Report on sole tagging experiments in 1959 and 1960.

by Gerd Matthäus

This report includes the recoveries from the two tagging experiments in 1959 and 1960 until January 1961.

For tagging we used exclusively the well-known Petersen discs which were connected by silver wire (1959) or titanium wire (1960). Titanium wire has the advantage of being very light, but has high elasticity, therefore difficulty in piercing it through the muscle part of the fish. This difficulty, however, may be overcome by cutting the wire very pointwise so that it is also suitable tagging. The colour of the discs was red for the blind side and yellow for the eye side. The tags were attached dorsally and somewhat ventral to the intermuscula, about halfway along the fish.

In the 1959 experiments 281 of the tagged fish were categorized according to vitality and scale conditions in the following manner (see Table 2):

Index " 4 " = active
Index " 3 " = sluggish
Index " 1 " = no scales missing or only occasional ones
Index " 2 " = few small patches free from scales
Index " 3 " = larger patches free from scales

From June to October, 1959, 641 sole were tagged in the southern North Sea (3[illegible] of them = 72,5 percent - near Helgoland, 91 = 20,7 percent - off the North Frisian and Danish coast, and the rest at different places in the southern North Sea). From this experiment 106 fish were returned up to August, 1961; this is about 24 percent within 2 years. In 1960 327 fish were liberated from May to September, mostly within a ten-miles circle round the island of Helgoland and off the island of Amrum. Up to August, 1961, 61 of these fish were returned (19 % within about one year). Further details may be seen from Table 1. For length distribution of the tagged and recovered fish see Fig. 1.

Table 1. Releasing and recovery data

Date	Tagging position Lat.N.	Long.E.	Number of tagged fish	Returns No.	%	Vessel
		a) 1959 experiments				
23./24.6.	54°15'	07°46'	114	30	26	Anton Dohrn
24.6.	54 17	07 40	18	7	39	" "
24.6.	54 13	07 20	4	1	25	" "
24.6.	54 24	07 07	7	4	57	" "
25.6.	53 38	06 58	2	0	0	" "
28.6.	53 03	04 03	1	0	0	" "
29.6.	53 19	05 16,5	3	2	67	" "
29.6.	53 39	02 43	1	1	100	" "
1.7.	55 51	07 44	30	15	50	" "
2.7.	55 46	07 37	5	2	40	" "
2.7.	55 04	08 04,5	23	8	35	" "
2.7.	54 49	08 06,5	27	5	19	" "
3.7.	54 26	08 04	6	2	33	" "
3.7.	54 07	07 57,5	4	0	0	" "
13.8.	54 15	07 46	54	6	11	Uthörn
20.8.	54 15	07 46	91	15	16	"
8.9.	54 15	07 46	15	4	27	"

[illegible]

[illegible] experiment

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Arum [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	108	[illegible]	
	54° 09'	07° 54'	[illegible]	[illegible]	4	[illegible]
		[illegible]	[illegible]	2	30	
		[illegible]	[illegible]	7	[illegible]	[illegible]
		[illegible]	50	4	8	"
		[illegible]	[illegible]			" "
		[illegible]	[illegible]	[illegible]	[illegible]	" "
		[illegible]	[illegible]		[illegible]	" "
		[illegible]	[illegible]	[illegible]	[illegible]	" "
	[illegible]	[illegible]	10	[illegible]	10	" "
	[illegible]	08 [illegible]	18	7	59	" "
[illegible]	[illegible]	[illegible] 40	4	[illegible]	25	" "
[illegible]	54 [illegible]	0[illegible] 46	7	1	14	Uthörn
[illegible]	[illegible]4 09	[illegible] 54	[illegible]	2	29	"
14 8.	54 09	07 54	53	7	13	"
[illegible]	54 [illegible]	07 54	11	1	9	from tank experiments
		Total	327	61	19	

Table 2. Release and return of different conditioned fish (for index see page 1).

Category	Number of tagged fish		Returns No.		Returns %	
A [illegible]	44	133	16	41	36.3	30.8
A [illegible]	79		25		31.4	
A [illegible]	10		0		----	
B	21	148	2	12	9.5	8.1
B [illegible]	99		9		9.1	
B [illegible]	28		1		3.6	

Table 3. Recoveries by countries

	1959 experiment No.	1959 experiment %	1960 experiment No.	1960 experiment %
Belgium	14	13.2	4	6.6
Danmark	9	8.5	-	-
England	10	9.4	4	6.6
France	7	6.6	1	1.7
Germany	15	14.2	11	18.0
Holland	51	48.1	41	67.2

The positions of the recaptures are plotted in the charts, Fig. 3. (for the 1959 experiment) and Fig. 4. (for 1960).

As shown by Fig. 5 (Table 3) most of the fish (1959 experiment 48 percent, 1960 experiment 67 percent) were recaptured by Dutch fishing vessels. The corresponding figures for German vessels are 14 percent and 18 percent. The rest is devided among Belgian, Danish, French and English vessels. These figures show clearly that the most

effective fishery on the sole stock is carried out by Dutch fishermen.

Discussion of the results

a) Migration: The place of recapture in the course of the time shows clearly a periodic migration of the sole. The sole tagged during the summer in the eastern North Sea at first make short distance and unoriented migrations, typical migrations for seeking food. From October there is a sudden long-distance migration towards the west (or southwest for the fish from the German coast). On their way westwards the fish reach their hibernation quarters (Dogger Bank, Brown Bank, Cleaver Bank, ect.). About the end of the year, after having migrated about 150 to 200 miles. This migration, no doubt, is induced by the cooling of the water in the southeastern North Sea in autumn. In March/April the sole return very quickly to the east and northeast, and are found in May/June within the shallow coastal waters, mostly to the east of their tagging position. In these areas the fish spawn, and after spawning they retire to somewhat deeper waters, where they remain until the migration westwards begins again in early autumn. The type of seasonal migration is clearly shown in Figs. 6 (for 1959) and 7 (for 1960), in which are plotted the displacements in relation to days after tagging (a) or date of recapture (b). It seems that the sole have what may be called a home sense, for all fish retaken in May/June were found not far from their tagging position.

It must be mentioned that we could find no differences in the migration behaviour between the smaller and the bigger fish.

Only 4 of the fish which were tagged in the southwestern part of the North Sea were recaptured, and this not far from their tagging position. Therefore nothing can be said about the question of whether the sole of the southwestern North Sea are also carrying out long distance migrations, or whether they form a separate and more stationary stock.

