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A Report on the Study of the Georges Bank Haddock Regulation

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Introduction

At the first annual meeting of the International Commission for the Northwest Atlantic Fisheries, Washington, D. C., 1951, it was agreed that it would be desirable as an experiment to establish a minimum mesh size for haddock fishing in Sub-area 5. It was further agreed that the mesh size should be set at a level which would allow a maximum proportion of unmarketable-sized haddock to escape with minimal effect on the catch of marketable-sized fish (Graham, 1952). Under the Commission, an international mesh regulation for haddock fishing was brought into effect for Georges Bank and the Gulf of Maine (Sub-area 5 of the Commission) on June 1, 1953.

The first step in the regulation called for advancing the mesh size of nets from an average of 2-7/8 inches to 4-1/2 inches, inside stretched measure. This step was estimated to advance the average age at first capture from 1-1/2 to 2-1/2 years, preventing the capture of most of the fish formerly discarded, while permitting the escape of some of the smallest of the sizes formerly landed (Graham and Premetz, 1955).

Predicted effects of the regulation

On the basis of information of the selection characteristics of the 4-1/2 inch mesh, studies of the culling practices at sea, and theoretical calculations, it was predicted that the regulation would virtually eliminate discard at sea, that during the first year of regulation there would be a 10 per cent drop in landings, and that the long-term effect would be an increase of perhaps 30 per cent in the average lifetime yield of year-classes (Graham, 1952). Because of the greater efficiency of the 4-1/2 inch mesh in catching larger fish, the predicted decrease in landings during the first year of regulation did not occur (Graham and Premetz, 1955).

Assessment of the long-term effects of regulation

Study of the long-term effect of the mesh regulation has necessarily been concerned with methods appropriate to the measurement of year-class strength in pre- and post-regulation years to provide a base line with which to compare catches at different ages and at different levels of fishing.

Taylor (1958b) has pointed out weaknesses which have been found in the process of developing and applying methods of estimating Sub-area 5 haddock population size. The report shows that if, as in earlier reports, it is assumed that there is a constant natural mortality rate, M, and constant q (the factor relating fishing intensity to the instantaneous fishing mortality coefficient, F), when in fact q alone varies in systematic fashion with age, estimates of the strength of a year-class may be more or less in error, depending on the number of years of data available. It follows that errors in estimates of the relative strengths of two year-classes may be especially great if comparisons are made between the estimates of abundance of a year-class which has been in the fishery a short time and one which has been fished for a longer period. These discrepancies may be smaller when the same age-groups are used for estimating the strength of each year-class, but errors may still be important should there be undetected differences in the variations of q between year-classes. When each of these year-classes has been subjected to fishing throughout its whole lifetime, effects of systematic errors during the early years will, of course, be partly averaged out.

Suggestions for improved analysis

A problem of prime importance in estimating year-class size is determining correct values of q and of the natural mortality rate, M. Tentative estimates of the magnitude of these quantities have been made (Taylor, 1958a) using a method suggested by Beverton and Holt (1957), but the errors associated with these estimates are sufficiently high to leave some doubt as to their usefulness. In addition, estimates were not possible for ages earlier than 4, whereas we require estimates of q and M for calculating abundance at earlier ages if we are to measure the effect of mesh regulation.

A new method of estimating q and M from data on annual catches and fishing intensities has been suggested by Paloheimo (1958b, in press). Adaptation of Paloheimo's method may help in deriving values of q and M at ages earlier than 4 -- ages at which q, and perhaps M, may be different from those of later ages (Taylor, 1958b), but we do not yet understand the biological basis for these differences.

It appears that some of the problems we face in estimating year-class size will be resolved simply by waiting until more of the post-regulation year-classes have completed their lifetimes in the fishery and their entire fishing history is available. At the moment statistics on the history of the 1952 year-class, the first to come fully under the mesh regulation, are complete only through 1956, so that, in a very real sense, attempts to assess the effect of the 4-1/2 inch mesh are premature. Data for the 1953 and 1954 year-classes are available for only 3 and 2 years, respectively.

