This paper not to be cited without prior reference to the author.

International Council for the Exploration of the Sea.

C.M.1971/F:24.
Demersal Fish (Northern) Committee.

The fecundity of the flounder (Platichthys flesus L.) in a Danish fjord.

by
Erik Hoffmann
Danish Institute for Fishery-and Marine Research.
Charlottenlund Slot,
Charlottenlund.

INTRODUCTION

Publications dealing with the fecundity of the flounder (Platichthys flesus L.) are available for the south east North Sea and for the western Baltic, (Kändler and Pirwicz, 1957) and for the Gdansk Bay (Cieglewicz and Musial,1964). The present paper deals with the fecundity of the flounder in Ringkøbing Fjord situated on the westcoast of Jutland. Ringkøbing Fjord is a shallow lagoon with a salinity of 10-15 $^{0}/_{00}$. An attempt has been made to give a description of the relation between fecundity and ovary weight, total weight, length and age respectively.

METHOD

The material was collected in january-february 1967 and consists of 32 mature females. In the laboratory the following parameters were measured: total weight (g), total length (mm), ovary weight (g), fecundity and age. The results are summarized in table 1. Ovaries were fixed and preserved in modified Gilson's fluid and agitated in the usual manner. (Simpson 1951). The method used for egg counting was nearly the same as that used by Bagenal (1957). The eggs were placed in a cylindrical museum jar and water was added until the volume was 1000 cm^3. An energetic stirring was carried out with a non-rotary action until the eggs were apparently randomly distributed. A glass-pipe (diameter o.8 cm) was used as a pipette and with this 4 samples (15-20 cm^3) containing eggs and water were taken. The removed volume was measured (=a) and transferred to a new jar. Water was added until the volume was 250 cm^3 or 500 cm^3 dependent of the size of the ovary. Again an energetic stirring was performed and 4 samples (15-20 cm^3) were taken with the pipette and the removed volume measured (=b). After this the eggs in volume b were transferred to a petri dish and the total number of eggs in the sample counted (=c). The number of eggs (=F) in the whole ovary were calculated from:

$$F= \frac{c.10^6}{a\cdot b\cdot 1000/250(\text{or } 500)}$$

The whole procedure was carried out 4 times for each ovary and an arithmetic mean was found. The method was designed by K.P.Andersen, Danish Inst.Mar.Fish. Res. and gives a coefficient of variation of approximately 7%.

RESULTS

The number of eggs of the flounder varies according to the size of the fish from 180.000 to 900.000. There is a great variability in the fecundity among fish of the same size. Fig. 2 and 3 show the relation between fecundity and ovary weight and total weight respectively, and Fig.1 shows the ovary weight against total weight.

It is in all three cases supposed that the relation between the two variables is of the form:

$$y=a\cdot x^b \qquad (1)$$

$$\text{or} \qquad \log\ y=\log a + b\cdot \log x \qquad (2)$$

The data in the log-log plot (2) are fitted to a straight line by the method of least squares. It must be pointed out that using equation (1) implies that the line goes through the origin.

The results of the analyses are shown in scheme 1.

Scheme 1.

Empirical regression equation	The 95 % confidence limits for the regression coefficient		Empirical variance
$Ow= 0.0917\cdot W^{1.1000}$	1.3946	013059	0.01550
$F = 12.329\cdot Ow^{0.9278}$	1.1223	0.7334	0.04307
$F = 0.6920\cdot W^{1.1224}$	1.4403	0.8046	0.07515
$F = 2.3193\cdot 10^{-8}\cdot L^{4.1779}$	5.3028	3.0531	0.07145

Ow = ovary weight (g) F = fecundity (thousands)
W = total weight (g) L = total length (mm)

Scheme 1 shows that the relations Ow-W, F-Ow and F-W are probably all linear since the regression coefficients b do not differ significantly from 1 at the 5 % level. To get a more simple expression for the relation between fecundity and weight the form:

$$F = b \cdot W \quad (3)$$

has been used and the value of b was found by the method of least squares. As mentioned above the use of expression (1) means that it is supposed that the line goes through the origin. To test whether a better estimate could be obtained the form:

$$F = a + b \cdot W \quad (4)$$

was used and the constant a and the slope b were found by the method of least squares. The results are summarized in scheme 2

Scheme 2.