There is to be mentioned one fish (No. BAH 11), which was recaptured in August 1960, 210 miles westwards of the tagging place after having been in sea for 370 days. Evidently this fish had not returned to the eastern North Sea in spring, but had separated from the bulk of the fish.

The recovery data show that a sole may migrate within 24 hours up to 4 miles, not included the uncontrollable roundabout routes! This is extraordinarily high for a fish which must be regarded as a very sluggish one, and which generally is active only during the night.

b) Growth: In Figs. 8a and 8b we have plotted the differences between fish length at recapture and at tagging in relation to days after tagging. In both the early and later recaptures there were fish whose length was less than at tagging (fish No.337, for instance, was in sea for about 360 days; its length had decreased by 6 mm!). This shrinkage of the fish may be due partly to errors when measuring, and partly to the fact that most of the returned fish were not measured immediately after they were caught, but were gutted, put on ice, and measured in the harbour. A shrinkage of the fish after this procedure seems to be possible. However, our tank experiments have also shown that the fish decreased in length after tagging, even though they are supplied with sufficient food, as may be seen from the following experimental data:

Tag No.	Date of tagging	Length at tagging	Length at 7.VII.60	Length at 1.VIII.60
231	30.IV.60	307 mm	301 mm	303 mm
225	30.IV.60	264 mm	258 mm	261 mm
35	30.IV.60	204 mm	202 mm	205 mm
30	30.IV.60	192 mm	188 mm	191 mm

It must be mentioned that no untagged fish were used as controls at the same time, so that the question remains of whether the shrinkage may also be observed in untagged fish.

From the recovery data we have calculated the average length increment for the three length groups: [illegible] cm, [illegible] cm, and [illegible] cm (Fig. 2a, 2b, and 2c), and within every one half year after liberation. Included are the negative figures for calculation, but not the value of 100 mm (fish no. [illegible]), which seems to be incorrect. The data are taken from only the 1959 experiments. The growth calculated in this manner, no doubt, is incorrect from the following reasons: a) it must be less than the actual growth of the untagged fish, for we could not take into consideration the "shrinkage" within the first weeks after liberation, and that the tagged fish are hindered in their activity and so in their feeding, etc. b) the calculated figures more represent the growth within 1/4, 3/4, 1 1/4 etc. year than that of 1/2, 1, 1 1/2 year etc., for all recovery data within the first, second, third half year etc. are equally considered.

c) Fish of different condition. As mentioned above in the 1960 experiments, 281 cod were [illegible] according to activity and scale condition before liberation. Of these [illegible], [illegible] (about [illegible] percent) were returned. Comparing the rate of recapture in the different categories, Fig. 3 and Table 2 show that the "A" fish by far dominate the "B" fish both in number and percentage: [illegible] percent of the category "A" were returned, compared with only [illegible] percent of the "B" category. Moreover, there is a decreasing rate of recapture from group "1" to group "3". From these evidences we may conclude that the survival rate depends directly on the condition of the fish (both the activity and the scale condition) at tagging, i.e. that the better conditioned fish have a higher rate of survival than the less conditioned ones.

When calculating the fishing mortality from the recapture data it is necessary to consider these facts, for the fishing mortality must be far higher than the percentage of recaptured fish [illegible]. It would be wrong to conclude from the [illegible] percent of recaptured fish that the fishing mortality within about one year of [illegible] amounts to the same percentage. It must be at least as high as the rate of recaptured "A" [illegible] fish, i.e. [illegible], as far as the [illegible] experiments are considered. Final conclusions in this respect, however, must wait until the recovery data of the other cruises [illegible].

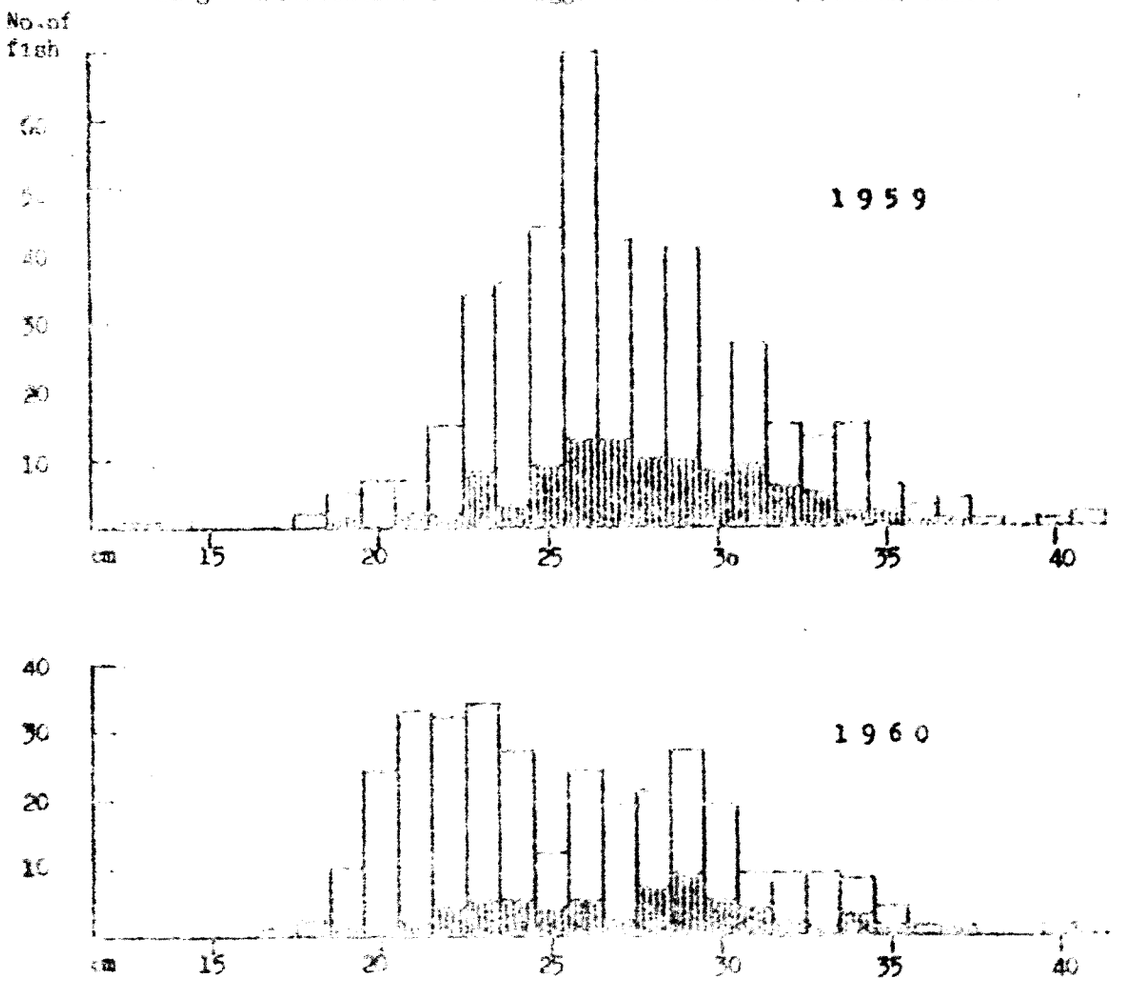
d) [illegible] In Fig. [illegible] the total the number of [illegible] a) 1/2 year, b) 1 year, c) 1 1/2 year, and d) [illegible] per month as well as [illegible] the Copenhagen [illegible].

