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On the Merits of Sampling Spawning Fish for Estimating the Relative Abundance of Different Year-Classes in Plaice

by

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Introduction

One of the methods of estimating the relative abundance of a fish species in an exploited stock is to determine the catches per unit of fishing effort. The fishing effort of a trawler can be defined as the product of the fishing power of this ship and the time spent fishing. The fishing power can be determined by reference to a standard ship by comparing their catches when fishing at the same time and place (Gulland, 1956; Beverton & Holt, 1957).

Several factors may influence the reliability of this catch per unit effort as a measure of the relative abundance, such as variations in catchability of the fish caused e.g. by changes in behaviour to the gear, or changes in efficiency of fishing operations and so on. This paper deals with the effects of unequal distribution of various age groups of plaice upon the relative abundance estimates of these age groups.

Catch per unit effort of different age groups of plaice

The length distribution of the total landings of plaice is determined in the usual way by stratified sampling in the fishmarket at IJmuiden (stratified by market categories and by categories of ships). The fishing effort is expressed in number of hours fishing of a standard ship of 2oo B.H.P. For this purpose the actual number of hours fishing of each ship has been converted to standard ship hours with correction factors based on the relation between the size of the catch of plaice and the engine power of the ships (Zijlstra & de Veen, 196o). The unit of fishing effort is loo hours fishing of the standard ship. From total landings and total fishing effort the catch and the length distribution per unit effort are calculated.

In addition to the length measurements, otolith samples are collected for the age determination. By means of length/age keys (per three months) the length distributions per unit effort are converted into age distribution per unit effort.

The logarithms of the numbers of plaice of each age group per unit effort landed at IJmuiden have been plotted in Figure 1 (average of the years 1958-62). Although the rate of decrease of the successive age groups can, with certain provisos, be used as a measure of total mortality (catch curve method), for our present purpose, the "coefficient of decrease" is used solely to characterize the age distribution.

Figure 1 shows that the rate of decrease is not constant, but changes at abt. age group VIII. Is this change real or caused by biased sampling or age determination?

If the age distribution of Figure 1 is separated into those of male and female plaice (Figure 2) it is evident that the bend in the line of Figure 1 is caused by the summation of the unequal age distributions of both sexes. The decrease for males and females is the same till the age group VI, but for older age groups the "coefficient of decrease" for females is smaller than that for males.

Is this picture of different age distributions of the sexes constant throughout the year? On considering the age distributions per quarter of the year, it is found that the catch per unit effort as well as the ratio of the successive age groups represented by the "coefficients of decrease" are varying in the different seasons. In all cases, however, the "coefficient of decrease" of the males is greater than that of the females (Figures 3-6). The highest value for the "coefficients of decrease" for both sexes is

found in the second quarter. The catch per unit effort for females is highest in the 2nd quarter and lowest in the 4th quarter. Thus, sampling in one quarter of the year only, may give a false picture of the true abondance ratio of the successive age groups. How could the most reliable data on the relative abundance of the various age groups be obtained?

Plaice is not the principal species in the Dutch demersal fisheries. Many vessels concentrate on fishing grounds where sole abounds. Now the distribution of sole generally does not wholly coincide with that of the plaice. This may be one of the reasons why the abundance of the various age groups of plaice in the landings differs between the seasons of the year.

Furthermore, the distribution of plaice in the sea is partly a function of the length of the fish, to the effect that with increasing length plaice is found at greater depth. This effect also causes differences in the areas of distribution of males and females, the latter growing faster than the former. Since the numbers decrease with increasing age (and thus with length) the density of plaice is often low in the area where the big fish occur. Therefore, if fishing for plaice, the vessels tend to concentrate in areas where young plaice and those of medium age predominate rather than in areas where the big ones occur rather sparsely. For these reasons it is likely that the relative abundance of the older age groups will be underestimated, the more so the older the fish is.

