

Introduction

Routine research surveys are a major source of fisheries independent information for estimating stock abundance. Bottom trawl surveys are routinely performed at a coarse spatial scale and when estimates are derived from coarse scale surveys they do not account for spatial variation occurring at finer scales. In this poster we present the results of a study to investigate spatial indices and the empirical distribution of catch data collected at different spatial scales. North Sea cod (*Gadus morhua* L.) is presented and catch rates of 2-year old cod in the central North Sea are analysed from the third quarter of 1995.

Material and Methods

In the North Sea, the International Bottom Trawl Survey (IBTS) is conducted annually and the English Ground Fish Survey (EGFS) has been incorporated within the IBTS since 1991. Other routine surveys with higher spatial resolution have been conducted in the region. Amongst these is the German Small-scale Bottom Trawl Survey (GSBTS) conducted since 1987, together with others to study the fine spatial distribution of fish abundance and the variability of catch rates within areas of the IBTS grid.

Sources of catch information for comparative study

The GSBTS and the EGFS/IBTS are undertaken within the North Sea at different levels of spatial coverage and at different months of the year. To enable an investigation of the variability of catch rates within these surveys the catch rates of 2-year old cod in the central North Sea were analysed. Survey data are available at a similar time of year for all three surveys during the 3rd quarter of 1995.

The GSBTS has a designated Box H in the central North Sea. Trawl stations of the EGFS/IBTS were selected to be within an area defined between longitude 1° and 4°, and between latitude 55° and 58° (Figure 1). Box H of the GSBTS provides catch data for 26 hauls, the area identified in close proximity to Box H covered by the EGFS provides 14 hauls, and the area identified in close proximity to Box H covered by the IBTS provides 36 hauls. These choices allow the variability of catch rates within the selected areas to be investigated for different levels of spatial coverage.

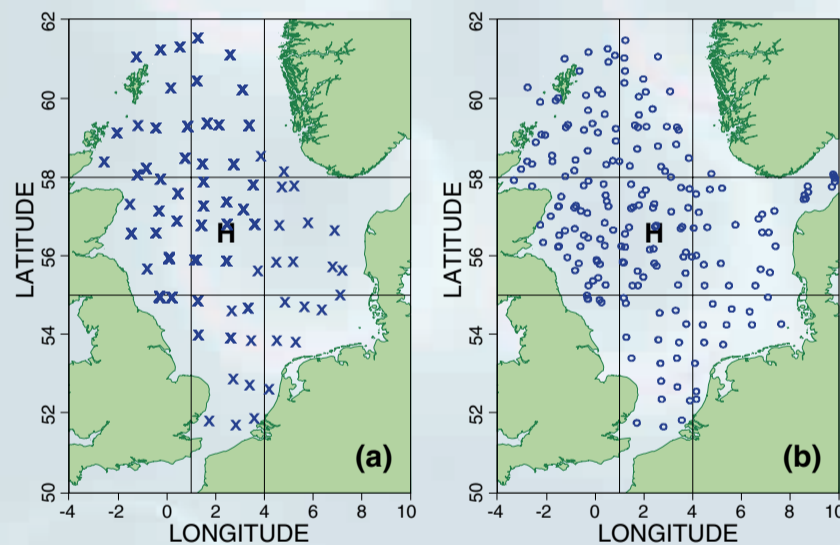


Figure 1. Location of all survey stations during the third quarter of 1995: (a) EGFS trawls (shown by the crosses), and (b) IBTS trawls (shown by the circles). The location of the GSBTS (Box H) indicated by the single letter H in each map.

Empirical distribution of catch

The empirical distribution of catch per tow can vary and depends on a number of different factors. Clumping, aggregation or contagion characterizes most populations in the wild and counts of individuals x_1, x_2, \dots, x_n in small sub-areas of known size are employed to understand such processes. The sub-area of interest is the sampled station - each station corresponding to a standard tow of fixed duration.

Spatial indices and over-dispersion

Spatial aggregation in the distribution of fish sampled may be investigated on the basis of calculated indices (\bar{x} , s^2 , I, ICS, ICF, IP, U). Once over-dispersion has been identified, there is a need to account for it, possibly with a probabilistic model. Representing the over-dispersion in catch data leads naturally to the idea of conditionality:

$$P_n(t) = \int_0^{\infty} \{ e^{-\alpha t} \alpha(t)^n / n! \} u(\alpha) d\alpha$$

mixture processes and the negative binomial distribution.

Results

Catch statistics

The GSBTS stations were taken during the three days 25-27 July 1995, the EGFS stations were taken during the period 15 August to 4 September 1995 and the IBTS stations were taken during the period 6 August to 4 September 1995. Histograms of the cod catches are distinctive (Figure 2) but those for the EGFS and IBTS are visually similar.

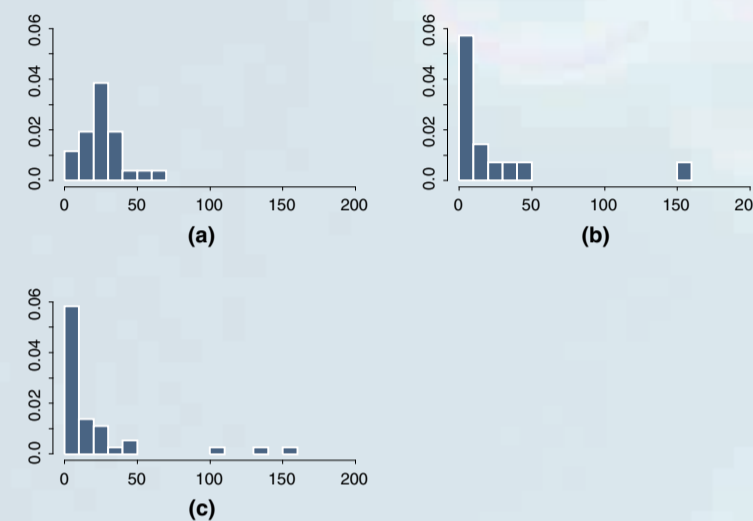


Figure 2. Histogram of the catch numbers of 2-year old cod in the central North Sea during the 3rd quarter of 1995: (a) GSBTS (Box H); (b) EGFS (stations near Box H); and (c) IBTS (stations near Box H).

