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The Number of Research Vessel Tows on the Flemish Cap is Never Enough

by

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Introduction

In a variety of ways the independent estimates of trends in abundance of a fish stock derived from research vessel surveys results can be of importance. The confidence with which the estimates can be treated depends in part on the use of standard methods and gears, on the timing and the degree of synopticity of sampling and on the intensity of sampling. In this paper the catch rates of cod in Canadian groundfish surveys on the Flemish Cap in the period 1977-81 are examined and 95% confidence intervals derived.

Materials and Methods

All fishing stations were selected at random within each stratum prior to the beginning of the cruises. The sampling intensity was roughly equal over all strata. Depths fished ranged from the shallowest depths at the top of the Bank to a maximum of 400 fath. Surveys were carried out by the R. V. Gadus Atlantica in January-February, 1978-81. The 1977 survey was done by the R. V. A. T. Cameron.

During the surveys it was the practice to measure all cod caught. The number caught per set is therefore known precisely.

Results

Frequencies of catches of cod were highly skewed to the right (Table 1). In this Table all catches are included. In the deepest strata with depth range 300-400 fath. cod are only rarely taken. The number of sets with zero catch is therefore a maximum. Means, standard deviations and coefficients of variation were calculated only for those sets of 300 fath. and shallower (Table 2). Also, the catch numbers increased by 1 were logarithmically transformed and the means, standard deviations and coefficients of variation of these were all substantially lower than the arithmetic ones. For the 4 years the weighted average logarithmic coefficient of variation is 0.469 while the corresponding arithmetic coefficient is 2.67.

If the distribution of catches were normally distributed and the sample coefficient were a reasonable approximation, the confidence range for 1.96 standard errors about the mean for a variety of sample numbers shown in Table 3 applies. However, it seems unlikely that the catch values are distributed normally.

If a log normal distribution applies, as it may well do, the amount of variation of the retransformed values varies with the size of the means (Table 4).

Discussion and Conclusions

It was assumed that the sample coefficients of variation each approximated some unique population parameter. In fact there is some indication, especially in the logarithmic series, that as the mean catch-per-tow increases, the standard deviation and the coefficient of variation decrease. The confidence ranges about retransformed mean values may therefore in fact be increasingly pessimistic and biassed as the mean value increases.

As expected the reduction in the spread of confidence limits about the mean is rapid as the number of sets increases up to about 50 and then the effect is progressively less pronounced.

As a reference point, the average number of successful sets in the Canadian surveys for the depth range up to 300 fath has been about 100. If the arithmetic means and variance apply, the abundance estimates are probably in the range of plus or minus 50%. This is not to say that the abundance estimates are necessarily accurate although one would expect that trends in the actual abundance of the stock would be evident in such survey estimates. If the logarithmic series is appropriate, at a level of 100 sets and an intermediate mean catch size, the abundance estimates are probably in the range of plus or minus 30%.

It is clear that the inherent variability in cod distribution precludes single abundance estimates in which absolute confidence can be placed. The number of sets can never be enough for this purpose. If the degree of variability can be defined, it is possible to determine the number of sets effective for the purpose in mind.

Table 1. Frequencies of ranges of catch numbers per set of cod in Div. 3M, 1977-1981.

Catch Range (Numbers)	1977	1978	1979	1980	1981
0	-	8	14	26	37
1-25	9	21	53	74	80
26-50	10	26	12	13	9
51-75	7	19	9	3	1
76-100	3	16	3	4	2
101-125	3	10	1	2	4
126-150	-	5	1	2	3
151-175	-	8	-	3	1
176-200	1	3	-	1	1
201-225	-	3	-	-	1
226-250	-	3	-	-	-
251-275	1	1	-	-	-
276-300	-	3	-	-	1
301-325	-	-	-	-	-
326-350	-	1	-	-	-
351-375	-	2	-	-	-
376-400	-	-	-	-	-
401-425	-	2	1	1	-
501-525	-	-	-	-	1
526-550	-	-	-	-	-
551-575	-	1	-	-	-
576-600	-	-	1	-	-
676-700	-	1	-	-	-
701-725	-	-	-	-	-
726-750	-	-	-	-	-
751-775	-	1	-	-	-
1076-1100	1	-	-	-	-
1401-1425	-	-	-	-	1
1926-1950	-	-	-	1	-
TOTAL SETS	35	134	95	130	142

Table 2. Derivation of coefficients of variations of the distribution of catches of cod on the Flemish Cap in 1977-81.