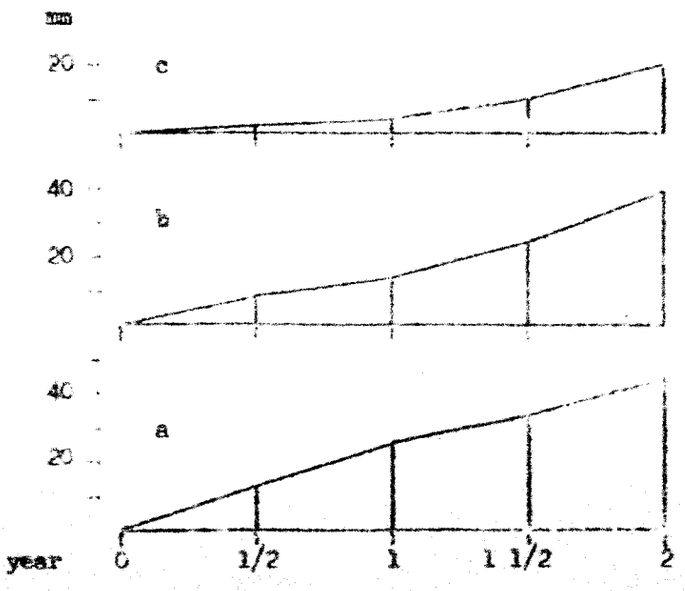
[illegible] relatively high numbers of returns. [illegible] 7 [illegible], from where we received [illegible] the 1960 experiment) [illegible] of [illegible] are due to the [illegible]. The tagged fish, therefore [illegible] than in other regions. [illegible] northwest of this island, [illegible], especially to the west and [illegible] grounds and therefore they are preferred for [illegible] fishing.

[illegible] SRs [illegible] along the "F"-way and north to it. [illegible] SRs together [illegible] of the returns from the 1959 and 1960 experiments [illegible] are to be mentioned SRs J 5 (west to the islands [illegible]) and [illegible] (northwest to the island Sylt) with each 5 percent of the returns from the 1959 experiment.

F I G . 1 .

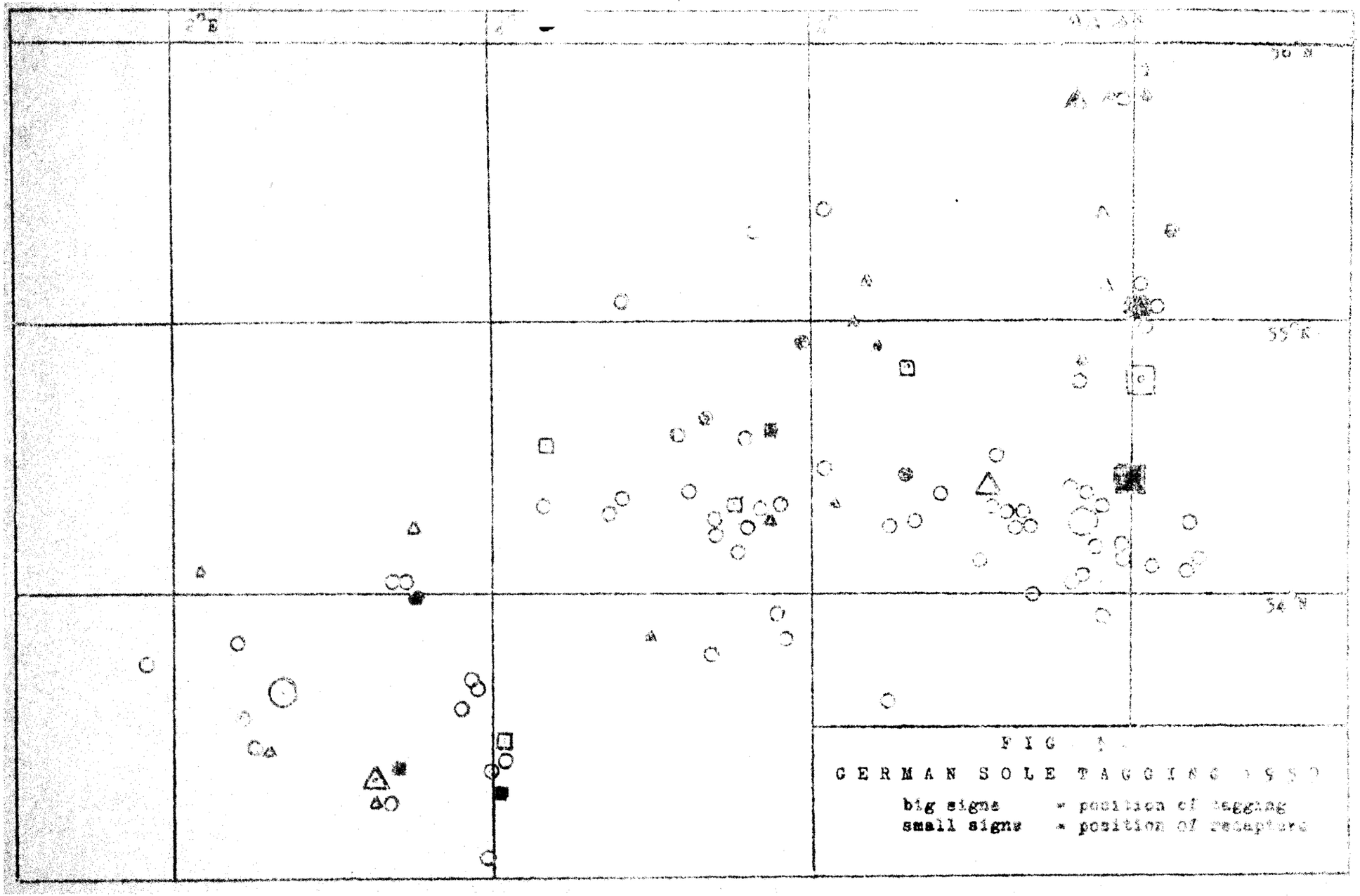
Length distribution of the tagged and returned (hatched) soles.