Empirical regression equation	Empirical variance	The 95 % confidence limits for the constant a.	
$F = 1.450 \cdot W$	10992.6	-	-
$F = -78.4303+1.6620 \cdot W$	10810.8	49.9273	-206.788

Symbols as in scheme 1.

From scheme 2 it appears that the hypothesis that the line goes through the origin can't be rejected since the constant a does not differ significantly from 1 at the 5 % level.

Length.

The relation between fecundity and length is shown in fig. 4. Again the method of least squares has been used to get an estimate of the a and b in the expression (2). The results are summarized in scheme 1. The regression coefficient b is 4.1779 and the 95 % confidence limit does not include 3.00.

The proportion between weight and length is generally accepted to be of the form $W = q \cdot L^3$ (Fulton 1891). This means that if the fecundity is accepted to be proportional to the weight it should also be proportional to the cube of the length, and in this case the regression coefficient b is found to differ from 3 at the 5 % level. To see whether other hypotheses could give a "better" estimate of the F - L relationship a number of regression analyses based on other hypotheses than (1) were performed. The results are summarized in scheme 3. The data have been grouped in length groups and tests of linearity have been carried out.

Scheme 3.

Empirical regression equation	Empirical variance	Test for form of regression curve. $v^2 = s_2^{\;2}/s_1^{\;2}$
$F = -1770.2 + 77.89 \cdot L$	11465.5	1.9153
$F = -625.5 + 1.318 \cdot L^2$	11359.0	1.9881
$F = -245.3 + 0.2955 \cdot 10^{-1} \cdot L^3$	11345.9	2.0077
$F = -54.70 + 0.7408 \cdot 10^{-3} \cdot L^4$	11424.8	1.8970

$v^2_{95} = 2.55$

None of the v^2-values are significant which demonstrates that the hypothesis regarding liniarity cannot be rejected on the basis of this test. The empirical variances are all within the same range.

Age.

The relation between fecundity and age is shown in fig. 5. Unfortunately only a few age groups (chiefly 3 and 4) are represented in the material. This is due to the fact that older fish are extremely rare in Ringkøbing Fjord as a result of the intensive fishery on the population. No calculations have been made on this material.

DISCUSSION

The calculations shown in scheme 1 seem to verify that the ovary is growing isometrically, i.e. that the ovary weight is proportional to the total weight. Further it is shown that fecundity is proportional to ovary weight. This indicates that the size of the eggs do not vary with fish size, in accordance with that pointed out by Beverton and Holt (1957). The relation between fecundity and total weight seems to be linear (scheme 1) and this is in agreement with the findings of several authors (Simpson 1951, Kändler and Pirwitz 1957 and Bagenal 1957). It is shown that the line for the F-W relationship goes through the origin (scheme 2) and the relative fecundity of the flounder in Ringkøbing Fjord is calculated to be 1.450 (weight in g, fecundity in thousands). This value is a little lower than the fecundity of the flounder from the southeast North Sea (Kändler and Pirwitz, 1957) and lower than that found for the flounder in the Gdansk Bay (Cieglewicz and Musial, 1964).

In the expression (1) for the relation between fecundity and length the regression coefficient b is found to be 4.1779 and this value is significantly different from 3 at the 5 % level. This is, as already mentioned, not in agreement with the general assumption that $W = q \cdot L^3$ and $F = b \cdot W$. The regression coefficient adopts values bigger than 3 for other species too. For the Grand Bank haddock it is found to be 5.110 (Hodder, 1963), for the Atlantic cod the value is 3.42 (May, 1967) and for the Southern Bight herring it is calculated to 4.33 (Baxter, 1959).

The results in scheme 3 show that none of the alternative hypotheses put forth can be rejected on the basis of the tests carried out. This is due to the fact that all the equations in scheme 3 will give fecundity values which deviate slightly compared with the variation observed between fecundity values of a given length. Corresponding to this Kändler and Pirwitz (1957) find that the fecundity of the flounder can be described by $F = a + b \cdot L$ as well as by $F = a + b \cdot L^3$. The same is shown for the cod in the western Baltic (Botros, 1962).

