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Contribution to the problem of designing length sampling schemes for the New England silver hake

by

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1. Introduction

This paper is a contribution to the discussion of Special Working Group on Statistics and Sampling on the variance of length and age measurement. The length sampling characteristics of the silver hake of the Southern New England coast are investigated but due to the lack of age/length key data age has not been investigated.

2. Data and Method of Analysis

The data used in this investigation are length distributions of silver hake from the US spring groundfish survey of 1972. These were made available to the author by Dr Brown of the Northeast Fisheries Center, Woods Hole, U.S.A. The area chosen for investigation was the Southern New England coast (Strata 1-12 in Fig. 1).

These 12 strata are arranged in four depth zones: <30 fathoms, 31-60 fathoms, 61-100 fathoms and >100 fathoms and into three areas whose boundaries run approximately perpendicular to the coast. Only tows which supplied catches of silver hake were considered and it was found that there were three or more such tows in each of the strata deeper than 30 fathoms. The shallowest zone only yielded occasional catches of this species and was therefore omitted from the investigation. It was decided to analyze these results using a method similar to that proposed by Brennan (1974) in her Table 5. However, as a refinement, depth and area were considered as rows and columns in the analysis of variance in a manner analogous to that used to analyze the Faroe Bank groundfish survey (Jones and Pope, 1973).

To simplify the analysis, for stratum in which there were more than three length distributions available, three of these length distributions were chosen at random to represent it. Thus the problem was cast in the form suitable for a 3-way analysis with three levels of depth, areas and tows. The variables analysed were the proportion of fish in each of the four length groups: 25-29 cm, 30-34 cm, 35-39 cm and 40-44 cm; other lengths contained too few results to be considered.

3. Results

The means squares obtained from the analyses of variance of four length groups are set out in Table 1. The only significant results are differences with depth for the proportion of fish in the 30-34 cm and 35-39 cm length groups. This was due to an increasing proportion of the 30-34 cm group in the deeper waters. The 35-39 cm group attained their highest proportion of the catch in the 61-100 fathom depth range.

Another result which was of interest but which did not quite reach the 5% level of significance was an area effect with the 30-34 cm group. Catches containing the highest proportion of this group were found in the most southerly area. In no case did tows differ significantly from the error term and the component due to this factor was added to the error term to give a combined error mean square. Estimates of the components of variance were calculated and these are shown in Table 2 (of Brennan, 1974, Table 5). This table is constructed so that the variance of $\bar{p}$ the average proportion,

$$\text{Var}\ (\bar{p}) = \frac{Se^2}{a \times d \times t \times \bar{m}} + \frac{Sa^2}{a} + \frac{Sd^2}{d}$$

where $\bar{m}$ is the 'average' number of fish in each sample (see Brennan, 1974), Se^2 is the error variance Sa^2, the variance due to area, Sd^2, the variance due to area, Sd^2 the variance due to depth and a, d and t the number of areas, depths and tows sampled.

Table 3 shows the likely standard deviation resulting from various possible values of $\bar{m}$, a, d and t. Thus sampling 75 fish per sample from three tows per stratum from three areas but only one depth would result in standard deviation of 0.22 and increase of more than 50% over the 0.14 standard deviation occurring when $m = 25$, $t = 3$, $a = 3$ and $d = 3$, although both schemes would result in precisely the same number of fish being measured.

4. Conclusions

Since the variance of the proportion of the fish does not differ systematically from tow to tow within a stratum there would seem to be no particular advantage in measuring a number of small samples from separate tows within a stratum as opposed to measuring one large sample per stratum. The former procedure might, however, seem the more prudent, presuming that there is little difference in effort between the two alternative systems.

Since the proportion of fish in some length groups does however change systematically with depth it is worthwhile taking separate samples from each depth zone. The effect of area is less certain but it is at least possible that an area split would produce a lower standard deviation.

It would therefore seem that for length sampling aboard commercial vessels it would be prudent to take samples of fish from each depth zone fished; it would also be wise to take separate samples when the fishing moves a significant distance along the coast. Sampling a number of tows in the same area would not, however, seem particularly worthwhile.

Shore sampling of vessels might well be stratified by depth with advantage but this would have to be assessed in the light of the extra effort such a stratification might generate.

5. Summary

An investigation of the components of variation of the proportion of fish in various length ranges for the Southern New England silver hake suggests that depth accounts for a greater proportion of the variance than other factors. It is, therefore, suggested that length sampling from all the various depth strata fished should be an important objective of the onboard sampling of commercial catch of this species. Shore-based sampling schemes might also find it worthwhile to adopt depth as a stratification, but the gain in precision in this case would have to be weighed against the probable extra effort involved.

References

Brennan, J. 1974. Research Document 74/29

Jones, B.W. and J.G. Pope. 1973. A groundfish survey of Faroe Bank. *Res. Bull. int. Comm. NW Atlant. Fish.*, No. 10, p. 53-61.

TABLE 1

MEAN SQUARES AND DEGREES OF FREEDOM FROM ANOVA OF VARIOUS LENGTH GROUPS OF SILVER HAKE

SOURCE	DF	25–29	30–34	35–39	40–44
Depths	2	.0350	.4301**	.1630*	.0018
Areas	2	.0227	.1399	.0349	.0013
Tows	2	.0516	.0340	.0145	.0014
Error	20	.0399	.04729	.0361	.0053
Error and Tows	22	.0410	.04609	.0341	.0052

**Significant at 1% level
*Significant at 5% level

TABLE 2

COMPONENTS OF VARIATION OF PROPORTION OF FISH IN VARIOUS LENGTH GROUPS FOR SILVER HAKE

Length range	s^2 error	s^2 area	s^2 depth	$\bar{p}$	$\bar{m}$
24–29	1.0250	-0.00233	0.00000	.201	25
30–34	1.1523	0.01029	0.04253	.420	25
35–39	0.8525	0.00009	0.01432	.144	25
40–44	0.1300	-0.06043	-0.00037	.038	25

TABLE 3

STANDARD DEVIATIONS RESULTING FROM VARIOUS POSSIBLE SAMPLING SCHEMES INVOLVING THE SAME AMOUNT OF SAMPLING EFFORT ON SILVER HAKE

m	t	a	d	Length Group			
				24–29	30–34	35–39	40–44
25	3	3	3	0.03	0.14	0.08	-
75	3	3	1	0.03	0.22	0.12	-
75	3	1	3	-	0.16	0.08	-
75	1	3	3	0.03	0.14	0.08	-
225	3	1	1	-	0.23	0.13	-
225	1	3	1	0.03	0.22	0.12	-
225	1	1	3	-	0.16	0.08	-