PERSISTENCE OF ACOUSTICALLY OBSERVED FISH BIOMASS IN A 220 KM² SURVEY REGION

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Introduction

Short-term harvest refuges have attracted the interest of fisheries managers as a means to protect juvenile fish. Implementation would require fishermen to report high catch rates of juveniles in a small area, whereupon the area would be closed to fishing for a specified period. Such management relies on the persistence of juvenile fish in the harvest refuge. We describe the design of an acoustic survey addressing persistence of young cod and the analysis of resulting data.

Material and Methods

The primary motivation for considering short-term harvest refuges within this study was to protect juvenile cod. This being the case, we decided to mimic conditions likely to lead to the creation of a juvenile cod refuge. We asked fishermen of the UK National Federation of Fishermen's Organizations (NFFO) to indicate an area where they were encountering high concentrations of juvenile cod. The fishing industry took a strong interest in this work and sent an observer, Fred Normandale, to assist. On his advice, we headed for a coastal area near Scarborough (54.4°N, 0.3°W). There we created a 220 km² survey region and monitored the distribution of fish with our 38 kHz transducer, whilst catching and tagging as many fish as possible. In processing our acoustic recordings, we focused on the region extending from 0.5 to 5 m above the seabed in an effort to obtain a high representation of cod in the acoustic echoes.

The acoustic survey consisted of 19 separate survey grids, of which 15 were in the vicinity of the designated refuge site (Figure 1). Overlaid on each grid in Figure 1 is a contour plot of acoustic S_A values (in m^2/Nm^2), made by weighting observations by the inverse of their squared distance from a given prediction site.

To quantify persistence, we fitted the following generalized additive model (GAM) to the acoustic data:

$$\log_e(S_A) = \mu + lo(d_a) + lo(d_o) + lo(d_a,d_o) + lo(t) + lo(t,d_o) + lo(t,d_a) + \gamma_1\sin(2\pi t) + \gamma_2\cos(2\pi t) + \varepsilon$$

where d_a represents the distance along shore in km, d_o the distance offshore (km), and t the time (in days) from the start of January. The *lo* term represents a LOESS smoothing function, while the sine and cosine terms were designed to represent cycles with a 24-hour period. The values of the parameters $\{\gamma_1, \gamma_2\}$ were estimated. Note that μ represents an intercept term (also to be estimated) and ε denotes a random error term assumed to be Normally distributed with mean zero and constant variance.

