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Measures of Abundance from Fisheries for more than one Species

by

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Introduction

Much of the theory pertaining to measurement of relative abundance in fish populations is based on the simple situation where, for practical purposes, but a single species is involved or, if more than one, where there is little difficulty in distinguishing the respective amounts of fishing effort. From the standpoint of ease of analysis it is perhaps fortunate that the large and important demersal fisheries of the world occur in far northern latitudes, where relatively few species abound. Progressing southward, these fisheries diminish in importance but increase in complexity because of increasing numbers of species. Thus, in a general way, the problem of defining effective fishing effort and catch-per-unit effort for individual species is a function of latitude.

Methods of estimating effort and catch-per-unit effort in cases where several species are caught by the same gear, in effect simultaneously, were the subject of a general discussion by the joint scientific meeting of ICNAF/ICES/FAO at Lisbon in 1957.[1] The purpose of this paper is to elaborate on some of the points raised by that meeting and, by way of an example from the trawl fishery off the west coast of Canada, to demonstrate problems which may be of common occurrence in mixed fisheries where the proportions of contributing species are subject to long-term trends.

Proportions of Species in Landings

For one of two reasons the proportion of a certain species in the landed catches of trawlers operating in a particular season within one area may range anywhere between 0 and 100 per cent. (1) Within the area there are variations in the amount of fishing effort exerted on individual fishing grounds, on each of which a different species is the exclusive object of fishing, but catch records are not sufficiently detailed to make distinctions among grounds. (2) Detailed records are available for individual grounds but, on each, several species are simultaneously accessible to the fishing gear and their proportions vary within the season.

In a mixed fishery, whether it consists of only two species or a great number, the proportion of a particular species "X" in the landings may have a frequency distribution comparable to any one of the curves in Figure 1 (attached). Curve A represents a situation where "X" is fished largely to the exclusion of others (because of overwhelming predominance or market preference) while Curve G represents the opposite extreme.

Catch and Effort Qualification

If a distinct break in the frequency distribution of the proportion of species "X" in the landings is lacking, an arbitrary decision is required in selecting trips which qualify for inclusion in estimation of catch-per-unit effort and of effective fishing effort. If the distribution were of Type D it might be sufficient to use data for all trips in which "X" amounted to say 6o per cent or more of the total fare landed. However, a critical point here would be whether or not the Type D distribution remained constant

1) "Fishing effort, the effect of fishing on resources and the selectivity of fishing gear". Spec.Publ. ICNAF, (2), 196o.

from year to year. If the abundance of "X", relative to that of other species, changes (or, if for economic reasons fishing efforts shifts to other species) then year-to-year estimates of catch-per-unit effort based on the same arbitrary limit of qualifying catch (and effort) will be biased.

As a stock of species "X", with a Type D distribution, declines in abundance relative to other species, there will be a shift in the direction of a Type E distribution. Catch-per-unit effort based on data qualifying at the 6o per cent threshold would underestimate the change in abundance which occurred during the transition from Type D to Type E. On the other hand, if a low threshold of catch qualification, say 2o per cent, were used to calculate catch-per-unit effort in the transition from Type D to E, then the decline would be overestimated. As mentioned in the report of the Lisbon meeting, such limiting values - biased in known direction - may between them define catch-per-unit effort with sufficient accuracy.

The foregoing remarks have dealt with an hypothetical situation which, as far as mixed demersal fisheries are concerned, is of only moderate complexity. By way of an actual example, it is instructive to consider a case where the proportion of a species in the landings has a Type E distribution initially and, as its abundance relative to other species declines, the distribution shifts to Type G.

Changes in Abundance of Petrale Sole

1. Background information

The following information is abstracted from a manuscript by Ketchen and Forrester (in preparation for publication) which deals with the population dynamics of the petrale sole:

(a) The petrale sole (*Eopsetta jordani*) is one of several important species of flounders fished by trawlers along the west coast of North America. Tagging has demonstrated the existence of a more or less independent stock on the continental shelf off the southwest coast of Vancouver Island between 48°3o' and 49°2o' N.Lat. The stock is fished jointly by Canadian and United States trawlers, mainly in the spring to autumn months. The general area occupied by the fishery at that time of year is about 1,ooo square miles, but the actual fishing grounds are considerably more concentrated.

