Northwest Atlantic Fisheries Organization

Serial No. N4565 **NAFO SCR Doc. 01/176**

SCIENTIFIC COUNCIL MEETING – NOVEMBER 2001

Effects in 2001 of Recent Modifications to the Design of the West Greenland Shrimp Survey

by

Michael C. S. Kingsley

Greenland Institute of Natural Resources
P.O. Box 570, DK–3900 Nuuk, Greenland

Abstract

Kingsley, M. C. S. 2001. Effects in 2001 of Recent Modifications to the Design of the West Greenland Shrimp Survey. NAFO SCR Doc. 01/176, Serial No. N4565, 5 p.

Design practices in the West Greenland shrimp survey have recently been changed. Changes include the use of shorter tows, fixing station positions from year to year, and annually revised allocation of stations between strata.

In 2001, it appeared that the distribution of the biomass was much different from recent years, so station allocation based on previous years' within-stratum variability was not optimal, and between-year correlation of catch at fixed stations was not significant. An analysis of components of variance confirmed past years' results that short-range variation in biomass density was small and using shorter tows did not make the survey less precise.

Introduction

A research trawl survey is a component of the assessment process for the stock of northern shrimp *P. borealis* fished off West Greenland (Kanneworff and Wieland, in prep.). The survey has been carried out annually since 1988. Since 1999, several changes have been made to the survey design practice, including the use of buffered sampling, fixing the positions of about 50% of stations from year to year, revising the algorithm used to allocated stations to survey strata, and shortening tow durations (Carlsson *et al*., 2000). Analyses of the effects of these changes were presented in 1999 and 2000 (Kingsley *et al*., 1999; Kingsley *et al*., in press). The present article briefly presents a review of their apparent effects in 2001.

Methods

Fishing methods were standard, and as previously described to meetings of the NAFO Science Council (Kanneworff and Wieland, in prep.). 11 zero-length tows were executed to estimate the end effect of the Skjervøy 3000 trawl, the execution and results of which are fully described in another document (Kingsley, 2001). A maximum likelihood analysis of the within-stratum variability of catches was carried out to compare short-range and long-range variability. Included in this analysis was an estimate of the end effect of the trawl. The analysis was performed on the standard survey tows only, and also on all tows including the end-effect experiments.

In the design of the survey, stations were allocated to minimise the expected standard error of total estimated biomass in regions C, D, S and W, predicting within-stratum variances from exponential smoothing of previous years' observed variances. The exponential weighting was further weighted by the number of stations on which each past year's variance had been based. To evaluate the allocation of the 204 stations that were trawled in Regions C, D, S and W, they were reallocated on a trial basis, first proportionally to stratum area, then according to the within-stratum variances actually obtained in this year's survey.

To assess the effect of fixed stations in the survey, within-stratum biomass correlations for the stations fixed from 2000 into 2001 were calculated. The standard error of a partial estimate of the change in biomass was calculated two ways: by considering the two years' surveys separately and also by calculating the mean and standard error of the change in biomass on a station-by-station basis for the fixed stations only.

Results and Discussion

Effect of tow duration on precision

The analysis of components of variance, as in the previous two years, indicated that the short-range component of variation was small, in fact negative. Plots of within-stratum standard error against mean biomass density for short and long tows confirmed that short (15-minute) tows were no more variable than 30-minute tows (Fig. 1). This result confirms that of previous years. The overall error coefficient of variation of the survey was only about 12.3%. This was slightly larger than in 2000. The slight increase is probably due to generally higher within-stratum variances than in 2000 and also to less optimal allocation of stations than was achieved in 2000, and does not indicate that shortening tow durations has made the survey less reliable.

In several strata, it occurred that 30-minute tows gave on average mean densities many times (i.e. several hundred times) higher than the average of 15-minute tows in the same strata (see Kingsley 2001, Fig. 3). This produced a negative estimate of the end effect of the trawl of about -5 minutes. However, when the experimental zero-length tows, (which mostly had high catches up to the equivalent of 9 minutes fishing at the same station), were included in the overall analysis, the overall estimate of end effect was plus 5.01 minutes. This estimate was significantly different from zero.

Allocation of stations to strata

The total biomass in 2001 was close to the 2000 value. If the within-stratum variances predicted by exponential smoothing had been obtained, a standard error for the total biomass estimate in Regions C, D, S and W would have been about 27 492 t. However, the distribution over depth strata was different with generally higher densities, and much higher variances, in the 200–300-m strata than in recent years. Taking the 2001 within-stratum variances as correct, area-based sampling would have given an overall standard error of biomass of about 52 024 t for the total for Regions C, D, S, and W. The sampling allocation used, based on smoothing of previous years' variances, gave a standard error of 42 946 t. 20/20 allocation of stations to give the minimum possible standard error for the within-stratum variances actually obtained would have given a standard error of 31 411 t.

For strata in Region W, for which depth stratification was available, the allocation based on previous years' variances systematically under-sampled the 200–300-m strata, on average by about 50%. The other strata were correspondingly over-sampled, the 300–600-m strata by a factor of close to 2 (Table 1). This indicates that the variation of catch per tow in the 200–300 m strata was higher than expected, probably owing to an unexpectedly high biomass in this depth band, distributed in a clumped fashion with presence of dense aggregations. The systematic error in allocation of stations might have been reduced if a predictive model for stock biomass, size distribution, and consequent distribution between depth strata could have been applied to designing this survey.