F I G . 2 .

Average growth of the length groups (a) 20 - 25 cm
(b) 25 - 30 cm
(c) 30 - 35 cm


56° N
55° N
54° N
FIG
GERMAN SOLE TAGGING
big signs = position of tagging
small signs = position of recapture

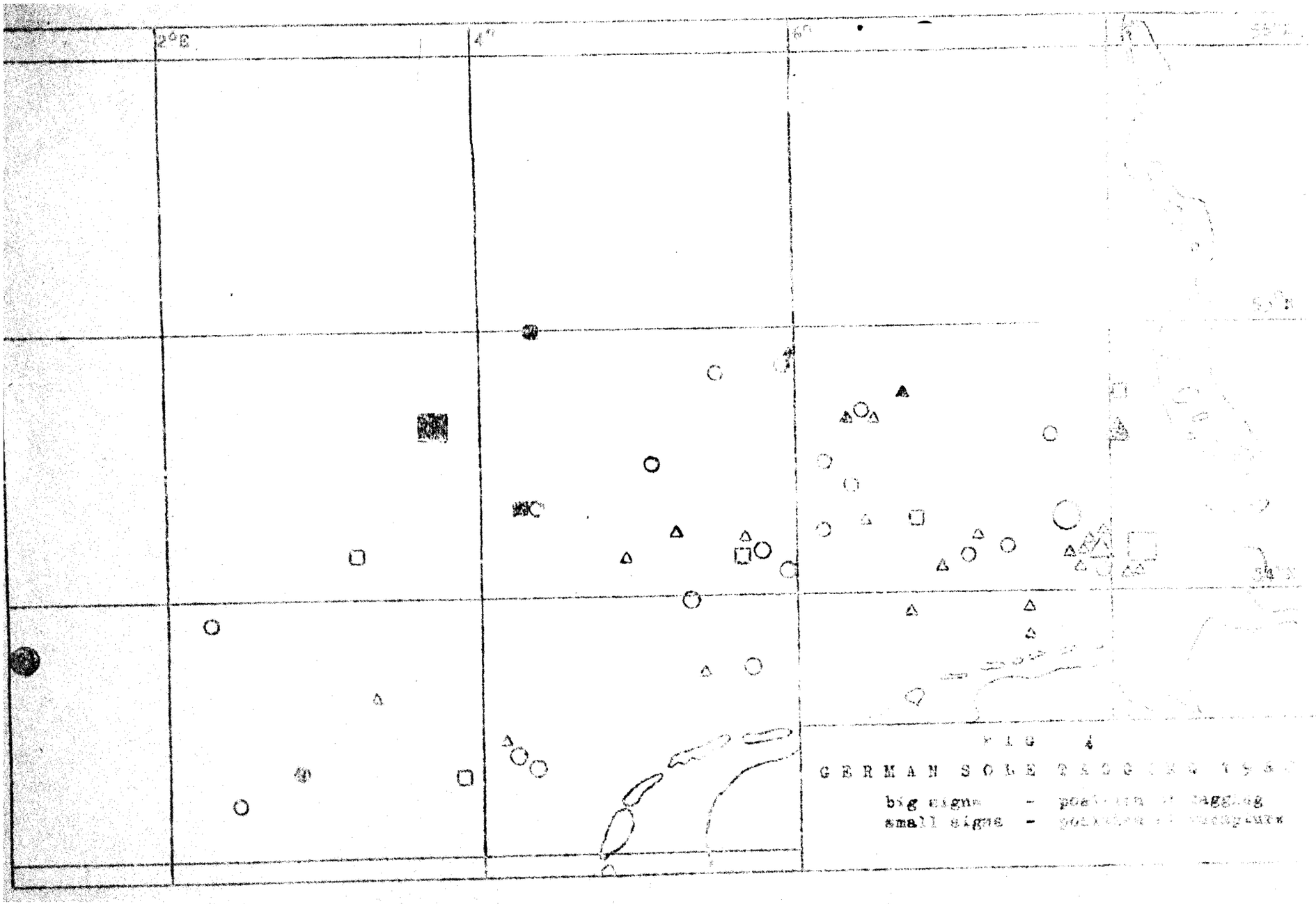
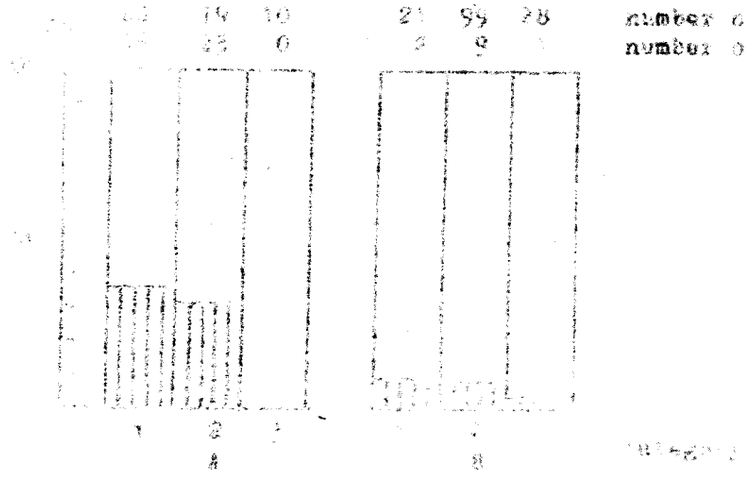


FIG 4

GERMAN SOLE RACE 1968

FIG 5.