(b) Canadian landings from this area consist of a score of species. However, as a rule, two or sometimes three species (not always the same ones) account for more than 5o per cent of the annual removal.

(c) Information on Canadian catch and fishing effort has been obtained by routine interviews with vessel skippers at the time of landing. Catch-per-unit effort of petrale sole has been based on the performance of a group of trawlers of 1o to 49 G.T. (averaging about 3o G.T.), employing what is known as single gear (a single towing warp with bridle to the otter-boards). The composition of this fleet remained virtually unchanged between 1948 and 196o, the period selected for the present study. The analysis of catch-per-unit effort has been further restricted to the months of May through August, for purposes of year-to-year consistency.

(d) Although records for the early years of the fishery (1938 to 1945) are only fragmentary, relative abundance of petrale sole apparently declined during that period. It rose after 1945 to a secondary peak in 1948 with the recruitment of several exceptionally strong year-classes. Thereafter, as a result of sharply declining recruitment, average size and age in the catch increased noticeably. Catch, as well as catch-per-unit effort, declined from 1948 through 1956. Though the market remained strong for petrale sole, it improved for other species. In the period 1948-5o about 35 per cent of the Canadian catch from the study area consisted of petrale sole. By 1954-56 it had declined to 9 per cent, a position of only incidental importance in the fishery.

Figure 3 shows the trend in frequency of petrale sole landings by four arbitrary categories:- Group I - landings containing 55 per cent or more of that species, Group II - 4o per cent or more, Group III - 25 per cent or more, and Group IV - 1o per cent or more. Between 1948 and 195o about 2o per cent of the landings belonged to Group I. By 1955 none was in this category and none has re-appeared in years since. Groups II and III diminished to zero in 1956, but re-appeared in subsequent years. Group IV persisted throughout the period of study, but even at this low level of composition it diminished to a mere 12 per cent of the landings in 1956 and 14 per cent in 1957.

3. Estimates of catch-per-unit effort

Figure 4 shows five estimates of average catch-per-unit effort based on various thresholds of catch qualification. Curve I was calculated from the catch and effort data pertaining to the Group I landings of Figure 3. Similarly, Curves II, III and IV apply to landings of Groups II, III and IV. Curve V was obtained by dividing the total landing of petrale sole by the effort of all vessels, excluding those which had 0 per cent of that species in their landings. This curve is virtually identical to one based on all fishing effort.

The limiting effects of high and low thresholds of catch qualification on the trends in catch-per-unit effort are difficult to discern, partly because of the complication of sharp changes in availability (most noticeable in 1951). However, the main factor is the decreasing reliability of the data, beginning in the early 195o's. As petrale sole abundance declined, catch-per-effort indices based on high thresholds (data from Groups I and II) became more and more subject to sampling error. Usable information on these groups diminished rapidly and ceased to exist after 1955.

In Curves II, III, IV and V of Figure 4, the net change (decrease) in catch-per-unit effort from 1948 to 1954, expressed as a percentage of the value in 1948, was 37, 52, 56 and 63 per cent, respectively. This accords with theoretical expectation, namely, under-estimation of the decline at high thresholds and over-estimation at low thresholds. Presumably the true net change lies somewhere between the extremes of these percentages.

Clearly, if a working basis were required for other analyses (e.g., observation of changes in age structure, mortality rates, etc.) the first criterion for selection of a particular series of catch-per-effort data is continuity. This leaves a choice between Curves IV and V in Figure 4. Another criterion is stability. For a relatively long-lived species such as the petrale sole (average age in the catch ranges between 7 and 9 years), a sharp fluctuation in catch-per-effort, such as depicted by Curve IV between 1956 and 1958, cannot be regarded as a valid reflection of changes in abundance. In this particular case it is the result of a change in availability and/or sampling error in the small amounts of usable data. Thus, the selection of a working basis for describing changes in relative abundance devolves upon Curve V, notwithstanding the possibility that it overstates the decline.