Our previous attempts to assess year-class strengths have consisted mainly and necessarily of analysis of gross annual statistics. It now appears that it will be profitable to study in greater detail, for both pre- and post-regulation year-classes: seasonal changes in catchability, seasonal changes in size composition, length and weight of fish caught and fish landed, and reliability of the sampling and statistical methods. This is a major undertaking which is underway and on which preliminary reports have been made (Taylor, 1957; Paloheimo, 1958a).

The continuing study demonstrates that our measurements of year-class strength prior to 1948 are subject to question because we do not have data on the actual catch of these year-classes at age 2. Taylor (1957) showed a curvilinear relation between landings per day at age 2 and lifetime landings in numbers (Fig. 1). Using recent available information on discards of young haddock at sea and the length composition of landings, it appears that this curvilinearity probably reflected a major change in sizes of fish landed. That is, a greater proportion of the smaller sizes were landed from the recent large year-classes, resulting in these cases in disproportionately high landings per day at age 2 compared to their total lifetime landings. A correction of the data on recent catches to make them comparable to earlier practices in terms of sizes landed gives a straight line relation (Fig. 2) between landing per unit effort of 2-year-olds and lifetime yield from the 1931 to 1953 year-classes, inclusive. Conversely, if we use the relation between recent total catch and lifetime yield as a basis, we can estimate from it the total catches of 2-year-olds which were probably made in earlier years. The difference between this catch, and the data on landings, represents small fish discarded at sea. That the relationship between catch per day at age 2 and lifetime yield is actually a straight line is supported by the observed linear relation between the catch per day of 3-year-olds and lifetime yield. Discards of 3-year-olds are negligible. The linearity of the relation is further confirmed by the straight line which is given by the theoretically simpler relationship between catch per day at age 2 and estimated year-class abundance (Fig. 3).

We thus have what appear to be improved estimates of catches of 2-year-olds in early years. From them we may calculate values of q and M appropriate for estimating abundance for this early age. It must be recognized, however, that these estimates can never be confirmed directly because the necessary discard information for earlier years is lacking.

<u>Change in length composition of the catch following regulation</u>

The continued study of our data shows some other interesting relationships which are consistent with the expected effects of regulation but which could not have been predicted without our improved knowledge of seasonal patterns of catch, discards and growth.

Figure 4 gives, for the 1948 and 1952 year-classes of haddock, the average annual size composition at ages 2, 3, and 4. It shows that the sizes of fish landed from the 1952 year-class were consistently larger than those landed from the 1948 year-class.

The 1952 year-class was fished by large mesh nets, which virtually eliminated the capture of small fish discarded in earlier years. Landings per day of the 1952 year-class are therefore equivalent to catch per day. The 1948 year-class was fished by small mesh nets and about 6.8 million small fish were caught and discarded as 2-year-olds. Landings per day of 2-year-olds are therefore lower in number but larger in average size than catches. There are no data on size and age composition of these discards, but if they were similar to the 1949 and 1950 year-classes, sizes of 2-year-old fish landed from the 1948 year-class were on the average 1 cm. larger than those caught. Discards of 3-year-old fish are negligible, so that landings per day for the 1948 year-class at this and older ages are equivalent to catches per day.

Taking this information on discards into account, it appears that in commercial landings, catches of the 1952 year-class at each age have been composed of consistently larger sizes than catches of the 1948 year-class. Our information on sizes of fish selected by the two sizes of net, and of seasonal variations in the availability of small fish to capture, indicates that these size-composition changes are a result of fishing by large mesh, and illustrates that benefits from the regulation are already reflected in the fishery.

The increase in size composition of catches of 2-year-olds from 1948 to 1952 appears to result from the delay in their average age at first capture from 1-1/2 to 2-1/2 years of age, although seasonal changes in catches indicate that few of them are ever available to the fishery during the first quarter of their life as 2-year olds. The 4-1/2 inch mesh with 50 per cent selection point at 37 centimetres therefore has eliminated the progressive fishing of the larger one-year-old fish, and somewhat dalayed capture in the second quarter of their second year. When they were eventually taken by the fishery, they had apparently reached a larger average size than before.