a) Returns of different conditioned fishes



b) Returns of tagged cods by countries

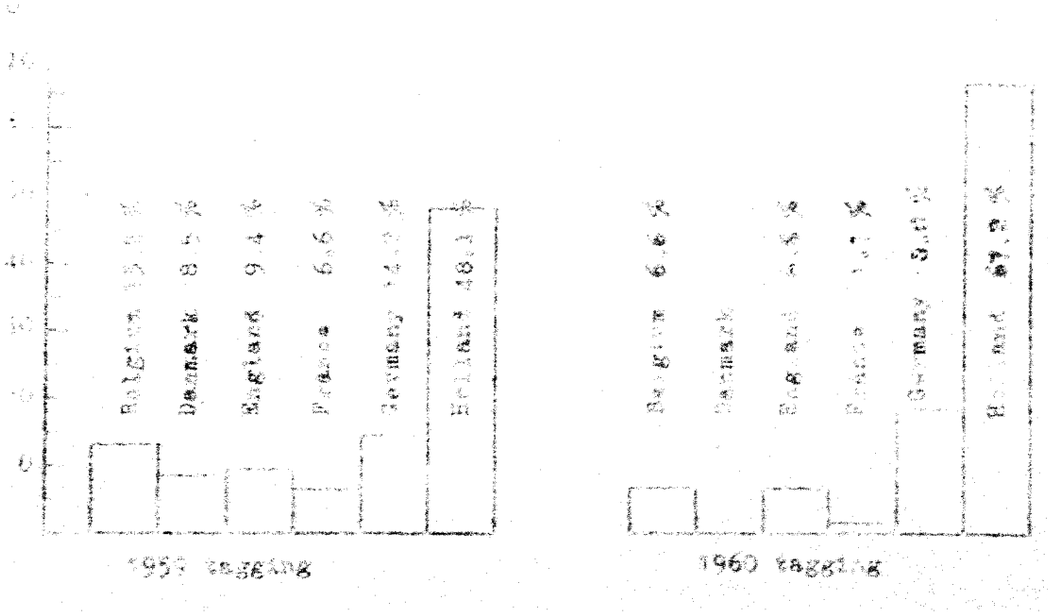


FIG. 6.

1959 TAGGING - made at seasonal migration (non-roost).

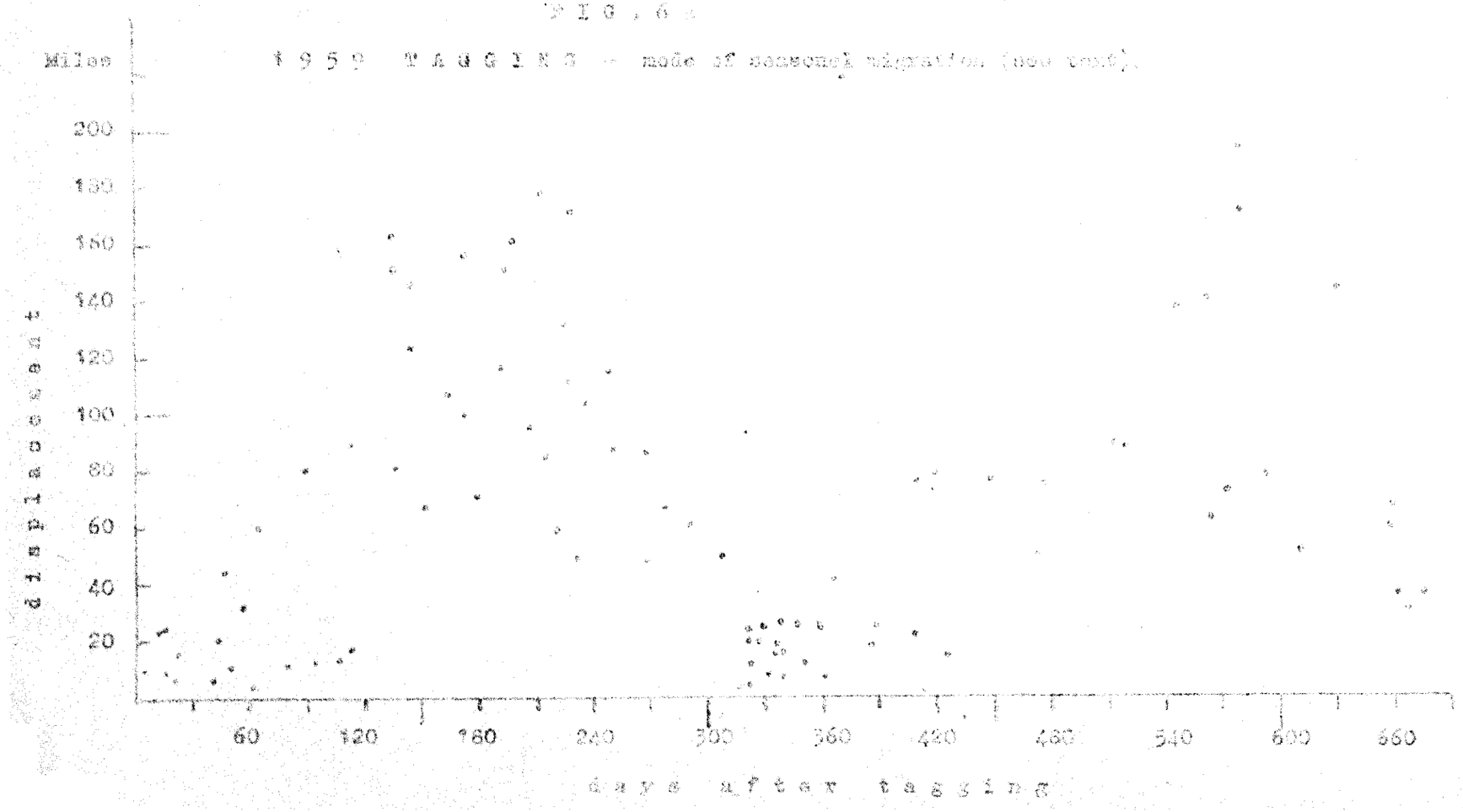
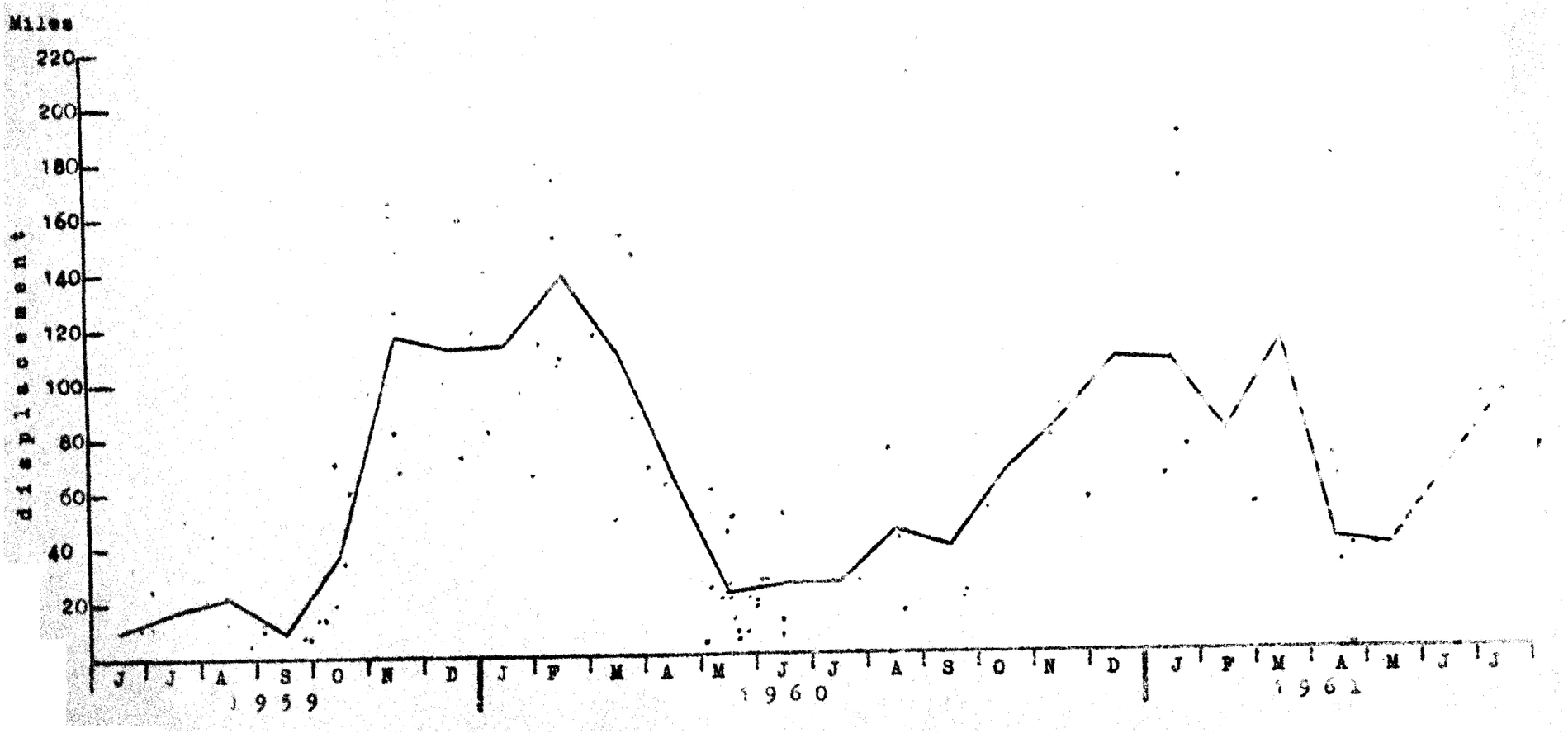