A factor which conceivably could have counterbalanced this bias is a long-term improvement in gear efficiency. The tonnage composition of the fleet used as standard remained essentially unchanged throughout the study period and most, if not all, of the vessels were equipped with depth recorders and radio direction finders by 1948. More advanced navigational aids such as radar and LORAN were not adopted until after 1958 and then only by one or two vessels. However, doubtless there were subtle improvements in trawl gear design, improvements in fishermen's knowledge of the fishing grounds and of the habits of the fish they were accustomed to pursuing. These factors would have the effect of under-estimating a true downward trend in catch-per-unit effort.

Conclusion

To the extent that the decline in catch-per-unit effort was due in large part to a decline in recruitment the foregoing example is perhaps an unusual one. However, whether the decline be due to recruitment or to selective over-fishing, the effect on species composition of the landed catches is the same. There is good reason to believe that the example has general usefulness in exposing the difficulties of a situation where (1) a fishery is sustained by a substantial mixture of species, (2) one of these species holds greater economic attraction than the others and hence is subjected to heavier exploitation, and (3) it declines in abundance to a point where, for lack of adequate data, the basis for maintaining a reliable, long-term index of abundance is disrupted, if not lost entirely.

Abstract

The problem of measuring trends in abundance of a particular species "X" in a mixed fishery is discussed with respect to the case where its abundance declines relative to that of cthers, so that fishing effort tends to be diverted more to other species or sub-areas within the general region. If the abundance of species "X" is measured by its catch-per-unit effort in all landings containing at least some minimum or threshold percentage of "X", then the trend obtained varies somewhat depending on the threshold value chosen. When the abundance of "X" decreases, the decline tends to be under-estimated with a high threshold and over-estimated with a low threshold. An example of petrale sole caught by the trawl fishery off the west coast of Canada demonstrates this effect and also reveals some additional difficulties involved in maintaining a reliable basis for measuring the true rate of decline over the long term.

