

3) That the unsettled weather tempts the cutters to look for their catch as near the harbour as possible.

Some of the marketable plaice in the Graadeep inshore waters that escape recovery during the autumn fishing migrate probably in the beginning of the winter out into somewhat deeper water. "With the first day of frost the plaice disappear", says the Esbjerg fisherman. In the marking experiment No. 11 in the Graadeep inshore waters on September 29, 1905, 3 specimens were recaptured in November near the place of liberation. But in the beginning of spring, 1906, in March and April, all the recovered specimens — three in all — were taken out in the very North Sea, one specimen even rather far at sea. Thus it is quite evident that these specimens in winter have migrated towards deeper water (see Table 22 p. 58).

At the Horns Reef grounds most of the plaice probably squeeze themselves into the bottom in

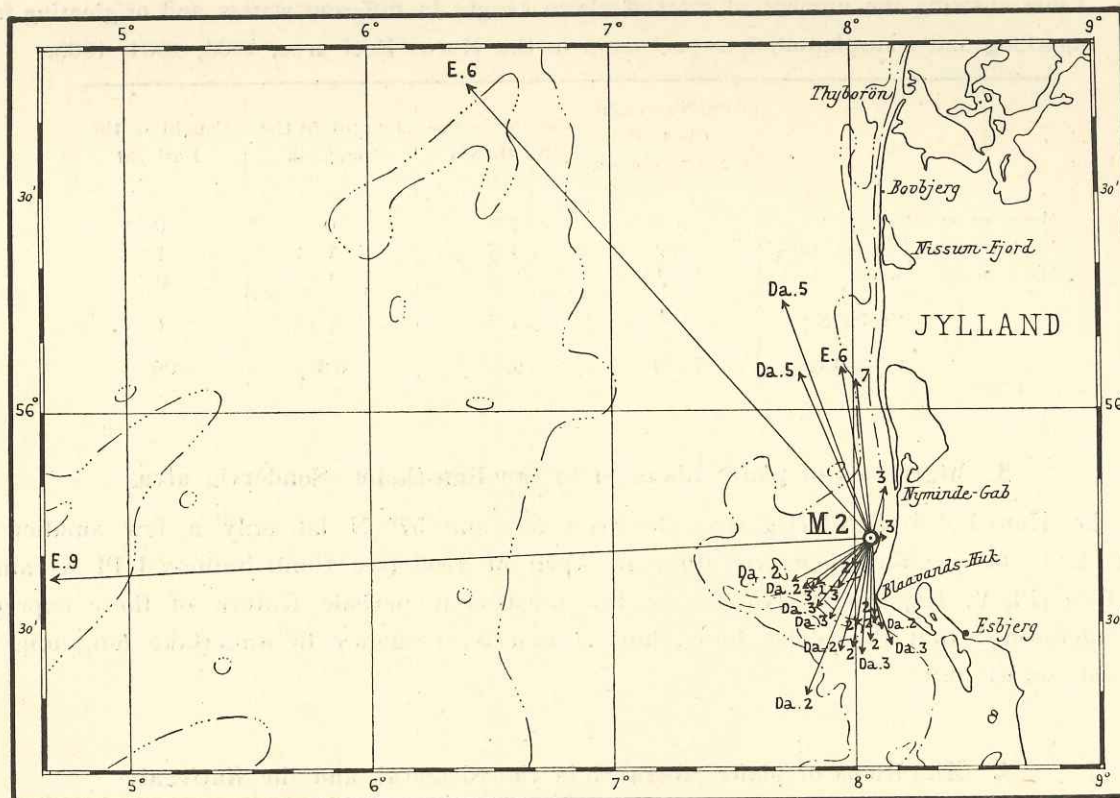


Fig. 7. Marking experiment with plaice. No. 2. 1904. February.

the beginning of winter. When the Esbjerg cutters in the middle of winter look for plaice at the Horns Reef grounds they hardly catch any. Some trawling experiments from the "Thor" in which an iron chain was attached to the ground-rope of the otter trawl, have proved, however, that marketable plaice may also be found in numbers on these grounds in winter.

Thus the migration of the plaice in the Horns Reef area may shortly be characterized as follows: The plaice show on the whole an inclination to migrate out into deeper water as they increase in size. But the migrations outward are not continual: In certain periods the fish seek shallow water.

In the spring months, March and April, the stock of marketable plaice shows a tendency to move into more shallow water. In April and May a great many specimens are caught at ca. 10—25 meters' depth. In the month of June the plaice begin to migrate out into greater depths, essentially in a north-western direction. In July and August the fish is mainly looked for in depths between 25—40 meters.

While the migrations towards the off-shore grounds probably continue in autumn as far as most



of the larger specimens are concerned, we may trace a tendency in the smaller specimens to seek more shallow water.

In winter some of the plaice migrate outward from the shallow grounds, but a great many stay probably in shallow water and squeeze themselves hard into the bottom.

From the summary below it may be seen that of 754 plaice recovered in the marking and transplantation experiments in the Horns Reef area in 1903, 1904 and 1905, 751 were recaptured in the North Sea, 2 in the Skagerak and 1 in the Kattegat. From this it appears clearly that the rich stock of young fish in the Horns Reef area does not play any considerable rôle for the renewal of the stock of marketable plaice in the Skagerak and Kattegat.

Table 45. Table showing the number of marked plaice caught in different waters and originating from the marking and transplantation experiments in the Horns Reef area, 1903, 1904, 1905.

	Total No. caught, Place of recovery known	Caught in the North Sea	Caught in the Skagerak	Caught in the Kattegat
Mark. exper., 1903 .....	321	321	0	0
Mark. & transpl. exper., 1904.	169	167	1	1
Mark. exper., 1905 .....	264	263	1	0
Total No....	754	751	2	1
Percentage...	100%	99.6	0.3	0.1

### 2. Migrations of plaice liberated in the Hanstholm—Søndervig area.

In the Hanstholm—Søndervig area between 56° and 57° N. lat. only a few smaller marking experiments have been undertaken, viz. three in April of 1903 (see Contributions I Pl. X) and one in March of 1905 (Pl. V, Experiment No. 5). As the most characteristic feature of these experiments it should be mentioned that the plaice here show a marked tendency to undertake long migrations in proportionately short time.

### 3. Migrations of plaice liberated in the Skagerak and the Kattegat.

In the Skagerak several marking experiments with plaice have been carried on. In studying the nature of the migrations of the plaice liberated in the Skagerak, it should be remembered, that the Danish cutter-fishery in the Skagerak comprises only the period from April to October and that foreign trawlers fish only very little in the southern Skagerak off the NW. Coast of Jutland at depths below 50 meters (on account of the stony condition of the bottom). Neither is any plaice fishery worthy of mention carried on near the coasts in the months from November to March except on the stretch Skagen—Spirbakken. Thus we cannot expect many recaptures of marked plaice from the Skagerak during these months.

A table recording where and when the cutters from Frederikshavn have carried on the fishery in the North Sea and the Skagerak is represented below (Table 46). This Table does not contain any information regarding the depths at which the cutters have been fishing, wherefore it is of less importance than the corresponding summary for the Esbjerg cutters. The Table has been worked out from the records in "Dansk Fiskeritidende". A supplementary Table showing at what depths a few of the cutters from Frederikshavn have been fishing is, however, adjoined.

Table 46. Table showing the Localities in the North Sea and the Skagerak, where the Frederikshavn cutters have been fishing in 1905.

Date			Locality	No. of Cutters
1905	April	16-22	Off Hirshals	a few
»	»	23-	} Tversted. — Hirshals. — Bulbjerg	40
»	May	6		
»	»	7-13	The Horns Reef Area	1
»	»	»	Jutlands Reef	1
»	»	»	Hirshals Rende	20-25
»	»	14-20	Hanstholm. — Hirshals. — Tversted	35-40
»	»	»	Large Reef, W of Løkken	3-4
»	»	»	Horns Reef	2
»	»	21-27	Horns Reef	1
»	»	28-	} Tversted — Hirshals and further westward	30-40
»	June	3		
»	»	»	Horns Reef	4-5
»	»	4-10	At Hirshals and further out in deeper water	20-25
»	»	»	The Horns Reef Area	6-7
»	»	11-17	Large Reef, W of Løkken	10
»	»	»	Horns Reef	a few
»	»	18-24	Off the west-coast of Jutland	25
»	»	»	Horns Reef	2
»	»	25-	} Tversted. — Hirshals. — W of Løkken	50
»	July	1		
»	»	2-8	Off the west-coast of Jutland	10
»	»	9-15	Tversted — Hanstholm	25-30
»	»	23-29	Off Bovbjerg	3
»	»	30-	} Tversted. — Hirshals and further westward	20
»	August	5		
»	»	6-12	Off Tversted. — Hirshals. — Hanstholm	25-30
»	»	13-19	Off the west-coast of Jutland	c. 20
»	»	20-26	W of Hirshals	15-20
»	»	27-	} W of Hirshals on the Reef	a few
»	September	2		
»	»	3-9	Hirshals — Tversted	15
»	»	10-16	Tversted and further westward	10-15
»	»	17-23	Hirshals — Tversted	10
»	»	24-30	Off the west-coast of Jutland	4-5
»	»	»	North Sea	several
»	October	1-7	North of Skagen	a few
»	»	8-14	North of Skagen	3-4
»	»	15-21	Skagen — Spirbakken	4-5

Table 47. Table showing the Localities and Depths where some of the Cutters from Frederikshavn have been fishing in 1905. Each statement comprises only one Cutter.

(After communication from Mr. CLOOS LORENTZEN, Frederikshavn.)

Date			Locality	Depth
1905	April	10-15	NE of Hirshals	10 fms.
»	May	3	20 miles NW of Hirshals	20 »
»	»	7-8	NNW of Hirshals	21 »
»	»	17	NW of Hirshals	20 »
»	»	17-18	N of Hirshals	16-18 »
»	»	25-27	20 miles NW of Hirshals	20 »
»	»	28-31	NW of Hirshals. 16 miles from shore	22 »



Table 47. Continued.

Date			Locality	Depth
1905	June	2—3	NW of Hirshals. 8 miles from shore	23 fms.
»	»	6—7	NW of Hirshals. E of the Reef	22 »
»	»	7—8	Off Rubjerg Knude	14 »
»	»	15—16	NNW of Hirshals	20 »
»	»	15—17	NNW of Hirshals	25—30 »
»	July	2	8 miles WNW of Hirshals	14 »
»	»	13	NW of Hirshals	16—17 »
»	»	13—15	NW of Hirshals	19—20 »
»	»	22	NW of Hirshals. NE of the Reef	22 »
»	»	23—24	N of Bulbjerg	20 »
»	»	24	Off Tversted	20 »
»	August	1—2	NNW of Hirshals. E of the Reef	22—24 »
»	»	»	Off Svinkleven. W of the Reef	26—27 »
»	»	»	NE of Hanstholm	32 »
»	»	4—5	NE of Hirshals	19 »
»	»	»	NNE of Hanstholm	22 »
»	»	»	NW of Hirshals	38 »
»	»	10	NE of Skagens L. V.	24 »
»	»	»	NW of Hirshals	20 »
»	»	24	Off Hirshals	25 »
»	September	5—6	NE of Hirshals	14 »
»	»	6—7	Off Hirshals	20—26 »
»	October	10—11	Off Tversted — Hirshals	6 »
»	»	11—13	Off Kandestederne	5 »

If we regard the charts over the marking experiments in the Skagerak, some characteristic features will quickly be noticed with regard to the migrations of the plaice in this water. In the first instance it is conspicuous that the plaice are only little stationary here. They undertake long migrations in relatively short time, and proportionally many specimens migrate away from this water, partly seeking the Kattegat, partly the North Sea. The experiments No. 3 and 4, March 1905 (Pl. V and VI) as well as the transplantation experiments No. 10 on March 1st, 1904 (Fig. 4 p. 19) show, that a great number of plaice move in the two directions: towards the Kattegat and towards the North Sea.

It would be natural to investigate if it be not particularly during one season that the plaice from the Skagerak emigrate to the Kattegat and during another season that they emigrate to the North Sea. The experiments show, however, that they at any rate in spring migrate in both directions.

Another characteristic feature of the plaice-migrations in the Skagerak is in correspondance with the observations made in the Horns Reef area. In the Skagerak it appears also that the plaice in spring show a marked tendency to migrate to more shallow water while in summer they show a just as marked reversed tendency. This was already experienced in the marking experiments in 1903 and again through the experiments in 1905. On the chart illustrating the experiment No. 4, 1905 (Pl. VI) it will be seen that most of the arrows pointing towards the coast are indicated 2, which means that the plaice were recovered 2 months after liberation, viz. in the month of May. If we regard on the other hand the arrows pointing towards the offshore-grounds we notice almost at them all the indications 3, 4, 5 or 6, which shows, that the fish were recovered during the months June, July, August and September. We might now suppose that the plaice which in summer are recovered on deeper water had already migrated out in spring without being caught, because no fishery was carried on there in spring. It will be seen, however, from Table 47 that the fishery from Frederikshavn takes place partly on deeper water in the Skagerak as early as the month of May.



In the Table below a summary is represented stating in which waters the marked plaice from the marking and transplantation experiments in the Skagerak were recovered. Though not more than 2–3 months have on an average elapsed between the date of liberation and the date of recovery, it will be seen that only 77% of the recovered marked fish were captured in the Skagerak itself. If we regard the few specimens recovered more than one year after liberation we obtain a still slighter percentage for the Skagerak. Among 9 of such specimens only 5 were recovered in the Skagerak while 2 were caught in the North Sea and 2 in the Kattegat.

While the plaice fishery takes place in the Skagerak only in the period April–October, it is carried on during all seasons in the Kattegat. The fishery goes on with the greatest intensity during the months from March till November, but also during the winter months a rather considerable plaice fishery takes place. In the north-eastern Kattegat

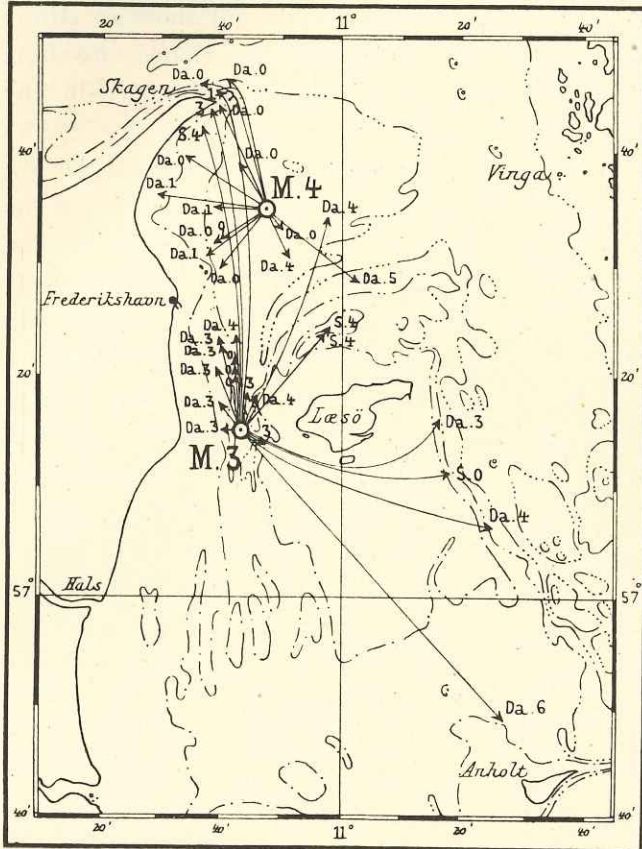


Fig. 8. Marking experiment with plaice. No. 3 and 4. 1904. March.

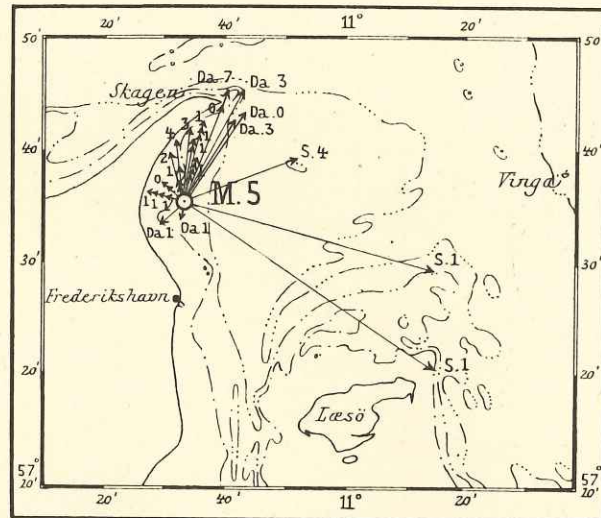


Fig. 9. Marking experiment with plaice. No. 5. 1904. March.

Table 48. Table showing the number of marked plaice caught in different waters and liberated in the Skagerak in the years 1903, 1904 and 1905.

	Total No. caught, Place of recovery known	Caught in the Skagerak	Caught in the North Sea	Caught in the Lim Fjord	Caught in the Kattegat
Mark. exper. 1903 .....	40	32	7		1
Transpl. exper. 1904 .....	45	26	11	3	5
Mark. exper. 1905 .....	326	259	33	1	33
Total No. ....	411	317	51	4	39
Percentage ..	100%	77.1%	12.4%	1.0%	9.5%

and in the south-western-Kattegat south of a line drawn from Fornæs to Gilbjergoved the plaice fishery is carried on with considerably less intensity than in the rest of the Kattegat, and it is only in summer



that a considerable plaice fishery is undertaken in the Aalborg Bight. If we compare the charts over the marking experiments in the Kattegat (Fig. 8, 9, 10; Pl. I, II, III, IV) with the charts over the marking experiments in the Skagerak (Pl. V, VI and Contributions I Pl. X) it appears that the plaice on the whole is more stationary in the Kattegat than in the Skagerak. The same may be seen if we compare the charts illustrating the transplantation experiments in the Skagerak and the Kattegat (Fig. 4 p. 19 and Fig. 5 p. 20).

The plaice in the Kattegat seem to be more inclined to undertake long migrations in relatively short time than the plaice in the Horns Reef area, but on the other hand they do not show so strong an inclination to change dwelling place quickly as the plaice in the Skagerak.

Among other characteristic features of the plaice-migrations in the Kattegat it may be mentioned that a rather extensive northward movement has evidently taken place towards the Skagerak, but apparently no extensive southward movement towards the Belt Sea and Baltic. This is evidently in connection with the fact that the majority of the marked plaice belongs to the northern form which seems to feel more at home under the life conditions in the Skagerak than under the life conditions in the Belt Sea and in the Baltic.

In a separate experiment (14 A.) which was carried on in the south-eastern Kattegat and which only included mature females, exclusively or mainly of the southern dwarf-form, there is on the contrary a distinct southward tendency. Experiment No. 14, which has been undertaken at the same place and at the same time with specimens partly belonging to the northern, partly to the southern

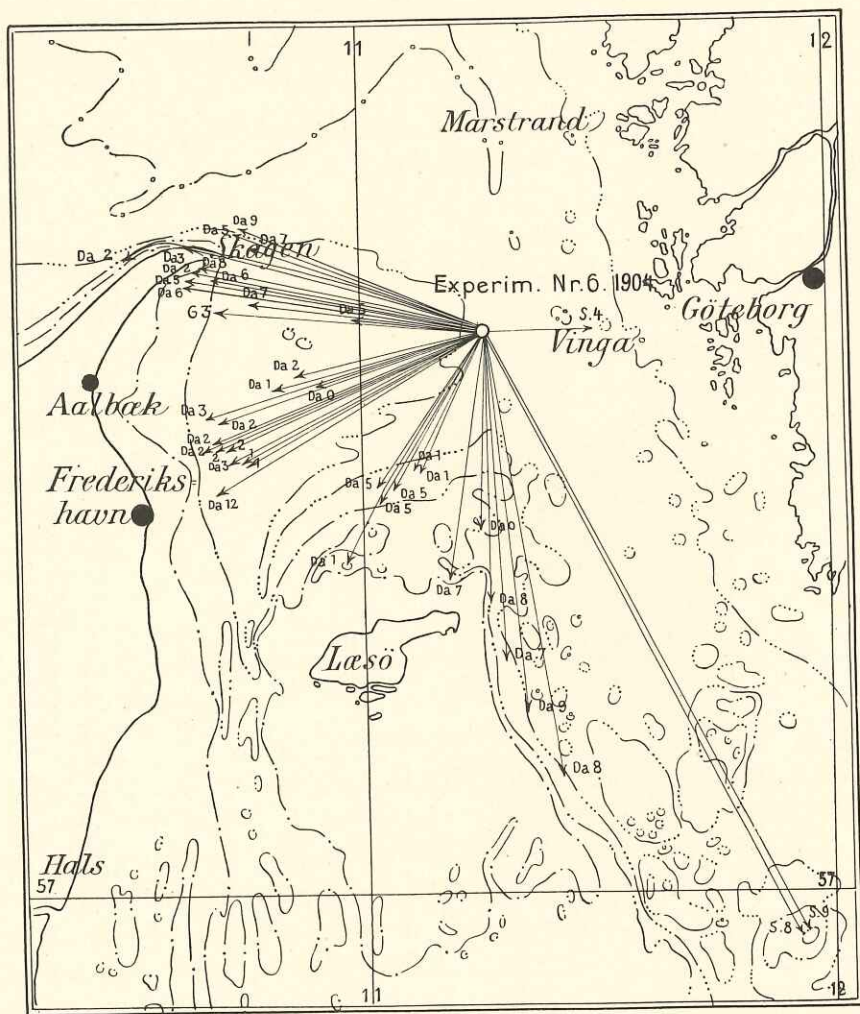


Fig. 10. Marking experiment with plaice. No. 6. 1904. October.

form (females mainly of the northern form, males without distinguishment) has given a result very different from that of experiment 14A. The majority of the specimens is here recovered north of the place of liberation. Thus we hardly commit any error in supposing the majority of the specimens which have here migrated northward to belong to the northern form.