Changes in length composition of catches at age 3 and 4 indicate that increased numbers of larger sizes of fish, which apparently resulted from savings during their earlier life, are showing up in significant numbers in catches of the 1952 year-class. At age 3, however, the smaller sizes are still liable to selection by large mesh. Therefore, although there are increased numbers of the larger 3-year-old haddock, the smaller 3-year-olds are less well represented. The 4-year-old fish appear to be the first age group not subject to selection by either size of net. In this case, the relative numbers of the smaller 4-year-olds in 1952 year-class are about equal to their numbers in the 1948.

Concommitant with these changes in size composition, there have been changes in the catch per day fished of the two year-classes. The large mesh nets permit more escapement of all sizes of 2-year-olds than do the small mesh nets, so that if the 1948 and 1952 year-classes had been of nearly equal size, it would be expected that 2-year-old catches of the 1952 year-class would be smaller than catches of the 1948 year-class, as in fact they were. However, the seasonal pattern of catches of 2-year-olds of the 1952 year-class suggests that they became available to the fishery relatively earlier than had the 1948 year-class and unexpectedly large numbers of them were taken during the second quarter of 1954. As a result, the annual catch of 2-year-olds of the 1952 year-class is relatively higher than we would have expected on the basis of mesh selection alone.

At 3 years of age the large mesh net still permits some escapement of smaller sizes. However, if use of this net had allowed appreciable savings at the earlier ages, it would be expected that the 1952 year-class would be relatively more abundant at 3 years of age. Figure 4 and Table I show that compared with the 1948 year-class, the 1952 year-class is slightly less well represented in the 3-year-old catch than the 2-year-old. This appears to have resulted from the increased availability of the 1952 year-class in their second season of capture as 2-year-olds, rather than a drop in their relative representation in the catch of 3-year-olds. Assessment of the effects of the greater percentage retention at 3 years of age must therefore await calculation of actual abundance, and studies of changes in availability with season.

The catch of the 1952 year-class at 4 years of age is higher than was the catch of the 1948 year-class. If initial abundance of each year-class was the same at the beginning of age 2, this increased relative catch (resulting primarily from increase of larger sizes) at age 4 must have resulted from the earlier savings.

In this comparison we have assumed that the 1948 and 1952 year-classes were of equal abundance near the beginning of age 2. Paloheimo (1958a) has concluded that this is the case. If on further study his conclusion is confirmed, the data presented here suggest that increased savings of small fish from age 1-1/2 to 2-1/2 will show the first benefit to the fishery as increased catch in numbers at age 4. However, it was earlier suggested by Taylor (1957), and seems quite possible on the basis of the continuing study (Taylor, 1958b), that the 1952 was smaller than the 1948 year-class near the beginning of age 2. In this case, the data on size-composition changes indicate that benefits in terms of increased catch in numbers may first appear at age 3.

Table I shows that benefits to the fishery in terms of weight of fish landed may appear at earlier ages than they do in terms of numbers of fish landed. The data of Table I show that in this particular case there were relatively more pounds of 2-year-olds landed from the 1952 year-class than from the 1948, even though there were fewer numbers caught. However, a part of this benefit was almost certainly a result of natural changes in seasonal availability of 2-year-olds from year to year. Further study may show that because of seasonal effects, detection of benefit in some years may be even more difficult than it appears to have been in this instance. In any case, reliable measurement of benefits will be possible only when we can make more accurate estimates of year-class strength.

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Table I. Annual statistics of the Georges Bank haddock fishery on ages 2 to 4 of the 1948 and 1952 year-classes.