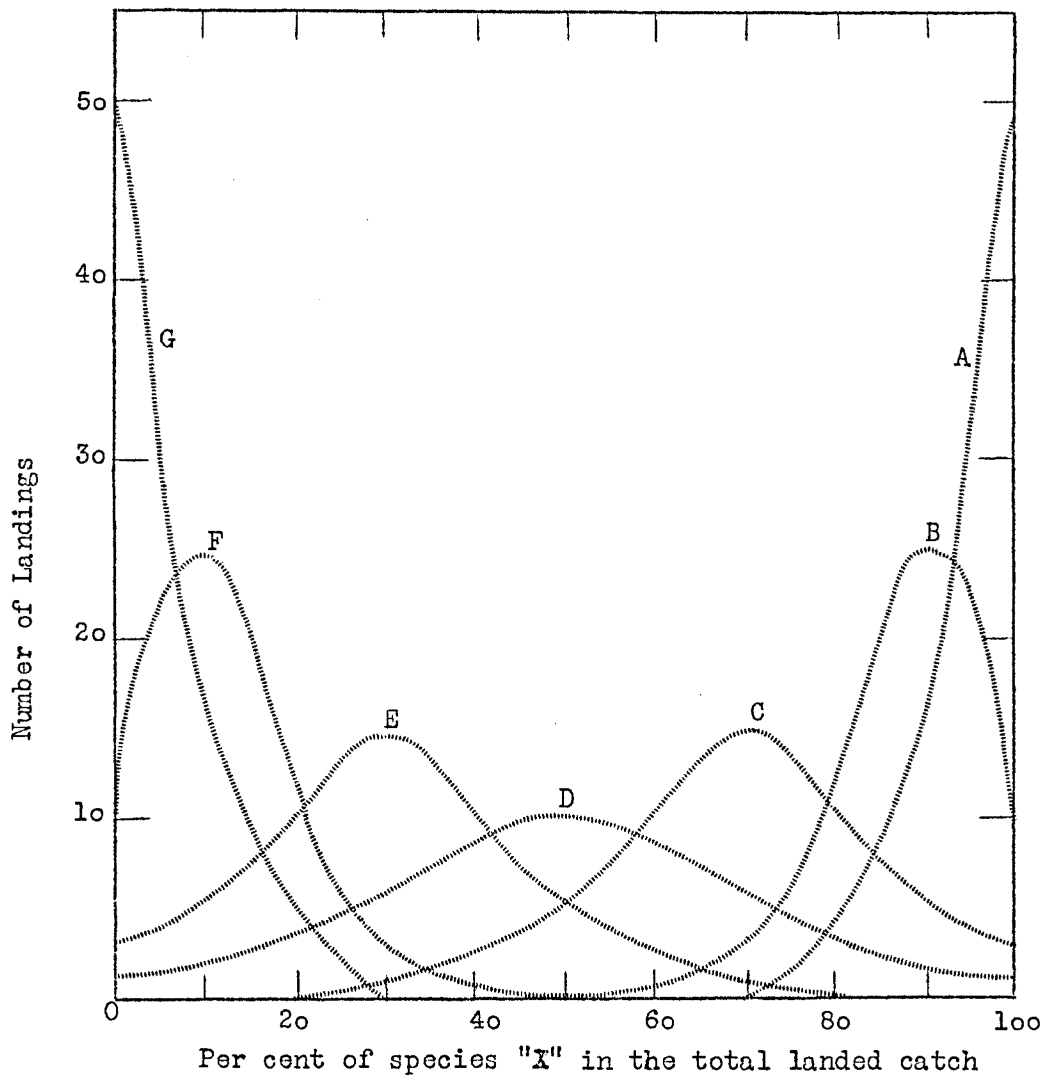

Figure 1. Hypothetical frequency distributions of the proportion of a particular species ("X") in landings from a mixed fishery.

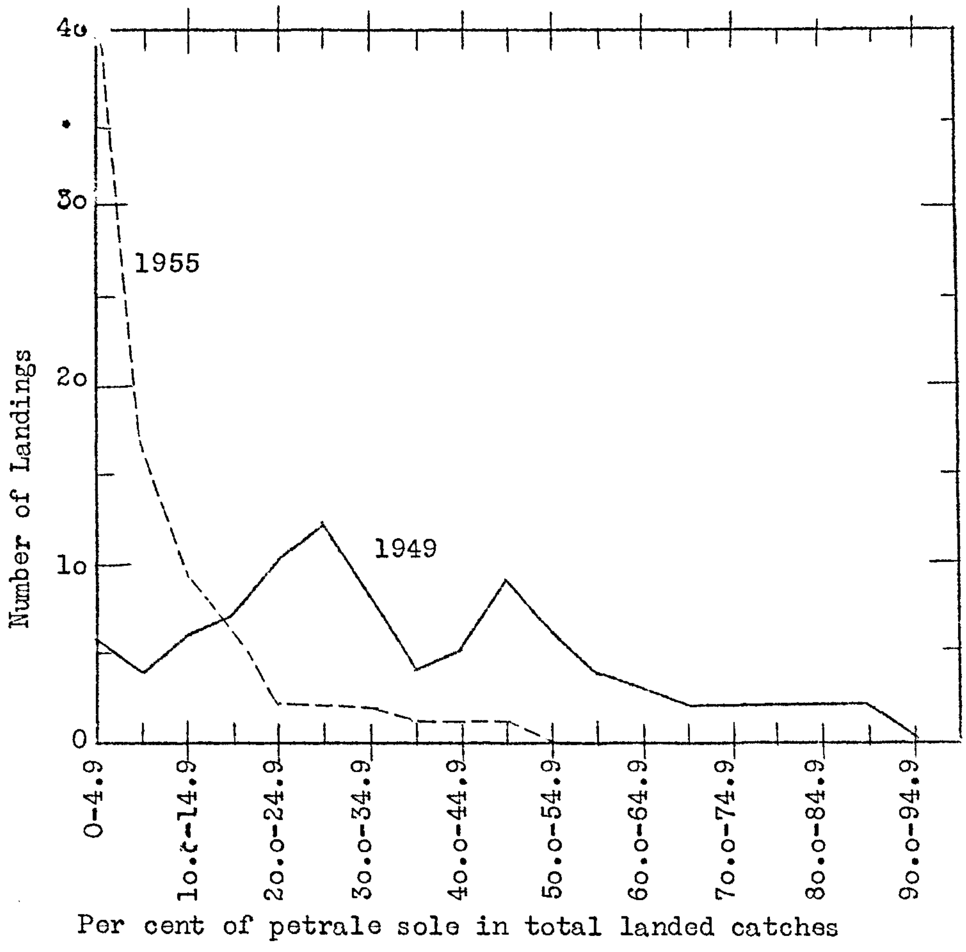

Figure 2. Frequency distribution of the proportion of petrale sole in landings from the southwest coast of Vancouver Island.