The migrations of plaice of the southern form in the Kattegat are surely very different from those of the northern form, but how far any considerable exchange takes place between the stock in the Belt Sea and the stock in the southern Kattegat has not yet been ascertained.

The tendency which we find in the plaice in the Horns Reef area and the Skagerak to migrate towards more shallow water in spring and out on greater depths in summer may also be traced in the



Kattegat plaice<sup>1</sup>. This appears most plainly in the experiments No. 4 and 5, 1904, and in No. 6 and 7, 1905 (see Fig. 8 and 9 p. 83 and Pl. III and IV).

The experience which many fishermen mean to have made that the plaice show a tendency to move towards more shallow water in autumn (before the spawning has begun) is quite in keeping with the results of the marking experiments in autumn 1904 (see Fig. 10 p. 84 and Pl. I Exper. No. 8).

All the marking experiments in the northern Kattegat point in the direction that the plaice show a disinclination to migrate to the eastern side of the deep channel in the northern Kattegat, as only very few of the marked fish have been recovered there. It is quite true that the fishing here is not carried on with strong intensity, but this is again essentially owing to the fact that the plaice do not show any inclination to immigrate to this area from the Danish rearing grounds. In the Swedish transplantation experiments the plaice has shown a far stronger tendency to migrate from the Swedish to the Danish coast (Trybom l. c.).

In a part of the southern and south-western Kattegat where the plaice fishery is carried on with no strong intensity only a slight number of the marked plaice have been recovered.

It will be seen from the summary below, that 92.3% of all the recovered marked plaice from the experiments in the Kattegat were recovered in the Kattegat, 6.6% in the Skagerak, 0.6% in the North Sea, 0.4% in the Sound and 0.1% in the Belt Sea.

Table 49. Table showing the number of marked plaice caught in different waters and liberated in the Kattegat, 1904 and 1905.

	Total No. caught, Place of recovery known	Caught in the Kattegat	Caught in the Belt Sea	Caught in the Sound	Caught in the Skagerak	Caught in the North Sea
Mark. exper. 1904 . . . .	305	272		2	28	3
Mark. exper. 1905 . . . .	498	469	1	1	25	2
Total No. . . . .	803	741	1	3	53	5
Percentage . . . . .	100%	92.3%	0.1%	0.4%	6.6%	0.6%

Do more plaice migrate from the Skagerak into the Kattegat than vice-versa?<sup>2</sup>

Through the "Thor's" investigations it has been made clear that in the Skagerak there does not exist any stock of plaice belonging to the southern dwarf form which might have immigrated from the southern Kattegat or the Belts and Baltic; but as the plaice living in the northern Kattegat are generally of the same type as those living in the Skagerak a mere investigation of the very plaice in these waters would not enable us to determine further details regarding their native place. Among the different measures we had to adopt in order to obtain information with respect to the exchange of the stock of plaice between the Skagerak and the Kattegat it was provisionally decided to undertake extensive marking experiments in both these waters. The results of such marking experiments are now at hand, and even if no perfectly certain information can be given on the basis of these how far more plaice migrate from the Skagerak to the Kattegat than vice-versa, the experiments have yet afforded very valuable information with respect to the extent of these migrations in both directions.

Thus it has become evident that the plaice-migration from the Kattegat into the Skagerak and

<sup>1</sup> It appears also from the German investigations in the Baltic that the grown up plaice in spring leave the deeper water and move towards the coastal grounds (S. STRODTMANN: Laichen und Wandern der Ostseefische. II Bericht. Wissensch. Meeresunters. N. F. Bd. VII. Heft 2. Abt. Helgoland 1906.

<sup>2</sup> This question was originally raised by C. G. JOH. PETERSEN who has given the "Thor" particular instructions to elucidate this matter as far as possible.



vice-versa is a most important phenomenon, and as this migration takes place mainly close to the coast off the northern side of Skagen, it plays a great economical rôle for the fishermen in Skagen. It is evidently not a quite small amount of the whole Kattegat and Skagerak stock of marketable plaice which passes the Skagen yearly either to escape or to be caught under the attempt (see also Contributions I, pag. 47).

The Tables 50 and 51 represent a view illustrating the extent of the migrations from the Kattegat to the Skagerak and vice-versa. The "southern side" of Skagen indicates here the stretch from Tranestederne to the NE. buoy of Skagen's Reef. The "northern side" of Skagen indicates the stretch from Spirbakken to Skagen's light-ship. These Tables show that a very considerable number of the specimens passing the Skagen either on migration from the Kattegat into the Skagerak or reversely are recovered at Skagen<sup>1</sup>. It is even probable, that the number of marketable plaice which are recovered at the southern or at the northern side of Skagen by far exceeds the number that unhindered is allowed to pass this stretch.

Whether the majority of the plaice which are recovered at the south-side of Skagen and which originate from the marking experiments in the Kattegat would have migrated out into the Skagerak if they had been allowed to pass unprevented cannot be said with certainty. And it is just as unsettled if the majority of the plaice which are recovered at the northern side of Skagen and which originate from the marking experiments in the Skagerak would have migrated out into the Kattegat if they had not been caught by the fishermen. If we regard only the percentage of the plaice which succeeded in migrating from the Kattegat to the Skagerak or vice-versa, it will be found that 6.6% of the plaice from the experiment in the Kattegat have been recovered in the Skagerak while 9.5% of the specimens from the experiments in the Skagerak were recovered in the Kattegat.

As there is reason to suppose — according to the number and rate of growth of the young plaice in the two waters — that at least as many plaice yearly grow up to a marketable size in the Skagerak as in the Kattegat<sup>2</sup> it would seem as if more marketable plaice migrate from the Skagerak into the Kattegat than vice-versa.

The view that the immigration of plaice from the Skagerak to the Kattegat is greater than the emigration from the Kattegat to the Skagerak — when both young specimens and marketable fish are taken into consideration — is also supported by the fact that at least as many plaice of the northern form yearly are fished in the Kattegat as in the Skagerak though the number of 0-group specimens of the northern form that yearly grow up in the Kattegat, is slight in proportion to the number of the 0-group specimens that grow up in the Skagerak<sup>2</sup>.

Among the plaice which migrate from the Kattegat to the Skagerak or the North Sea, comparatively many specimens are of a considerable size. Of 537 recovered plaice of original length 20—29 cm., 29 specimens or 5.4% were recovered in the Skagerak or in the North Sea. Of 286 plaice of original length 30—39 cm., 29 specimens or 10.1% were recovered in the Skagerak or in the North Sea. If we regard the position of the places of liberation it will even be seen that most specimens of a length from 20—29 cm. are liberated in the northern Kattegat and most specimens from 30—39 cm. in the middle and southern Kattegat. Thus it is evident that the larger specimens show a more marked tendency to migrate out from the Kattegat to the Skagerak than the smaller ones.

<sup>1</sup> A proportionally considerable number of plaice in the Swedish marking experiments in the Kattegat have also been recovered near Skagen (F. TRYBOM: Märkning af rödspättor vid Sveriges vestkust. 1902 och 1903. Svenska Hydrografisk-biologiska Kommissionens Skrifter. Häftet II. Göteborg 1904. — Svenska rödspättemärkningar och mätningar. 1904 och 1905, ibd. Häftet III. Göteborg 1906.

<sup>2</sup> A. C. JOHANSEN: Ueber die Schollenfischerei im Kattegat und die Mittel sie zu heben. Rapports et Procès-Verbaux. Conseil perm. internat. Vol. 5. 1906. p. 80—112. Taf. VI.



Table 50. Table elucidating the migration of plaice from the Skagerak to the Kattegat etc.  
Marking experiments in the Skagerak. 1903, 1904, 1905.

Place of Liberation	Date	No. of experiment	Total No. caught, Place of recovery known	Caught on northern side of Skagen	Caught on southern side of Skagen	Caught in the Kattegat (excl. south. side of Skagen)	Caught in the Skagerak, E. of Skagens L. V.	Caught in the North Sea	Caught in the Lim Fjord
NW of Hirshals. 57°41' N 9°38' E	1903 April 17	6 1903	2	1	..	..	..	..	..
W by N of Kettrup. 57°19' N	» » 17	7 »	7	..	..	1	..	..	..
9°28'-9°33' E	» » 17	8 »		..	..	..	..	..	..
NE of Bulbjerg. 57°20' N 9°10' E	» » 17	9 »		12	..	..	..	6	..
NE of Bulbjerg. 57°17' N 9°11' E	» » 18	10 »	6	..	..	..	..	..	
N of Skagen. 57°46' N 10°36' E	» » 21	11 »	1	1	..	..	..	..	
Off Tversted. 57°38' N 10°12' E	» » 21-22	12 »	7	..	..	..	..	..	
N of Tversted. 57°36' N 10°12' E	» » 22	13 »	5	..	..	..	..	1	
Jammer Bay. 57°12'-57°21' N 8°45'-9°17' E	1904 March 1	Tr.10 1904	45	2	4	1	1	11	3
2 miles W of Spirbakken. 57°42' N 10°23' E	1905 March 20	3 1905	56	15	5	7	..	..	..
Off Bulbjerg—Svinkleven	» » 22	4 »	270	13	10	11	3	33	1
Total {			411	32	19	20	4	51	4
Percentage..			100%	7.8%	4.6%	4.9%	1.0%	12.4%	1.0%

Table 51. Table elucidating the migration of plaice from the Kattegat to the Skagerak and further westward.  
Marking experiments in the Kattegat in 1904 and 1905.

Place of Liberation	Date	No. of experiment	Total No. caught, Place of recovery known	Caught on southern side of Skagen	Caught on northern side of Skagen	Caught in the Skagerak, E of Skagens L. V.	Caught in the Skagerak, W of Spirbakken	Caught in the North Sea
Læsø Rende	1904 March 5	3 1904	25	2	1	..	..	..
8½ mil. NE of Hirsholmene	» » 7	4 »	15	1	2	..	..	..
Off Aalbæk	» » 14	5 »	36	12	1	..	..	..
Trindelen	» » 21	Tr.11 »	35	1	1	..	1	..
WNW of Vinga	» October 5	6 »	42	6	2	1	..	..
Off Trindelen	» » 11	7 »	8	..	..	1	..	..
Off Trindelen	» » 12	8 »	24	..	3	1	1	..
2 miles E of Aalbæk	» » 17	9 »	24	4	1	..	1	..
Pakhus Bay, Anholt	» » 25	10 »	4	..	1	..	1	..
8 miles S of Anholt Knob	» » 27	11 »	7	..	..	..	1	..
9 miles SE of Kobbergrund	» » 28	12 »	2	..	..	..	..	..
6 miles NW of Anholt Knob	» » 28	13 »	6	..	1	..	..	..
10 miles NW by W of Kullen	» » 29	14 »	60	2	5	..	3	3
10 miles NW by W of Kullen	» » 29	14A »	17	..	..	..	..	..
5 miles N of Anholt Light	1905 March 15	1 1905	62	..	3	1	1	1
SW of Anholt	» » 16-17	2 »	216	1	2	..	1	1
5 mil. N½ W of Hirsholmene	» » 29	6 »	170	66	5	..	6	..
Aalborg Bay	» April 1	7 »	50	..	6	..	..	..
Total {			803	95	34	4	15	5
Percentage..			100%	11.8%	4.2%	0.5%	1.9%	0.6%

If we regard the size of the specimens which migrate from the Skagerak to the Kattegat we notice the reversed tendency. The smaller specimens show here a stronger inclination to migrate into the Kattegat than the larger ones. Of 47 recovered specimens of original length 16—24 cm. 8 or 17% were



recovered in the Kattegat. Of 304 recovered specimens of original length 25—29 cm. 27 specimens or 8.9% were recovered in the Kattegat and of 70 specimens of original length 30—37 cm. 4 specimens or 5.7% were recovered in the Kattegat.

These migrations from the Kattegat to the Skagerak which we notice in the larger plaice of ca. 30—39 cm. length, and reversely in the smaller plaice of ca. 15—29 cm. seem — at any rate to a certain degree — to appear as spawning migrations and food migrations. Specimens of a length of ca. 30—39 cm. of the northern form generally approach maturity for the first time and migrate now out on relatively deep and salt water in the North Sea and Skagerak during the sensible spawning period. Many of these specimens are probably developed and have grown up in these waters.

The specimens of 15—29 cm. are on the other hand generally immature fish and in searching for grounds with rich food many of them come into the Kattegat.

The tendency of emigration from the Kattegat to the Skagerak may be traced both in winter and spring. In the autumn experiments comparatively many more marked fish were recovered in the Skagerak and the North Sea than in the spring experiments.

The immigration from the Skagerak into the Kattegat takes place to a great extent in spring (see Fig. 4 p. 19 and Pl. V and VI). If it goes on also to any considerable extent during other seasons is not settled by the experiments, but it does probably.

In the Tables below a view is represented over all the recovered marked plaice from the experiments in the Kattegat and the Skagerak in 1903—1905 together with a statement showing which specimens have been recovered in the Skagerak or the North Sea from the Kattegat experiments, and which specimens have been recovered in the Kattegat from the Skagerak experiments.

Table 52.

Original length of all recaptured plaice in the marking experiments in the Skagerak in 1903—1905, and length of specimens captured in the Kattegat.

Original length	Total number of recaptured plaice	Number of specimens recaptured in the Kattegat
16 cm.	2	..
17 »	1	..
18 »	2	1
19 »	..	..
20 »	4	..
21 »	8	1
22 »	6	1
23 »	9	1
24 »	15	4
25 »	37	7
26 »	49	1
27 »	71	6
28 »	73	8
29 »	74	5
30 »	47	4
31 »	12	..
32 »	3	..
33 »	4	..
34 »	1	..
35 »	1	..
36 »	1	..
37 »	1	..
	<hr/> 421	<hr/> 39

Table 53.

Original length of all recaptured plaice in the marking experiments in the Kattegat in 1904—1905, and length of specimens captured in the Skagerak and the North Sea.

Original length	Total number of recaptured plaice	Number of specimens recaptured in the Skagerak and the North Sea
20 cm.	1	..
21 »	5	..
22 »	50	4
23 »	48	5
24 »	71	1
25 »	61	3
26 »	79	4
27 »	64	2
28 »	72	4
29 »	86	6
30 »	80	3
31 »	52	3
32 »	54	11
33 »	39	6
34 »	21	3
35 »	17	1
36 »	16	1
37 »	4	1
38 »	1	..
39 »	2	..
	<hr/> 823	<hr/> 58



#### 4. Do the plaice wander in shoals?

If we regard some one or other chart illustrating a marking experiment, it will as a rule be noticed that the plaice liberated on a certain spot have spread a short time afterwards over considerable areas and have migrated in far different directions. From this fact we are not, however, entitled to conclude that the plaice wander about separately and do not gather in shoals. The results of the Danish marking experiments in 1903–1906 tend to confirm the experience which many fishermen believe to have made, that the plaice show an inclination to gather in shoals. It has namely appeared, that two or three plaice from the same experiment have been recovered at the same time and on the same spot far from the place of liberation and that plaice liberated in different experiments on different localities later on have been recovered on the same spot and at the same time. A series of examples elucidating these matters will be given here.

##### a. Marked plaice from one experiment recovered at the same time and on the same spot at considerable distance from the place of liberation.

*Experiment No. 3, 1903.* On April 10th of 1903, 445 marked plaice were liberated 4 miles SE. of Vyl light-ship, 55°21' N. 7°52' E., at 10–11 fms.

1) On April 27th of 1903 two different cutters captured 2 of these plaice 4 miles W. of Graadeep, 55°25' N. 8°8' E., at 8 fms. The distance between the place of recovery and the place of liberation was ca. 10 miles.

2) On April 28th, 2 plaice were again caught by two different cutters 8 miles W. of Graadeep, 55°24' N. 8°1' E., at 8 fms. The distance between the place of recovery and the place of liberation was here ca. 6 miles.

3) On April 28th another couple of these plaice were recaptured by the cutter "Mathilde" 5 miles SW. by W. of Graadeep, 55°22' N. 8°9' E., at 8 fms. Distance ca. 10 miles.

4) On April 28th, 2 of these plaice were also recovered by the cutter "Birgitte" 6 miles W. by S. of Graadeep at 8½ fms. Distance 7 miles.

5) On April 29th, 2 specimens were again recovered by the cutter "Margrethe" 6 miles W. of Graadeep at 7½ fms. Distance 8 miles.

6) On May 1st, 2 specimens were recovered by the cutter "Kirstine" 3 miles SW. of Cancer at 7 fms. Distance 7 miles.

7) On May 1st, 2 specimens were recaptured by the cutter "Emanuel" 6 miles NW. of Graadeep at 8 fms. Distance 11 miles.

8) On May 2nd, 2 specimens were recovered by the cutter "Augusta" 2 miles W. by S. of Cancer in 8 fms. Distance 9 miles.

9) On May 23rd, 3 specimens were recovered by two different cutters 3 miles NW. of Slugen at 11 fms. Distance ca. 14 miles.

10) On August 16th, of 1903 1 specimen was recovered 20 miles NW. of Horns Reef L. V. On August 17th, 1 specimen was recovered in the same place. Distance 43 miles.

*Experiment No. 5, 1903.* On April 11th of 1903, 286 marked plaice were liberated N. of Horns Reef at 55°35' N. 7°40' E., 6–7 fms.

1) On April 25th and 26th of 1903, 2 of these plaice were recaptured by the cutter "Mary" 4 miles SE. of Vyl buoy. Distance between place of liberation and place of recovery 14 miles.

2) On April 30th, 2 specimens were recovered by the cutter "Thora" 7 miles W. of Graadeep in 8 fms. Distance 17 miles.



3) On May 7th, 3 of the marked fish were recovered by the cutter "Føniks" 4 miles N. of Slugen at 9 fms. Distance ca. 6 miles.

4) On May 26th, 2 of the plaice were recovered by the cutter "Aage" 2 miles NW. of Kærgaarde Bn. Distance ca. 17 miles.

*Experiment No. 9, 1903.* On April 17th of 1903, 13 marked plaice were liberated 11 miles NE. of Bulbjerg at 57°20'N. 9°10'E.

On April 26th of 1903, 1 specimen was recovered off Thyborøn, and on May 1st another specimen was caught at the same locality. Distance ca. 52 miles.

These examples which all originate from the experiments in 1903 might be supplemented by many others from the experiments in 1903—1905, as may be seen in the detailed tables over liberation and recovery of marked plaice.

If the specimens recovered at the same spot and at the same time far away from the place of liberation have moved together cannot be ascertained in each separate case; but as the phenomenon is very common it has in all probability often been the case.

If we regard the charts illustrating the marking experiments, the impression is often immediately conveyed that the plaice wander in shoals. On the charts Pl. XI and XII (Contributions I) it appears as if large shoals of plaice have moved towards the coast in the Horns Reef area in April and May 1903. On Pl. VI, Experiment No. 4 it will be seen, that several plaice have been recovered near Skagen ca. 60 miles from the place of liberation and ca. 1 month after liberation. If we submit the data to a closer examination it appears that 3 of the specimens were here recovered on the same day, on April 10th of 1905, and three again on April 29th (see Table 20 p. 42—43).

b. Marked Plaice liberated in different localities but recovered at the same place at the same time.