			Arithmetic			Logarithmic		
Ship	Year	Number of sets	$\bar{x}$	Sx	$\frac{Sx}{\bar{x}}$	$\bar{x}$	Sx	$\frac{Sx}{\bar{x}}$
ATC 257	1977	35	89.23	179.82	2.02	1.87	1.02	0.264
GADUS 5	1978	119	116.05	126.04	1.09	4.12	0.99	0.229
GADUS 17	1979	80	40.46	81.88	2.02	2.94	1.23	0.418
GADUS 30	1980	111	46.92	189.46	4.04	2.60	1.42	0.546
GADUS 45	1981	122	39.16	140.75	3.59	2.17	1.57	0.724

Table 3. Confidence ranges about the arithmetic mean for cod on the Flemish Cap in 1977-81.

Number of tows	Percent Variation(±)
10	165
20	117
30	96
40	83
50	74
60	68
70	63
80	59
90	55
100	52
120	48
140	44
160	41
180	39
200	37

Table 4. Confidence ranges about the mean retransformed from the log mean (catch +1) for cod on the Flemish Cap in 1977-81.

	Mean					Mean				
	Logarithmic		Retransformed Arithmetic			Logarithmic		Retransformed Arithmetic		
	1.0		1.718			3.0		19.086		
Number of sets	Lower limit	Upper limit	Lower limit	Upper limit	% Error	Lower limit	Upper limit	Lower limit	Upper limit	% Error
10	0.709	1.291	1.032	2.636	40-53	2.128	3.872	7.398	47.038	61-147
20	0.794	1.206	1.212	2.340	29-36	2.383	3.617	9.837	36.226	48-90
30	0.832	1.168	1.298	2.216	24-29	2.497	3.503	11.146	32.215	42-69
40	0.855	1.145	1.351	2.142	21-25	2.564	3.436	11.988	30.062	37-58
50	0.870	1.130	1.387	2.096	19-22	2.610	3.390	12.599	28.666	34-50
60	0.881	1.119	1.413	2.062	18-20	2.644	3.356	13.069	27.674	32-45
70	0.890	1.110	1.435	2.034	16-18	2.670	3.330	13.440	26.938	30-41
80	0.897	1.103	1.452	2.013	15-17	2.692	3.308	13.761	26.330	28-38
90	0.903	1.097	1.467	1.995	15-16	2.709	3.291	14.014	25.870	27-36
100	0.908	1.092	1.479	1.980	14-15	2.724	3.276	14.241	25.470	25-33
120	0.916	1.084	1.499	1.956	13-14	2.748	3.252	14.611	24.842	23-30
140	0.922	1.078	1.514	1.939	12-13	2.767	3.233	14.911	24.356	22-28
160	0.927	1.073	1.527	1.924	11-12	2.782	3.218	15.151	23.978	21-26
180	0.931	1.069	1.538	1.912	10-11	2.794	3.206	15.346	23.680	20-24
200	0.935	1.065	1.547	1.901	10-11	2.805	3.195	15.527	23.410	19-23

	Logarithmic		Retransformed Arithmetic		
	5.0		147.4		
	Lower limit	Upper limit	Lower limit	Upper limit	% Error
10	3.547	6.453	33.71	633.6	77-330
20	3.972	6.028	52.09	413.9	65-181
30	4.161	5.839	63.14	342.4	57-132
40	4.273	5.727	70.74	306.0	52-108
50	4.350	5.650	76.48	283.3	48-92
60	4.407	5.593	81.02	267.5	45-82
70	4.451	5.549	84.71	256.0	43-74
80	4.486	5.514	87.77	247.1	40-68
90	4.516	5.484	90.47	239.8	39-63
100	4.540	5.460	92.69	234.1	37-59
120	4.580	5.420	96.51	224.9	35-53
140	4.612	5.388	99.69	217.8	32-48
160	4.637	5.363	102.20	212.4	31-44
180	4.657	5.343	104.30	208.1	29-41
200	4.675	5.325	106.20	204.4	28-39