In the spawning season adult plaice of all ages concentrate on the spawning grounds. This gives an opportunity to try to sample the various age and length groups more representatively. There are, however, a few complications. First the older plaice arrive in the spawning area, and only later on the younger ones. Moreover, the position of the area of optimum spawning shifts in the course of the spawning season. If the fishery covers, however, the whole spawning area throughout the whole spawning season, it will be possible to obtain a reliable picture of the age composition of the adult stock.

The principal spawning areas in the southern North Sea can be located in the Southern Bight and in the German Bight. The latter is heavily exploited during the spawning season by the Dutch fishing fleet, whereas the former is left almost untouched during spawning. It is, however, possible to collect sufficient samples from the Southern Bight area also.

Catch per unit effort of mature plaice of different age groups

In the first quarter of 1960 and of 1961 mature plaice was sampled extensively from landings at IJmuiden and Scheveningen. The landings came from three regions, viz. the Southern Bight and the German Bight spawning areas and a transition zone (Figure 7). Length/age keys were calculated for each area per fortnight in the case of males, whereas for mature females (occurring much less frequently in the samples) only one length/age key by area and season could be produced.

The age distributions per unit effort of the males were calculated per fortnight and by averaging these figures the age distribution per unit effort for the whole season has been found. For the females the age distribution per unit effort per area was calculated directly for the whole season.

In Figures 8-10 the average age distributions (for 1960 and 1961) are given by area and sex. Clear differences do occur between the areas. Although the youngest adult male age groups are of about the same abundance in the three areas, the "coefficient of decrease" in the Southern Bight area is much less than in the German Bight and the transition area. The abundance and the abundance ratio of the age groups of the females in both spawning areas do not differ much, whereas these values in the transition area are quite different. Furthermore, it is striking to find that the abundance of the females is in general much less than that of the males. This will partly be caused by a difference in behaviour between males and females. Whereas mature females spend a relatively short time on the spawning grounds only, the males stay there for weeks and weeks as was found in recent tagging experiments on mature plaice. Another fact is that the determination of the maturity stage is more difficult in males than in females. What is called mature in males may include partly spent and nearly ripe individuals, whereas in females the criterion mature can be defined more precisely. The difference in the "coefficients of decrease" of the males from both spawning areas reflect a difference in mortality rate, which is partly caused by differences in fishing intensity at the spawning grounds. It has also been shown (de Veen, 1962) that the plaice of the two spawning areas belong to separate spawning communities.

From recent tagging experiments on mature plaice in both spawning areas it appeared that with the exception of the first quarter of the year when the landings consist mainly of German Bight group plaice, a mixture of the Southern Bight and German Bight groups is landed. The difference in the abundance ratio of the various age groups between seasons, described in the previous section, may therefore partly be due to seasonal differences in the proportions of both plaice groups in the landings.

Comparison of abundance estimates of age groups, based on samples of landings throughout the year, with those obtained from sampling the spawning stock

Taking into account that the annual landings of plaice in the Netherlands consist of a mixture of fish belonging to the group spawning in the German Bight and that spawning in the Southern Bight, it could be expected that the "coefficient of decrease" of the age groups estimated from the annual landings should be intermediate between those obtained from the two spawning areas. It is noteworthy, however, that the annual figure for female plaice is higher than those found for both spawning areas. The annual figure for males comes very close to the high figure obtained for the German Bight spawning group, though a far lower figure would have been expected for a mixture (the landings in the 3rd quarter e.g. may consist for more than 60% of Southern Bight plaice).

Practically all plaice reaches maturity at an age of four or five years. It is very unlikely that the low "coefficient of decrease" for spawning plaice of 5 to 10 years of age is due to delayed recruitment to spawning. It is, therefore, concluded that the hypothesis developed above, that in the annual landings the abundance of older plaice is underestimated, is correct. The most reliable information on the abundance ratio of the year-classes of plaice and thus on mortality will indeed be obtained from sampling the spawning stock.

It is obvious that for a study of the two spawning communities of the North Sea plaice, sampling of the spawning stock is essential, since in the remaining part of the year the landings are a mixture of these two groups.

