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Studies on Georges Bank Sea Scallop Abundance and Distribution.

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Sea scallop investigations on Georges Bank have included three major fields: assessing the abundance of sea scallop populations; determining their distribution on the bank; and measuring fishing and natural mortality rates. To facilitate these studies, the bank has been divided into a grid whose co-ordinates are at 10 minutes of latitude and 10 minutes of longitude. The resulting squaresor "Unit Areas " have an approximate area of 75 square nautical miles. Catch and effort data of both the Canadian and United States scallop fleets are reported by these unit areas.

Sampling surveys to assess abundance and distribution of Georges Bank scallop populations were carried out in August-September 1961 and in August 1963. The 1961 work was done from a chartered commercial scalloper, M. V. Cape Eagle, and the 1963 work from the research vessel A. T. Cameron. Three unit areas were sampled: 7, 18, and 33. The former two areas are on the northeast peak and the latter on the northern edge of the bank. Heavy fishing took place in area 33, medium fishing in area 7 and light fishing in area 18.

Several sampling problems were investigated during these two survey cruises. We were interested in determining the number of samples which must be taken to adequately assess scallop populations in a unit area and on the bank as a whole. Further information on patterns of scallop distribution within unit areas and over the bank was required. Do scallops occur in small, densely populated aggregations (schools) or are they more or less evenly distributed over large areas of the bank? We also wanted to determine if we could return to specific locations on the bank by ordinary navigational instruments (loran and decca) and resample scallop populations.

The sampling procedure was the same in both years. Each unit area was divided into 100 "quadrats" by a 10 x 10 grid. Each quadrat has an area of 0.75 square nautical miles. Thirty to forty quadrats in each unit area were chosen randomly and sampled. All tows were of short duration (10 minutes) and shell heights (distance from umbone to ventral margin) of all scallops in the catch were measured and recorded. An odometer was attached to the drag to measure the distance towed and the density of scallops sampled has been expressed as numbers per 1,000 square yards.

In 1961, samples were taken in all three unit areas. Commercial scallopers tow two drags simultaneously, one on either side of the boat. In the 1961 work we towed two drags simultaneously, one knit with 3-inch rings and the other knit with 4-inch rings. This allowed us to double our sampling effort by taking two samples at the same time. A few of the quadrats in unit areas 7 and 33 were revisited during the cruise and duplicate tows were made in these few quadrats.

In the 1963 work, sampling was only carried out in unit area 7. Furthermore, only one drag was towed. Forty quadrats were sampled and when these tows were completed, repeat tows were made in 20 of the sampled quadrats. The repeat positions for these duplicate tows were determined by navigatic instruments (loran and decca) and the ground covered was as similar to that previously sampled as these instruments would permit.

In this report, we consider some of the statistical analyses of these surveys related to determining the abundance and distribution of scallops. A study of the survival and the effect of fishing during the period 1961 to 1963 in unit area 7 has not yet been completed.

Abundance

In Table I, the estimated relative abundance of scallops per 1000 square yards, along with the 95% limits, are shown. The figures are relative, since the gear, i.e., a 3-inch or 4-inch scallop drag, is not 100% efficient. Table I shows the great variations in the abundance of scallops from place to place, especially among the smaller sized scallops.

Table I. Mean relative abundance and 95% limits of scallops per 1000 square yards - 1961 data.

	Area 7	Area 18	Area 33
Scallops > 100 mm			
3" ring	263±52	148±68	532±294
4" ring	290±57	136±63	528±292
Scallops < 100 mm			
3" ring	109±64		875
4" ring	35±21		631

For instance, although in area 33 the larger (over 100 mm) scallops appear to be roughly twice as abundant as in area 7, the smaller (less than 100 mm) scallops seem to be eight to twenty times more abundant in area 33 than in area 7. Unless the gear efficiency, mortality or growth rates in the two areas are greatly different, this suggests marked differences in the settlement of young scallops, unrelated to the size of the parent population.

Distributions

For purposes of statistical analysis, the numbers of scallops caught per tow were transformed by taking their logarithms. In all cases but one (out of 8) the frequency distributions of transformed catches are adequately described by a normal distribution. Hence we may say that the catches follow a log normal distribution. A priori the variances of the log normal distributions of catches are related to the sizes and densities of scallop "schools" on the bottom. The (theoretical) relationship between the school sizes and densities and the resultant variance in transect type samples such as obtained by dragging are currently being studied, but no results are yet available.

In Table II, the variances of the log catches are given. From the sizes of the variances, we conclude that the degree of heterogeneity varies greatly from area to area. This is reflected in the limits for the estimated relative abundance figures based on these variances and which were included in Table I. Thus, for instance, in area 7 the limits for larger scallops are about ±20% and in area 33 about ±55% for roughly twice the number of samples.

We also note that the small scallops in each of the sample areas exhibit a greater heterogeneity than the larger ones. This could be due to gradual dispersal of scallops as they get larger, to higher mortality in denser schools or to concentration of the fishing on larger and denser schools, or to combinations of all these factors. Further specification of

the sources of change in distribution can only be obtained by more extensive surveys and by counting the dead scallops(i.e., scallop shells) found in different localities and in different-sized schools.

The variance "between duplicate" tows in the 1961 sampling was as great as "between quadrats". This means that there is no correlation between the duplicate tows in that area or, in effect, that the duplicate tows were not duplicates but were just like other random samples in the area. However, in the 1963 survey the variance between duplicate tows was about half of that between quadrats. We conclude that the ordinary navigational aids do not pinpoint the locality of the previous tow well enough to allow return to the original position.

<u>Table II.</u> The components of the variance of log catches - 1961 and 1963 data.

	Unit Area 7 1961		Unit Area 7 1963		Unit Area 18 1961		Unit Area 33 1961	
Components of variance	Scallops < 100 mm	Scallops > 100 mm	Scallops < 100 mm	Scallops > 100 mm	Scallops <100 mm	Scallops >100 mm	Scallops <100 mm	Scallops >100 mm
Between quadrats	.182	.056	.255	.022		.191	.243	.225
Between parallels	.148	.0054	--	--		.035	.369	.045
Between duplicates	.321	.060	.171	.012				

The variance "between parallel" tows is considerably smaller than "between quadrats" of "between duplicates". Comparing the size of the "between parallels" variance in 1961 (.0054) in area 7 with that of "between duplicates" in 1961 (.060) and "between duplicates" in 1963 (.012), it appears that the former is about one-tenth to one-half of the latter. Although the figure "one-half" is based on a "between years" comparison and hence may not be entirely appropriate, results of the comparisons imply that in doing gear efficiency studies in this area only from one-half to one-tenth as many observations are required if the two gears to be compared are towed in parallel than if duplicate tows are made.

In one case studied, namely the small scallops in area 33, the "between parallels" variance was not smaller than the "between quadrats" variance. This suggests that in this area small scallops were distributed in "pockets" or "schools" which often had diameters small enough so that only one of the two drags operated from opposite sides of the boat was towed through them. If distribution is this heterogeneous, accuracy of the sampling may be greatly increased by towing the two drags.

Comments

The analysis of the survey data is being continued to determine the rate of growth of scallops during the 1961-63 period in an attempt to isolate and estimate the abundance of the length groups which should have been represented in both surveys. From such data, a direct estimate of survival may be obtained. In area 7, covered in both surveys, the sampling variances indicate that there is a chance of being able to detect a 25% or greater annual mortality rate. On account of the greater heterogeneity in the other two areas, the sampling would have to have been about four times greater than it was for comparable accuracy of mortality estimates.

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