The conclusion is that the length is not very suitable for predicting fecundity and it seems unreasonable to describe this relation with simple forms. If a description of a fecundity-length relationship is wanted some kind of a transformed length value, taking other factors into account, must be used.

In the fecundity-age data (fig. 5) the variations in the fecundity within the same agegroup are extremely high. It seems that the size rather than the age determines the fecundity. The same result is obtained by Bagenal (1957) and Cieglewicz and Musial (1964).

A plausible explanation of the great variation in the fecundity among fish of the same age is given by Hodder (1963). He proposed that fecundity of individual fish may be related to the number of times the fish has spawned (greater fecundity in fish which have spawned more often), and presented some indirect evidence for Grand Bank haddock to support his hypothesis.

References:

Bagenal, T.B., 1957. The breeding and fecundity of the long rough dab *Hippoglossoides platessoides* (Fabr.) and the associated cycle in condition. J.Mar.Biol.Ass.U.K., vol. 36, 339-373.

Baxter, I.G., 1959. Fecundities of winter-spring and summer-autumn herring spawners. J.Cons.Explor.Mer., vol. 25, no.1.

Beverton, R.J.H. and S.J.Holt, 1957. On the dynamics of exploited fish populations. Fish.Invest. Ser.2, vol. 19.

Botros, G.A., 1962. Die Fruchtbarkeit des Dorsches (*Gadus morrhua* L.) in der westlichen Ostsee und den westnorwegischen Gewässern. Kieler Meeresf., 18, 67-80.

Cieglewicz, W. and R.Musial, 1964. The fecundity of the flounder in the Gdańsk Bay. I.C.E.S., C.M. 1964, Baltic-Belt Seas Committee, No. 64.

Fulton, T.W., 1891. The comparative fecundity of Seafishes. Fish.Board.Scotl. 9th Ann.Rep. Part 3.

Hodder, V.M., 1963. Fecundity of the Grand Bank haddock. J.Fish.Res.Bd. Canada, 20, no. 6.

Kändler, R. und W.Pirwitz, 1957. Uber die Fruchtbarkeit der Plattfische im Nordsee-Ostsee Raum. Kieler Meeresf., 13, 11-34.

May, A.W., 1967. Fecundity of Atlantic cod. J.Fish.Res.Bd. Canada, 24, no.7.

Simpson, A.C., 1951. The fecundity of the plaice. Fish.Invest. Ser.2, vol.17(5).

Tabel 1. The length, weight, ovary weight, age and egg counts of female flounders.

Weight (g)	Length (mm)	Ovary weight (g)	Fecundity (thousands)	Age
225	263	30.0	362	?
243	260	37.1	325	3
410	302	35.3	476	3
472	322	73.7	626	?
276	267	22.4	211	4
460	311	73.9	737	3
235	273	37.9	226	4
191	255	33.5	347	3
209	260	45.9	360	3
485	341	74.1	571	6
282	277	39.1	538	4
451	305	51.9	610	6
240	260	27.8	224	4
353	298	95.8	728	3
293	281	52.0	337	3
357	294	57.0	467	3
250	265	39.0	434	2
262	271	35.0	253	3
315	296	53.0	467	4
490	312	98.0	695	?
481	328	97.0	845	3
272	273	38.5	292	4
323	293	60.2	570	3
530	337	84.4	784	4
488	328	70.2	779	3
368	310	50.3	558	3
319	289	60.6	615	3
258	275	15.5	183	4
330	289	51.9	484	3
338	298	41.2	452	3
552	330	76.6	843	2
518	323	84.8	901	3