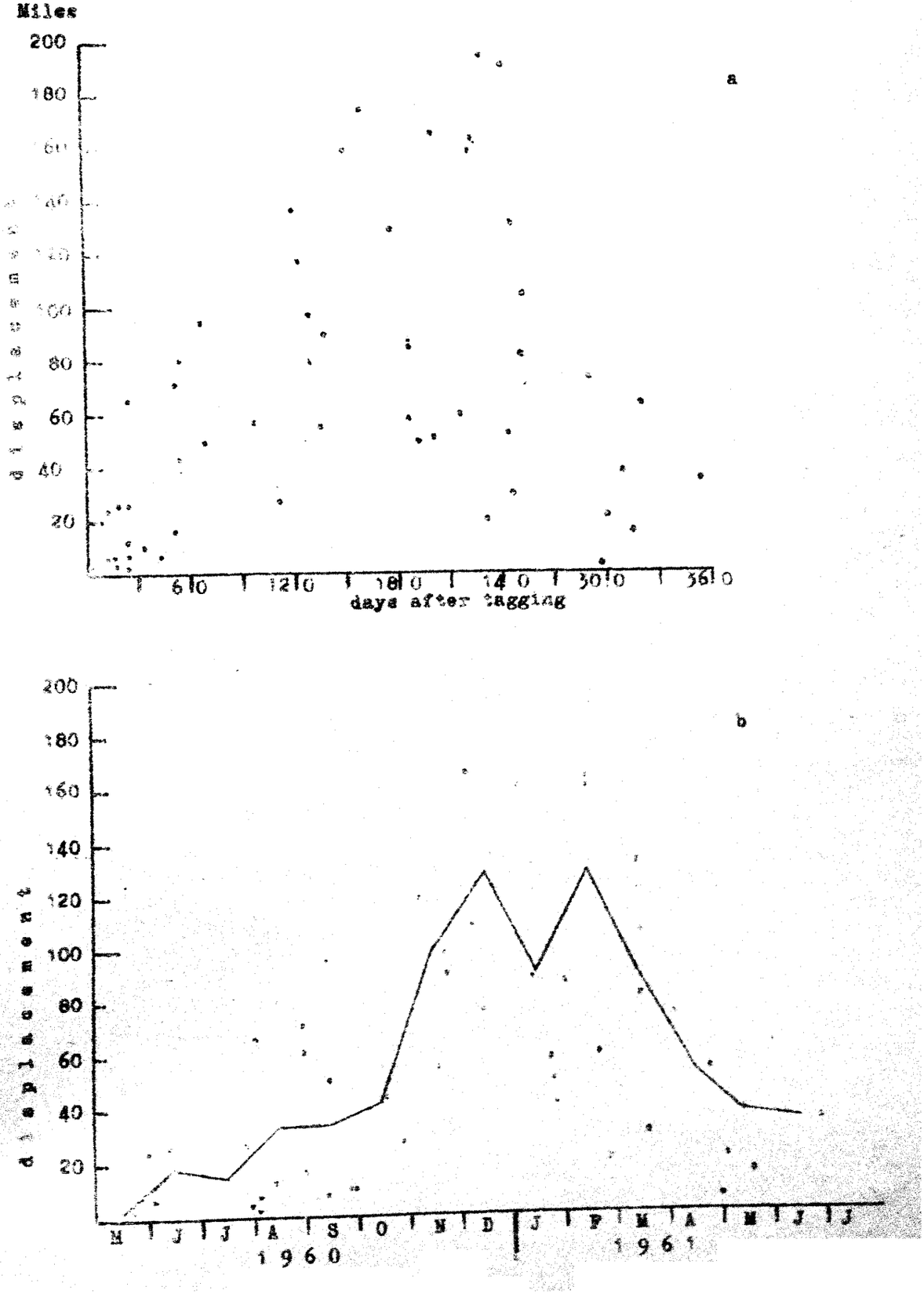
FIG. 6b

1959 TAGGING - mode of seasonal migration (see text)



F I G . 7.