Age	1948 year-class					1952 year-class					Ratio '52/'48 of C/E in numbers
	Numbers caught (millions)	Weight landed (millions lbs.)	Effort (thousands days fished)	C/E No. caught ('000)	C/E Wt. landed ('000)	Numbers caught (millions)	Weight landed (millions lbs.)	Effort (thousands days fished)	C/E No. caught ('000)	C/E Wt. landed ('000)	
2	35.8	38.3	5.49	65.3	69.8	32.6	47.5	5.81	56.1	81.8	.86
3	26.7	49.3	6.49	41.1	76.0	18.2	38.2	5.33	34.1	71.6	.83
4	8.4	21.2	5.93	14.2	35.7	11.3	29.4	7.14	15.8	41.2	1.14

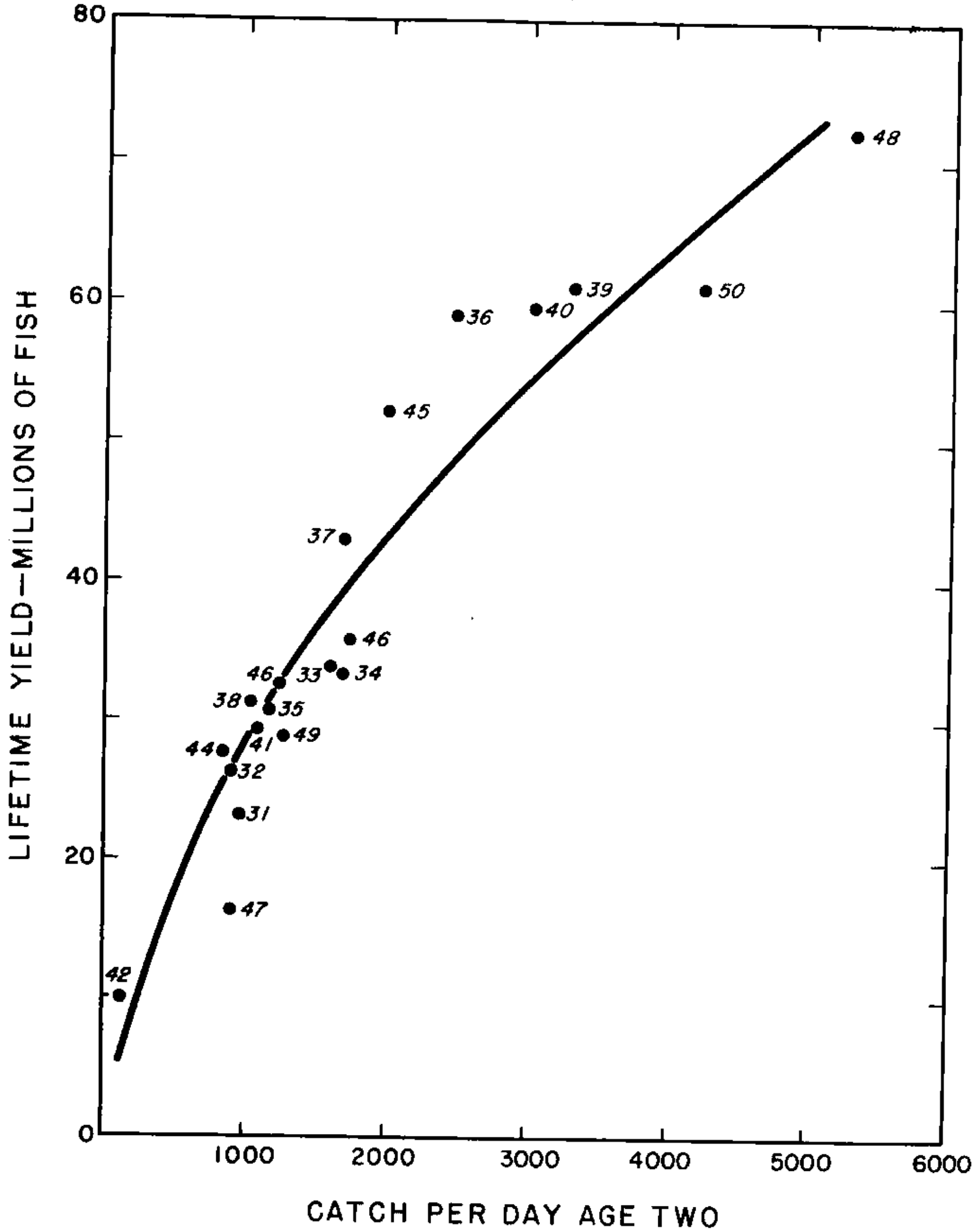

Figure 1.--Curvilinear relation indicated by lifetime landings plotted against landings per day at age 2.