It should, however, be remembered that the sex ratio in the samples from the spawning stocks gives a completely false picture of the real sex ratio, grossly underestimating the females.

Summary and Conclusions

The catch per unit effort of the different age groups of plaice has been determined from samples of Netherlands' landings throughout the year and has been compared with the catch per unit effort of the different age groups of spawning plaice.

The following results have been obtained:-

1) The age distributions of male and female plaice are different. In females old fish are relatively much more abundant.

2) The abundance ratio of young and older plaice of the same sex obtained in various seasons is different. Probably this is partly due to the fact that in most seasons plaice is only a by-catch of the Dutch sole fishery, and partly to the fact that the landings consist of varying proportions of the two main plaice spawning communities, which demonstrate different age distributions.

3) Samples of the spawning stock contain relatively more old fish than samples taken throughout the year, even if adult fish only is considered. It is concluded that, because of the different distribution of young and old plaice, the old fish is not properly represented in the landings outside the spawning season. The samples of the spawning stock give a reliable picture of the age composition of the total stock. The age composition of mature plaice is different in the two spawning areas studied.

4) The sex ratio from samples of the spawning stock is not representative for the total abundance of males and females and is very different from the sex ratio determined from samples collected throughout the year.

5) The older age groups of plaice spawn earlier and in another part of the spawning area than the younger age groups. For a correct abundance estimate it is necessary to sample throughout the whole spawning season and over the entire spawning area.

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Gulland, J. A.	1956	"On the fishing effort in English demersal fisheries". M.A.F., Fish.Invest., Series II, XX(5).
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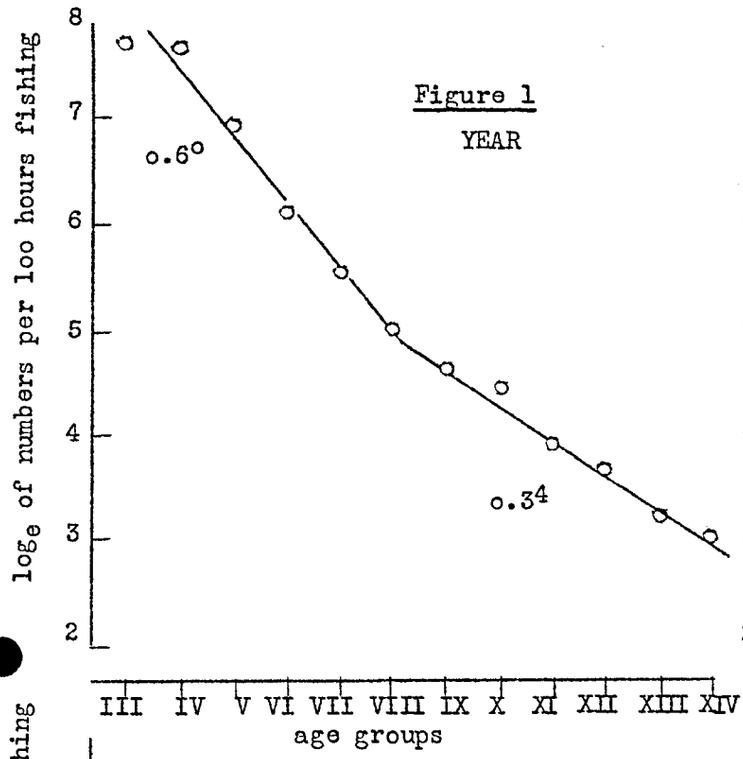