1 9 6 0 T A G G I N G — mode of seasonal migration (see text)



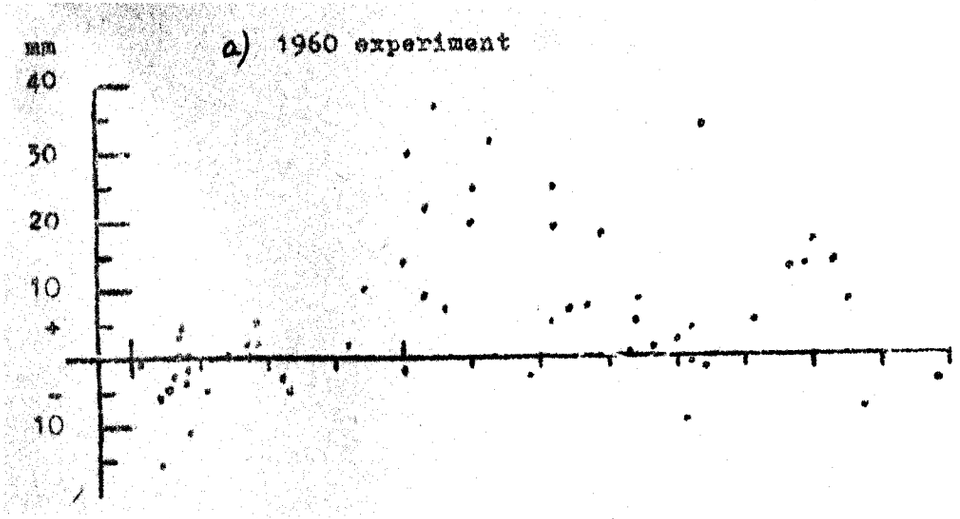
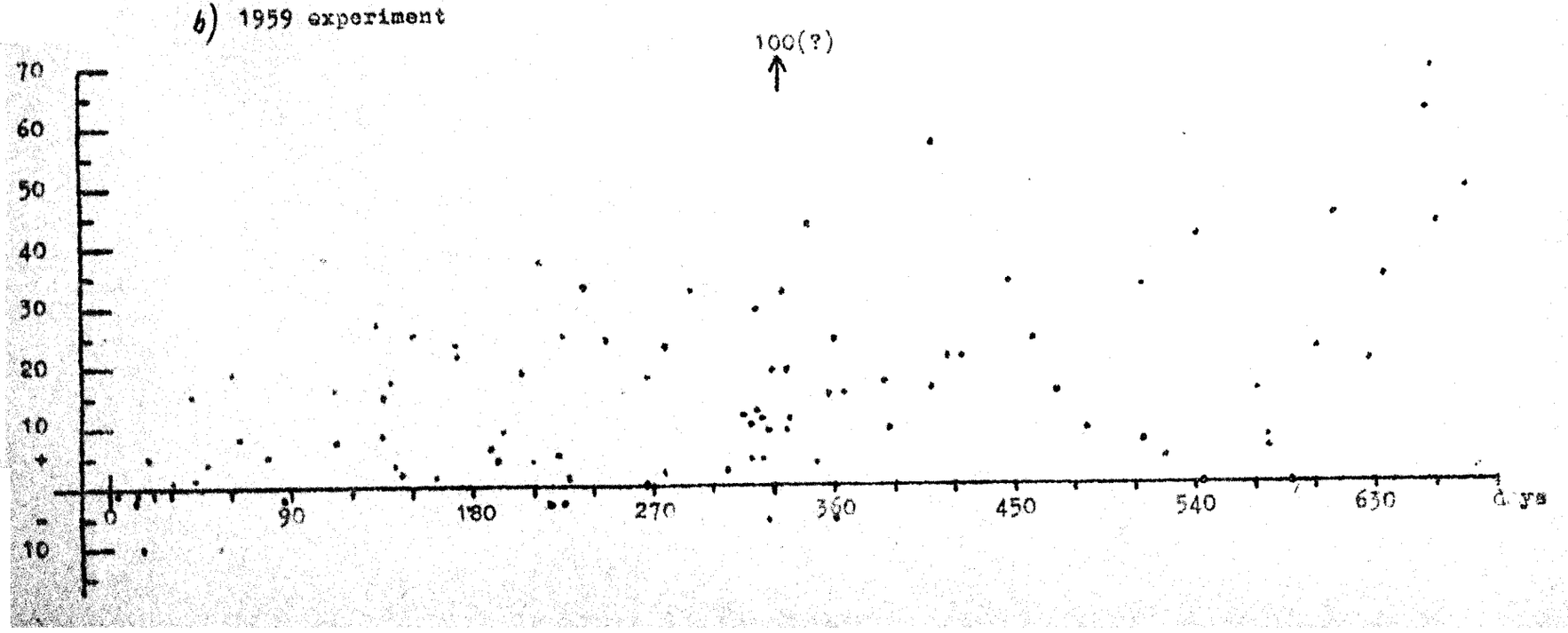


FIG 6.

Difference between length at recovery and length at release in relation to number of days after tagging.