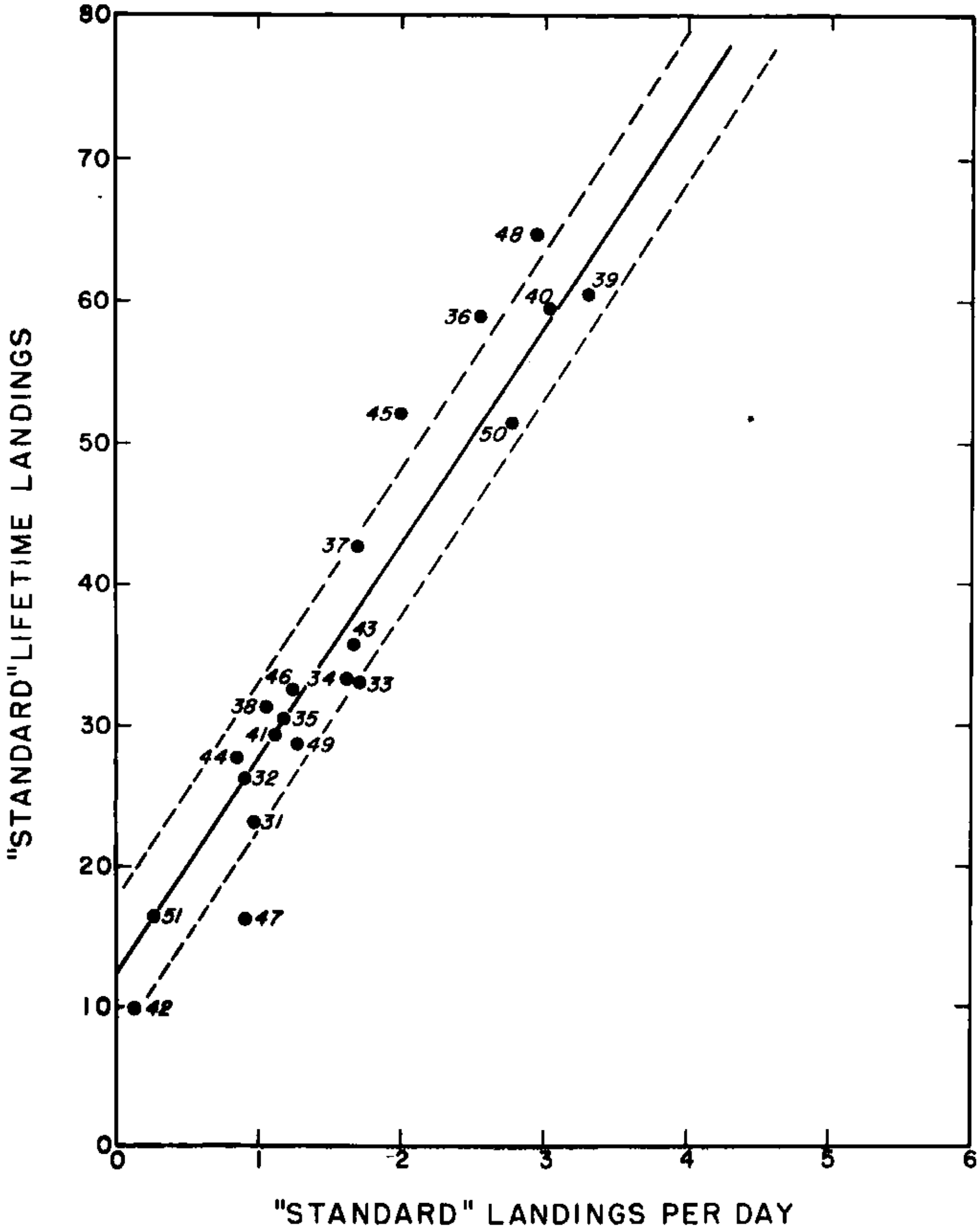

Figure 2. --Linear relation indicated when landings per day at age 2 are corrected to a standard size composition by removing from the landings per day and the lifetime yield the numbers of small fish landed in certain years which would have normally been discarded.