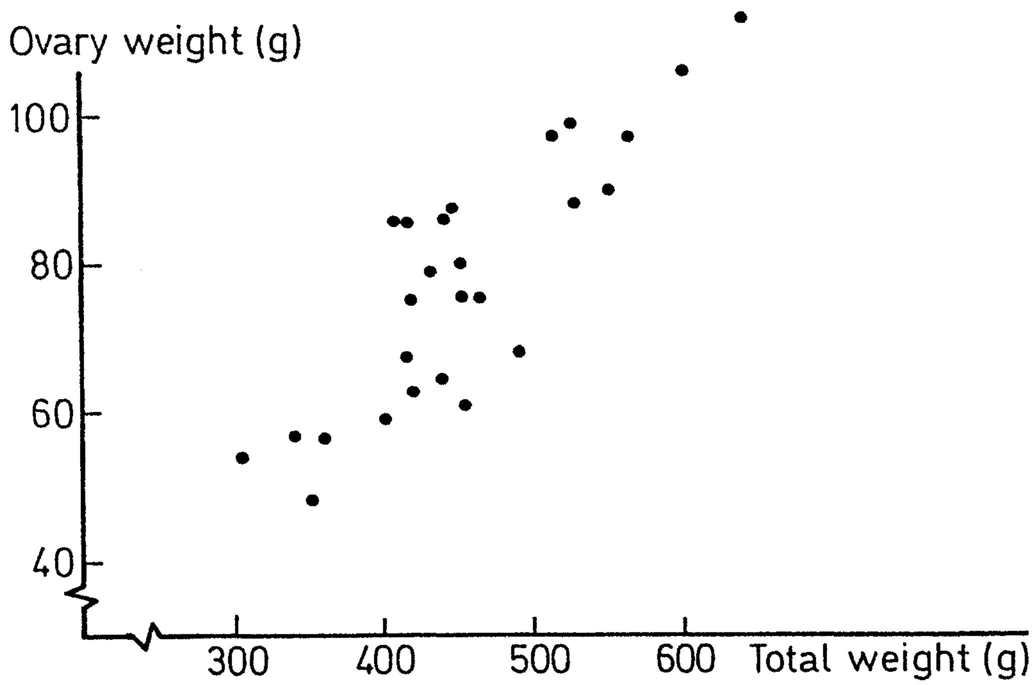

Fig.1. Relation between ovary weight and total weight.