The catches range from a minimum value of 7 fish per station to a maximum of 69 fish per station within Box H on the GSBTS and from a minimum of zero fish to a maximum of 153 fish on both the EGFS and the IBTS. The empirical catch distributions are similar for the EGFS and the IBTS but both are different from that of the GSBTS.

Spatial indices and over-dispersion

The catch data are clearly over-dispersed for the three surveys and the indices of dispersion are all highly significant (Table 1).

Table 1. Summary statistics of the catch numbers of 2-year old cod in the central North Sea during the 3rd quarter of 1995 for the three surveys: (a) GSBTS (Box H); (b) EGFS (stations near Box H); and (c) IBTS (stations near Box H). The statistic $(n-1)I$ provides the homogeneity test statistic (probability, $p = 0$, for all values).

Survey	Mean \bar{x}	Variance s^2	$(n-1)I$
GSBTS: Box H	26.83	210.77	196.43
EGFS: near Box H	22.16	1592.49	934.04
IBTS: near Box H	21.02	1286.14	2141.59

Calculated indices of clumping and aggregation are positive and indicative of the presence of heterogeneity within the catch rates on each of the three surveys. The catch distributions are aggregated and a negative binomial distribution is a good fit to each survey's catch data. Maximum likelihood estimation of the two parameters of a negative binomial distribution for each of the three surveys independently yields estimates of 4 and 0.13, respectively, for the GSBTS (Box H) and estimates of 1 and 0.04, respectively, for both the EGFS (stations near Box H) and the IBTS (stations near Box H).

Simulated catch distributions

To illustrate the suitability of the negative binomial distribution and to indicate the inherent level of variability, simulated catch rates were generated using the appropriate negative binomial distribution for the EGFS survey (Figure 3).

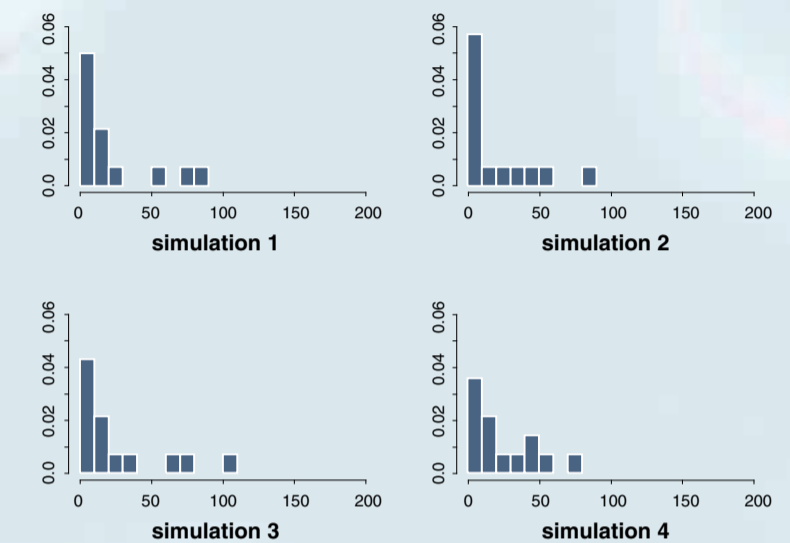


Figure 3. Four simulated realizations of a negative binomial distribution with parameters 1 and 0.04. Each simulation is constrained to generate the same number of values (namely, 14) as stations encountered by the EGFS in the vicinity of Box H.

Conclusions

It is important to identify the spatial scale over which sampling is contemplated and for which subsequent model-based inferences are to be made. Differences in the parameter estimates obtained for the mixture distribution fitted to the GSBTS (Box H) and the EGFS/IBTS in the vicinity of Box H were found. Clearly, the GSBTS (Box H) may be viewed as a local survey consisting of repeatedly trawling within the same region; whilst the EGFS and IBTS may be viewed as both trawling within different regions. In principle, each EGFS/IBTS station may be considered as a single observation taken from a heterogeneous process of the type sampled within the GSBTS (Box H). From such a viewpoint, it is hardly surprising that a common distribution of catch rate seems appropriate for different surveys. The difference in the estimated values of parameters might be due to the estimation being related to different underlying processes.

In addition, the following general conclusions can be stated:

- The estimated mean catch rates of the three surveys investigated are similar but the estimated variances are different for the fine-scale and coarse scale surveys.
- The type and appearance of the catch frequency distribution depend amongst others upon the extent of the area in which the hauls took place.
- The negative binomial distribution is suitable to describe the catch distribution at the different spatial scales considered.
- Fine-scale surveys like the GSBTS provide information on within IBTS station variability; whilst the coarse scale EGFS/IBTS provide information on between station variability.
- Further fine-scale surveys would be helpful to understand the processes of clumping and aggregation; improving the design of surveys and the calculation of abundance indices and associated confidence intervals.

Funding

This poster was prepared with funding support provided by the Ministry of Agriculture, Fisheries and Food (contract MF0316) to the first author (CMO'B); together with funding support provided to all three authors by the Commission of the European Communities Directorate General for Fisheries (DG XIV) under project contract 98/029 (Survey-based abundance indices that account for fine spatial scale information for North Sea stocks - FINE).

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