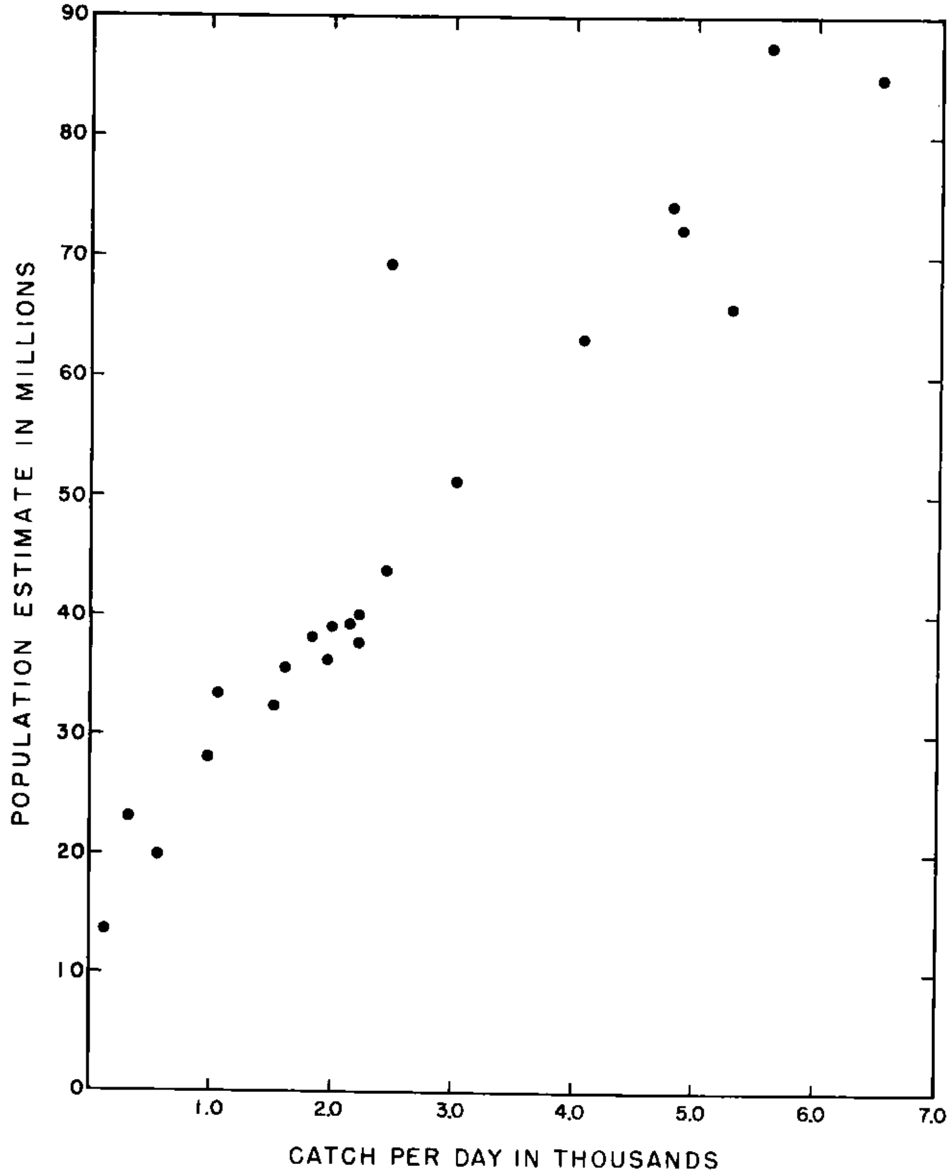

Figure 3. --Linear relation indicated when the catch per day at age 2 (landings plus discards for the 1948 to 1952 year classes and landings plus estimated discards for the 1931 to 1947 year classes) are plotted against the estimated population size.