Figure 1
YEAR

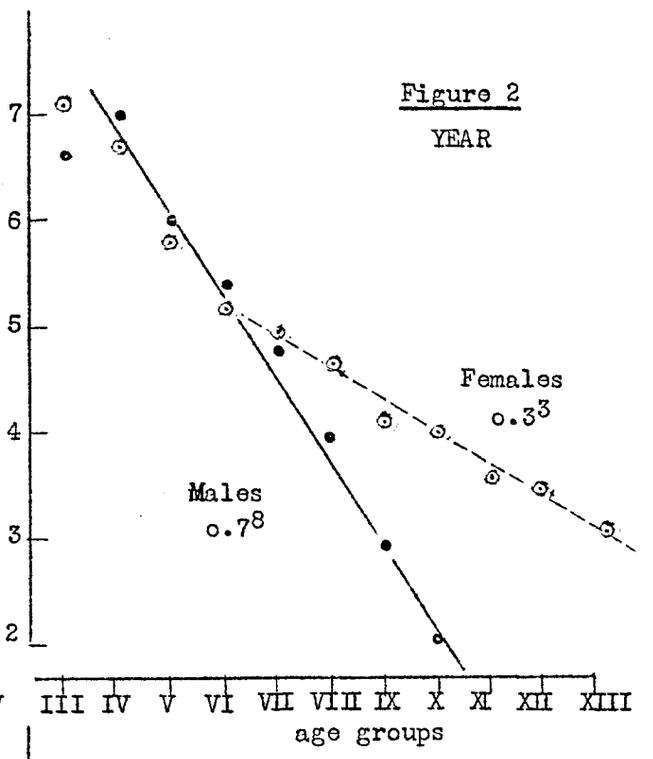
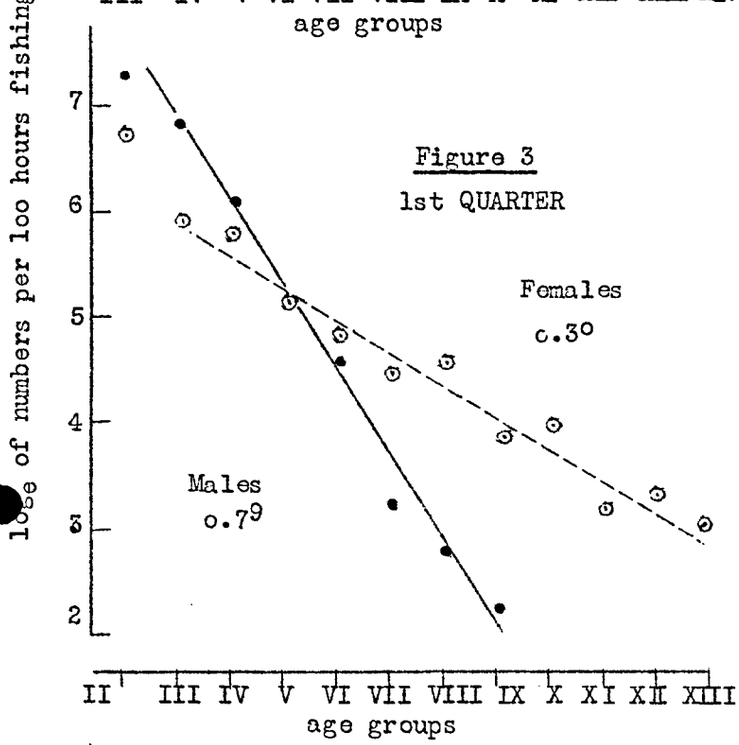


