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Role of study boats using small-mesh nets in assessing effects of the Georges Bank haddock regulation

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From 1953 to 1957 a number of boats was licensed to fish in ICNAF Sub-area 5 with small-mesh nets to provide information on effects of the newly introduced large mesh on catches of haddock. At the Lisbon meeting in 1957, the continued usefulness of this study fleet was questioned (Report of *Ad Hoc* Committee on Population Dynamics and Statistics). It was recommended that in view of practical difficulties of maintaining the study fleet, and the progress that had already been made in the study of effects of the regulation, that small-mesh fishing be suspended pending further analyses. It is the purpose of this report to review, in the light of these more recent analyses, some of the ideas pertinent to a final decision on the need for study boats in the measurement of benefits.

Objectives of the study and proposed methods of realizing them

The primary objective of the study of the Georges Bank haddock population, subsequent to regulation, has been to measure the change in yield resulting from it. The regulation was from the first considered as an experiment in improving the yield of a fishery (Graham, 1952). The data collected from this experiment were to show in what measure the predicted benefits had been realized. Secondarily, it was hoped that the study might yield information which would be useful in the consideration of any additional regulations which could further improve the yield.

Theoretically, the primary objective of this experiment could be satisfied by comparing a series of annual catches made before and after the regulation (Graham, 1952). However, this comparison assumes that changes have resulted from the regulation alone, an assumption which it might be difficult to confirm without more information than is supplied by catches using the new gear. Furthermore, the variations in catch induced by changes in recruited year-class strength, and fishing effort, are likely to result in such variation in annual catch that only very large differences between the averages of two periods could be reliably measured. It appears that benefit of the regulation can only be reliably measured if we can obtain in addition to catch statistics information on year-class strength, and on any other factors which contribute importantly to variations in annual yield.

Considerations of this kind led to the establishment of the study fleet of small-mesh boats as part of the experiment. It was designed as a means for estimating the size of year-classes after regulation, relative to their size before the regulation was introduced. It appeared, in fact, to be the only way in which year-class sizes in the two periods could be compared, as at the time the regulation was brought into force there was no information on natural mortality rate to use in calculations of actual population size. It was also recognized that the small-mesh fleet would be valuable as a control to detect deviations of the operation of selection by the large-mesh from prediction, and for detecting other unexpected sources of variation.

By 1957, methods had been developed for estimating natural and fishing mortalities from detailed catch data, and there was already much information on the relative selection by the two types of fishing gear. These advances indicated that it may be possible to measure year-class size in the two periods, using different types of fishing gear. It was therefore recommended that the study fleet be suspended, pending a study of available data to see if they might be sufficient to fulfil the primary objective of the experiment.

Alternative methods for measuring effects of mesh size changes

Before turning to an examination of the recent analyses, it is pertinent to consider in what different ways the data could be used to satisfy the primary objective of the experiment, that is, to measure the effects of fishing with the larger mesh. There are two ways in which this can be done. The first has been considered in most previous discussion of this problem. The second appears to have been overlooked.

Method 1: Measure year-class strength and lifetime yield for a number of year-classes before and after regulation, then making appropriate adjustments in yield for differences in effort and in initial year-class strength, obtain a measure of relative yields from small- and large-mesh fishing.

Method 2: Measure the catches made by a small- and large-mesh fleet of boats fishing at the same time, and from them calculate what either type of fleet would have caught by itself as a measure of the effects of a change in mesh size.

At first sight these two methods seem to be rather different. Actually, they are similar. In Method 1 we begin with catches of two year-classes. From them we estimate initial abundance and adjust the yields accordingly to obtain a measure of benefit. In the second case we know that initial abundance is the same, but use calculations like those used in Method 1 estimates of abundance to adjust the catches and make comparisons.

There appears to be only one piece of information of fundamental importance to biologists which might be obtained from the first method but which the second method does not yield. That is, we cannot measure changes in natural mortality rate that might have resulted from the regulation. Given comparable data, then, a preference for use of the first method lies largely with our belief that measures of the population parameters are precise enough to detect changes in natural mortality rate before and after regulation. There is some doubt that this is so.

Ideally, we should use the information from our mesh experiment to calculate benefits by both methods. They should give identical results provided that the regulation had not induced natural mortality changes. In practice, the analyses of the Georges Bank haddock data to date indicate that both methods should be equally useful, but that we may not have the data which will permit us to use Method 1.

It will immediately be recognized that Method 1 makes use of a small-mesh study fleet largely as a control. If the large mesh can be made to measure abundance of post-regulation year-classes at the early age (1½ years) where the regulation leads to the first appreciable savings and its function as a control is satisfied, then small-mesh fishing can be dropped. Where there is doubt that this is true, some continued sampling of early year-class abundance is necessary to measure full benefit.

Method 2 requires use of both types of fishing for several more years.