The plaice mentioned below were liberated in the following experiments in the Horns Reef Area:

Experiment No. 2. April 10., 1903. 255 Plaice liberated at 55°22'N. 7°55'E., at 9 fms.

Experiment No. 3. April 10., 1903. 445 Plaice liberated at 55°21'N. 7°52'E., at 10—11 fms.

Experiment No. 5. April 11., 1903. 286 Plaice liberated at 55°35'N. 7°40'E., at 6—7 fms.

1) On April 28., 1903, the cutter "Harboøre" caught two marked plaice, No. 428 and No. 769, 8 miles W of Graadeep at 8 fms. No. 428 came from the above mentioned experiment No. 3. No. 769 originated from the experiment No. 5. The distance of removal was respectively 6 and 17 miles.

2) On the same day, April 28., the cutter "Hvidtfeldt" caught two marked plaice 4 miles SW. by W. of Graadeep at 7 fms. One of the specimens, No. 601, originated from the above mentioned experiment No. 3 and had moved 10 miles. The other specimen came from experiment No. 5 and had moved 21 miles.

3) On April 30., 1903, the cutter "Thora" captured three marked plaice 7 miles W. of Graadeep in 8 fms. One of the specimens, No. 76, came from the above mentioned experiment No. 2 and had moved 5 miles. The two other specimens, No. 843 and No. 910, came from the experiment No. 5 and had moved 18 miles.

4) On May 2., 1903, the cutter "Karen og Ejnar" captured 2 marked plaice, No. 560 and No. 830, 1 mile SW. by W. of Cancer. No. 560 came from the experiment No. 3, No. 830 from experiment No. 5, the distance being respectively 9 and 13 miles.

5) On May 7., 1903, the cutter "Julie" captured 2 marked plaice 1 mile W. of Kærgaarde Bn. at 4½ fms. One of them, No. 43, came from experiment No. 2 and had moved 21 miles. The other, No. 697, came from experiment No. 3 and had moved 23 miles.



6) On June 16., 1903, a cutter captured two marked plaice, No. 181 and No. 791, 12 miles NE. of Horns Reef L. V. at 11 fms. They came from the experiments No. 2 and 5 (April 1903) and had moved respectively c. 23 and 8 miles from the places of liberation.

7) On August 17th of 1903, 2 marked plaice, No. 584 and No. 754, were captured 20 miles NW. of Horns Reef L. V. (It is not known if they were caught by the same cutter). They came from the experiments 3 and 5, the distance being respectively 43 and 31 miles.

These examples which solely originate from the experiments in 1903 might be supplemented by many others from the experiments in 1903, 1904 and 1905.

### 5. How quickly are the plaice able to move?

In the Table below a view is represented over the greatest rapidity noticed for the plaice in the Danish marking experiments in 1903—1906. The average speed per day means here the distance between the place of recovery and the place of liberation divided by the number of days passed between liberation and recovery. The "average speed" hereby obtained is naturally only a minimal-statement as the plaice cannot be supposed to have moved in a straight line.

In the Table 54 no specimen has been taken into consideration which was not recovered at least 45 miles away from the place of liberation.

Table 54. The greatest speed observed for plaice in the Danish marking experiments in 1903—1906.

No. on label	Place of liberation	No. of experiment	Distance betw. place of liberation and place of recapture, miles	Time between liberation and recovery, No. of days	Average speed pr. day, miles
[Da 04 415	Horns Reef Area	Trpl. exper. No. 4 1904	77	5	15.40]
Da 1029	Skagerak	Mark. exper. No. 9 1903	52	9	5.78
Da 4 327	Southern Kattegat	Mark. exper. No. 14 1904	310	54	5.74
Da 04 302	Horns Reef Area	Trpl. exper. No. 3 1904	104	22	c. 4.7
Da 1025	Skagerak	Mark. exper. No. 9 1903	52	14	3.71
Da 05 1007	Skagerak	Mark. exper. No. 4 1905	62	20	3.10
Da 05 667	Skagerak	Mark. exper. No. 4 1905	57	19	3.0
Da 05 712	Skagerak	Mark. exper. No. 4 1905	57	19	3.0
Da 05 867	Skagerak	Mark. exper. No. 4 1905	57	19	3.0
Da 1211	North Sea off Hanstholm	Mark. exper. No. 17 1903	52	18	2.89
Da 05 1071	Skagerak	Mark. exper. No. 4 1905	57	20	2.85
Da 05 944	Skagerak	Mark. exper. No. 4 1905	128	45	2.84
Da 05 877	Skagerak	Mark. exper. No. 4 1905	169	63	2.68
Da 05 635	Skagerak	Mark. exper. No. 4 1905	117	46	2.54
Da 05 1125	Skagerak	Mark. exper. No. 4 1905	131	52	2.52
Da 4 365	Southern Kattegat	Mark. exper. No. 14 1904	335	141	2.38
Da 05 267	Middle Kattegat	Mark. exper. No. 2 1905	74	33	2.24
Da 05 1096	Skagerak	Mark. exper. No. 4 1905	91	41	2.22
Da 05 1102	Skagerak	Mark. exper. No. 4 1905	129	63	2.05
Da 1024	Skagerak	Mark. exper. No. 9 1903	108	53	2.04
Da 04 412	Horns Reef Area	Trpl. exper. No. 4 1904	46	23	2.0
Da 04 1720	Skagerak	Trpl. exper. No. 10 1904	118	59	2.0
Da 05 989	Skagerak	Mark. exper. No. 4 1905	c. 70	35	c. 2.0
Da 05 1161	Skagerak	Mark. exper. No. 4 1905	c. 70	35	c. 2.0

For comparison with the speed given in Table 54 it may be stated that the greatest speed for plaice which BOLAU and TRYBOM noticed in the German and Swedish marking experiments in 1903 and 1904 was as follows:



1 specimen	5	miles per day	in 14 days	(Bolau).
1	»	5	» » » 14	» (Bolau).
1	»	3·72	» » » 43	» (Bolau).
1	»	3·05	» » » 23	» (Bolau).
1	»	2·86	» » » 28	» (Trybom).
1	»	2·76	» » » 29	» (Bolau).
1	»	2·67	» » » 30	» (Bolau).

As showed in Table 54 a far greater speed was observed for one single specimen than for any of the others, namely 15·40 miles per day. As a fact it does not seem incredible that a plaice should be able to move with such a considerable speed<sup>1</sup>; but as this result stands quite isolated, and as mistakes may easily occur in the statement about place of recovery it will for the present time be safest to distrust this statement.

The next greatest speed we notice is 5·78 miles per day and the third greatest 5·74 per day, as one plaice seems to have covered a distance of ca. 52 miles in 9 days and another a distance of 310 miles in 54 days. A speed of ca. 5 miles per day is recorded by Bolau for two specimens in the German marking experiments in 1904. As we thus possess several results pointing in the same direction and as this "average speed" is not conspicuously great in comparison with other statements we may regard it as probable, that plaice are able to move at least with a speed of 5—6 miles per day.

A speed from 2—4 miles per day has been noticed for several plaice, but it is evidently quite exceptionally that they move with so great a speed in the same direction and for a fairly long time.

It will be seen in Table 54 that the majority of the specimens for which a speed of over 2 miles per day has been noticed originate from the experiments in the Skagerak. We find in this an expression of the fact, that the plaice in the Skagerak move much faster than the plaice in the Kattegat and in the Horns Reef area. The specimens originating from the Horns Reef area which have moved with a speed of more than 2 miles per day all come from the transplantation experiments which suggest that the transplanted specimens move far quicker from one place to another than the not transplanted ones (compare p. 20). It should here be remembered that several times as many specimens were recaptured in the ordinary marking experiments as in the transplantation experiments in the Horns Reef area.

## 6. Causes of observed migrations of plaice.

The causes of the migrations of the plaice are of various kinds. The migration is probably among others influenced by the following factors.

### 1. The distribution of the food.

When the plaice show a general tendency to migrate away from the coast as they grow up, and hereby enlarge their area of distribution, it is surely among others the distribution of the food which here plays a rôle<sup>2</sup>. A large stock of grown up fish would not be able to live in the narrow shore belt where the young bottom stages of the youngest series are distributed.

The migrations of the grown up plaice are undoubtedly also often influenced by the distribution of the food, but it is very difficult to decide when the migrations should be regarded as food migrations and when other factors than the food essentially influence the specimens' change of residence<sup>3</sup>.

<sup>1</sup> FULTON has observed that grown up plaice gently swimming in the spawning pond at the Fishery Board's Laboratory at Aberdeen may move 100—140 feet per minute, or considerably over a mile an hour. (Scottish Fishery Board Rep. 21, 1903, p. 42).

<sup>2</sup> H. C. REDEKE: "The distribution of the plaice on the Dutch coast". *Rapports et Procès-Verbaux*, Vol. III, Conseil perm. intern. pour l'explorat. de la mer. 1905.

<sup>3</sup> C. G. JOH. PETERSEN is of opinion that the plaice seek the shallow water in spring in the search for food. — GARSTANG supposes that the off-shore migration of plaice in summer is in relation with their search for food (North Sea Fisheries



## 2. The temperature.

As it appears that the plaice in the warmest as well as in the coldest season show an inclination to migrate away from the quite shallow water towards the deeper and more temperate water we have reason to suppose that this migration, at least partly, is dependent on the temperature, which also is a general opinion<sup>1</sup>.

The fact, that the plaice during the spawning period show a disinclination to stay in quite shallow water<sup>2</sup> is possibly in accordance with the circumstance that they are at times in such waters exposed to such low temperatures which may be injurious to them.

## 3. The salinity.

What rôle the salinity plays for the active migrations of the plaice is but little elucidated. Generally the plaice avoid the water of less salinity than c. 5<sup>0/00</sup> and they do not seem to be able to pass all stages of their development in such water. But otherwise the plaice is very euryhaline.

The dwarf and brackish water form which is distributed in the Belt Sea and the southern Kattegat may sometimes occur in water of a salinity exceeding 34.5<sup>0/00</sup>.

## 4. The currents.

The distribution of the pelagic stages of the plaice is naturally in the highest degree dependent on the currents. The young bottom stages are also in all probability drifting with the current to no slight extent.

If the older stages of plaice show a general tendency to drift with the current or to move against it is not yet known.

At the east-coast of Scotland FULTON has noticed that the movement of the plaice is on the whole in a direction opposite to the prevailing current<sup>3</sup>, and GARSTANG is of opinion, that there is much in the results of more recent experiments to support the idea that the migration of plaice have a preponderating tendency in opposition to the prevailing currents (North Sea Investigations I. c. p. 31).

## 5. Wind and shelter.

That the plaice during gales blowing on the shore either must leave the shallow water or squeeze themselves hard down into the bottom is *a priori* probable.

At the northern side of Skagen it appears that most plaice are captured after south-western, western or north-western gales. It is a probable explanation of this fact, that many plaice during the gale leave the shallow water in the Tannis Bay and take shelter in the deeper water off the northern side of Skagen.

At the northern side of Skagen only a few plaice are recaptured after eastern gales<sup>4</sup>.

Investigation Committee. Report (No. 2 — Southern Area) on Fishery and Hydrographical Investigations in the North Sea etc. 1905.)

<sup>1</sup> See for instance: H. KRØYER: Danmarks Fiske, Bd. II, Kjøbenhavn, 1843—45, p. 272. — H. C. REDEKE: The Distribution of the Plaice on the Dutch coast. Rapports et Procès-Verbaux, vol. III. Conseil internat. pour l'exploration de la mer. 1905. — A. C. JOHANSEN: Contributions to the Biology of the Plaice, I. Medd. fra Komm. for Havunders. 1905, p. 25—27.

<sup>2</sup> E. L. V. HOLT in Journal Mar. Biol. Assoc. III. 1895, p. 395. — T. W. FULTON in Report Fishery Board for Scotland VII, Part III, 1889, p. 188; ibd. VIII, Part III, 1890, p. 261. Report on Fishery and Hydrographical Investigations in the North Sea etc., 1902—1903, p. 593 etc. London 1905.

<sup>3</sup> Report Fishery Board of Scotland. 11. Part III, p. 186. 15. Part III, p. 374. 21. Part III, p. 42. Report on Fishery and Hydrographical Investigations in the North Sea, etc. 1905. p. 594.

<sup>4</sup> On the migrations' probable dependence on wind and lee see for instance: OLAVIUS: Schagens Beskrivelse, Kjøbenhavn 1787, p. 178—180. H. KRØYER: Danmarks Fiske, Bd. II, Kjøbenhavn 1843—45, p. 272. W. LILLJEBORG: Sveriges och Norges Fiskar, Bd. II, Upsala 1891, p. 375. W. GARSTANG: Fishery and Hydrographical Investigations in the North Sea, etc., Southern Area, 1905, p. 10 and 31.



## C. The intensity of fishing.

### a. The intensity of fishing in different areas.

A view over the percentage of plaice recaptured in the ordinary Danish marking experiments with plaice in 1903 to 1906 will be represented in the following. The four areas:—the Horns Reef area, the Hansthalm—Søndervig area, the Skagerak and the Kattegat will here be treated separately.

#### 1. The intensity of fishing in the Horns Reef area.

In the Table 55A a view is represented over the total number of liberated and recaptured specimens in the ordinary Danish marking experiments in the Horns Reef area during the years 1903—1906. It will be seen that the average recapture in the course of one year amounts to ca. 42% of all the liberated specimens. A far greater percentage was recovered of the larger specimens than of the smaller ones. Thus it appears in Table 55B that 55.2% of 1001 specimens of initial length 25 cm. or above were recovered within one year. In comparison with this it should be noted that 815 specimens which at liberation were of a length of below 25 cm. only gave 209 recaptures or 25.6% in the same time.

Of the specimens which at liberation had a size of 25 cm. or above the following numbers were recovered within one year (in 1906 within 6 months).

	No. liberated	No. recovered	Percentage recovered
In the experiments in April, 1903 . . . .	522	219	42.0%
» » » » Febr., 1904 . . . .	51	37	72.5%
» » » » April, 1905 . . . .	248	176	71.0%
» » » » April, 1906 . . . .	180	121	67.2%

It is here obvious that only a relatively slight percentage was recaptured of the specimens liberated in 1903.

It should be noticed that a specimen from the experiments in 1903 was taken "dead and rotten" on the sea bottom shortly after liberation. This fact would seem to indicate that all the experiments at Horns Reef in 1903 have not been quite successful.

It is also worthy of note that in the year in which the least percentage was recovered, the Esbjerg cutters yield of the plaice-fishery was comparatively slight while the yield was far more considerable in 1904 and 1905 when the high percentages were recaptured (see p. 60—63). We might imagine the reason of the slight yield in 1903 to be, that proportionally many plaice had this year succeeded in leaving the Horns Reef area without being caught by the fishermen. As has been referred to previously there is, however, also the possibility that the slight yield of the fishery in the Horns Reef area in 1903 may be owing to the circumstance, that the plaice increased proportionally slowly in that year wherefore comparatively few young specimens obtained a marketable size.

According to BOLAU<sup>1</sup>, 264 plaice of a length of 13—55 cm. were liberated in the Horns Reef area at 23—30 meters depth on March 18th of 1904. In the course of one year 86 specimens or 32.6% were recovered. Of 156 specimens measuring 25 cm. or above, ca. 42% were recaptured. In other German experiments which were undertaken on July 20th, 1904, 72 specimens were liberated in the same area at 25—27 meters depth. Until the end of April, 1905 only one specimen or 1.4% was recovered. The reason of this slight percentage may presumably be ascribed to the fact, that the experiment was carried on at a time when the intense spring fishery was over (if we dare take for granted that the specimens were quite well and strong at liberation).

The German experiments with aluminium-rings are not taken into consideration here, as this method of marking has proved to be unsatisfactory.

<sup>1</sup> BOLAU: Die deutschen Versuche mit gezeichneten Schollen. I. Bericht. Wissensch. Meeresuntersuch. VII. B. 1905.



The experiments which have hitherto been mentioned can only give an idea of the intensity of fishing in the Horns Reef area at depths below 30 meters. At greater depths where the fish are less numerous, the fishing is also less intense.

In a marking experiment carried on by the English research steamer "Huxley" on the Horns Reef Outer Grounds at 55°25' N. lat. 6°2' E. long. on the 15th September, 1903, 29 specimens were set free and seven of these or 24·1% were recaptured within one year<sup>1</sup>.

In a Danish marking experiment on the Horns Reef Outer Grounds at 45 meters depth 5 marked plaice of 35—57 cm. length were set free on September 28th, 1904. None of these specimens have later on been recorded as recovered. (Concerning the Danish transplantation experiments in the Horns Reef area, see p. 15—17.)

Table 55A. Number of specimens recaptured in the ordinary marking experiments with plaice in the Horns Reef Area. 1903—1906.

Date of Liberation	Station No.	Number of Experiment	Locality and Depth of Liberation	Total No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Septbr. 30., 1906	Percentage recaptured until Septbr. 30., 1906
1903 April 10	36	1 1903	7 miles WSW of Nymindegab. 17 meters	12	0	0.0	2	16.7
» » 10	38	2 1903	6 miles SE by E of Vyl Light-ship. 17 m.	255	56	22.0	65	25.5
» » 10	39	3 1903	4 miles SE of Vyl Light-ship. 20 m.	445	112	25.2	121	27.2
» » 11	40	4 1903	18 miles WNW of Horns Reef Light-ship. 32-34 m.	2	1	50.0	1	50.0
» » 11	41	5 1903	2 à 3 miles N of Tuxen. 11—13 m.	286	124	43.4	132	46.2
1904 Febr. 22-23	192	1 1904	7 miles S by W ½ W from Blaavand. 14 m.	165	48	29.1	57	34.5
» » »	195	2 1904	3½ miles W ¾ S from Kærgaarde Bn. 15 m.	45	28	62.2	29	64.4
1905 April 15	381	8 1905	8 miles SSW of Blaavands Point. 14 m.	200	143	71.5	146	73.0
» » 15	382	9 1905	Northern Part of Slugen. 15 m.	145	89	61.4	90	62.1
» » 15	...	10 1905	Graadeep, inside the bar, 6 m.	40	28	70.0	29	72.5
» Septbr. 29	...	11 1905	Graadeep W of Esbjerg Harbour. 9 m.	21	7	33.3	7	33.3
1906 April 7	799	1 1906	9 miles SW by W of Blaavand. 16 m.	150	80 <sup>1</sup>	53.3 <sup>1</sup>	80	53.3
» » 10	805	2 1906	N of Slugen. 55°34' N. 7°46' E. 13 m.	50	46 <sup>1</sup>	92.0 <sup>1</sup>	46	92.0
				1816	762	42.0	805	44.3

<sup>1</sup> show recaptures until Septbr. 30., 1906.

Table 55B. Number of specimens recaptured in the ordinary marking experiments with plaice in the Horns Reef Area. 1903—1906.

Date of Liberation	Station No.	No. of Experiment	Specimens of 25 cm. or above when set free					Specimens below 25 cm. when set free				
			No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906	No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906
1903 April 10	36	1 1903	...	...	...	...	...	12	0	0.0	2	16.7
» » 10	38	2 1903	66	28	42.4	28	42.4	189	28	14.8	37	19.6
» » 10	39	3 1903	211	74	35.1	75	35.5	234	38	16.2	46	19.7
» » 11	40	4 1903	2	1	50.0	1	50.0	...	...	...	...	...
» » 11	41	5 1903	243	116	47.7	122	50.2	43	8	18.6	10	23.3
1904 Febr. 22-23	192	1 1904	23	16	69.6	16	69.6	142	32	22.5	41	28.9
» » »	195	2 1904	28	21	75.0	22	78.6	17	7	41.2	7	41.2
1905 April 15	381	8 1905	130	101	77.7	101	77.7	70	42	60.0	44	62.9
» » 15	382	9 1905	95	60	63.2	60	63.2	50	29	58.0	30	60.0
» » 15	...	10 1905	20	14	70.0	14	70.0	20	14	70.0	15	75.0
» Septbr. 29	...	11 1905	3	1	33.3	1	33.3	18	6	33.3	6	33.3
1906 April 7	799	1 1906	132	76 <sup>1</sup>	57.6 <sup>1</sup>	76	57.6	18	4 <sup>1</sup>	22.2 <sup>1</sup>	4	22.2
» » 10	805	2 1906	48	45 <sup>1</sup>	93.8 <sup>1</sup>	45	93.8	2	1 <sup>1</sup>	50.0 <sup>1</sup>	1	50.0
			1001	553	55.2	561	56.0	815	209	25.6	243	29.8

<sup>1</sup> show recaptures until Septbr. 30., 1906.