Figure 2
YEAR



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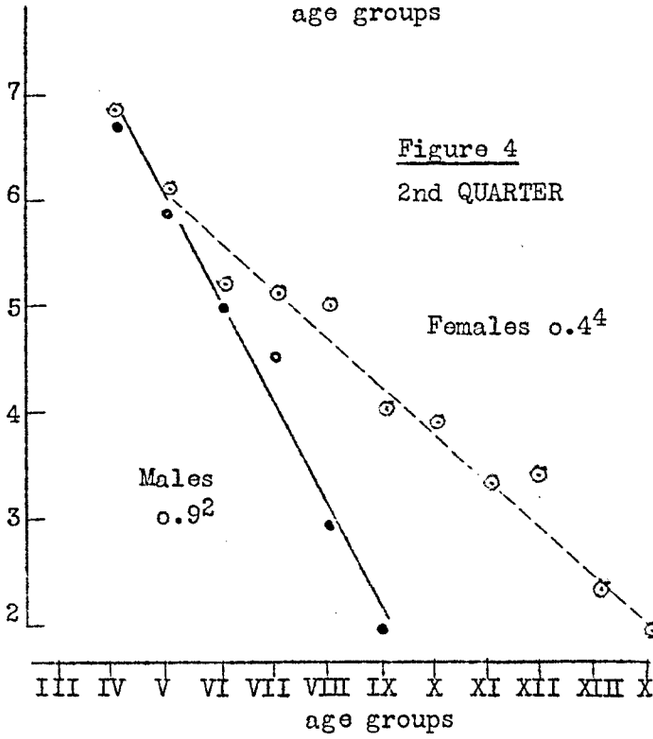

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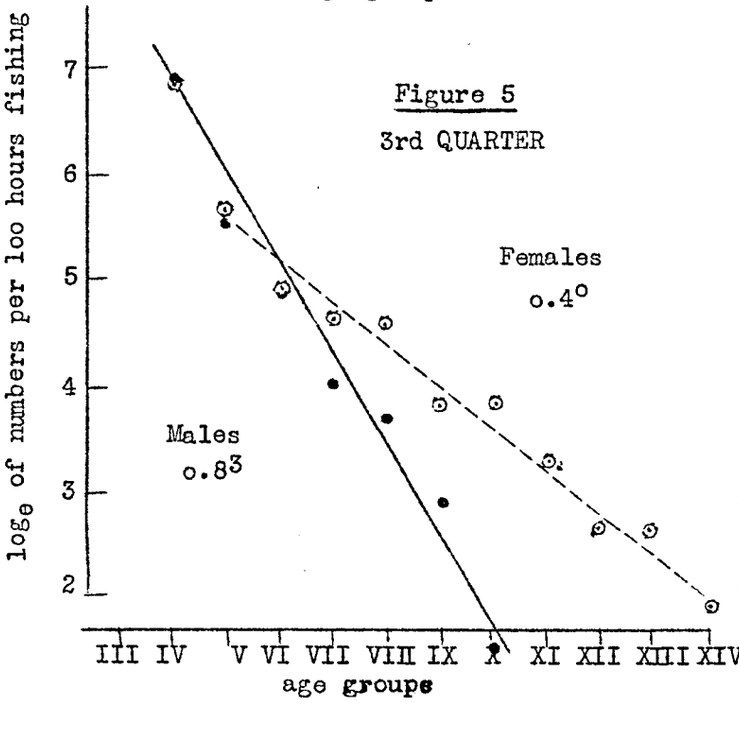