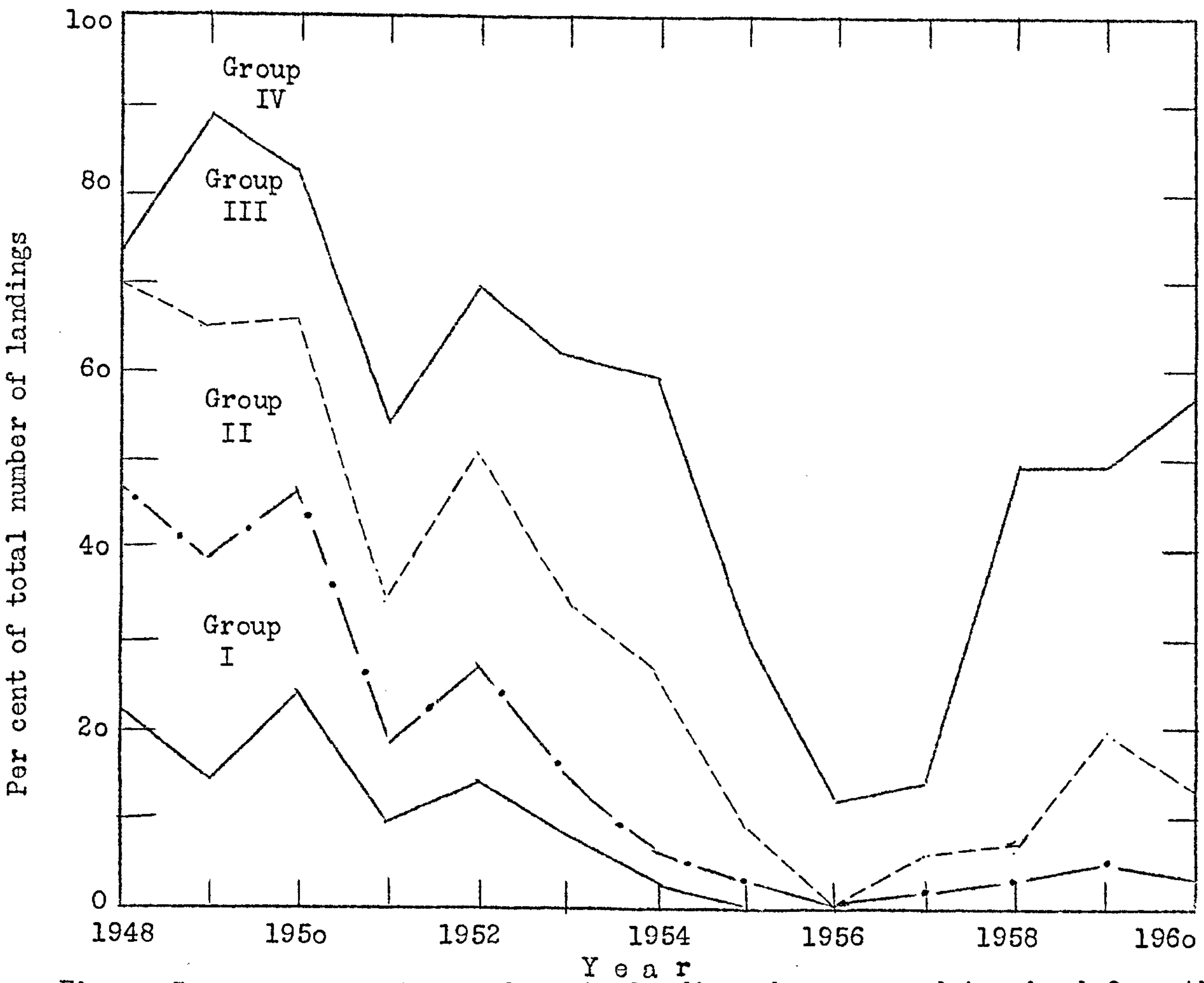

Figure 3. Frequency of petrale sole landings by groups determined from the petrale sole/total catch ratio.