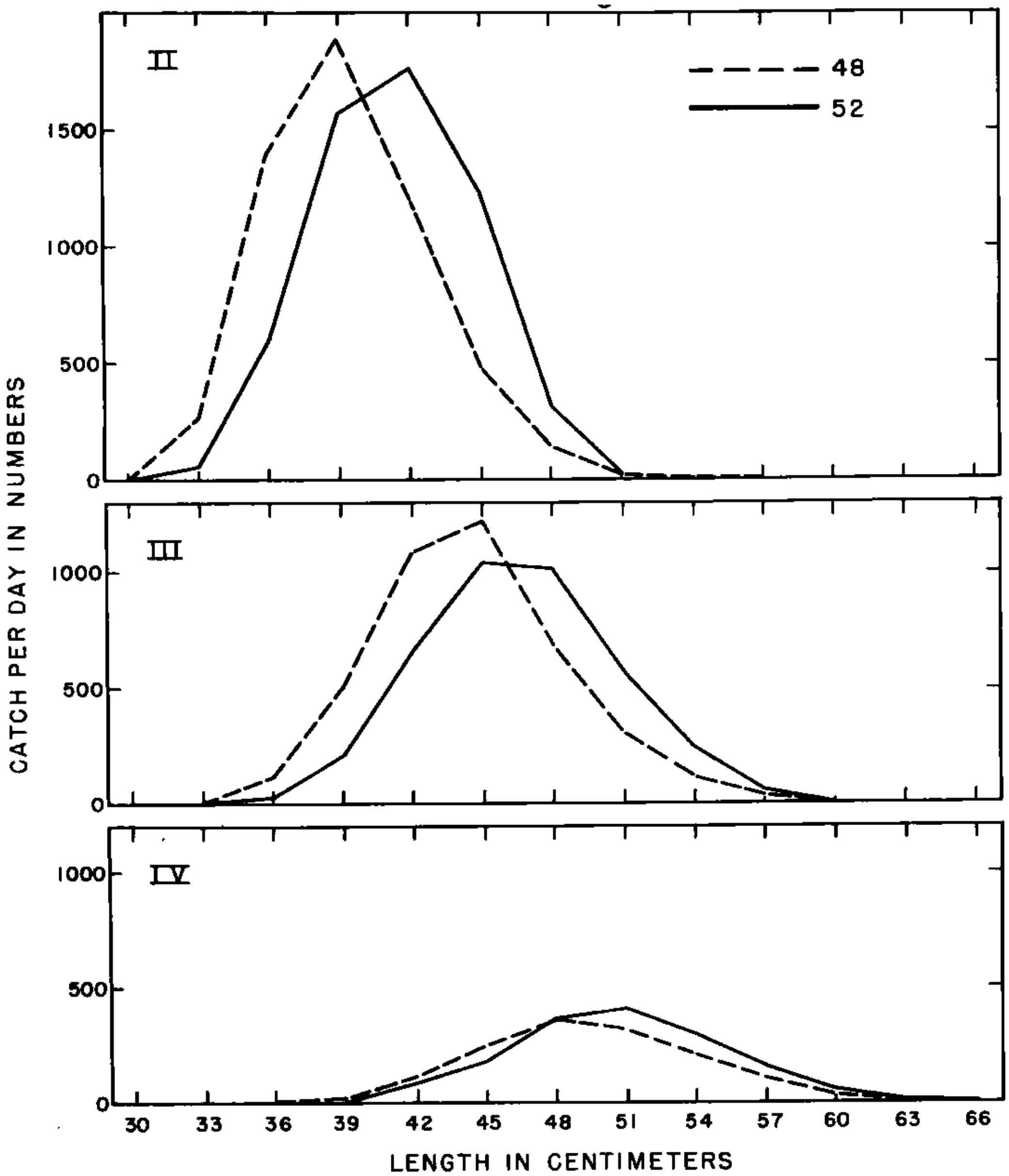

Figure 4. --Size compositions of catches at ages 2, 3, and 4 of the 1948 year class (dashed line) compared to those of the 1952 year class (solid line).