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3rd QUARTER

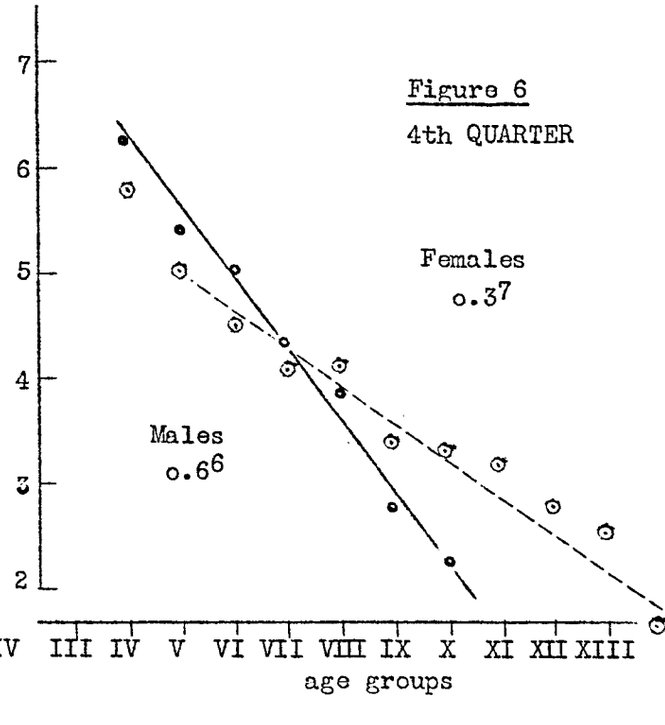

Figure 6
4th QUARTER

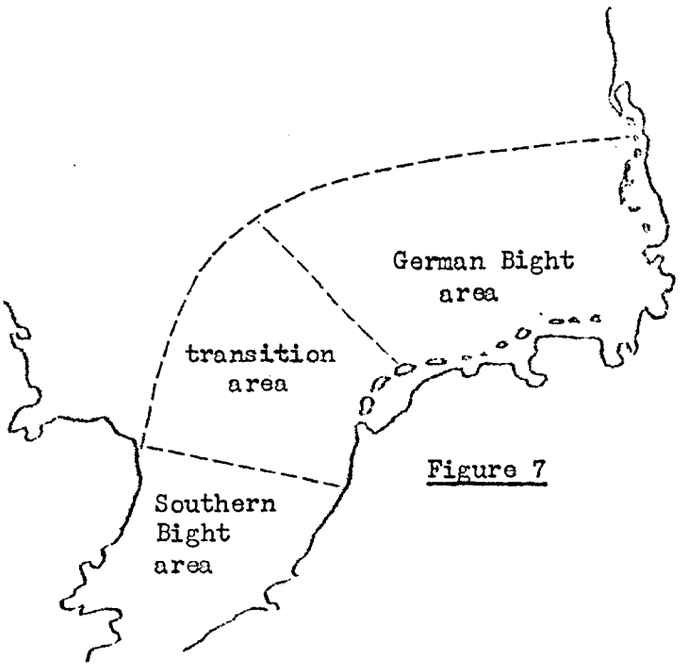
German Bight
area
transition
area
Southern
Bight
area

Figure 7

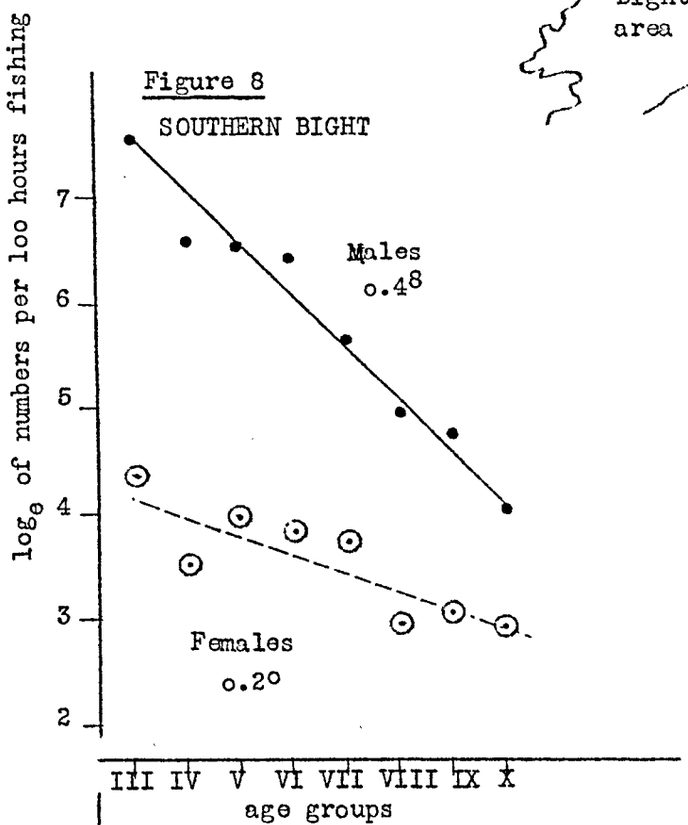
Figure 8
SOUTHERN BIGHT
log$_e$ of numbers per 100 hours fishing
Males
0.48
Females
0.20
III IV V VI VII VIII IX X
age groups

