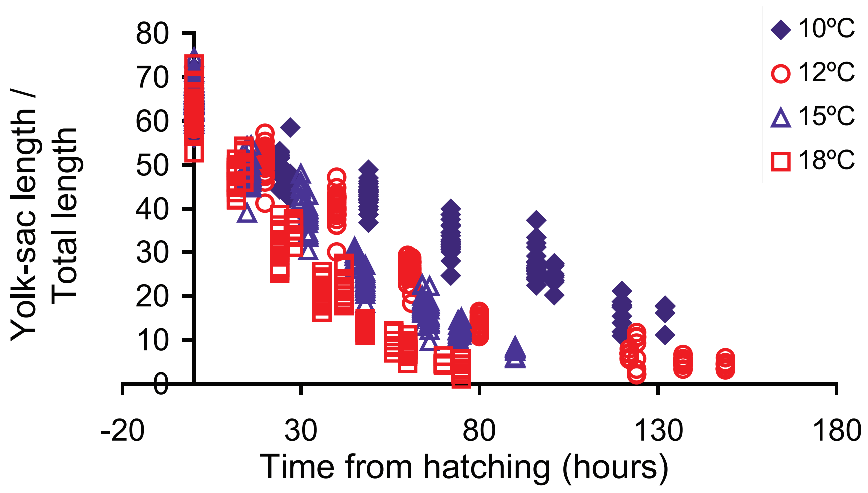
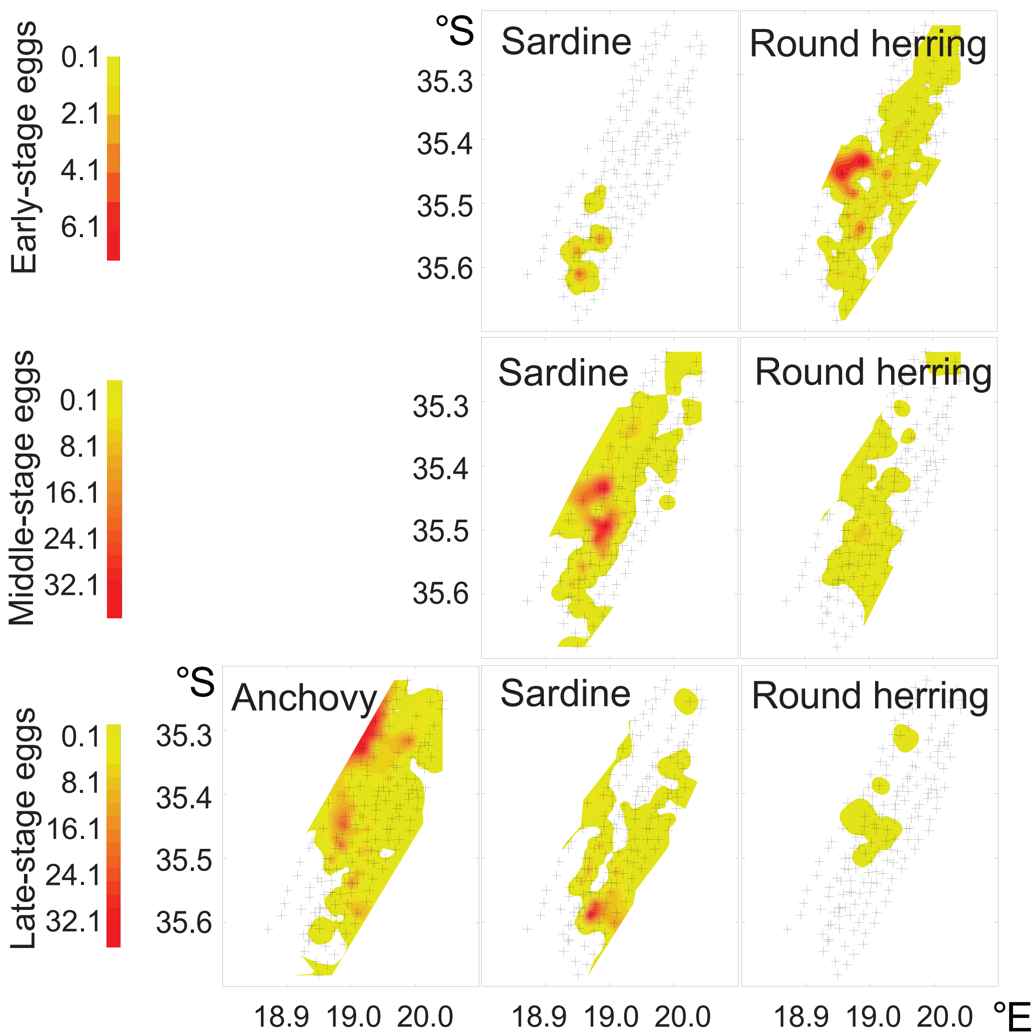


Plate 8



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