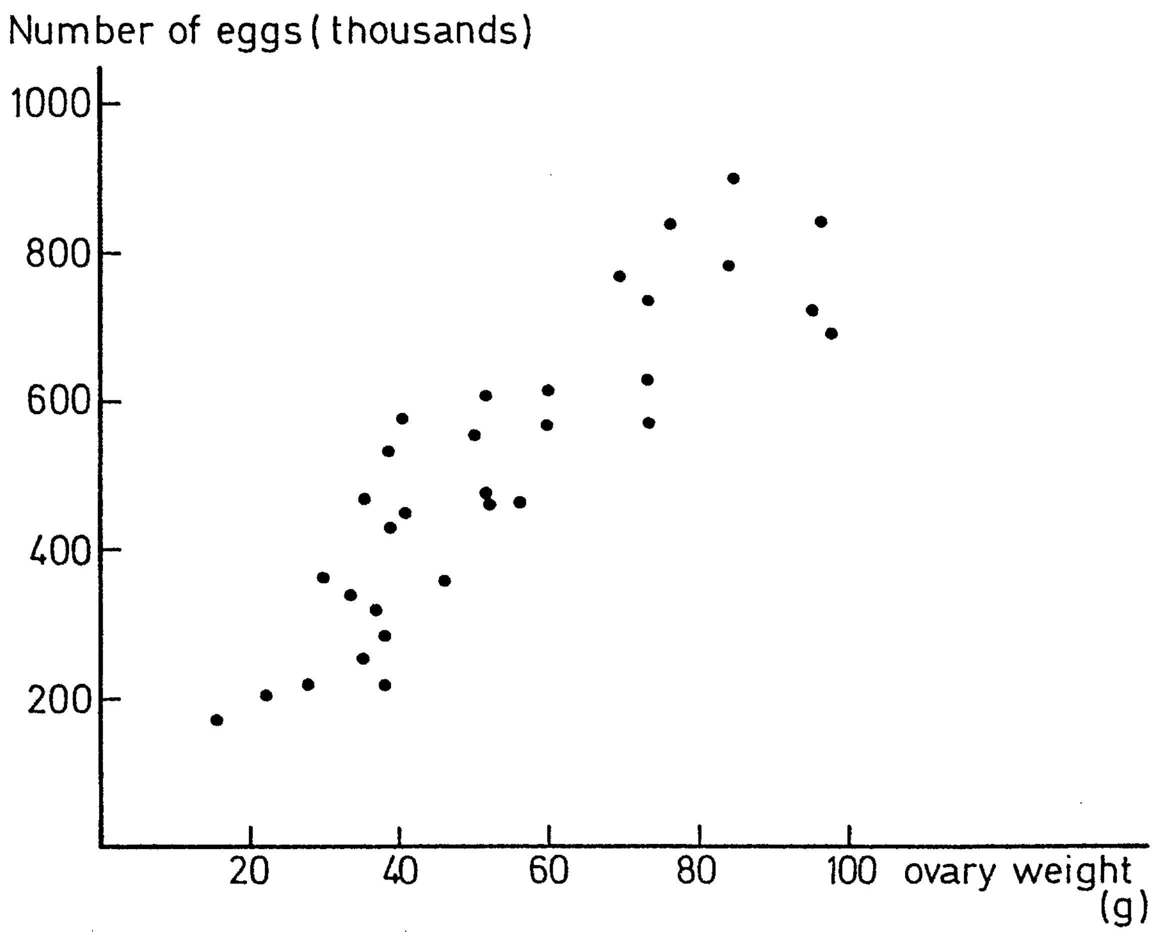

Fig.2. Relation between fecundity and ovary weight.