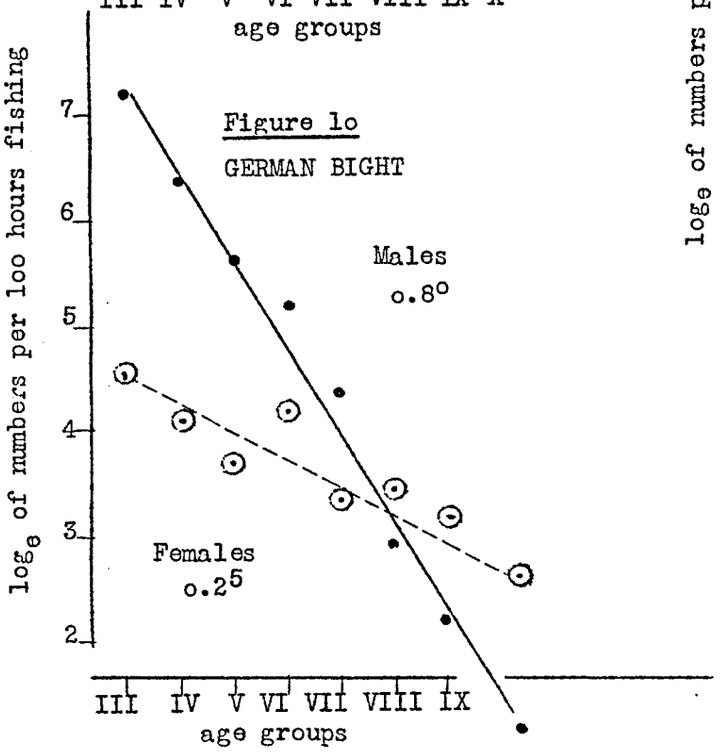
Figure 10
GERMAN BIGHT
log$_e$ of numbers per 100 hours fishing
Males
0.80
Females
0.25
III IV V VI VII VIII IX
age groups

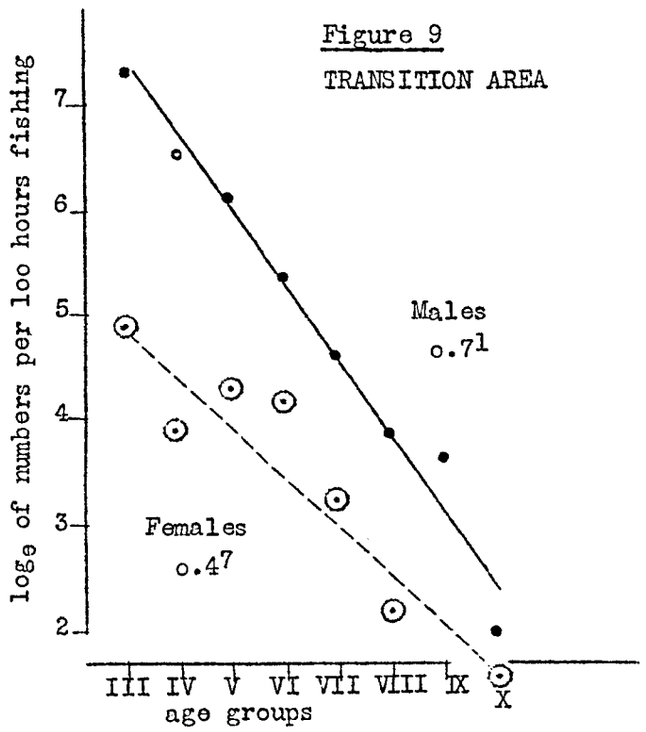
Figure 9
TRANSITION AREA
log$_e$ of numbers per 100 hours fishing
Males
0.71
Females
0.47
III IV V VI VII VIII IX X
age groups