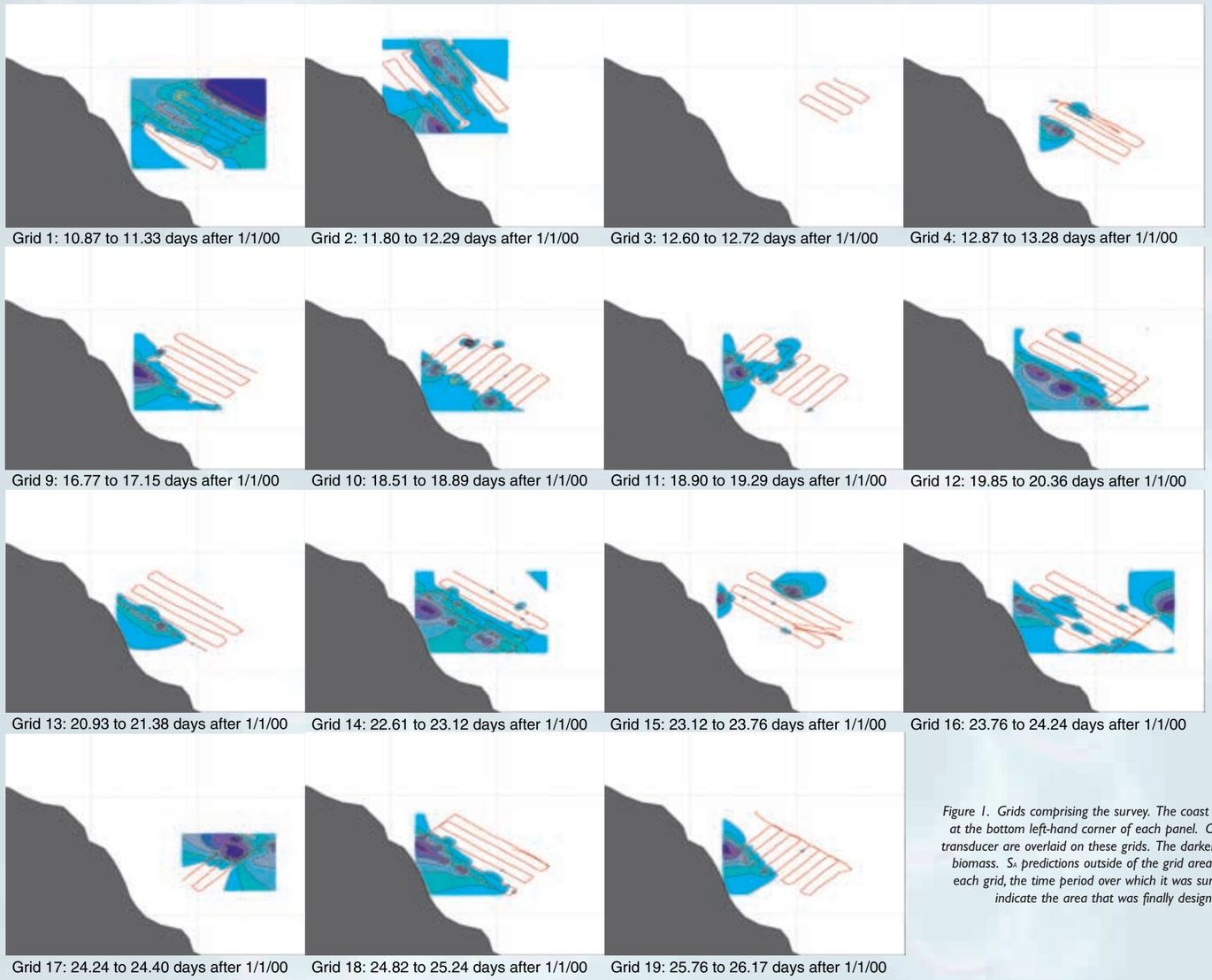

Figure 1. Grids comprising the survey. The coast of Yorkshire is indicated in dark grey at the bottom left-hand corner of each panel. Contour lines of S_A from the 38 kHz transducer are overlaid on these grids. The darker contour colours indicate the highest biomass. S_A predictions outside of the grid area are shown for comparison. Under each grid, the time period over which it was surveyed is indicated. Grids 11 to 16 indicate the area that was finally designated as the harvest refuge.

Results

Fish were found most reliably on the inshore edge of the region (Figure 1), particularly on the western tip, an area difficult to fish because of numerous wrecks. There were brief appearances of large fish concentrations in eastern offshore areas. Cod represented about 10% of the catch by weight, most of which was whiting. Figure 2 shows the length distribution of the cod.

All terms of the GAM model were significant at the customary 5% level. Figure 3 shows the temporal component of the GAM fit, indicating the overall trends in biomass. This Figure suggests fish abundance varied by about 50% in a period of two to three days.

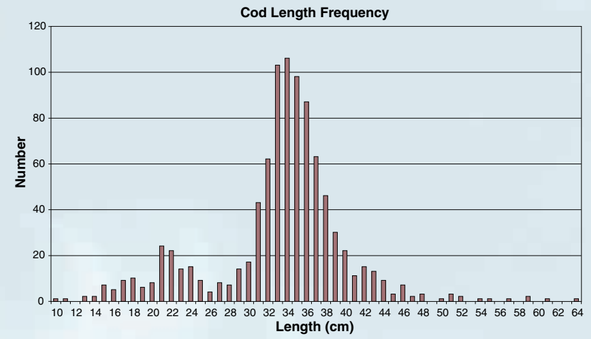

Figure 2. The length distribution of the cod caught in the trawl gear over the entire survey.

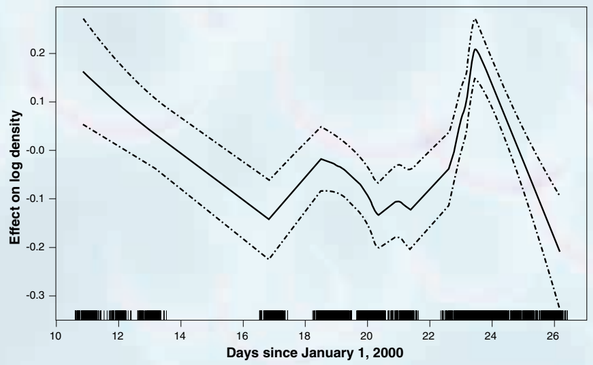

Figure 3. The effect of time on fish abundance as detected by the 38 kHz transducer.

Discussion

In view of the biomass fluctuation in a 220 km² area, larger regions would be required to provide adequate protection to juvenile cod.
This conclusion assumes, however, that cod movements are similar to those of the entire demersal assemblage, as we were unable to distinguish cod from other fish in our acoustic data.

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