<sup>1</sup> GARSTANG: Report on Experiments with marked fish during 1902—1903. Report (No. 2. Southern Area) on Fishery and Hydrographical investigations etc. for 1902—1903. London 1905.



## 2. The intensity of fishing in the Hanstholm—Søndervig Area.

In the Hanstholm—Søndervig area where the Danish plaice fishery is of far less importance than in the Horns Reef area a proportionately small number of plaice have been marked, namely 99 in 1903 and 40 in 1905.

It may be seen in the Tables 56 A & B that in one year ca. 30% of all the liberated specimens were recaptured and ca. 40% of the specimens which at liberation were of a length of 25 cm or above. Of 53 specimens measuring below 25 cm. at liberation only 9 specimens or ca. 17% were recovered within one year. Though the recovered percentage of marked plaice is rather considerable also in this area, it is far less than in the other areas: Horns Reef, Skagerak and Kattegat. This must evidently — at any rate essentially — be ascribed to the fact that the west-coast of Jutland is destitute of fishing harbours on the proportionally long distance between Skagen and Esbjerg.

At Tarbot Bank at 56°28'—56°34' N. lat. 5°57'—6°17' E. long and 30—45 meters depth, the German investigators liberated in September 1903 and March 1904 85 specimens measuring 24—51 cm. In the course of one year 10 specimens or 11·8% were recovered (BOLAU l. c.). It is also here confirmed, that the plaice-fishery is carried on with far less intensity on the off-shore grounds than on the costal grounds.

Table 56 A. Number of specimens recaptured in the ordinary marking experiments with plaice on the shore-grounds off Hanstholm—Søndervig (the North Sea). 1903 and 1905.

Date of Liberation		Station No.	Number of Experiment	Locality and Depth of Liberation	Total No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Septbr. 30., 1906	Percentage recaptured until Septbr. 30., 1906
1903	April 23	62	15 1903	5 miles WSW of Bjergehuse Bn. 21—24 m.	21	5	23·8	5	23·8
»	» 23	64	16 1903	1½ mile W of Torup Bn. 17—19 m.	48	14	29·2	18	37·5
»	» 23	...	17 1903	3 miles W of Hanstholm. 23 m.	30	10	33·3	11	36·7
1905	March 24	354	5 1905	3 miles W of Torup Bn, 18 m.	40	14	35·0	14	35·0
					139	43	30·9	48	34·5

Table 56 B. Number of specimens recaptured in the ordinary marking experiments with plaice on the shore-grounds off Hanstholm—Søndervig (the North Sea). 1903 and 1905.

Date of Liberation	Station No.	No. of Experiment	Specimens of 25 cm. or above when set free					Specimens below 25 cm. when set free					
			No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906.	Percentage recaptured until Sept. 30., 1906	No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906	
1903	April 23	62	15 1903	10	4	40·0	4	40·0	11	1	9·1	1	9·1
»	» 23	64	16 1903	31	11	35·5	15	48·4	17	3	17·6	3	17·6
»	» 23	...	17 1903	15	8	53·3	9	60·0	15	2	13·3	2	13·3
1905	March 24	354	5 1905	30	11	36·7	11	36·7	10	3	30·0	3	30·0
				86	34	39·5	39	45·3	53	9	17·0	9	17·0

## 3. The intensity of fishing in the Skagerak.

In Table 57 A a view is represented over the number of liberated and recovered plaice in the ordinary marking experiments in 1903 and 1905. Ca. 41% of all the liberated specimens are on an average recovered here.



Of 750 specimens which at liberation were of a length of 25 cm. or above, 45·7% were recovered in the course of one year. Of 146 specimens measuring 15—24 cm. at liberation, only 27 specimens or 18·5% were recovered in the same time (see Table 57 B).

Table 57 A. Number of specimens recaptured in the ordinary marking experiments with plaice in the Skagerak. 1903 and 1905.

Date of Liberation	Station No.	Number of Experiment	Locality and Depth of Liberation	Total No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Septbr. 30., 1906	Percentage recaptured until Septbr. 30., 1906		
1903	April	17	49	6 1903	10 miles NW ½ N of Hirshals. 49 m.	2	2	100·0	2	100·0
»	»	17	51	7 1903	3 à 4 miles W by N of Kjettrup. 11—15 m.	12	6	50·0	8	66·7
»	»	17	52	8 1903	6 miles W by N of Kjettrup. 13 m.	6	1	16·7	1	16·7
»	»	17	53	9 1903	11 miles NE of Bulbjerg. 17—19 m.	13	12	92·3	12	92·3
»	»	18	54	10 1903	10 miles NE of Bulbjerg. 13—17 m.	19	5	26·3	6	31·6
»	»	21	58	11 1903	1 mile N of Skagen's Light. 19 m.	2	1	50·0	1	50·0
»	»	21-22	59	12 1903	Off Tversted. 15—23 m.	45	7	15·6	7	15·6
»	»	22	60	13 1903	Off Tversted. 7—13 m.	14	5	35·7	5	35·7
»	»	22	61	14 1903	4 miles NE of Hanstholm. 24—28 m.	8	0	0·0	0	0·0
1905	March	20	349	3 1905	2 miles W of Spirbakken Bn. 17 m.	200	56	28·0	56	28·0
»	»	22	...	4 1905	Off Bulbjerg — Svinkleyen. 10—16 m.	575	275	47·8	278	48·4
						896	370	41·3	376	42·0

Table 57 B. Number of specimens recaptured in the ordinary marking experiments with plaice in the Skagerak. 1903 and 1905.

Date of Liberation	Station No.	No. of Experiment	Specimens of 25 cm. or above when set free					Specimens below 25 cm. when set free						
			No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906	No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906		
1903	April	17	49	6 1903	2	2	100·0	2	100·0	..	..	...	..	...
»	»	17	51	7 1903	3	3	100·0	3	100·0	9	3	33·3	5	55·6
»	»	17	52	8 1903	1	1	100·0	1	100·0	5	0	0·0	0	0·0
»	»	17	53	9 1903	8	8	100·0	8	100·0	5	4	80·0	4	80·0
»	»	18	54	10 1903	5	2	40·0	2	40·0	14	3	21·4	4	28·6
»	»	21	58	11 1903	2	1	50·0	1	50·0	..	..	...	..	...
»	»	21-22	59	12 1903	16	6	37·5	6	37·5	29	1	3·4	1	3·4
»	»	22	60	13 1903	2	1	50·0	1	50·0	12	4	33·3	4	33·3
»	»	22	61	14 1903	2	0	0·0	0	0·0	6	0	0·0	0	0·0
1905	March	20	349	3 1905	150	49	32·7	49	32·7	50	7	14·0	7	14·0
»	»	22	...	4 1905	559	270	48·3	273	48·8	16	5	31·3	5	31·3
					750	343	45·7	346	46·1	146	27	18·5	30	20·5

#### 4. The intensity of fishing in the Kattegat.

The greater part of the Kattegat belongs to the waters where the plaice-fishery is carried on with the greatest intensity. As shown in the Table 58 A, 60·6% of 1250 marked plaice have been recovered within one year after liberation. Of 997 specimens of initial length 25 cm. or above, 619 or 62·1% were recovered within twelve months. Of 253 specimens measuring 20—24 cm., 138 specimens or 54·5% were recovered in the same time.



Table 58A. Number of specimens recaptured in the ordinary marking experiments with plaice in the Kattegat. 1904 and 1905.

Date of Liberation	Station No.	Number of Experiment	Locality and Depth of Liberation	Total No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Septbr. 30., 1906	Percentage recaptured until Septbr. 30., 1906	
1904	March 5	206	3 1904	Læsø Rende. 16 m.	30	24	80.0	25	83.3
»	» 7	207	4 1904	NE of Hirsholmene. 29 m.	20	15	75.0	15	75.0
»	» 14	215-216	5 1904	Aalbæk Bay. 12 m.	40	37	92.5	37	92.5
»	October 5	266	6 1904	11 miles WNW from Vinga. 44 m.	72	43	59.7	44	61.1
»	» 11	278	7 1904	2½ miles SSW from Trindelen. 34 m.	19	8	42.1	8	42.1
»	» 12	280	8 1904	8 miles NW by N from Trindelen. 42 m.	43	24	55.8	24	55.8
»	» 17	288	9 1904	Aalbæk Bay. 7 m.	26	24	92.3	24	92.3
»	» 25	303	10 1904	Pakhus Bay. S of Anholt. 24-30 m.	10	4	40.0	4	40.0
»	» 27	305	11 1904	8 miles S of Anholt Knob. 32 m.	25	6	24.0	7	28.0
»	» 28	307	12 1904	SE by S of Kobbergrund. 24-40 m.	6	2	33.3	2	33.3
»	» 28	308	13 1904	6 miles NW from Anholt Knob. 30 m.	20	6	30.0	7	35.0
»	» 29	309	14 1904	10 miles NW by W from Kullen. 32 m.	139	67	48.2	81	58.3
1905	March 15	341	1 1905	5 miles N of Anholt Light. 19 m.	95	70	73.7	70	73.7
»	» 16-17	344-347	2 1905	SW of Anholt Harbour. 15-17 m.	305	210	68.9	219	71.8
»	» 29	359	6 1905	Aalbæk Bay. 16 m.	300	170	56.7	171	57.0
»	April 1	361	7 1905	Aalborg Bay. 15 miles SE of Hals L. V. 9 m.	100	47	47.0	50	50.0
					1250	757	60.6	788	63.0

Table 58B. Number of specimens recaptured in the ordinary marking experiments with plaice in the Kattegat. 1904 and 1905.

Date of Liberation	Station No.	No of Experiment	Specimens of 25 cm. or above when set free					Specimens below 25 cm. when set free					
			No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906	No. of specimens liberated	No. recaptured within one year	Percentage recaptured within one year	No. recaptured until Sept. 30., 1906	Percentage recaptured until Sept. 30., 1906	
1904	March 5	206	3 1904	12	8	66.7	9	75.0	18	16	88.9	16	88.9
»	» 7	207	4 1904	13	10	76.9	10	76.9	7	5	71.4	5	71.4
»	» 14	215-216	5 1904	30	28	93.3	28	93.3	10	9	90.0	9	90.0
»	October 5	266	6 1904	58	40	69.0	40	69.0	14	3	21.4	4	28.6
»	» 11	278	7 1904	15	8	53.3	8	53.3	4	0	0.0	0	0.0
»	» 12	280	8 1904	38	21	55.3	21	55.3	5	3	60.0	3	60.0
»	» 17	288	9 1904	4	4	100.0	4	100.0	22	20	90.9	20	90.9
»	» 25	303	10 1904	10	4	40.0	4	40.0	...	...	...	...	...
»	» 27	305	11 1904	25	6	24.0	7	28.0	...	...	...	...	...
»	» 28	307	12 1904	6	2	33.3	2	33.3	...	...	...	...	...
»	» 28	308	13 1904	20	6	30.0	7	35.0	...	...	...	...	...
»	» 29	309	14 1904	139	67	48.2	81	58.3	...	...	...	...	...
1905	March 15	341	1 1905	95	70	73.7	70	73.7	...	...	...	...	...
»	» 16-17	344-347	2 1905	300	208	69.3	216	72.0	5	2	40.0	3	60.0
»	» 29	359	6 1905	179	109	60.9	109	60.9	121	61	50.4	62	51.2
»	April 1	361	7 1905	53	28	52.8	30	56.6	47	19	40.4	20	42.6
				997	619	62.1	646	64.8	253	138	54.5	142	56.1

β. On marked "undersized" fish and the percentage of these which were again recovered as "undersized" fish, i. e. at a size below 25 cm.

It has appeared in the marking experiments that a considerable percentage of the liberated undersized fish were captured again as undersized fish. This fact is of great importance, as it shows that the very stock of undersized fish is highly influenced by the fishing.



Table 59. Number of "undersized" plaice (i. e. below 25 cm.) recaptured in the ordinary Danish marking experiments with plaice in the North Sea and the Skagerak in 1903—1906.

No. of Experiment	Month of Liberation	Place of Liberation	Size of "undersized" plaice at Liberation cm.	No. of "undersized" plaice liberated	No. of plaice recaptured as "undersized" within one year	Percentage recaptured within one year
1, 2, 3, 5 1903	April, 1903	Horns Reef area. 11—20 m.	12—24	478	58	12.1
1—2 1904	Febr., 1904	Horns Reef area. 14—15 m.	19—24	159	30	18.9
8—9 1905	April, 1905	Horns Reef area. 14—15 m.	21—24	140	45	32.1
11 1905	Septbr., 1905	Graadeep inshore waters. 6 m.	20—24	18	6	33.3
1—2 1906	April, 1906	Horns Reef area. 13—16 m.	24	20	3	15.0
15—17 1903	April, 1903	Hanstholm—Søndervig area. 17—24 m.	13—24	43	5	11.6
5 1905	March, 1905	Hanstholm—Søndervig area. 18 m.	23—24	10	1	10.0
7—14 1903	April, 1903	Skagerak. 8—28 m.	15—24	80	11	13.8
3—4 1905	March, 1905	Skagerak. 10—19 m.	19—24	66	5	7.6
			12—24	1014	164	16.2

Table 60. Number of "undersized" plaice (i. e. below 25 cm.) recaptured in the ordinary Danish marking experiments with plaice in the Kattegat in 1904 and 1905.

No. of Experiment	Month of Liberation	Place of Liberation	Size of "undersized" plaice at Liberation cm.	No. of "undersized" plaice liberated	No. of plaice recaptured as "undersized" within one year	Percentage recaptured within one year
3 1904	March, 1904	Læsø Rende. 16 m.	21—24	18	4	22.2
4 1904	March, 1904	NE of Hirsholmene. 29 m.	21—24	7	4	57.1
5 1904	March, 1904	Aalbæk Bay. 12 m.	22—24	10	5	50.0
6 1904	Octbr., 1904	11 miles WNW from Vinga. 44 m.	21—24	14	3	21.4
7—8 1904	Octbr., 1904	At Trindelen. 34—42 m.	20—24	9	2	22.2
9 1904	Octbr., 1904	Aalbæk Bay. 7 m.	20—24	22	8	36.4
2 1905	March, 1905	SW of Anholt Harbour. 15—27 m.	21—24	5	0	0.0
6 1905	March, 1905	Aalbæk Bay. 16 m.	22—24	121	46	38.0
7 1905	April, 1905	Aalborg Bay, SE of Hals. 9 m.	21—24	47	18	38.3
			20—24	253	90	35.6

It will be seen from the Table 59 that of 1014 undersized fish liberated on the grounds off Jutland's west-coast in the North Sea and in the Skagerak, 164 specimens or 16.2% were recovered in the course of one year, before they had reached a size of 25 cm. In the same time 81 specimens or 8% were recovered at a size of 25 cm. or above. In the experiments in the Horns Reef area in 1905 even more than 30% were recaptured as undersized fish of a length of 20—24 cm.

In the Kattegat experiments the percentage of recovered undersized fish has been far greater than in the North Sea and the Skagerak. Of 253 liberated undersized fish, 90 specimens or 35.6% were recovered as undersized fish in the course of one year. During the same period 48 specimens or 19% were recovered at a size of 25 cm. or more.

The here stated percentages point in the direction that the stock of undersized fish of ca. 16—24 cm.<sup>1</sup> is highly influenced by the fishing in the Kattegat and in the coast-belt off the west-coast of Jutland. The influence is even far greater here than we get an impression of by looking over the recorded percentages,

<sup>1</sup> Only very few specimens have been marked at a size below 16 cm.



as the small specimens lose their labels proportionately easily and on the whole suffer more by the marking than the larger specimens.

On the rearing grounds for plaice in the Kattegat and the Skagerak the fishing by otter-trawl and other gears injurious to the young plaice is only carried on to a slight extent. In the North Sea a considerable trawl-fishery is taking place on the rich rearing grounds in the Horns Reef area and off the German and Dutch coasts. The trawlers destroy here multitudes of young plaice which would have invaded the scarcely populated off-shore grounds later on if not wasted.

#### D. The proportions of the marked fish caught by the various participating fishing vessels.

Of the plaice which were liberated in the Danish marking and transplantation experiments in the Horns Reef area in 1903, 1904 and 1905, ca. 762 specimens were recovered in the North Sea until September 30, 1906. The Danish cutters or smaller vessels caught 594 specimens or 79.0%, while 158 specimens or 21.0% were recovered by foreign trawlers. Of the 158 specimens 123 were caught by English trawlers, 30 by German trawlers, 3 by Belgian trawlers and 2 by Dutch trawlers. The captures by the vessels from the various countries in the years 1903, 1904 and 1905 are represented in the Table below.

Table 61. Number of marked plaice caught in the North Sea by the various participating fishing vessels. Marking and transplantation experiments in the Horns Reef Area. 1903, 1904, 1905.

	Captured by Danish fishermen	Captured by English fishermen	Captured by German fishermen	Captured by Belgian fishermen	Captured by Dutch fishermen	Total
Mark. exper. 1903.....	244	60	15	1	0	320
Mark. and Trpl. exper. 1904.....	130	27	9	0	1	167
Mark. exper. 1905.....	220	36	6	2	1	265
Number.....	594	123	30	3	2	752
Percentage...	79.0%	16.4%	4.0%	0.4%	0.3%	100%

In Table 62 a view is represented over the proportion of the marked plaice caught by the various participating fishing nations on different depths in the North Sea off the west-coast of Jutland. It will be seen from this summary, that the majority of the marked plaice have been recovered by Danish fishermen at depths below 30 meters, while most fish outside this line were recovered by foreign trawlers.

At depths between 1—10 meters 97.6% of the recovered fish were taken by Danish vessels and only 2.4% by foreign trawlers. At depths between 11 and 20 meters the percentage of the Danish recaptures amounts to 91.2 while the percentage of foreign recaptures amounts to 8.8%. At depths between 21 and 25 meters the percentage of Danish and foreign recaptures is respectively 69.0 and 31.0. At depths between 26 and 29 meters the number of foreign recaptures approach the number of Danish recaptures. The percentage is here 58.6 for Danish vessels and 41.4 for foreign vessels. At depths exceeding 30 meters the foreign vessels catch constantly more of the marked fish than the Danish do. The percentage for the Danish vessels has here fallen down to 19.6 while for the foreign vessels it has risen to 80.4.

It will be seen in Table 62 that the great majority of the recovered specimens were fished at depths between 11 and 20 meters. Of the recovered 707 specimens for which the depth at the place of recovery is known, 5.9% were recovered at depths between 1—10 meters, 64.2% at depths between 11—20 meters, 17.8% between 21 and 25 meters, 4.1% between 26—29 meters, and 7.9% at depths above 30 meters.



Table 62. The proportion of marked plaice caught by the various participating fishing vessels at various depths in the North Sea. Marking and transplantation experiments in the Horns Reef Area 1903, 1904, 1905.

Nation	Year	1-10 meters	11-20 meters	21-25 meters	26-29 meters	30 meters and above	Total. Depth at Place of recovery known
Denmark	1903	17	159	42	2	6	226
»	1904	16	85	20	8	0	129
»	1905	8	170	25	7	5	215
»	1903-1905	<b>41</b>	<b>414</b>	<b>87</b>	<b>17</b>	<b>11</b>	<b>570</b>
England	1903	0	18	20	3	15	56
»	1904	0	4	8	2	11	25
»	1905	0	12	8	3	5	28
»	1903-1905	<b>0</b>	<b>34</b>	<b>36</b>	<b>8</b>	<b>31</b>	<b>109</b>
Germany	1903	0	3	0	1	6	10
»	1904	1	1	1	2	2	7
»	1905	0	0	1	0	5	6
»	1903-1905	<b>1</b>	<b>4</b>	<b>2</b>	<b>3</b>	<b>13</b>	<b>23</b>
Belgium	1903	0	0	0	0	1	1
»	1904	0	0	0	0	0	0
»	1905	0	1	1	0	0	2
»	1903-1905	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>3</b>
Netherlands	1903	0	0	0	0	0	0
»	1904	0	0	0	1	0	1
»	1905	0	1	0	0	0	1
»	1903-1905	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>2</b>
<b>Total</b>	<b>1903-1905</b>	<b>42</b>	<b>454</b>	<b>126</b>	<b>29</b>	<b>56</b>	<b>707</b>

Of the recaptured plaice which were liberated in the Horns Reef area at depths between 7 and 20 meters in April, 1903, February, 1904, and April, 1905, the great majority were during the first months after liberation caught by Danish fishermen. After a few months the marked plaice had, however, moved so far out to sea that about half of the landed specimens were recovered by foreign trawlers. It will be seen in the summary below that in the period after August 1903, 29 specimens of the marked plaice liberated in April, 1903, were recovered by Danish fishermen, and 26 by foreign trawlers. Of the specimens liberated in February, 1904, 17 specimens were recovered by Danish fishermen and 17 by foreign trawlers in the period after August, 1904. Of the specimens liberated in April, 1905, 14 specimens were recovered by Danish cutters and 19 by foreign trawlers after August, 1905.