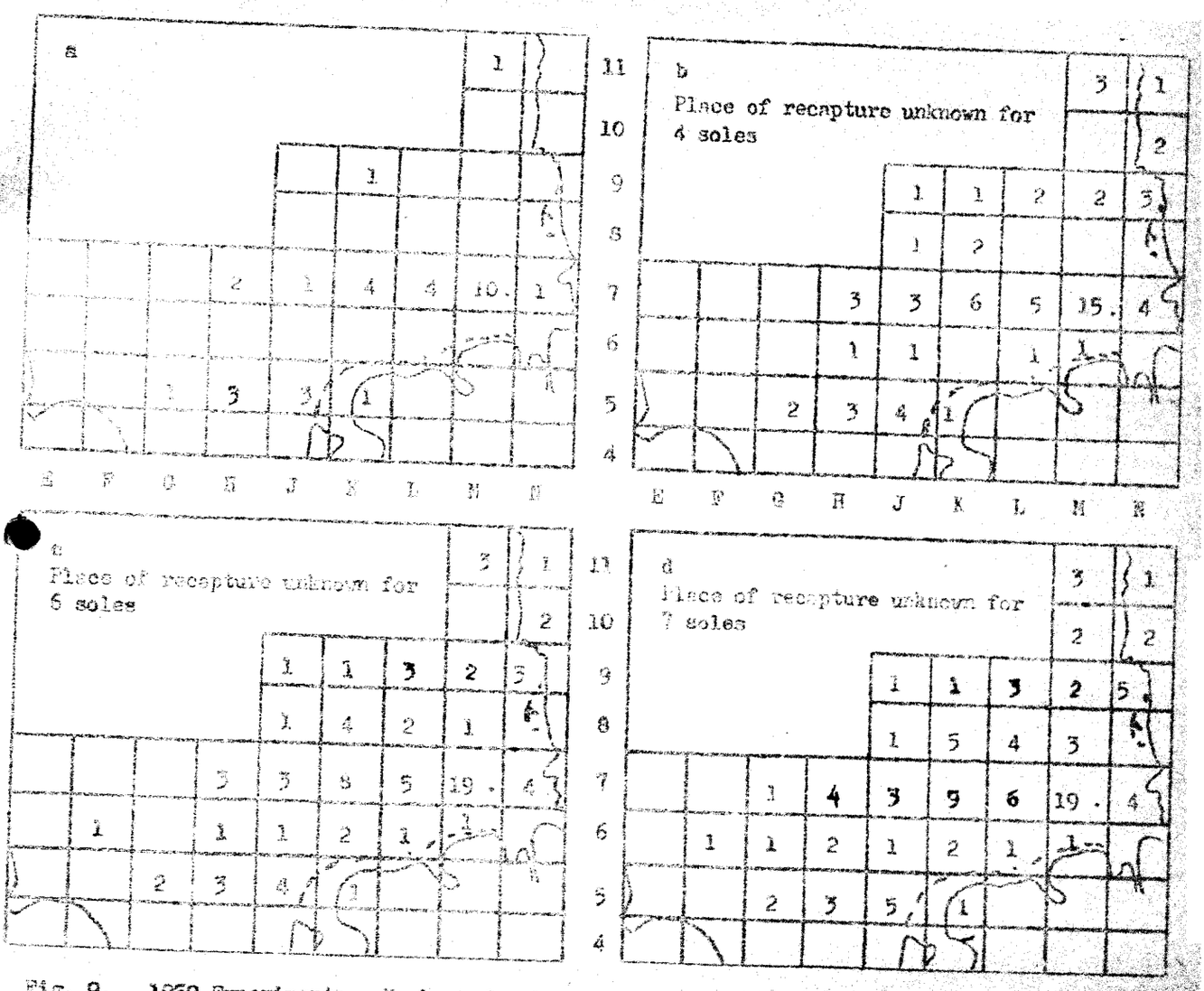


Fig. 9. 1959 Experiments. Number of sole recaptured in the different statistical rectangles within a) 1/2 year, b) 1 year, c) 1 1/2 year, and d) 2 years after tagging

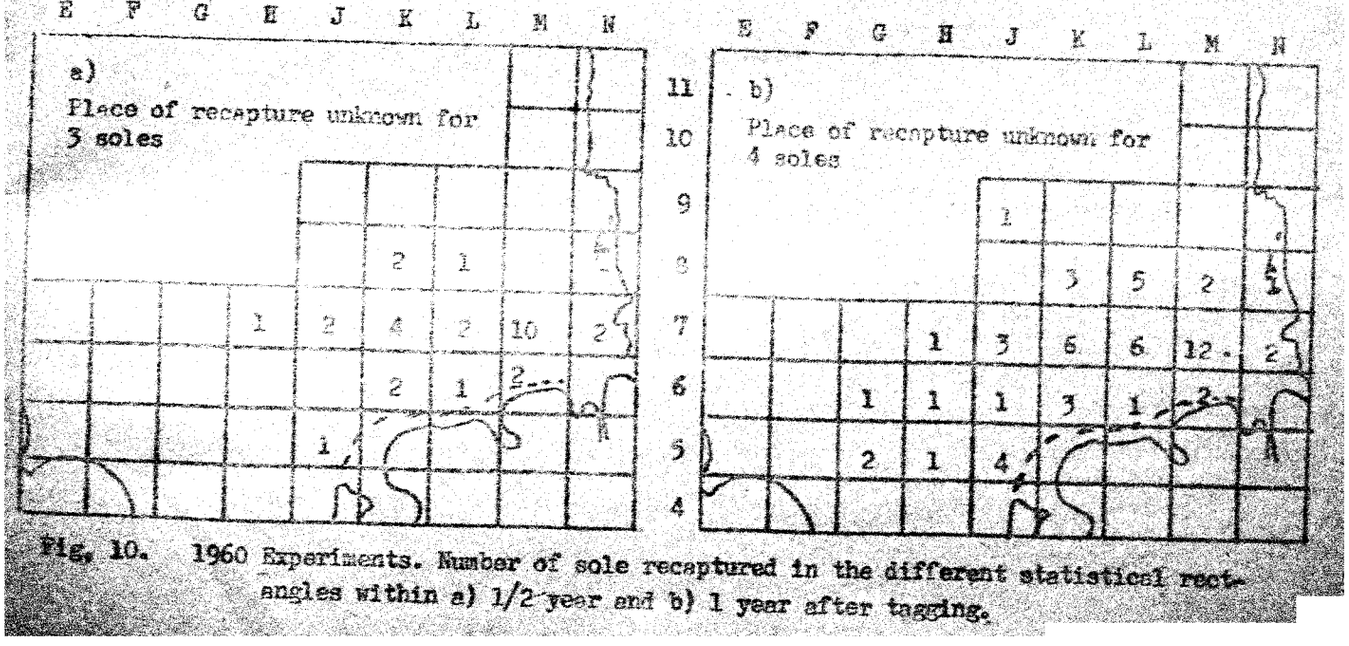


Fig. 10. 1960 Experiments. Number of sole recaptured in the different statistical rectangles within a) 1/2 year and b) 1 year after tagging.