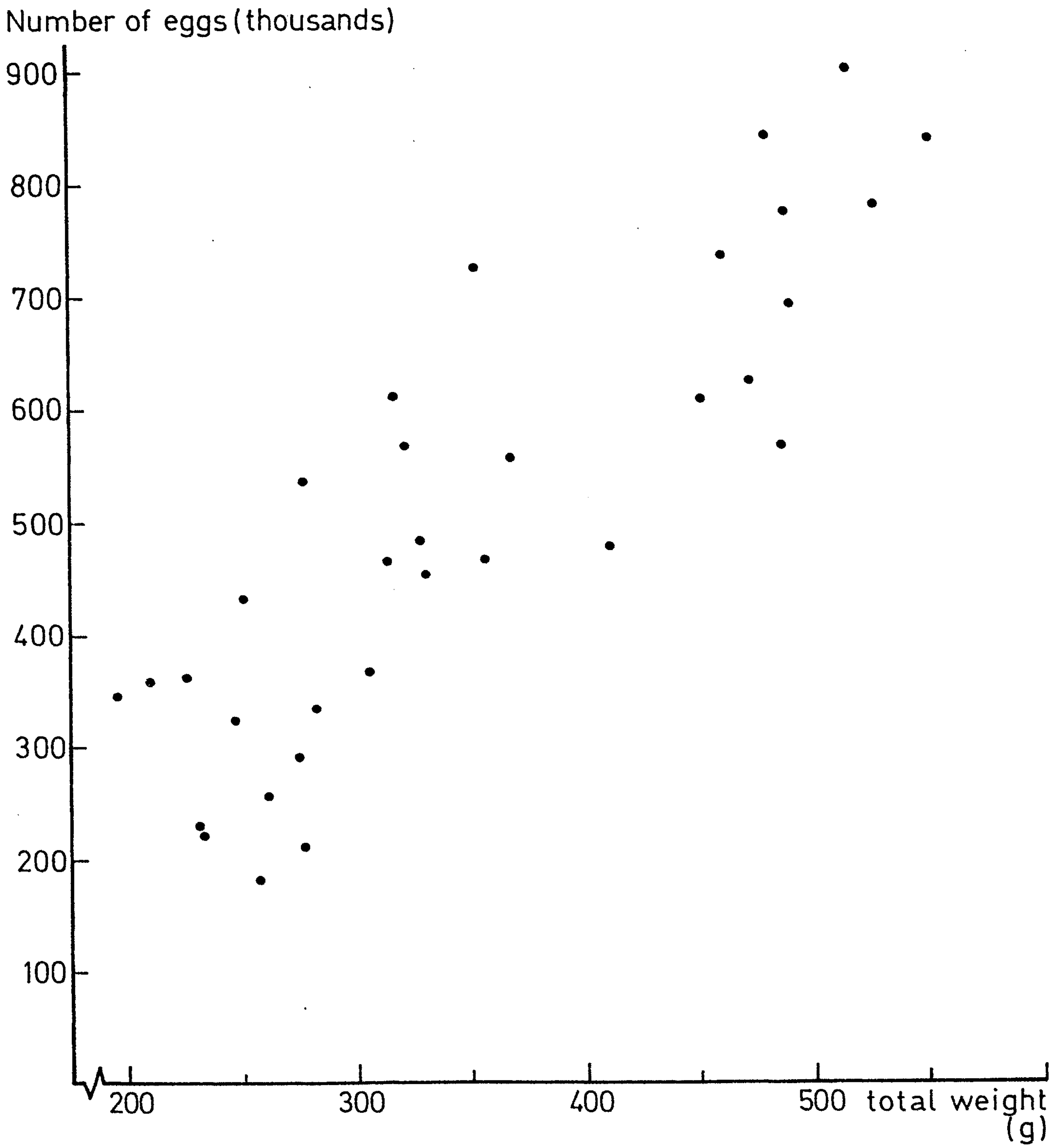

Fig.3. Relation between fecundity and total weight of flounder

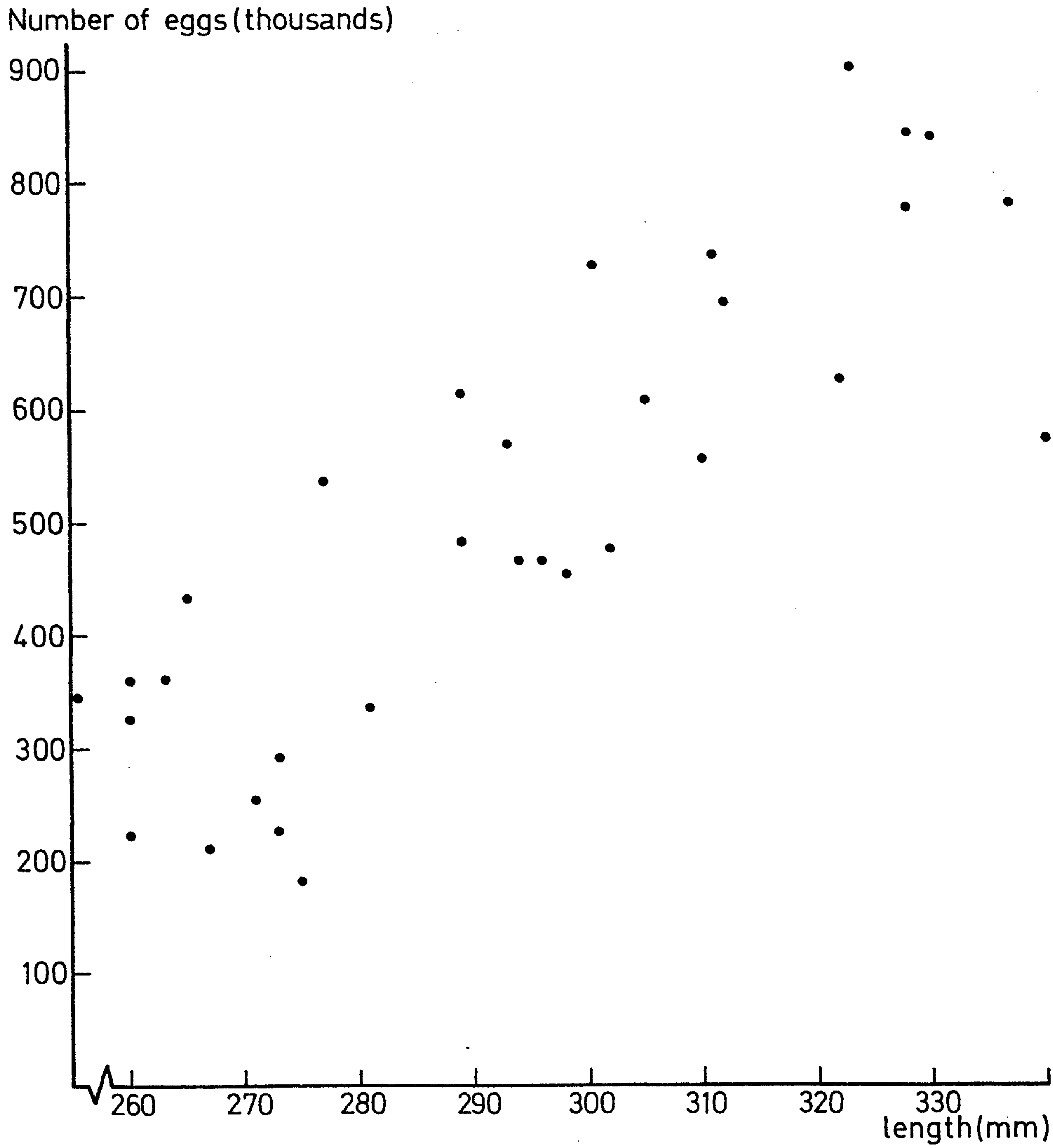