The plaice fishery in the Skagerak on the continental slope of Jutland is almost exclusively carried on by Danish fishermen, as the stony condition of the bottom as a rule keeps foreign trawlers off the shallow water. It will be seen in Table 66 that about 99% of the plaice recovered in the Skagerak from the marking experiments in this water were captured by Danish fishermen. At the Swedish slope of the Skagerak, on the other hand, the majority of the plaice is caught by Swedish and German fishermen, but the stock of plaice is not very considerable there.



Table 63. The proportion of marked plaice caught by the various participating nations.  
Marking experiments in the Horns Reef Area in April 1903 No. 1, 2, 3 and 5. Depth below 20 m.

	Captured by Danish fishermen	Captured by English fishermen	Captured by German fishermen	Captured by Belgian fishermen	Total
1903 April .....	90	15	4	0	109
» May .....	98	11	1	0	110
» June .....	23	11	0	1	35
» July .....	4	4	3	0	11
» August .....	4	5	2	0	11
» Septbr. ....	0	1	2	0	3
» October .....	0	2	0	0	2
» Novbr. ....	3	1	0	0	4
» Decbr. ....	0	1	1	0	2
1904 January .....	0	1	0	0	1
» March .....	4	0	0	0	4
» April .....	5	3	0	0	8
» May .....	6	1	1	0	8
» June .....	5	1	0	0	6
» August .....	1	0	0	0	1
1905 February .....	0	0	1	0	1
» May .....	0	2	0	0	2
» June .....	0	1	0	0	1
» July .....	1	0	0	0	1
Number .....	244	60	15	1	320
Percentage ..	76.3	18.8	4.7	0.3	

Table 64. The proportion of marked plaice caught by the various participating nations.  
Marking experiments in the Horns Reef Area in Febr. 1904. Depth below 20 m. Marking experiments  
No. 1 and 2, Transpl. exper. No. 1, 8 and 9.

	Captured by Danish fishermen	Captured by English fishermen	Captured by German fishermen	Captured by Dutch fishermen	Total
1904 March .....	10	1	0	0	11
» April .....	37	0	0	0	37
» May .....	20	1	1	0	22
» June .....	8	4	0	0	12
» July .....	7	0	1	1	9
» August .....	4	3	0	0	7
» Septbr. ....	2	1	0	0	3
» October .....	1	0	1	0	2
» Novbr. ....	1	1	1	0	3
1905 February .....	0	0	1	0	1
» March .....	1	1	0	0	2
» April .....	1	0	1	0	2
» May .....	3	1	1	0	5
» June .....	2	2	0	0	4
» July .....	2	0	0	0	2
» August .....	0	2	0	0	2
» Septbr. ....	0	1	0	0	1
Number .....	99	18	7	1	125
Percentage ..	79.2	14.4	5.6	0.8	



Table 65. The proportion of marked plaice caught by the various participating nations.  
Marking experiments in the Horns Reef Area in April 1905. Mark. exper. No. 8, 9 and 10. Depth below 20 m.

	Captured by Danish fishermen	Captured by English fishermen	Captured by German fishermen	Captured by Belgian fishermen	Captured by Dutch fishermen	Total
1905 April.....	84	0	0	0	0	84
» May.....	62	5	1	0	0	68
» June.....	39	13	0	1	0	53
» July.....	20	4	1	1	0	26
» August.....	5	0	0	0	0	5
» Septbr.....	6	4	1	0	0	11
» October.....	1	7	1	0	0	9
» Novbr.....	0	0	1	0	0	1
1906 January.....	0	1	1	0	0	2
» April.....	1	1	0	0	0	2
» May.....	1	0	0	0	1	2
» June.....	0	1	0	0	0	1
» Septbr.....	1	0	0	0	0	1
Number....	220	36	6	2	1	265
Percentage..	83.0	13.6	2.3	0.8	0.4	

Table 67 shows that the Danish fishermen have also caught the majority of the marked fish, which emigrated from the Skagerak and were recovered in other waters; 81.9% of these were recovered by Danish fishermen and 14.9% by English fishermen.

Table 66. Plaice recaptured in the Skagerak in the Danish experiments in the Skagerak by the fishing vessels of the different nations.

	Captured by Danish fishermen	Captured by Swedish fishermen	Captured by German fishermen	Captured by English fishermen	Total. Place of recovery known
Mark. exper. 1903....	33	0	0	0	33
Transpl. exper. 1904..	25	0	0	0	25
Mark. exper. 1905....	255	1	1	2	259
Number....	313	1	1	2	317
Percentage..	98.7%	0.3%	0.3%	0.6%	100%

Table 67. Plaice recaptured outside the Skagerak in the Danish experiments in the Skagerak by the fishing vessels of the different countries.

	Captured by Danish fishermen	Captured by Swedish fishermen	Captured by German fishermen	Captured by English fishermen	Total. Place of recovery known
Mark. exper. 1903....	7	0	0	1	8
Transpl. exper. 1904..	15	0	1	3	19
Mark. exper. 1905....	55	2	0	10	67
Number....	77	2	1	14	94
Percentage..	81.9%	2.1%	1.1%	14.9%	100%



In the Danish marking and transplantation experiments in the Kattegat in 1904 and 1905, 823 specimens were recovered between March 5th, 1904, and September 30th, 1906. Of these 741 were recovered in the Kattegat, 53 in the Skagerak, 5 in the North Sea, 3 in the Sound, and 1 in the Belt Sea, while the place of recovery is unknown for 20 specimens. Of the 741 specimens recovered in the Kattegat 728 were taken by cutters and smaller vessels, and 13 by steam-trawlers. Thus it will be seen that hardly 2% of the recovered marked fish were taken by steam-trawlers. Of the 728 specimens which were recovered by cutters and smaller vessels the 627 must be ascribed to Danish, the 101 to Swedish fishermen. Of the 13 trawl-caught fish 10 were taken by German fishermen, 1 by English, 1 by Danish and 1 by Swedish fishermen.

Of all the specimens recovered in the Kattegat 84.8% were taken by Danish fishermen. A similar percentage of the specimens which emigrated from the Kattegat before recapture were taken by Danish fishermen (see Table 68 and 69).

Table 68. Number of marked plaice caught in the Kattegat by the fishing vessels of the different nations. Marking and transplantation experiments in the Kattegat. 1904—1905.

	Caught by Danish fishermen	Caught by Swedish fishermen	Caught by German fishermen	Caught by English fishermen	Total
Mark. & Transpl. exper., spring of 1904..	84	21	0	0	105
Mark. exper., autumn of 1904 .....	138	25	4	0	167
Mark. exper., spring of 1905 .....	406	56	6	1	469
Number ....	628	102	10	1	741
Percentage ..	84.8%	13.8%	1.3%	0.1%	100%

Table 69. Number of marked plaice caught outside the Kattegat by the fishing vessels of the different nations. Marking and transplantation experiments in the Kattegat. 1904—1905.

	Caught by Danish fishermen	Caught by Swedish fishermen	Caught by German fishermen	Caught by English fishermen	Total
Mark. & Transpl. exper., spring of 1904..	5	1	0	0	6
Mark. exper., autumn of 1904 .....	21	1	3	2	27
Mark. exper., spring of 1905 .....	26	1	0	2	29
Number ....	52	3	3	4	62
Percentage ..	83.9%	4.8%	4.8%	6.5%	100%

In the Tables 70, 71 and 72 a view is represented to show how many of the marked fish were recovered by the different fishing vessels during the different seasons in the Danish marking experiments in the Kattegat. The Tables comprise the specimens which have been recovered in the Kattegat as well as those recaptured outside the Kattegat.

Of the recovered specimens in the marking experiments in spring most were captured during the first months after liberation, and from the month of April a gradual decrease may be noticed in the number of recaptures for each month. Most of the specimens which were liberated in the autumn experiments were recovered during the spring months, March, April, May. Most of the trawl-caught fish were recaptured during the winter months and most of those recovered by Swedish cutters during the summer half-year.



Table 70. Number of marked plaice caught in the Kattegat by the various participating fishing vessels, in each month.

Mark. exper. No. 3, 4, 5 and Transpl. exper. No. 11. Kattegat, March, 1904.

	Caught by Danish Cutters and small boats	Caught by Swedish Cutters and small boats	Total
1904 March.....	19	4	23
» April.....	24	2	26
» May.....	5	3	8
» June.....	18	1	19
» July.....	7	11	18
» August.....	4	0	4
» Septbr.....	3	0	3
» October.....	1	0	1
» Novbr.....	1	0	1
1905 March.....	1	0	1
» July.....	1	0	1
Number...	84	21	105
Percentage..	80.0%	20.0%	100%

Table 71. Number of marked plaice caught in the Kattegat by the various participating fishing vessels, in each month. Mark. exper. No. 6—14. Kattegat, October of 1904.

	Caught by Danish Cutters and small boats	Caught by Swedish Cutters and small boats	Caught by Danish Steam Trawlers	Caught by Swedish Steam Trawlers	Caught by German Steam Trawlers	Total
1904 October.....	9	0	0	0	0	9
» Novbr.....	20	0	0	0	0	20
» Decbr.....	19	0	0	0	0	19
1905 January.....	9	0	0	0	1	10
» February.....	10	1	0	1	2	14
» March.....	17	2	1	0	0	20
» April.....	9	1	0	0	0	10
» May.....	18	9	0	0	0	27
» June.....	7	3	0	0	0	10
» July.....	5	4	0	0	0	9
» August.....	0	1	0	0	0	1
» Septbr.....	4	1	0	0	0	5
» October.....	3	1	0	0	0	4
» Novbr.....	0	1	0	0	0	1
» Decbr.....	0	0	0	0	0	0
1906 January.....	2	0	0	0	0	2
» February.....	2	0	0	0	0	2
» March.....	0	0	0	0	1	1
» April.....	1	0	0	0	0	1
» May.....	1	0	0	0	0	1
» June.....	1	0	0	0	0	1
Number.....	137	24	1	1	4	167
Percentage..	82.0%	14.4%	0.6%	0.6%	2.4%	100%



Table 72. Number of marked plaice caught in the Kattegat by the various participating fishing vessels, in each month. Mark. exper. No. 1, 2, 6, 7. Kattegat, March and April of 1905.

	Caught by Danish Cutters and small boats	Caught by Swedish Cutters and small boats	Caught by English Steam Trawlers	Caught by German Steam Trawlers	- Total
1905 March .....	89	0	0	1	90
» April .....	106	2	0	1	109
» May .....	81	22	0	0	103
» June .....	33	12	0	0	45
» July .....	32	14	1	0	47
» August .....	19	3	0	0	22
» Septbr. ....	16	0	0	0	16
» October .....	9	0	0	0	9
» Novbr. ....	3	1	0	1	5
» Decbr. ....	3	0	0	0	3
1906 January .....	2	0	0	1	3
» February .....	2	0	0	0	2
» March .....	3	0	0	2	5
» April .....	5	0	0	0	5
» May .....	0	0	0	0	0
» June .....	1	2	0	0	3
» July .....	1	0	0	0	1
» August .....	1	0	0	0	1
Number ....	406	56	1	6	469
Percentage ..	86.6%	11.9%	0.2%	1.3%	100%

### E. On the weight and value of all liberated specimens compared with the weight and value of the recaptured ones.

As I have explained elsewhere the marking experiments enable us in certain places to show that it will not pay to base the plaice fishery on plaice of a quite small size<sup>1</sup>. The experiments show in many cases that when we mark and liberate fish of a comparatively small size, the value of the recovered specimens will exceed that of all the liberated ones. This fact is of great importance when we try to elucidate how far it may be profitable to fix a size-limit for the plaice. In finding the size-group for which the value of all the liberated specimens is equal to the value of all the recovered ones we may be able to give an important hint as to which size-groups it will pay to protect. If we fix the size-limit where it appears that the value of all the liberated specimens corresponds with the value of the total recaptures we may be sure that it has not been fixed too high. The recorded recaptures are not the total recaptures, at any rate only a minimum. Some fish lose their labels, others die shortly after marking etc. (see p. 3—5, 18).

If in a certain water a size-limit for plaice has been imposed, this will influence the kind of gear used as well as where and with what intensity the fishery is carried on. In this way the size-limit will also exercise influence as to how many of the marked plaice are recovered and at which size they are recovered. Thus we may not by adopting the above mentioned measures once for all expect to get settled where the size-limit for the plaice may be fixed with the greatest advantage. But if a size-

<sup>1</sup> A. C. JOHANSEN: Contributions to the biology of the plaice I. Medd. fra Komm. for Havunders. Ser. Fiskeri. Bd. I. No. 2. 1905 p. 27—30. — Ueber die Schollenfischerei im Kattegat und die Mittel, sie zu heben. Rapports et Procès-verbaux Vol. V, 1906, p. 119—121.



limit is imposed where there has been none before, or if a new size-limit is imposed in a place where there was one before the marking experiments ought to be repeated and the new results taken into consideration.

In the following a survey will be given over the value of all the liberated specimens of each size in the Danish marking experiments together with a view over the value of the recovered specimens. In the calculation of the value the scale set forth in Table 75 has been employed. This scale of value is based upon the veritable market prices for plaice of different sizes in Frederikshavn in the years 1904 and 1905<sup>1</sup>. The prices are first-hand wholesale prices. The quoted value refers to the plaice from the northern Kattegat and Skagerak. The same value is in the calculation in the following transferred to the plaice from the experiments in the Horns Reef area. No scale of value has hitherto been worked out for the less valuable plaice from the southern Kattegat, for which reason the experiments in the southern Kattegat have been left out of consideration in the following.

The value of the plaice increases with the length according to a more strongly rising scale than the weight. The values of plaice of different sizes and the proportions between these values changes, however, from time to time and from place to place. Calculations of value based upon market prices in a certain place during a certain brief period may therefore not be expected to have validity neither for long distances nor for a long time.

A comparison between the weight of all the liberated specimens of a certain size and the weight of all recovered specimens of the same initial size is also represented in the following. By this comparison it may be shown that the weight of all the recovered specimens in certain cases surpasses or very nearly approaches the weight of all the liberated specimens.

The scale on Table 73 has been employed for the plaice in the Horns Reef area. For plaice in the Skagerak and Kattegat the scale of weight on Table 74 has been employed.

Table 73. Relation between Length and Weight of Plaice captured in the Horns Reef Area. September, October. 1903 and 1904.

Length in cm.	Average weight in gram, observed	Average weight in gram, amended	No. of specimens weighed
12 cm.	19	19	40
13 »	23	23	40
14 »	28	28	40
15 »	35	35	40
16 »	44	42	40
17 »	50	50	40
18 »	58	58	40
19 »	65	66	40
20 »	74	76	40
21 »	88	88	40
22 »	102	102	40
23 »	119	117	40
24 »	128	133	40
25 »	152	150	40
26 »	168	168	40
27 »	188	188	40
28 »	210	210	40
29 »	235	235	30
30 »	262	262	17
31 »	300	300	4
32 »	338	330	3
33 »	375	365	1
34 »	400	400	1
35 »	425	430	2

<sup>1</sup> A. C. JOHANSEN: Ueber die Schollenfischerei etc. I. c. p. 71.



Table 74. Relation between Length and Weight of Plaice captured in the Skagerak and Kattegat. September, October. 1903 and 1905.

Length in cm.	Average weight in gr., observed	Average weight in gr., amended	No. of specimens weighed	Length in cm.	Average weight in gr., observed	Average weight in gr., amended	No. of specimens weighed
15	36	36	9	35	434	440	23
16	45	45	13	36	463	480	23
17	55	55	12	37	531	520	22
18	66	66	7	38	598	570	21
19	78	77	9	39	628	620	20
20	85	88	6	40	665	670	21
21	98	100	7	41	695	720	15
22	110	113	3	42	768	770	15
23	123	127	8	43	855	830	9
24	143	143	18	44	930	900	10
25	171	163	21	45	980	980	5
26	181	185	20	46	958	1060	8
27	211	210	25	47	1180	1150	8
28	233	235	30	48	1224	1240	5
29	266	260	20	49	1390	1340	4
30	298	290	16	50	1480	1440	1
31	330	320	18	51	1590	1550	4
32	350	350	12	52	1540	1660	1
33	367	380	27	53	1820	1770	1
34	402	410	27	54	1833	1880	2

Table 75. Relation between Length and Value of Plaice.

Length in cm.	Value in Øre	Length in cm.	Value in Øre	Length in cm.	Value in Øre
20	1	32	17	44	54
21	1.3	33	20	45	59
22	1.5	34	23	46	64
23	1.8	35	26	47	69
24	2.3	36	29	48	74
25	3.3	37	31	49	80
26	5	38	34	50	86
27	7	39	37	51	93
28	9	40	40	52	100
29	11	41	43	53	106
30	13	42	46	54	113
31	15	43	50	55	120

The Tables 76, 77 and 78 give a comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice of 20--32 cm. liberated in the three years 1903, 1904 and 1905, in the ordinary marking experiments in spring in the Horns Reef area.

While Table 76 shows that the value of all liberated specimens surpasses the value of all the recovered ones, when we regard each size group separately, the Tables 77 and 78 give quite another picture. Here we see that the value of the recovered specimens surpasses the value of all the liberated ones, both when we regard most of the size groups separately and when we look at the total number of specimens.

In the experiments in 1904, 39 specimens of 26--30 cm. length and of a total value of 289 Øre were liberated. Thirty of these specimens were recovered, and these had at recovery a value of 344 Øre.



The time that passed between liberation and recovery was on an average 3 à 4 months. In the experiments in 1905, 156 specimens of a length of 26–30 cm. and of a total value of 1134 Øre were liberated. Of these were recovered 113 specimens, the total value of which was 1243 Øre at recovery. Only ca. 2 months passed on an average between liberation and recovery.

The experiments in 1906 seem to yield a still higher percentage of recaptures than the experiments in 1904 and 1905. The proportionately slight percentage of recaptures in 1903 must thus — if it really represented a reliable view of the intensity with which the fishing was carried on in the Horns Reef area at that time (what is very doubtful, however) — be regarded as a passed stage.

The experiments in 1904–1905 point in the direction that fish below 30 cm. might be protected with advantage in the Horns Reef area when we consider the interests of all the nations concerned, but the Tables 76–78 convey the impression that it would not be advisable for Denmark alone under the present conditions to raise the Danish size-limit (ca. 25.6 cm.) for the plaice in the North Sea. Of the 39 specimens of a length of 26–30 cm. of a total value of 289 Øre and liberated in 1904 the Danish fishermen recovered 24 specimens of a total value of 230 Øre at recovery. Of the 156 specimens of 26–30 cm. liberated in 1905, total value 1134 Øre, the Danish fishermen recovered 94 specimens of a value of 894 Øre at recovery. The value of the specimens recovered by Danish fishermen is thus somewhat less than the value of all the liberated fish.

To judge from the Tables 77 and 78 it would be natural to suppose, that the present Danish size-limit for the North Sea plaice, which only regards Danish fishermen, neither brings us much loss nor much profit.

Table 76. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size.