Fixed stations

In both 1999 and 2000, fixing stations significantly decreased the uncertainty of estimating the change in stock biomass, and catch correlations between years were high. In 2001, it seemed that the distribution of the stock had changed more from the previous year. Correlations were low, and overall were barely significant (Table 2). The standard error of the change in biomass calculated from the fixed stations was almost the same whether calculated as independent samples or by a pairwise comparison of the catches in the two years at each station. Therefore, fixing station positions between 2000 and 2001 has had little effect on the precision of estimating change in biomass.

Conclusion

The biomass in the shrimp survey area appeared to be distributed differently in 2001 from how it was in the previous two years and tested the present survey design practices. It had a different depth distribution from 2000, so station allocation between strata was not optimal, and some strata had high catch variances. In spite of this, the overall standard error of the biomass estimate was among the lowest ever obtained. The use of short tows did not

appear to make the survey less precise. The biomass distribution appeared to have changed also even within strata, sufficiently to make the use of fixed stations ineffective for improving the precision of estimating change in biomass.

References

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Table 1. Station allocation in Region W of the West Greenland shrimp survey, 2001, compared with an optimal allocation for the observed within-stratum variability.

		Depth range (m)				Total
		150–200	200-300	300-400	400-600	
W1	planned	2	3	16	2	23
	optimal	2	10	6	2	20
	difference		-70%	167%		15%
W2		2	4	10	7	23
		2	17	7	2	28
			-76%	43%	250%	-18%
W3		2	20	5	3	30
		2	46	2	2	52
			-57%	150%	50%	-42%
W4		4	4	11	5	24
		2	2	2	2	8
		100%	100%	450%	150%	200%
W5		3	16	5	4	28
		2	15	2	2	21
		50%	7%	150%	100%	33%
W6		4	7	4	2	17
		2	4	2	2	10
		100%	75%	50%		70 %
W7		2	8	2	2	14
		2	18	2	2	24
			-56%	0%		-42%
Total		19	62	53	25	159
		14	112	24	14	164
		36%	-45%	121%	79%	-3%

Table 2. Catch correlations between years within strata, for strata with 2 or more stations fixed from 2000 to 2001.

Stratum	Number of fixed stations	Between-year correlation	Chi-square
C32	2	1	
D1	3	0.998	5.601
D3	2	-1	
D9	2	1	
S1	10	0.175	1.012
W12	2	1	
W13	9	0.550	3.475
W22	2	-1	
W23	6	0.025	0.497
W24	3	-0.929	-2.407
W32	10	0.069	0.637
W33	3	-0.674	-1.244
W34	2	-1	
W42	2	1	
W43	6	0.684	3.351
W44	3	0.704	1.315
W51	2	1	
W52	8	0.276	1.299
W53	3	0.998	5.453
W54	2	1	
W61	2	-1	
W62	3	0.871	1.943
W72	4	0.023	0.480
	Count of +1	6	p for sum of chi-square:
	Count of -1	-4	6.5%

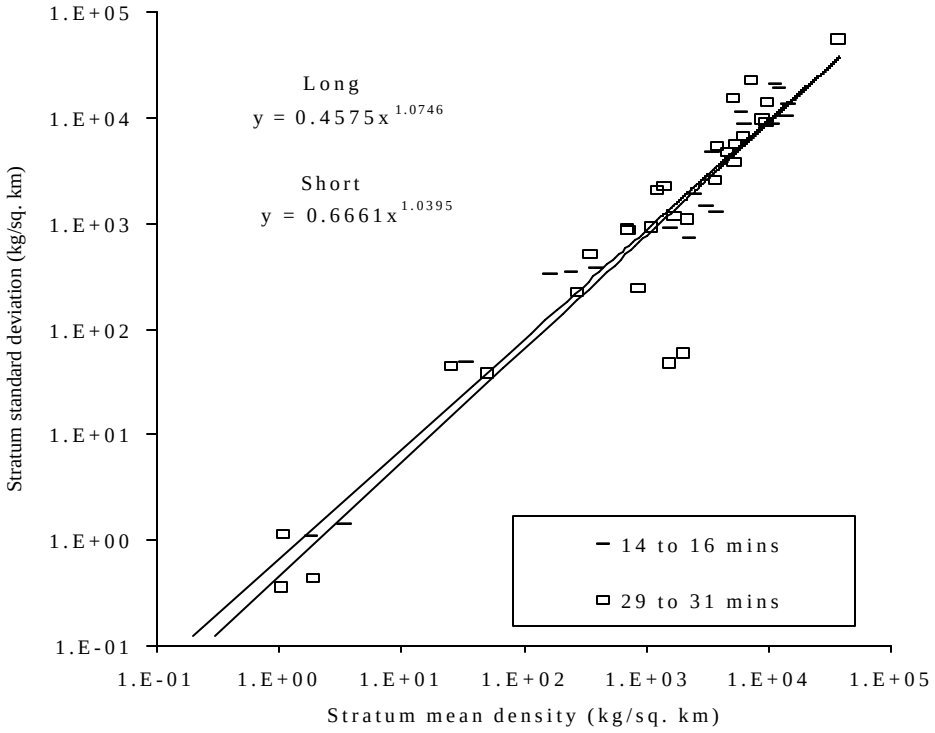

Fig. 1. Stratum mean and standard deviation of biomass density for short and long tows in the West Greenland shrimp survey in 2001.