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Effect of Fixing Stations in the 2000 West Greenland Shrimp Survey on the Detection of Changes in Biomass

by

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Abstract

Kingsley, M. C. S. 2000. Effect of fixing stations in the 2000 West Greenland shrimp survey on the detection of changes in biomass. NAFO SCR Doc. 00/86, Serial No. N4343, 3 p.

The positions of 90 stations in the 2000 West Greenland shrimp survey were fixed from the previous year. Within strata, catches at fixed stations were positively correlated between years with, overall, high statistical significance. Partial biomass estimates calculated from the fixed stations showed that because of this positive between-years correlation, the estimate of the year-to-year change was more precise than the standard errors of the separate years' estimates would indicate.

Introduction

A research trawl survey is a component of the assessment process for the stock of northern shrimp *P. borealis* fished off West Greenland. It occupies a 722-ton trawler for about 2 months. Recent reviews of its design have raised the question of possible advantages from fixing the positions of stations between years. To do so would not affect the statistical properties (i.e. bias or precision) of single surveys, but may affect survey series. If two similar consecutive surveys are independent, the standard error of their mean is half the standard error of their difference: yet in stock assessments, less weight is often attached to the average estimate of stock biomass than to its upward or downward trend. If the distribution of the stock is positively correlated between years, fixing stations causes the errors in consecutive surveys to be positively correlated: i.e. if the estimate in one year is an overestimated, then the next year is more likely also to be an overestimate. As a result, change in biomass from year to year is more precisely estimated if stations are fixed, while the average biomass over a number of years is less precisely estimated.

If survey stations are placed by independent random sampling, stations are irregularly placed, and biomass estimates would be sensitive to changes in stock distribution if stations were fixed. From 1999, stations of the West Greenland shrimp survey were placed by buffered sampling (Kingsley *et al*. 1999), which distributes them more evenly, and therefore makes biomass estimates less sensitive to possible changes in distribution; fixing stations therefore became more practicable. 92 station positions of the 1998 survey were fixed to be re-used in 1999, and 90 were fixed from 1999 to 2000.

This document presents results of simple analyses of comparing of catches at fixed stations between-years.

Methods

Sample stations in both 1999 and 2000 were placed using buffered sampling, in which stations were not placed closer to one another than a stratum-specific prescribed limiting distance. The station-placement algorithm worked with a fine grid of potential station positions which were first sorted into random order; positions which had been used in 1999 were considered for selection in 2000 before those which had not, until the required number of fixed-station positions had been selected. Then the stratum total requirement was filled with newly selected positions. The objective was to fix the positions of 50% of the 210 stations used in 2000; this sometimes conflicted with the buffered sampling and in such cases, fewer stations were fixed than was planned.

The stations were fished using standard methods for the West Greenland assessment survey (Carlsson and Kanneworff 1998). Stations were only fished between 0700 and 1900 UTC. Trawling speed was about 3 knots. A *Skjervoy 3000* shrimp trawl with a 20-mm cod-end was used with *Greenland Perfect* doors. The start of the tow was indicated by the reading of a Furuno® trawl-eye mounted on the head-rope. Swept area was calculated from the change in GPS position between the start and end of the tow, and from the average of the door-spreads reported by Scanmar® sensors. The catches of shrimp were weighed and recorded. Samples were sorted by species and weighed, and individual *P. borealis* were measured. The catch of *P. borealis* was divided by the swept area to give a resource density.

Within-stratum correlations between 1999 and 2000 were calculated, for strata with at least 2 fixed stations. The significance levels of the individual stratum correlations for the strata with at least 3 fixed stations were calculated and accumulated using additive chi-square[1]. For strata with only 2 fixed stations and correlations of plus one or minus 1, a chi-square test for equal probability was carried out on the counts of positive and negative correlations, and this chi-square also added to the significance test.

Calculating correlation coefficients gave an estimate of the statistical properties of fixed stations but only a qualitative indication of their effect on the precision of biomass estimates. A partial biomass estimate was calculated for 1999 and for 2000 only for those strata for which there were 2 or more fixed stations the SE of the change from the individual SEs; a biomass change, and its SE was calculated from the station-by-station differences.