Marking experiments in the Horns Reef Area. April, 1903. Exper. No. 1, 2, 3, 4, 5.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column									
				Total No. of recovered specimens				Recovered by Danish fishermen			Recovered by foreign Trawlers		
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery
20	30	30	2280	6	c. 12	639	c. 7 months	3	c. 5	c. 9 months	3	c. 7	c. 5 months
21	50	65	4400	8	c. 26	1070	c. 8 »	6	c. 22	c. 9 »	2	c. 4	c. 5 »
22	72	108	7344	12	c. 34	1501	c. 3 »	7	c. 26	c. 4 »	5	c. 9	c. 2 »
23	92	166	10764	22	c. 76	3132	c. 4 »	12	c. 41	c. 4 »	10	c. 34	c. 3 »
24	115	265	15295	35	c. 166	5774	c. 3 »	26	c. 89	c. 2 »	9	c. 78	c. 7 »
25	120	396	18000	32	c. 143	5219	c. 2 »	27	c. 125	c. 3 »	5	c. 18	c. 1 »
26	111	555	18648	49	335	9306	c. 2 »	36	212	c. 1 »	13	123	c. 5 »
27	78	546	14664	40	302	7765	c. 1 »	33	251	c. 1 »	7	51	c. 1 »
28	85	765	17850	41	401	9036	c. 1 »	32	298	c. 1 »	9	103	c. 4 »
29	49	539	11515	22	248	5262	c. 1 »	20	222	c. 1 »	2	26	c. 3 »
30	36	468	9432	19	277	5431	c. 2 »	16	225	c. 2 »	3	52	c. 3 »
31	13	195	3900	7	112	2195	c. 1 »	6	92	c. 1 »	1	20	c. 5 »
32	20	340	6600	10	179	3405	c. 1 »	9	156	c. 1 »	1	23	c. 2 »
	871	4438	140692	303	c. 2311	59735	c. 2 months	233	c. 1764	c. 2 months	70	c. 548	c. 4 months

The experiments in the Skagerak in spring of 1903 suggest that it does not pay to land plaice from this water of a smaller size than ca. 23 cm. (see Table 79 p. 111). For the rest, the results of



Table 77. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size.

Marking experiments in the Horns Reef Area. February, 1904. Exper. No. 1 and 2.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column									
				Total No. of recovered specimens				Recovered by Danish fishermen			Recovered by foreign Trawlers		
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery
20	38	38	2888	12	34	1451	c. 6 months	10	31	c. 7 months	2	3	c. 3 months
21	54	70	4752	9	66	1646	c. 9 »	6	17	c. 4 »	3	49	c. 17 »
22	34	51	3468	11	53	1684	c. 5 »	9	42	c. 5 »	2	11	c. 5 »
23	17	31	1989	9	51	1544	c. 6 »	8	36	c. 4 »	1	15	c. 15 »
24	12	28	1596	6	23	900	c. 2 »	6	23	c. 2 »	..	..	..
25	11	36	1650	7	32	1140	c. 3 »	7	32	c. 3 »	..	..	..
26	12	60	2016	9	60	1709	c. 3 »	7	35	c. 2 »	2	25	c. 5 »
27	13	91	2444	10	104	2342	c. 3 »	8	72	c. 3 »	2	32	c. 6 »
28	10	90	2100	8	128	2460	c. 5 »	7	91	c. 3 »	1	37	c. 21 »
29	2	22	470	1	15	300	c. 3 »	1	15	c. 3 »	..	..	..
30	2	26	524	2	37	695	c. 4 »	1	17	c. 2 »	1	20	c. 7 »
31	1	15	300	1	15	300	c. 2 »	1	15	c. 2 »	..	..	..
	206	558	24197	85	618	16171	c. 5 months	71	426	c. 4 months	14	192	c. 9 months

Table 78. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size.

Marking experiments in the Horns Reef Area. April, 1905. Exper. No. 8, 9, 10.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column									
				Total No. of recovered specimens				Recovered by Danish fishermen			Recovered by foreign Trawlers		
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery	No.	Value in Øre	Average time passed between liberation and recovery
21	2	3	176	..	..	..	..	..	..	..	..	..	..
22	3	5	306	..	..	..	..	..	..	..	..	..	..
23	61	110	7137	38	219	6624	c. 3 months	29	126	c. 2 months	9	93	c. 6 months
24	74	170	9842	51	221	8096	c. 2 »	40	153	c. 2 »	11	68	c. 4 »
25	89	294	13350	63	406	11796	c. 2 »	57	353	c. 1 »	6	53	c. 3 »
26	54	270	9072	39	292	7783	c. 1 »	37	276	c. 1 »	2	16	c. 2 »
27	50	350	9400	36	354	8095	c. 2 »	30	250	c. 1 »	6	104	c. 4 »
28	31	279	6510	22	337	6531	c. 3 »	15	192	c. 2 »	7	145	c. 5 »
29	19	209	4465	14	230	4402	c. 2 »	11	163	c. 2 »	3	67	c. 3 »
30	2	26	524	2	30	592	c. 1 »	1	13	c. 1/2 »	1	17	c. 2 »
	385	1716	60782	265	2089	53919	c. 2 months	220	1526	c. 1 1/2 months	45	563	c. 4 months

the experiments in 1903 and 1905 do not invite the consideration of any essential change of the Danish size-limit for the plaice in the main part of the Skagerak.

It should be remembered that the experiments in spring, 1905, cannot yet be regarded as completely finished.



Table 79. Comparison of the value and weight of recovered plaice with the value and weight of the total number of plaice liberated, at each size. Marking experiments in the Skagerak. April, 1903.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
15-19	43	0	2484	5	11	544	c. 3 months
20	10	10	880	3	28	628	c. 5 »
21	7	9	700	4	57	1178	c. 9 »
22	8	12	904	3	14	522	c. 2 »
23	5	9	635	1	2	143	c. $\frac{1}{3}$ »
24	7	16	1001	2	5	286	c. $\frac{1}{2}$ »
25	2	7	326	1	3	163	c. 2 »
26	5	25	925	1	5	185	c. 0 »
27	3	21	630	1	17	350	c. 4 »
28	4	36	940	3	44	930	c. 2 »
29	7	77	1820	3	41	900	c. 1 »
30	5	65	1450	3	41	900	c. 1 »
31	3	45	960	2	30	640	c. 1 »
32	3	51	1050	3	78	1320	c. 3 »
33	3	60	1140	3	69	1230	c. 2 »

Table 80. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size. Marking experiments in the Skagerak. March, 1905. Exper. No. 3 and 4.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
22	3	5	339	..	...	...	.....
23	27	49	3429	5	20	817	c. 3 months
24	35	81	5005	7	55	1534	c. 4 »
25	83	274	13529	26	186	5530	c. 3 »
26	103	515	19055	37	300	8325	c. 3 »
27	144	1008	30240	65	661	16385	c. 3 »
28	151	1359	35485	68	882	19545	c. 3 »
29	136	1496	35360	71	1005	21590	c. 3 »
30	69	897	20010	44	749	15080	c. 3 »
31	21	315	6720	10	170	3440	c. 2 »
32	1	17	350	..	...	...	.....
33	1	20	380	1	20	380	c. 1 »

The experiments in the Kattegat have given some very interesting results with respect to the value of the recovered specimens in proportion to the value of all the liberated fish (Table 84). From the experiments in March and October, 1904, as well as from the experiments of 1905 it has become evident that the size at which the value of all the recovered specimens is equal to the value of all the liberated ones is higher than the present Danish size-limit for the Kattegat plaice (ca. 25.6 cm.). In the experiments in March, 1904, this size will be found at 28-29 cm., in the experiments in October, 1904, at 26 cm. and in the experiments in March, 1905, at 26-27 cm.



This is the most important result of the Danish marking experiments in 1903—1905 and invites the consideration of an international size-limit for the Kattegat plaice somewhat higher than the present Danish one<sup>1</sup>. Table 84 is a summary of the Tables 81, 82 and 83 as far as the specimens between 22 and 36 cm. are concerned. It is here obvious that up to and with a size of 26 cm. the value of all the recovered specimens surpasses greatly the value of all those liberated.

It should be remembered here, that the experiments in 1905 cannot yet be regarded as finished, and that at any rate one of the largest of the experiments in 1905 (No. 6) was not quite successful. The greater importance should therefore be attached to the fact, that the size at which the value of all the recovered specimens is equal to the value of all those liberated is as high as 26—27 cm.

Table 81. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size. Marking experiments in the northern Kattegat. March, 1904. Mark. exper. No. 3, 4, 5. Trpl. exper. No. 11. Comprise recaptures until Septbr. 30., 1906.

Length in cm.	Liberated fish			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Total value in Øre	Total weight in gr.	No.	Total value in Øre	Total weight in gr.	
21	7	9	700	4	7	483	c. 2 months
22	20	30	2260	18	91	3176	c. 4 »
23	19	34	2413	11	62	2068	c. 3 »
24	39	90	5577	30	171	5767	c. 3 »
25	20	66	3260	14	81	2724	c. 2 »
26	20	100	3700	12	110	2855	c. 3 »
27	12	84	2520	11	95	2545	c. 1 »
28	5	45	1175	5	53	1285	c. 1 »
29	4	44	1040	3	35	810	c. 1/2 »
30	1	13	290	1	15	320	c. 1 »
31	1	15	320	1	15	320	c. 1 »
32	2	34	700	2	34	700	c. 1/2 »

Table 82. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size. Marking experiments in the middle and northern Kattegat. October 1904. (Mark. exper. No. 6—13.)

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
20	2	2	176	1	2	127	c. 7 months
21	5	7	500	1	5	185	c. 9 »
22	10	15	1130	7	32	1173	c. 5 »
23	10	18	1270	8	31	1308	c. 4 »
24	17	39	2431	10	58	1925	c. 4 »
25	9	30	1467	7	48	1451	c. 6 »
26	15	75	2775	8	75	1925	c. 5 »
27	17	119	3570	9	83	2140	c. 3 »
28	13	117	3055	10	122	2790	c. 4 »
29	14	154	3640	10	132	2930	c. 4 »
30	13	169	3770	7	112	2300	c. 4 »
31	13	195	4160	10	191	3710	c. 4 »
32	21	357	7350	12	283	5110	c. 6 »
33	14	280	5320	4	92	1640	c. 3 »
34	9	207	3690	5	127	2180	c. 3 »
35	10	260	4400	4	117	1960	c. 4 »
36	10	290	4800	3	108	1810	c. 8 »

<sup>1</sup> A. C. JOHANSEN: Ueber die Schollenfischerei im Kattegat etc.



Table 83. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size. Mark. exper. in the Kattegat. March, 1905. Exper. No. 1, 2, 6, 7.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
21	3	4	300	..	...	...	.....
22	50	75	5650	25	67	3379	c. 3 months
23	53	95	6731	29	130	4979	c. 4 »
24	67	154	9581	31	143	5473	c. 3 »
25	75	248	12225	40	233	7835	c. 3 »
26	91	455	16835	57	476	12990	c. 3 »
27	63	441	13230	42	411	11220	c. 2 »
28	81	729	19035	51	601	13900	c. 3 »
29	92	1012	23920	66	852	18950	c. 2 »
30	73	949	21170	56	876	18140	c. 2 »
31	36	540	11520	28	510	10100	c. 3 »
32	37	629	12950	26	491	10390	c. 3 »
33	27	540	10260	23	559	9950	c. 3 »
34	18	414	7380	14	347	6330	c. 3 »
35	13	338	5720	7	188	3160	c. 4 »
36	13	377	6240	12	387	6470	c. 3 »

Table 84. Comparison of the value and weight of recaptured plaice with the value and weight of the total number of plaice liberated, at each size. Mark. exper. in the middle and northern Kattegat. 1904 and 1905.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
22	80	120	9040	50	190	7728	c. 4 months
23	82	147	10414	48	223	8355	c. 4 »
24	123	283	17589	71	372	13165	c. 3 »
25	104	344	16952	61	362	12010	c. 3 »
26	126	630	23310	77	661	17770	c. 3 »
27	92	644	19320	62	589	15905	c. 2 »
28	99	891	23265	66	776	17975	c. 3 »
29	110	1210	28600	79	1019	22690	c. 2 »
30	87	1131	25230	64	1003	20760	c. 2 »
31	50	750	16000	39	716	14130	c. 3 »
32	60	1020	21000	40	808	16200	c. 4 »
33	41	820	15580	27	651	11590	c. 3 »
34	27	621	11070	19	474	8510	c. 3 »
35	23	598	10120	11	305	5120	c. 4 »
36	23	667	11040	15	495	8280	c. 5 »

In the transplantation experiments in the North Sea and Skagerak, it has constantly been experienced that the value of the recovered specimens did not by far approach the value of those liberated, irrespective of which size-groups we consider. In a transplantation experiment with plaice transferred from Aalbæk Bay to Trindelen in the northern Kattegat in March, 1904, the matter has been different, as the value of the recovered specimens has been considerably greater than the value of the liberated fish of 22—26 cm. length (see Table 85). This experiment suggests further to investigate if it will pay to



transplant young plaice from the rearing grounds in the Nissum Bredning or the Horns Reef area to the areas of the middle Kattegat which are poor on young plaice.

Table 85. Comparison of the value and weight of recovered plaice with the value and weight of the total number of plaice liberated, at each size. Transplantation experiment No. 11, 1904.

Length in cm.	Liberated specimens			Recovered specimens of those mentioned in the previous column			Average time passed between liberation and recovery
	No.	Value in Øre	Weight in gr.	No.	Value in Øre	Weight in gr.	
21	5	7	500	2	3	240	c. 2 months
22	13	20	1469	11	61	2013	c. 4 »
23	13	23	1651	5	37	1066	c. 4 »
24	19	44	2717	14	78	2663	c. 3 »
25—26	10	43	1762	3	49	990	c. 10 »
	60	137	8099	35	228	6972	c. 4 months

## F. Concluding remarks on the importance of the experiments in practical regard.

The Danish marking and transplantation experiments in the years 1903—1906 have in several respects yielded results which are of importance when we try to answer the three burning questions concerning the plaice fishery: the size-limit question, the fishing-gear question and the transplantation question.

The question about legislative interference with the plaice fisheries has often been connected too intimately with the question whether the plaice fisheries are deteriorating or not. If we possess means to increase the yield of the fisheries and thus make the fishing more profitable we ought naturally to employ them, even if the available evidence suggested that the fisheries were not deteriorating<sup>1</sup>.

That the stock of plaice has been treated in an uneconomical manner for many years ought not to be a sufficient reason to treat it in the same manner for ever.

### 1. The size-limit question.

#### a. The Kattegat.

In a previous paper: "Ueber die Schollenfischerei im Kattegat und die Mittel, sie zu heben" I have dealt with the question whether we possess any means to increase the yield of the plaice fishery in the Kattegat. My conclusion is that the establishment of an international size-limit somewhat higher than the present Danish one (25.6 cm.) would in all probability be very advantageous. The principal facts bearing on this question and arrived at by the marking experiments are as follows:

1) It has been found in the marking experiments that the value of the fish recaptured exceeded the original value of the entire series thrown overboard when we regard the sizes below 27 cm. (see p. 111—113).

2) The fishery in the Kattegat is carried on so intensively that more than 60% of the liberated marked plaice were registered as recovered within the first year after liberation (see p. 98).

3) Specimens from 20—29 cm. increase on an average ca. 6—8 cm. in the course of one year (see p. 66—69).

If we take a growth of 7 cm. as the normal one, we get the following increase in value during one year (see p. 108).

<sup>1</sup> Comp. C. G. JOH. PETERSEN: Report VI from the Danish Biological Station. København 1897.



Specimens of a length of 20 cm. increase in value from 1 to 7 Øre.

»	»	- 21	»	»	»	1·3 - 9	»
»	»	- 22	»	»	»	1·5 - 11	»
»	»	- 23	»	»	»	1·8 - 13	»
»	»	- 24	»	»	»	2·3 - 15	»
»	»	- 25	»	»	»	3·3 - 17	»
»	»	- 26	»	»	»	5 - 20	»
»	»	- 27	»	»	»	7 - 23	»
»	»	- 28	»	»	»	9 - 26	»
»	»	- 29	»	»	»	11 - 29	»

5) More than 92% of the plaice recovered in the Danish marking experiments in the Kattegat were again captured in the Kattegat (see p. 85).

6) The evidence arrived at from the marking experiments is that at least as many plaice migrate from the Skagerak to the Kattegat as vice versa (see p. 85—88).

#### b. The Skagerak.

The plaice fishery in the Skagerak is at present carried on in a rather satisfactory manner. On the coastal grounds where many young plaice are living, namely off the NW. coast of Jutland, the fishery is only carried on by gear that spares the young fish and for those a rather considerable size-limit is established as far as Denmark is concerned. And this is at present almost sufficient, as the coast-belt from 0—50 meters off the north-western coast of Jutland is almost entirely visited by Danish fishermen.

At depths from ca. 50—ca. 100 meters a not inconsiderable number of plaice are captured by Danish and Swedish cutters and by German and English trawlers; but the plaice living at this depth are so large that there would be no reason to protect them by a size-limit.

As the plaice fishery is carried on with great intensity in the parts of the Skagerak nearest on the border of the Kattegat, especially on the stretch Skagen—Spirbakken, and as the majority of the plaice are also here caught by gear, that does not hurt the young specimens, it would be reasonable to place these parts of the water together with the Kattegat when an international size-limit for the plaice is to be imposed.

The results of the marking experiments in the Skagerak recommend that Denmark should retain a size-limit for the plaice in this water even if the foreign countries would not join us (see Table 79 p. 111 etc.).

#### c. The North Sea.

The question about an international size-limit for the plaice in the North Sea is of great importance, firstly for England, secondly for Germany, Holland, Belgium and Denmark. In its whole extent the question will not be discussed here. We may only here call attention to the fact, that the results of the Danish experiments in the Horns Reef area in 1904 and 1905, suggest that it is probably uneconomical to land plaice of a smaller size than ca. 30 cm. from this area when we regard the profit of all the nations concerned. The experiments show that the value of the specimens recaptured exceeded the original value of all the specimens thrown overboard (see the Tables 77 and 78 p. 110).

If we regard Denmark's profit alone, it is rather doubtful how far the size-limit (of 25·6 cm.) which is only in force for Denmark is an advantage or loss for us as long as a similar size-limit is not imposed for other nations. The experiments in 1904 and 1905 point in the direction that it has neither brought us much advantage nor much loss (see the Tables 77 and 78 p. 110).

As many of the young plaice, which are spared by the Danish fishermen on account of the



Danish size-limit, move out into the off-shore grounds later on, and are caught there by English and German trawlers it can hardly be doubted that this size-limit is profitable to England and Germany.

How far it would be advantageous for Denmark to accept such a high international size-limit as 30 cm. for the plaice in the North Sea is doubtful at present. The question about this is very complicated, as among others we would have to consider on the one side, that gradually as the plaice grow up they migrate out into deeper water where the foreign fishery at present predominates, and on the other side that such a size-limit would probably keep foreign trawlers at a considerable distance from the coasts of Jutland.

## 2. The fishing-gear question.

It has for years been a highly discussed question how far and under what circumstances it is injurious to the plaice fishery to employ gear which hurt or kill the young immature fish. This matter must be regarded in the light of the question about the frequency of the young "undersized" plaice. In the case of over-production it will probably do no harm to kill a greater part of them. But if there is ample room and food for them all it will be bad economy to use gear which destroy them in great numbers.

The investigations regarding the frequency of young plaice in the North Sea, Skagerak and Kattegat point plainly in the direction that no over-production of "undersized" fish takes place. There is in all probability ample room and food for many more than there exist. There are assuredly areas where we find over-population of young fish, as among others may be seen from the fact that the specimens grow relatively slowly. But these places are of slight extent in proportion to the areas where there is but a thin population, but enough food for the fish, as among other things may be seen from the fact that the few specimens living there grow relatively quickly.

If a steam-trawler is fishing on a rearing ground where there is over-population of young fish, it may perhaps be of some use at the very place to kill a lot of specimens which take up the room for others and restrain the growth of these<sup>1</sup>. But the use which the trawler possibly does in such a place probably does not compensate for the great mischief it causes by destroying fish, which later on might have migrated out to less populated areas where they would have increased proportionately quickly in size.

In the Danish marking experiments with undersized plaice of ca. 15—25 cm. length it has been ascertained that a quite considerable percentage — in the North Sea ca. 16·2%, in the Kattegat ca. 35·6% are known to have been recovered as undersized fish in spite of the fact that such small fish lose their labels easily (see p. 98—100). This points in the direction that the number of undersized fish is very limited and that we ought to treat this stock with care.

In the Kattegat and Skagerak the plaice fishery by ottertrawl or other gear destructive to the young plaice is only carried on to a slight extent on the rearing grounds. An extensive trawl-fishery takes place on the contrary in the North Sea on the rich rearing grounds off the continental coasts at depths below 30 meters.

At the same time as the question about a size-limit for the plaice in the North Sea is treated, we ought also to consider the question: how to keep the fishing vessels which destroy multitudes of young fish off the rearing grounds. It is worth while to consider if this had better be done by simply prohibiting these vessels to fish on these grounds or by imposing so high a size-limit for this class of vessels that the fishery in this way is rendered unprofitable on these grounds. A lower size-limit might very well be in force for the smaller vessels using fishing gear which were not injurious to the stock of small plaice. We might thereby gain that only this last class of vessels fished on the rich rearing grounds.