Fig.4. Relation between fecundity and length of flounder

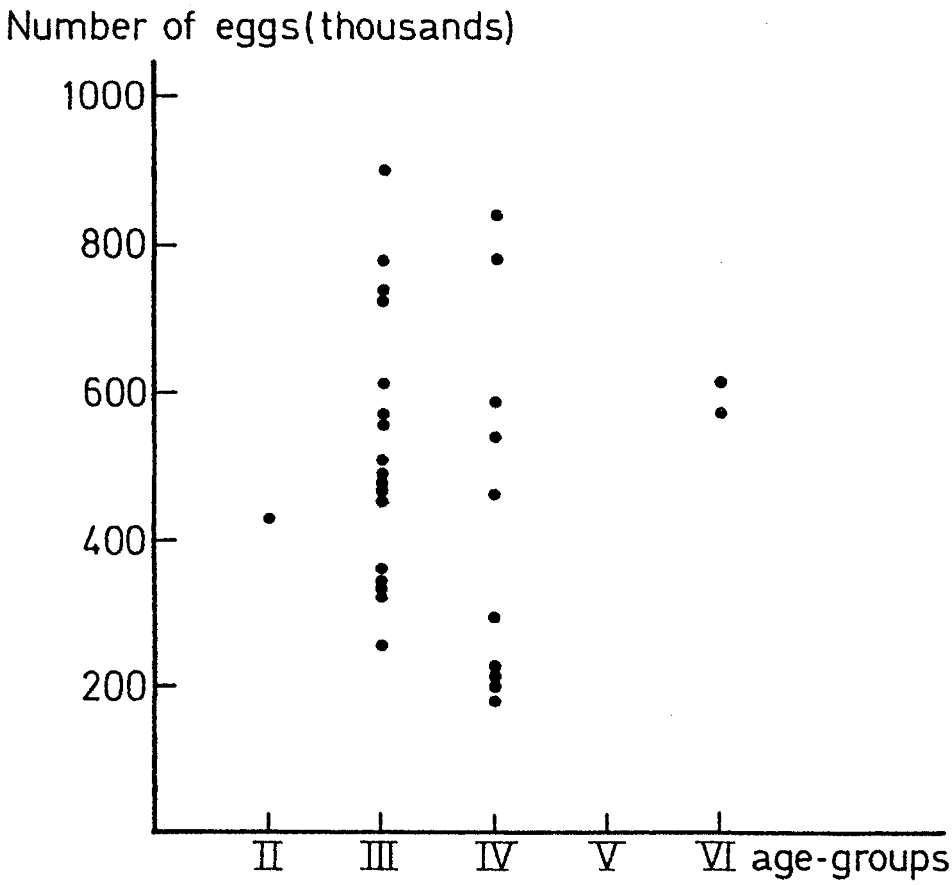

Fig.5. Relation between fecundity and age of flounder.