Results and Discussion

For strata with 3 or fixed stations, correlations between years in density estimates by station were usually positive, sometimes strongly so; there were 2 negative correlations, both small (Table 1). Overall, correlations were statistically significant (Table 1).

From 72 fixed stations in 24 strata, partial biomass estimates were 231 844 tons in 1999 and 27 7284 in 2000, with standard errors of 32 435 and 25 877 tons. Error coefficients of variation at 14.0% and 9.3% were not very different from those obtained from the two years' entire survey data sets. The biomass difference was estimated at 45 440 tons, and its standard error, estimated from the separate standard errors of the two partial biomass estimates, was 41 493 tons. This calculation of standard error for the difference wrongly assumes that the two estimates are independent and is therefore fallacious. A standard error estimated from the station-by-station differences, which is correct even if there is correlation between year, was 32 705 tons, about 20% less. This result is less impressive than that obtained in 1999 from station-by-station comparison with 1998 catches (Kingsley *et al*. 1999), but points to the same conclusion that survey designs using fixed stations are likely to be more reliable in detecting changes in biomass between years, although the results of a reduced number of degrees of freedom have not been investigated.

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[1] Each calculated correlation coefficient was converted to a significance level and the significance level was converted to the equivalent critical value of chi-square on 1 d.f. Using the additive property of independent chi-square, these values were then summed and a single chi-square test applied to the hypothesis that overall, correlations were positive.

Conclusion

The conclusions from this study are similar to those from last year, that fixing station positions will make surveys more reliable in detecting changes in biomass. However, the estimation of the improvement has proved difficult, and is complicated by the random allocation of fixed stations to the rather large number of strata in the West Greenland shrimp survey; 20% of fixed stations were the only fixed stations in their strata, and only 24 of 52 strata had more than 1 fixed station. It is recommended that the proportion of fixed stations should be maintained at about 60–70%, and that fixed stations should be allocated in such a way that there should never be 1 fixed station nor 1 non-fixed station in a stratum (i.e. if there are 2 or 3 stations in a stratum, they should either all be fixed or all replaced). This would facilitate calculating the effects of fixing stations: otherwise, although the effects of fixing stations can be qualitatively stated as positive correlation between survey errors and more precise estimates of change in biomass, they are difficult to measure.

References

Carlsson, D. M., and P. Kanneworff. 1998. Offshore stratified-random trawl survey for shrimp (*Pandalus borealis*) in NAFO Subareas 0+1, 1998. NAFO SCR Doc., No. 118, Serial No. N4027, 18 p.

Kingsley, M. C. S., P. Kanneworff, and D. M. Carlsson. 1999. Modifications to the design of the trawl survey for *Pandalus borealis* in West Greenland waters: effects on bias and precision. NAFO SCR Doc., No. 105, Serial No. N4184, 15 p.

Table 1. Within-stratum correlations of density estimates at fixed stations in the West Greenland shrimp survey between 1999 and 2000.

Stratum	No. of fixed Stations	Within-stratum correlation	One-sided significance	Chi-square equivalent
C3-2	2	1		
D1	2	1		
D3	2	1		
D4	2	1		
D7	2	1		
D9	2	1		
S1	3	0.904	0.1409	2.168
W1-2	2	1		
W1-3	7	0.845	0.0084	6.948
W2-2	2	-1		
W2-3	4	0.875	0.0626	3.467
W2-4	2	1		
W3-2	7	-0.031	0.5266	0.401
W3-3	2	1		
W3-4	2	-1		
W4-2	2	1		
W4-3	2	1		
W4-4	4	0.946	0.0270	4.892
W5-2	9	0.600	0.0438	4.065
W5-3	3	-0.166	0.5531	0.352
W6-1	2	1		
W6-2	3	0.614	0.2894	1.123
W7-2	2	-1		
	2-station correlations	+ve	-ve	
		12	3	6.623
	Sum of chi-square on 9 d.f. for positive correlation			23.416***