<sup>1</sup> Comp. W. GARSTANG: Provisional Report on the Natural History of the Plaice. Rapports et Procès-Verbaux. Vol. III. 1905.



### 3. The transplantation question.

The question how far it will pay to transplant young plaice in the open sea from grounds where they are exceedingly numerous and grow slowly to grounds where they are scarce and increase rapidly was raised in 1897 by Dr. PETERSEN<sup>1</sup>. The Danish experiments in 1903—1905 have to a certain degree elucidated this question with regard to the Skagerak and the Kattegat.

The marking and transplantation experiments in the Skagerak have shown that a very large percentage of the marked specimens migrate away from this water already in the course of a few months (see p. 82—83). This circumstance in connection with the fact that the investigations in 1905 gave the result, that there is a considerable stock of the 0-group in this water makes it inadvisable for economical reasons to transplant young plaice into the Skagerak in spite of the fact, that they increase quickly there.

A single transplantation experiment which took place in the Kattegat in spring of 1904 gave a very favourable result, as the transplanted specimens increased relatively quickly and a considerable percentage was recovered in the Kattegat itself.

This experiment ought to be followed by others on a somewhat larger scale as we have good reason to suppose that it will pay to transport young plaice from the rich rearing grounds in the North Sea or the Nissum Bredning to the middle Kattegat, where there are only few young plaice which increase with considerable rapidity (see p. 67—69).

Two facts revealed by the Danish experiments make in some cases the question about profitable transplantations of plaice in the open sea somewhat complicated. In the first instance it must be considered that the plaice may increase in size with a rather unequal rapidity in different years on the same grounds (p. 60—63). Secondly it plays a rôle that the transplanted specimens show a stronger inclination to change their dwelling place quickly than the not transplanted specimens (see p. 20 and p. 91—92).

## Summary of Chap. III.

In this chapter I have wished, especially, to draw attention to the following points.

### A. The rate of growth of plaice.

1) The males of the "northern" form of the plaice in the North Sea and the northern and middle Kattegat increase in growth with nearly the same rapidity as the females until they reach a size of ca. 30 cm. (see p. 59).

2) The plaice of ca. 20—29 cm. length in the Horns Reef area increase in length with a different rapidity in different years: The average increase per year has been as follows (see p. 62—63):

In 1903: ca. 4 cm.

In 1904: ca. 6 cm.

In 1905: ca. 7—8 cm.

3) There seems to be a connection between the rapidity of the growth of plaice in the Horns Reef area and the yield of the plaice fishery in that area, the yield being small in the years when the plaice grow slowly and great in the years when they grow rapidly (see p. 60—63).

4) The yearly average increase of plaice of ca. 24—31 cm. length in the Hanstholm—Søndervig area has been as follows (see p. 64):

<sup>1</sup> Report VI from the Danish Biological Station p 29—30. København 1897.



In 1903: ca. 8 cm.

In 1905: ca. 7—8 cm.(?)

5) The yearly average increase of plaice in the Skagerak has been as follows (see p. 65—66):

In 1903 for specimens of 15—24 cm. length ca. 10 cm.

» 1904 » transplanted specimens of 21—27 cm., length 7—8 cm.

» 1905 » specimens of 23—30 cm., length 7—8 cm.

6) The yearly average increase of plaice in the northern and middle Kattegat has been as follows in 1904 and 1905 (see p. 68—69):

for specimens of 20—29 cm. length: ca. 6—8 cm.

» » - 30—34 » » : » 5 »

» » - 35—39 » » : » 1.5 »

7) The mature females of ca. 26—36 cm. length in the southern Kattegat grow on an average only ca. 2 cm. a year (see p. 70).

#### B. The migrations of plaice.

1) The plaice show on the whole an inclination to migrate out into deeper water as they increase in size. But the migrations outward are not continual. In two periods of the year the grown up fish seek shallow water, namely in spring and autumn (p. 70—85).

2) The movements of the plaice influence very much the movements of the fishing boats, a fact which appears very clearly in the Horns Reef area (p. 76—80).

3) When the plaice in the beginning of the summer migrate out into deeper water from the Horns Reef grounds they move mainly in a north-western direction (p. 77—78).

4) The rich stock of young plaice of 2 and 3 years age in the Horns Reef area does not play any rôle worth mentioning for the renewal of the stock of plaice in the Skagerak and the Kattegat (p. 80).

5) The plaice in the Skagerak and the adjacent parts of the North Sea show a marked tendency to undertake long migrations in a relatively short time (Fig. 4 p. 19; Pl. V and VI; p. 80—82).

6) A great part of the plaice in the Skagerak emigrate to the North Sea and the Kattegat (p. 83, Fig. 4 p. 19; Pl. V and VI).

7) Between the stock of plaice in the Skagerak and the stock of plaice of the northern form in the northern and middle Kattegat a considerable exchange of specimens takes place. The migrations of plaice from the Skagerak to the Kattegat and vice versa play evidently a great economical rôle for the fishermen in Skagen (p. 85—86; Pl. I—VI).

8) The southern dwarf form of plaice in the southern Kattegat, the Belt Sea and the Baltic does not partake in the migrations to the Skagerak (p. 85).

9) It would seem that the number of plaice which move from the Skagerak to the Kattegat is greater than the number which go the opposite way (p. 85—87).

10) The larger plaice show a more marked tendency to emigrate from the Kattegat to the Skagerak than the smaller ones. For plaice moving from the Skagerak to the Kattegat we notice the reversed tendency (p. 86—88).

11) The marking experiments seem to show that specimens often go together during the migrations (p. 89—91).

12) Several specimens have moved with a rapidity of more than 2 miles per day. A few specimens seem to have wandered at least 5—6 miles per day (p. 91—92).

13) (The causes of migrations are discussed on p. 92—93).



### C. The intensity of fishing.

1) The stock of marketable plaice is very much affected by the fishing. In the ordinary marking experiments in 1903—1906 the following number of plaice of 25 cm. and above has been recovered within twelve months after liberation (p. 94—98):

Area.	Month of Liberation	No. of spec. of 25 cm. and above liberated	No. of spec. recovered within 12 months	Percentage recovered within 12 months	Remarks
Horns Reef Area	April, 1903	522	219	42.0	
» » »	Febr., 1904	51	37	72.5	
» » »	April, 1905	248	176	71.0	
» » »	April, 1906	180	121	67.2	fRecaptured within { 6 months
Hanstholm-Søndervig Area	April, 1903	56	23	41.1	
» » »	March, 1905	30	11	36.7	
Skagerak	April, 1903	41	24	58.5	
»	March, 1905	709	319	45.0	
Kattegat	March, 1904	55	46	83.6	
»	October, 1904	315	158	50.2	
»	March, April, 1905	627	415	66.2	

2) The stock of "undersized" plaice of ca. 16—24 cm. length is also much affected by the fishing. Of 1014 undersized plaice liberated off the west-coast of Jutland, in the North Sea and the Skagerak, 164 specimens or 16.2% were recaptured within one year, before they had reached a size of 25 cm. In the same time were recaptured 81 specimens or 8.0% which had reached a length of 25 cm. or above.

In the Kattegat the percentage of "undersized" fish recovered has been much higher than in the North Sea and the Skagerak. Of 253 "undersized" plaice liberated, 90 specimens or 35.6% were recaptured as undersized fish within 12 months after liberation. In the same time 48 specimens or 19.0% were recovered at a size of 25 cm. or above (p. 98—99).

### D. The proportion of the marked fish caught by the various participating fishing vessels.

1) Of 752 plaice recovered in the North Sea and originating from the Danish marking and transplantation experiments in the Horns Reef area in 1903—1905, 594 specimens or 79.0% were caught by Danish cutters and small boats, and 158 specimens or 21.0% by foreign trawlers (p. 100).

2) The percentage of marked fish caught by Danish vessels and foreign trawlers on the various depths in the North Sea off the west-coast of Jutland was as follows (see p. 100—101):

Depth 0—10 meters:	42 specimens recovered,	97.6% by Danish vessels,	2.4% by foreign trawlers.
» 11—20 » :	454 »	91.2% - »	8.8% - »
» 21—25 » :	126 »	69.0% - »	31.0% - »
» 26—29 » :	29 »	58.6% - »	41.4% - »
» above 30 » :	56 »	19.6% - »	80.4% - »

3) The great majority of the recaptured specimens of the plaice liberated in the Horns Reef area at depths between 7—20 meters were during the first months after liberation recaptured by Danish fishermen. In the course of a few months the marked plaice had, however, moved so far out to sea that about half of the landed specimens were captured by foreign trawlers (p. 102—103).

4) About 99% of the plaice recovered in the Skagerak in the Danish marking experiments in this water were taken by Danish fishermen (p. 103).



5) About 98% of the marked plaice recaptured in the Kattegat were taken by cutters and small boats; hardly 2% by steam-trawlers (p. 104).

6) Of 741 marked plaice recaptured in the Kattegat in the Danish experiments, 84.8% were caught by Danish fishermen, 13.8% by Swedish, 1.3% by German and 0.1% by English fishermen (p. 104).

**E. On the weight and value of all the liberated specimens compared with the weight and value of the recaptured ones.**

1) In the experiments in the Horns Reef area in April of 1903 the value of the liberated specimens of all size-groups surpasses the value of the recaptured ones (p. 109).

2) In the experiments in the Horns Reef area in February, 1904, and April, 1905, the value of the recovered specimens of 23—30 cm. original length is considerably higher than that of all specimens thrown over board. If we compare the value of all the liberated specimens at liberation with the value of the specimens recovered solely by Danish fishermen, we find the first mentioned group to be of the highest value (p. 110).

3) In the experiments in the Skagerak in April, 1903, the value of the recovered specimens of 20—22 cm. original length is considerably higher than the value of all the liberated ones (p. 111).

4) In the experiments in the Skagerak in April, 1903, and March, 1905, the value of the liberated specimens of 23—33 cm. is on the whole higher than the value of the recovered ones (p. 111).

5) In the Danish marking experiments in the Kattegat in 1904 and 1905 the value of the recovered specimens of 22—26 cm. original length is considerably higher than the value of all the liberated ones. From 27—31 cm. the value of the liberated ones exceeds a little the value of those recovered. From 32 cm. and upwards the value of the liberated ones is considerably higher than that of the recovered ones (p. 111—113).

6) In a transplantation experiment with plaice in the northern Kattegat in March, 1904, the value of the recovered specimens of 22—26 cm. original length was higher than the value of all those thrown over board (p. 113—114).

As to the importance of the marking and transplantation experiments in practical regard the section F: «Concluding remarks on the importance of the experiments in practical regard» (p. 114—117) must be referred to *in extenso*.

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I am much indebted to Dr. H. M. KYLE, who has been good enough to read through the proofs.

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## Explanation of the Plates.

The Plates I—VI illustrate the Danish marking experiments with plaice in 1904 and 1905. The small circles indicate place of liberation. The arrow-heads indicate place of recovery. The Arabic numerals represent number of months between liberation and recovery. The letters beside the arrow-heads represent the nationality of the vessels which recaptured the plaice, B meaning Belgium, Da = Denmark, E = England, H = Holland (Netherlands), G = Germany, S = Sweden. In cases where no letters stand beside the arrow-head Da is omitted.

The migration-routes of the individual plaice are naturally unknown. We know only place of liberation and place of recapture.

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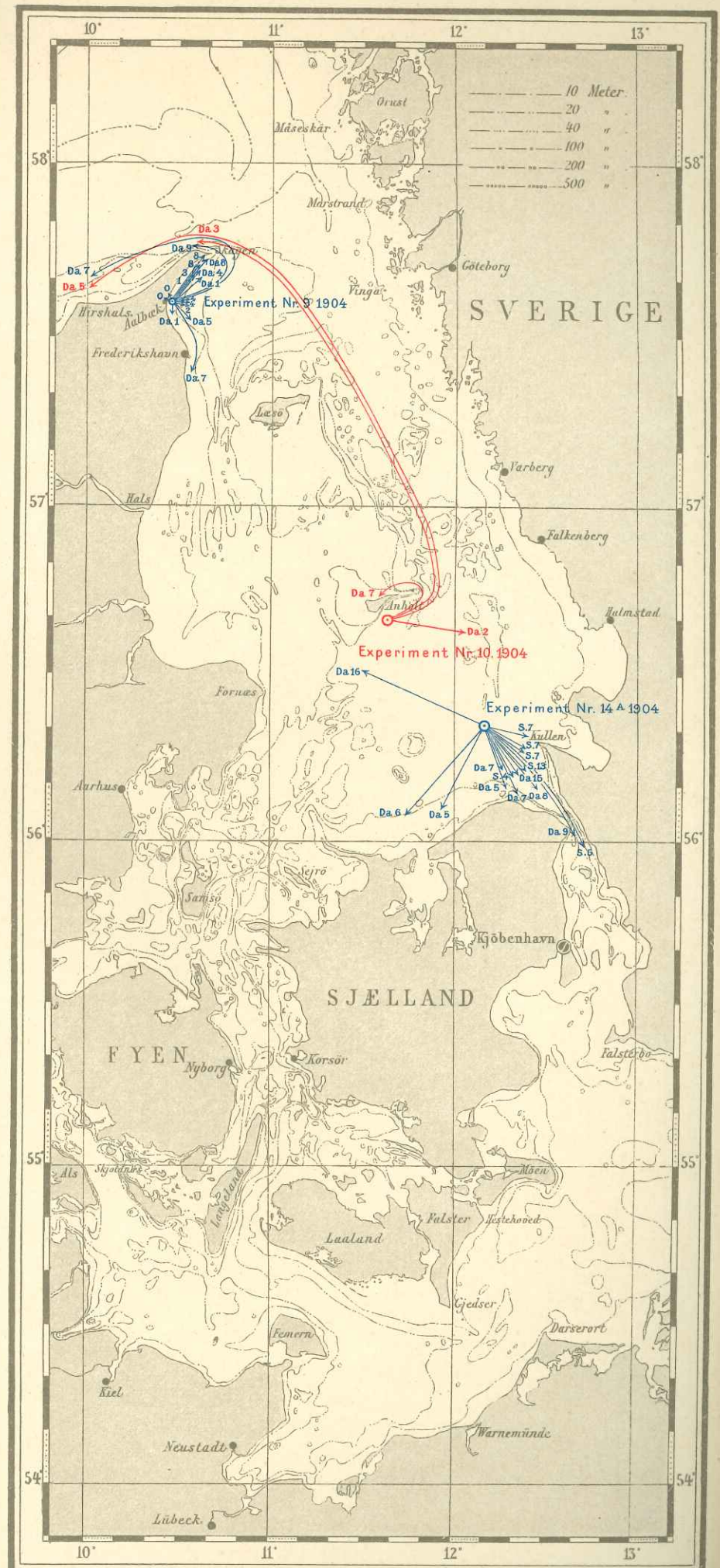
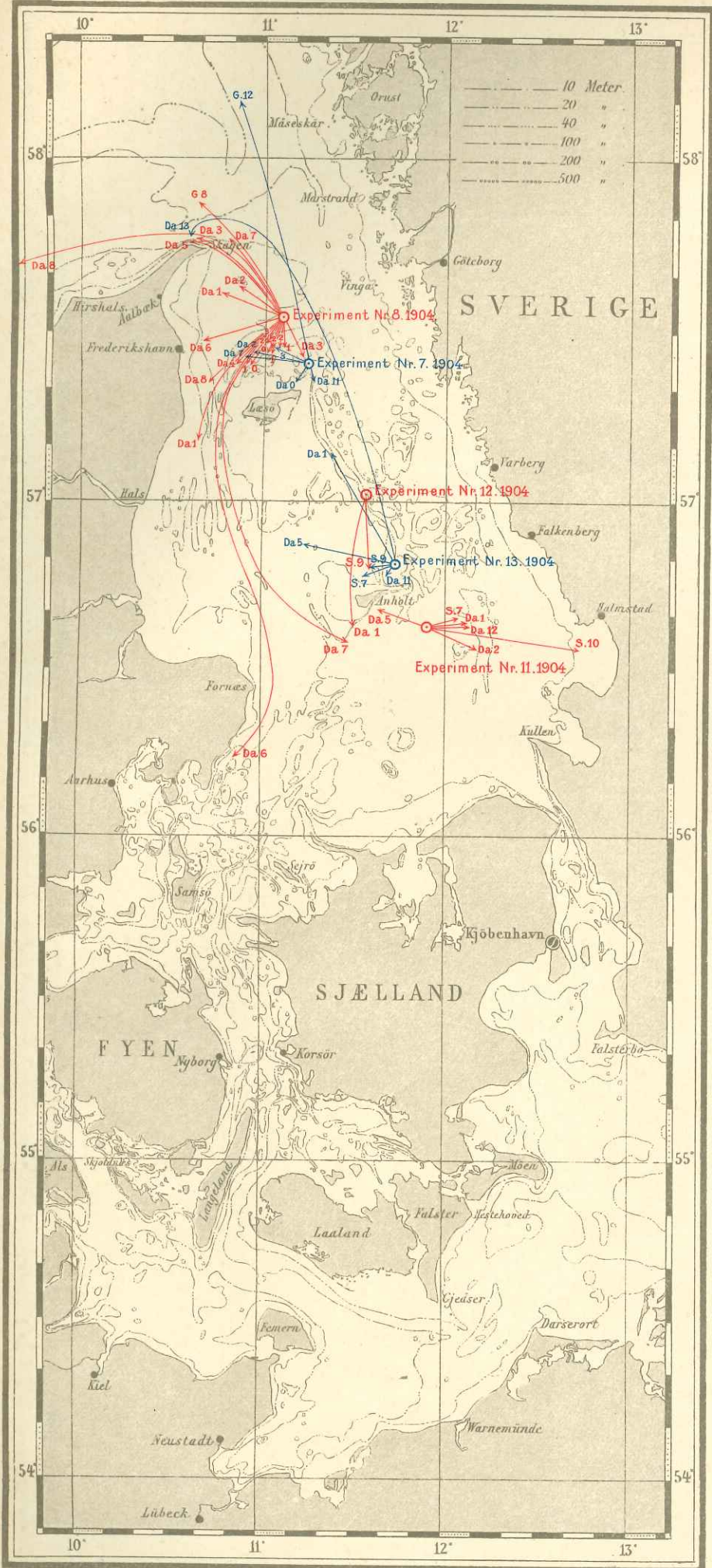


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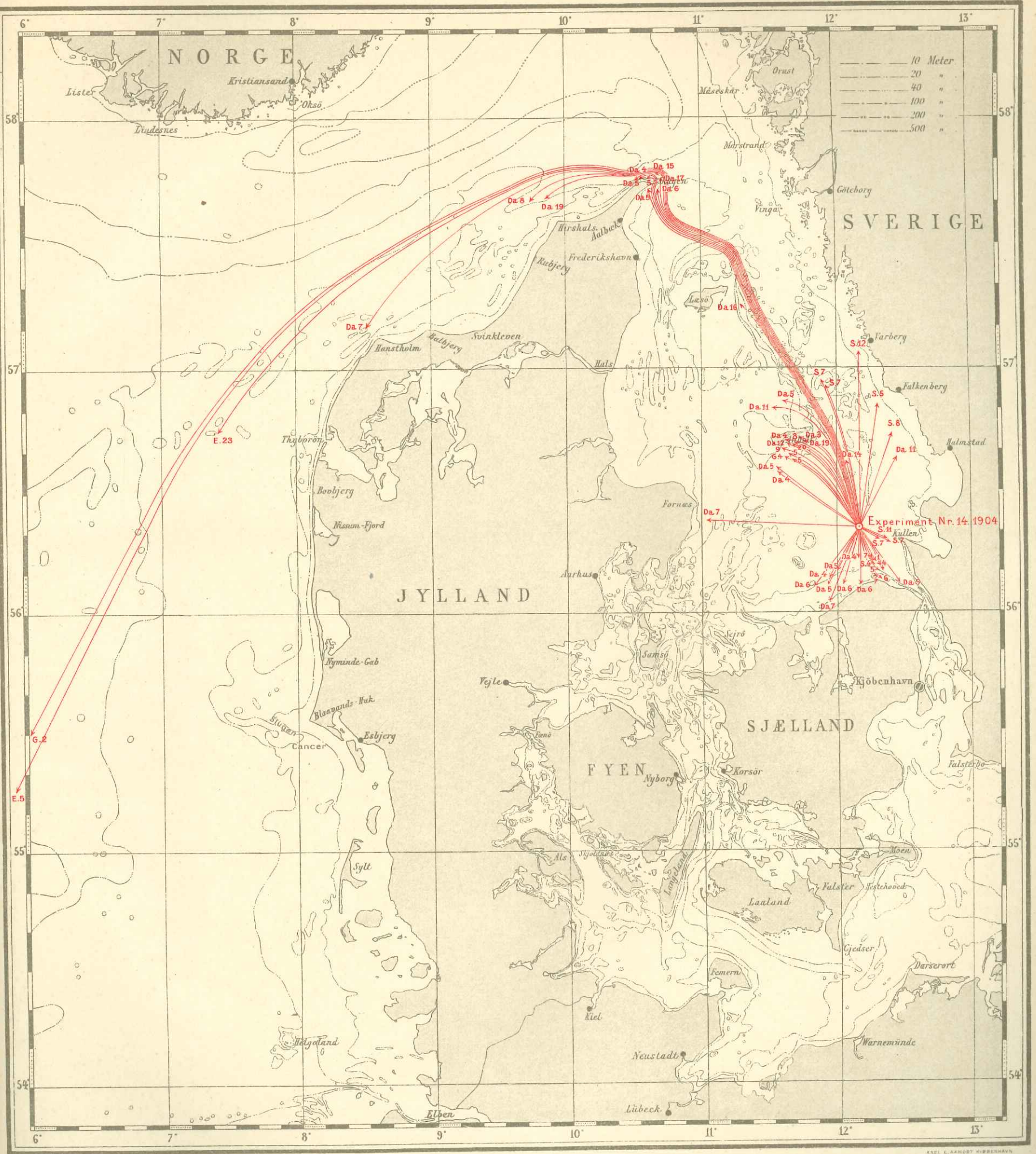