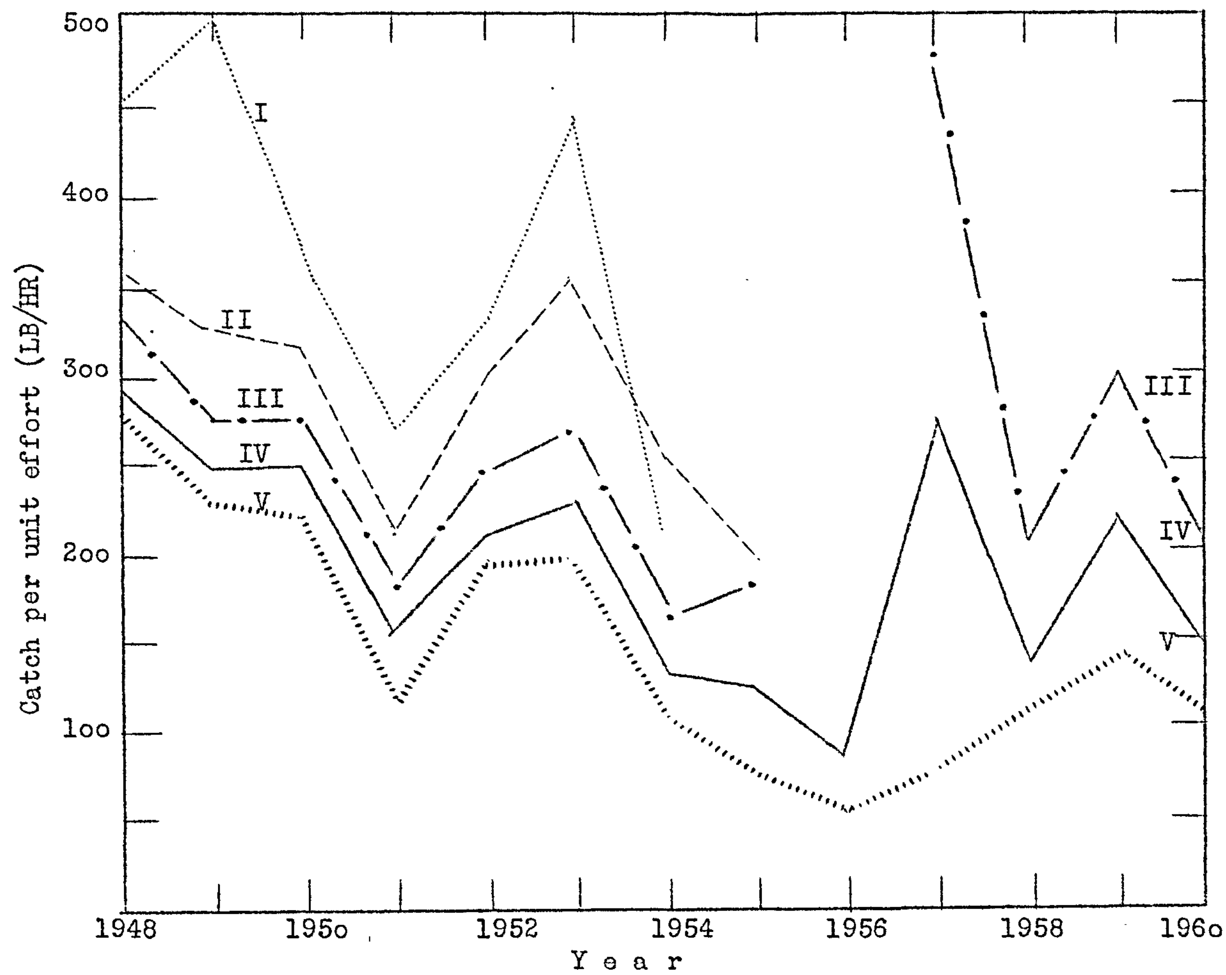

Figure 4. Estimates of petrale sole catch-per-unit effort based on five categories of qualifying catch and effort.