Possibilities of measuring benefits

Taylor and Dickie (1958) have pointed out that precise calculations of pre-regulation year-class abundance at ages 1 and 2 cannot be made for year-classes before 1949. There are two reasons for this: First, data on discards of haddock by age-classes are not available before 1951. For periods before this, Taylor and Dickie used the discard information of more recent years, together with a long series of data on length composition of landings, to calculate a total catch of 2-year-olds for the early year-classes. Best estimates of abundance at the beginning of age 2 must be based on this. No such correction could be made for the catches of 1-year-olds. Second, there appear to be great variations in the seasonal availability of at least the young haddock. This makes calculations of catches of early years from a short series of recent data a questionable procedure.

With these weaknesses in our data, it is apparent that the best we can hope to do in measuring benefits with Method 1 and using only large-mesh catches is to compare catches from the beginning of age 2 on. This measures but a fraction of the total benefit which was predicted (the larger mesh size was calculated to advance average age at first capture from 1½ to 2½ years of age). But with seasonal changes in availability, it is questionable whether or not we can use our calculated catches as a basis for abundance estimates. Seasonal variations may even be operative at later ages, since Taylor (1958) has shown that estimates of natural mortality rate have confidence limits that are so wide that they are rendered almost useless. Colton (1955) has shown a concentration of large haddock in deeper water on the northern edge of Georges Bank. Year-to-year variations in these concentrations could account for part of the variability found by Taylor.

It appears, therefore, that the original hopes for measuring benefits from the Georges Bank haddock regulation cannot be sustained without ancillary information, some of which might be supplied by a small-mesh study fleet. However, using Method 1, our calculations of benefit based on calculated catches, seem unnecessarily open to question. Even though information from a study fleet could increase our reliance on the calculated catches, there seems to be little room for doubt that they could be used more profitably in a Method 2 type of calculation.

Use of study fleet catches to calculate benefits

A consideration of the need for a study fleet requires some assurance that the data so obtained could be used. This problem appears to be solved rather simply by the following considerations suggested by J. E. Paloheimo (personal communication).

In calculating initial abundance from a series of catches we have become accustomed to calculate from the ratio of abundance indices in two successive years the total instantaneous mortality rate

$$Z = qf + M \qquad \ldots\ldots (1)$$

where M is the instantaneous natural mortality rate, f the number of units of effort and q the factor of proportionality ralating effort f to instantaneous fishing mortality

$$F = qf.$$

The term q may therefore be defined as the fraction of the population, N, which is taken by one unit of effort.

If two types of effort, f_1 and f_s, are operating on the population then

$$F = q_1 f_1 + q_s f_s$$

$$= q_1 \left(f_1 + \frac{q_s}{q_1} f_s\right) \qquad \ldots\ldots (2)$$

If q_1 and f_1 are the "catchability" and effort of the large-mesh fleet and q_s and f_s the corresponding parameters for the small-mesh fleet, we may estimate abundance from catch data in the usual way (Taylor, 1957; Paloheimo, 1958) using figures for effort of the two fleets, provided we can estimate the ratio $\frac{q_s}{q_1}$.

Suppose that ${}_tC_1/f_1$ represents the catch per unit effort of the large-mesh fleet during a short interval of time, t, and ${}_tC_s/f_s$ is the same for the small-mesh fleet during the same short period. Then by definition

$${}_tC_1/f_1 = q_1 N_t \qquad \text{where}$$

N_t is the mean population during time interval t. We may write a similar equation for the small mesh, from which we get the ratio

$$\frac{{}_tC_s/f_s}{{}_tC_1/f_1} = \frac{q_s N_t}{q_1 N_t} = \frac{q_s}{q_1} \qquad \ldots\ldots (3)$$

That is, for any short period of time the ratio of catchabilities is the same as the ratio of the catches per unit effort (cf. Dickie, 1955).

If we wish to calculate the total effort in terms of small-mesh units, a form like equation (2) with 1 and s interchanged is appropriate.

It appears then that Method 2 may be used to calculate the fishing mortality coefficients of either type of fleet. They may be used in turn to calculate catches from a population. If the two types of effort fish the same populations these calculations should be affected equally by seasonal changes in availability within any one year-class over the period when they are available to both types of gear, an advantage which is not shared by Method 1.

A limitation on the use of Method 2 should, however, be emphasized. Paloheimo (1958) has shown that estimation of q and M depends on there being changes in the total effort over the period to be studied. If a sample fleet of constant size were to be used, it would not be possible to obtain such estimates for ages earlier than those at which the varying large-mesh fleet made a significant proportion of the landings. To overcome this limitation it would be necessary to vary the size of the study fleet by at least a factor of 2 over the period of the study. Variations in the size of this fleet would be desirable anyway as a means of measuring progressive changes in yield for different degrees of savings at early ages, and providing a check on the predicted effects.

Finally, it should be pointed out that the variability in the catch data from year-to-year and age-to-age is great. Whether or not we can measure effects of any change in fishing parameters depends on results of a study of this variability. No such systematic study has yet been undertaken, although some indication of the need is given by Taylor's (1958) results.

Conclusion

Had the data on the early history of the Georges Bank fishery included the details of discards, we might fulfil the primary objective of the mesh regulation experiment without additional data from a study fleet. However, recent analyses indicate that some important information on young fish is lacking. The most satisfactory alternative method for meeting the original objectives appears to be continued use of a varying sized study fleet of boats using small-mesh nets, and comparing their catches with those of a large-mesh fleet.

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