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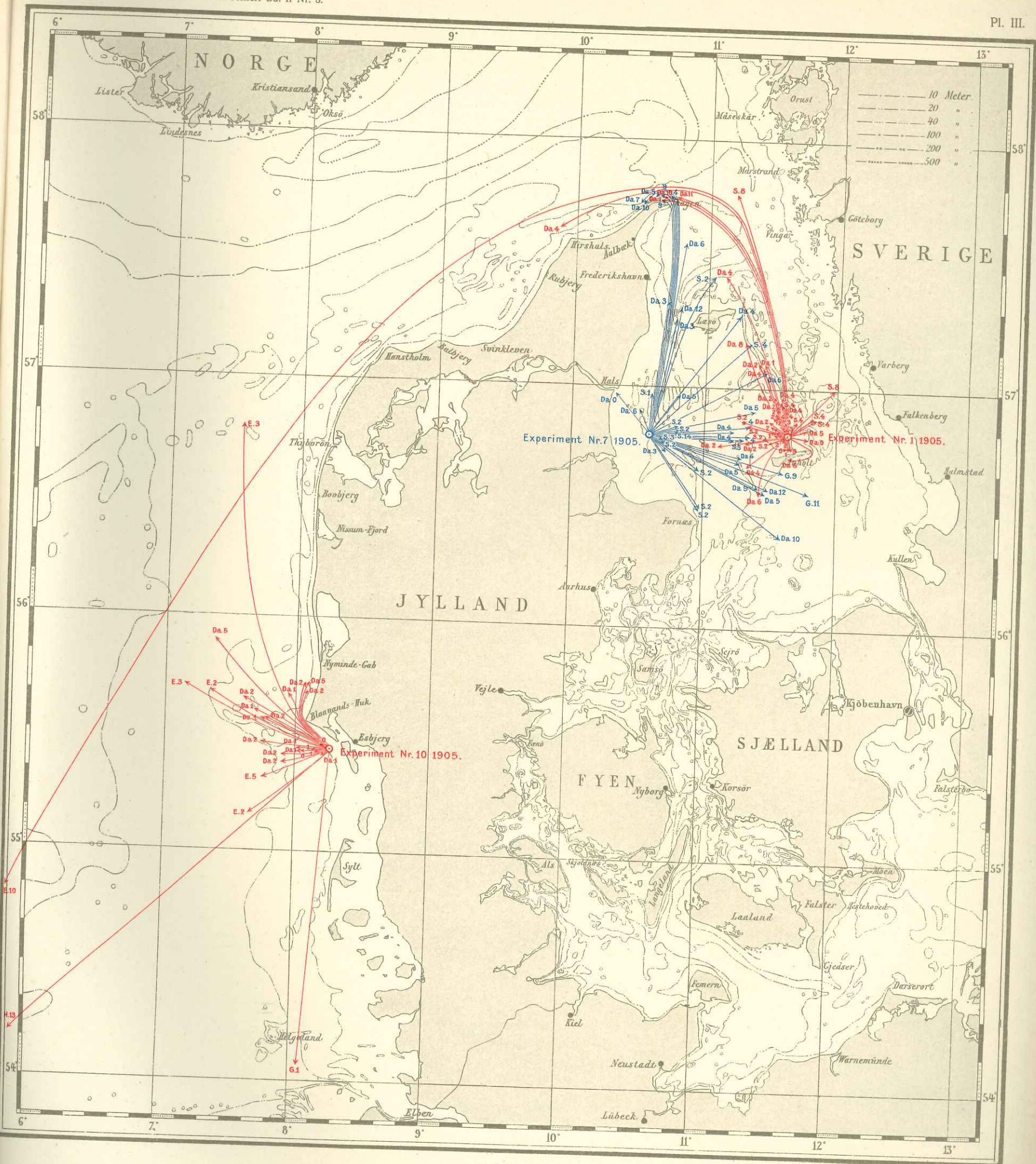


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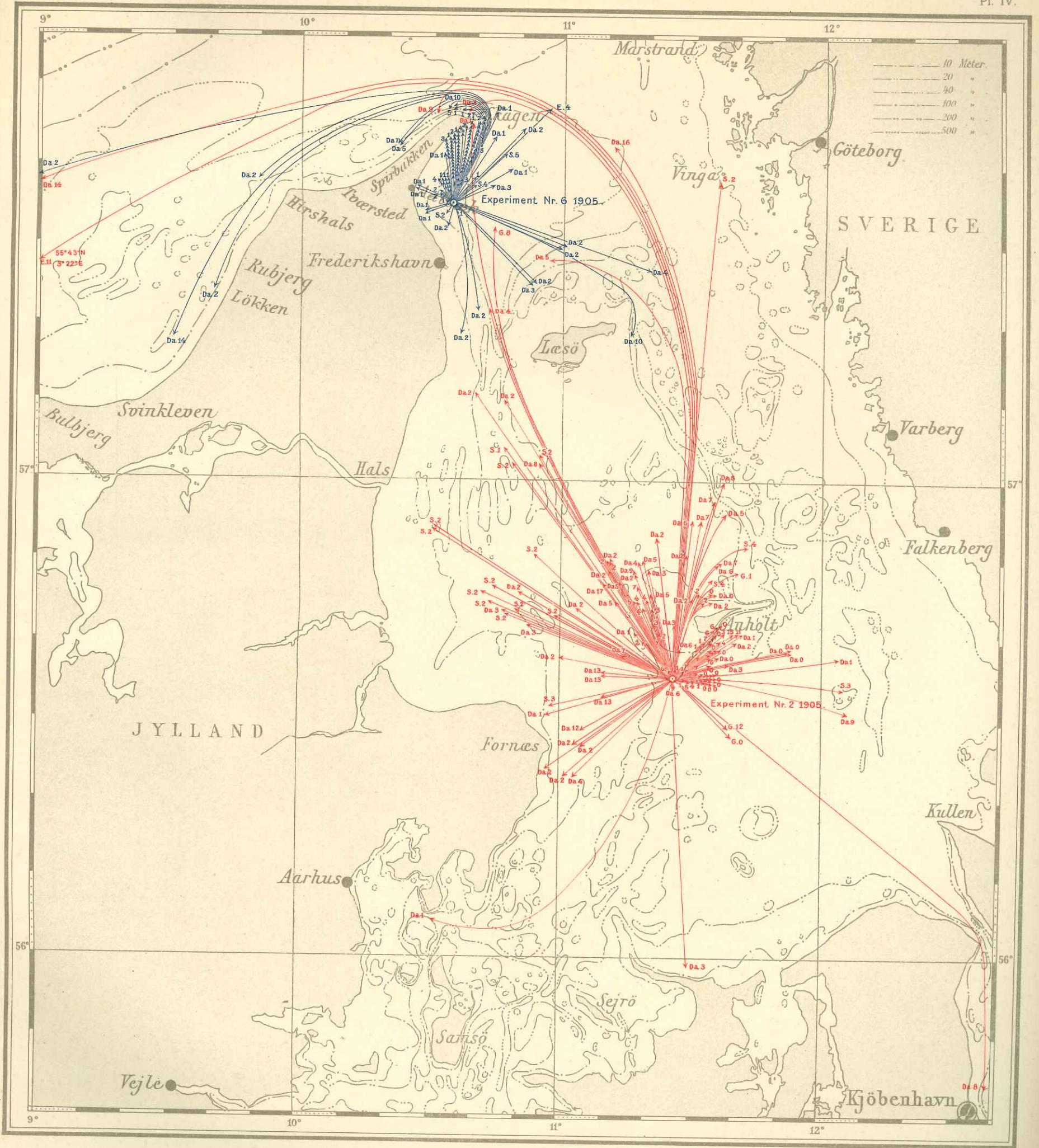


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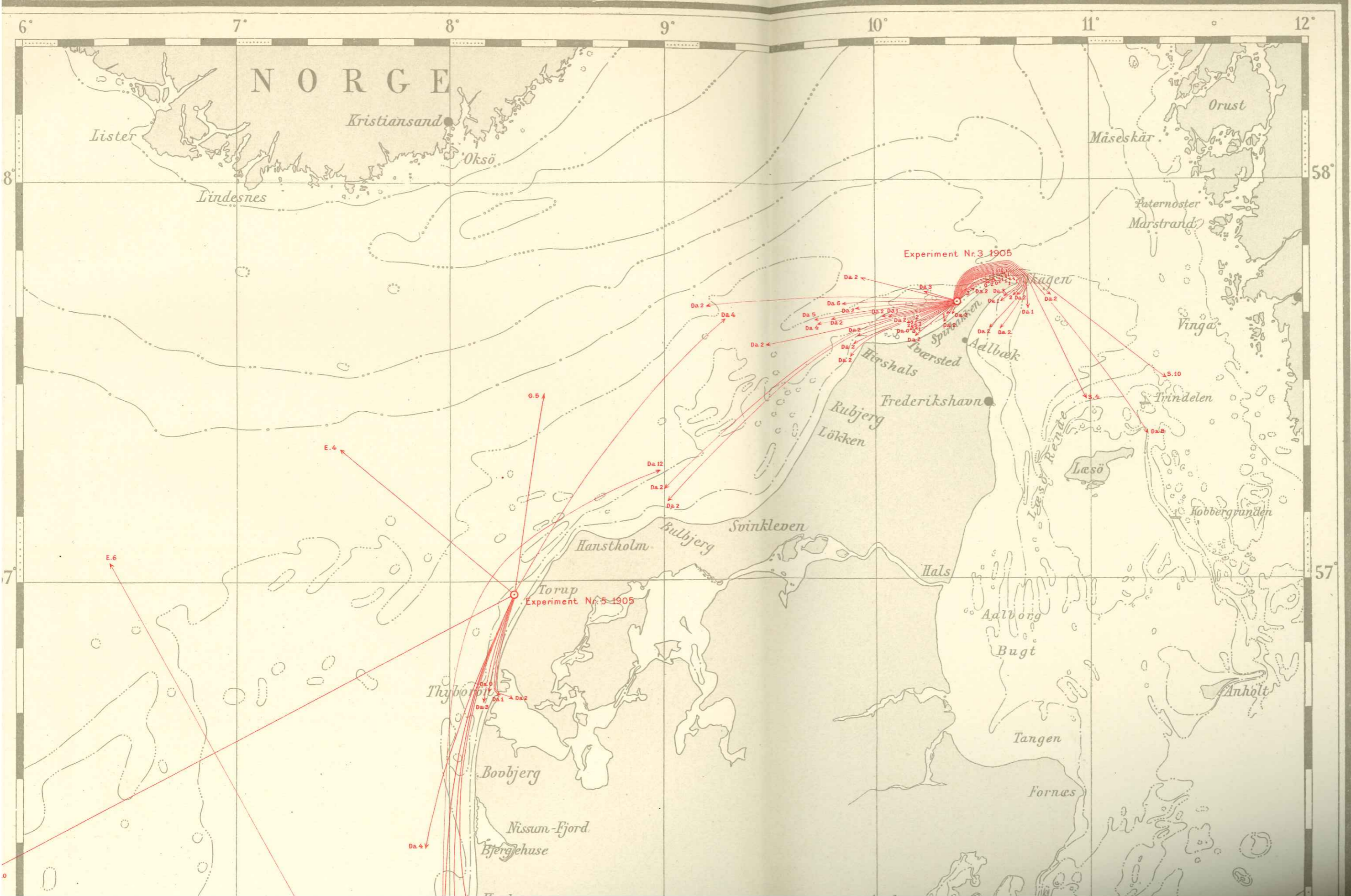




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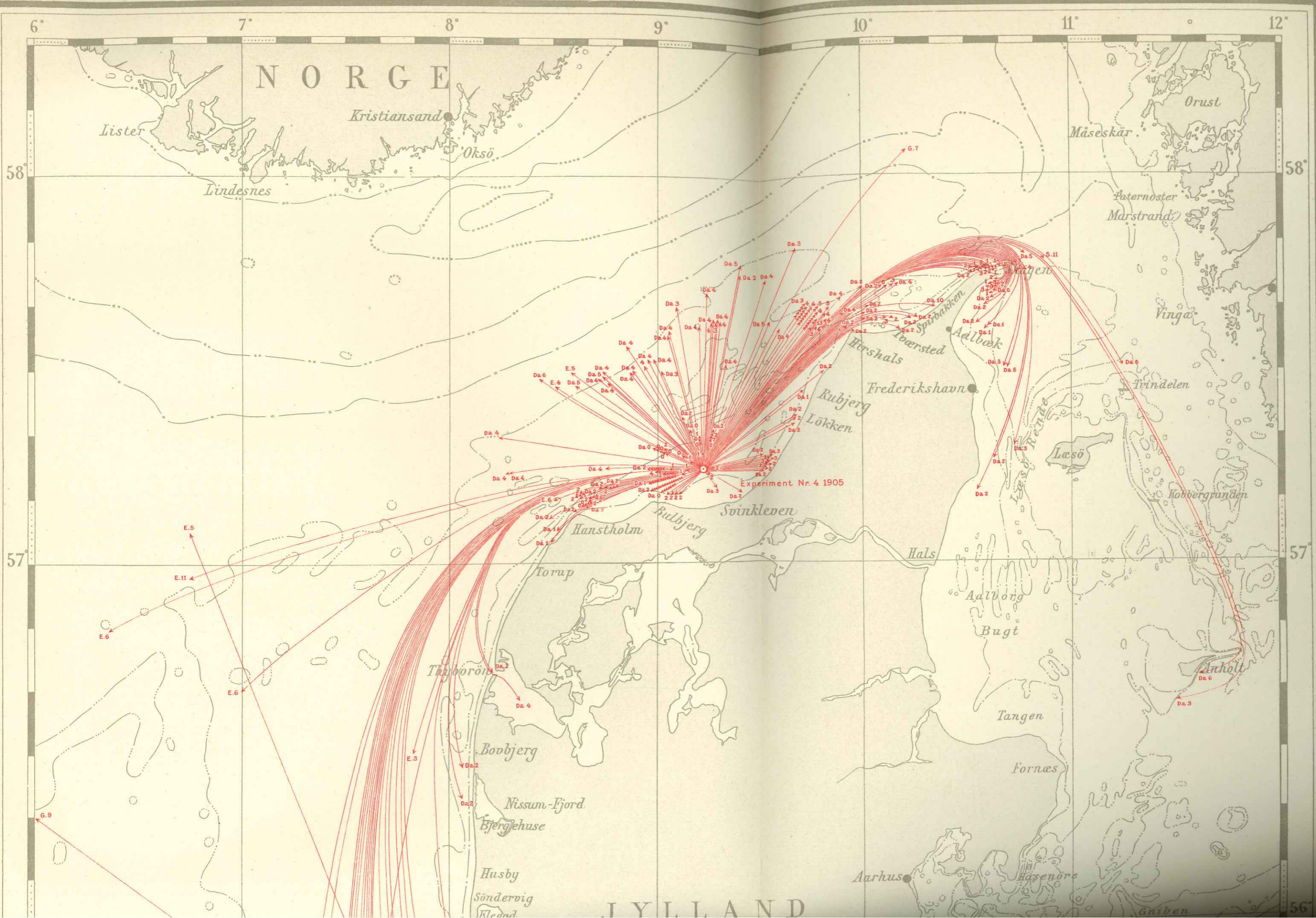




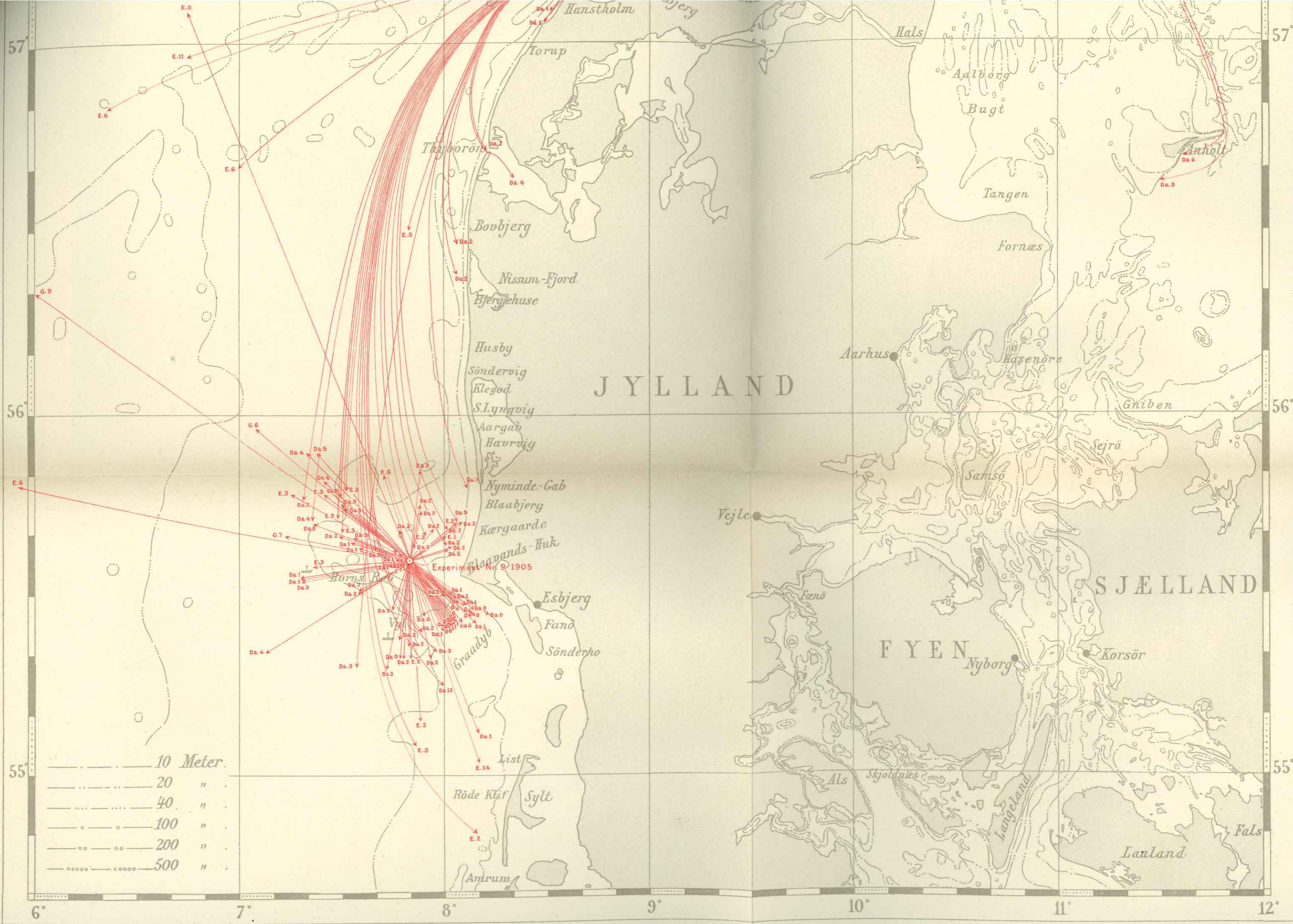
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