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Exploration of the Sea

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ICES HERRING TAGGING EXPERIMENTS IN 1957 AND 1958

by

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I. Preface

It is a pleasure for the Council to present this report on herring tagging experiments in the North Sea in 1957 and 1958. The successful completion of the task is due to the willingness of a number of countries to co-operate and the competence of a large group of experts who have contributed in one way or another.

The plan was supported by the following member countries of the Council:- Denmark, the Federal Republic of Western Germany, the Netherlands, Poland, Sweden, the United Kingdom and the U.S.S.R. Each of these countries contributed 2o.ooo Danish kroner to the tagging scheme of 1957, and they made it possible to continue the plan in 1958 by an additional grant of lo.ooo kroner. Each of these countries has, therefore, alloca' 3o.ooo kroner altogether. Besides this, Norway has supported the plan by placing gear, tags and scientific equipment at free disposal and she did not charge the Council for the invaluable services of Mr. Olav Aasen, who acted as scientist-in-charge throughout the whole period of experiment. Without his skill and experience the plan would have been much more difficult to carry out.

I am pleased to extend my thanks to all the scientists who have been engaged in the tagging scheme and special thanks must be paid to those who have spent their effort in compiling one or more of the preliminary reports which have been distributed to all instances concerned. Besides the members of the Editorial Committee, which is responsible for the present final report, the names of Erik Bertelsen, David Cushing, Gerhard Krefft and Hans Höglund should be mentioned.

Reference must be made to the "History of the Project" in this report and special tribute should be paid to those countries which have placed research vessels at disposal, as mentioned in the report.

It is hoped that the good experience, which has been gained through this international co-operation within the frame of ICES, may encourage similar undertakings in the future when urgent solutions of vital questions are required.

Finally, it should be noted that this report deals only with the internal taggings in 1957 and 1958 and the results obtained through them, and furthermore only for recaptures during the autumn season in the year of tagging. The working up of the data from the external taggings will have to be left until a later date.

Árni Fridriksson

II. Introduction

The socalled "Industrial Fishery" for immature herring on the Bløden Ground began in July 195o[1] when a Danish cutter accidentally found dense concentrations of young herring 6o-1oo n.m. west of Esbjerg (Ref. 9). Since that time this fishery has developed into important industries in Denmark and in the German Federal Republic (Table 1.).

Table 1. Danish (I) and German (II) Landings (1ooo tons) of industrial Herring in Spring (a) and Autumn (b) for the Period 195o-1959. [2]

Year		195o	51	52	53	54	55	56	57	58	59	Total
I	a	o.5	4.8	6.6	6.2	11.o	8.2	19.6	19.5	3o.7	24.3	131.4
	b	4.9	26.7	25.4	42.9	44.8	51.9	57.2	58.7	93.o	84.6	49o.1
II	a	-	-	-	-	-	-	-	-	-	-	-
	b	-	7.2	13.7	25.3	38.4	48.o	24.2	17.1	25.8	4o.5	24o.2
Total	I	5.4	31.5	32.o	49.1	55.8	6o.1	76.8	78.2	123.7	1o8.9	621.5
	II	-	7.2	13.7	25.3	38.4	48.o	24.2	17.1	25.8	4o.5	24o.2
Total	a	o.5	4.8	6.6	6.2	11.o	8.2	19.6	19.5	3o.7	24.3	131.4
	b	4.9	33.9	39.1	68.2	83.2	99.9	81.4	75.8	118.8	125.1	73o.3
Grand Total		5.4	38.7	45.7	74.4	94.2	1o8.1	1o1.o	95.3	149.5	149.4	861.7

The herring is caught by single trawls and pair trawls and is utilized almost exclusively for processing in reduction plants. Typically, there are two fishing seasons: the spring fishery (January-beginning of May) and the autumn fishery (July-October). The fish belong mainly to the I-and II-group herring with average lengths about 15 and 2o cm in spring, while for the autumn the corresponding figures are 19 and 22 cm. Occasionally also O-group and III-group herring are caught. Usually the catches include a small amount of whiting and similar species. The "Bløden herring" is further characterized by having a mean vertebral number of 56.57, while the average number of keeled scales is 14.79 (Ref. 15). Further information on the fishing and composition of the catch are found in Refs. 7, 9, 1o, 11, 12, 13, 14, 15, 16, 18, 19, 2o, and 21.

As a general rule, according to Bertelsen and Popp Madsen (Ref. 7), the herring tend to aggregate in the autumn on the border between water masses of different temperatures, and hence the area of the "Bløden" fishery may be roughly defined as the ground east and north-east of the Dogger Bank covered by bottom water of low temperature.

This rapidly expanding fishery for small herring did not fail to attract attention of the fisheries' authorities and the herring biologists in the various countries participating in the herring fisheries of the North Sea. The crucial question was:-

> To what extent did the "Bløden" fishery for small herring affect the North Sea herring fisheries as a whole?

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1) A Danish fishery for O-group herring had been in progress since 1948.

2) German spring landings insignificant.

When the East Anglian herring fisheries changed character in the 1951 season (Ref. 8), one school of thought maintained that one of the prime causes for the failure was the new industrial fishery for immature herring. The material at hand, however, failed to yield conclusive evidence and the opinions of the scientists differed widely. It was evident that additional data would be needed for solving the riddle.

III. History of the Project

In 1956 a special scientific meeting was called in order to discuss the recent disturbing changes in the herring fisheries of the southern North Sea (Ref. 2). The meeting agreed in a resolution "... to urge all interested countries to participate in a co-ordinated programme ..." including ".... an intensive tagging programme".

The Herring Committee considered this proposal and appointed an ad hoc Committee to draft a general programme of work. The ad hoc Committee submitted a draft (Ref. 1) which was agreed upon by the Herring Committee and passed with a recommendation to the Council (Loc.cit.) and subsequently approved (Loc.cit., p.15/16).

Acting on this decision a group of three nominated experts met in Copenhagen primo November 1956 and made a detailed plan of work for the Bløden Ground taggings with an estimate of expenses. On strength of this the Secretary General of ICES approached the various Governments and seven countries agreed to participate in the scheme.

With the financial support thus secured, the Secretary General in due course convened a meeting of representatives from the participating countries. At this meeting, which took place in Copenhagen medio February 1957, the final administrative decisions were made and ipso facto green light given for the ICES Bløden Ground herring tagging experiments in 1957 (Appendix I).

The details of the further preparations were now placed in the hands of appointed bodies of experts who carried the scheme through with notable success. At the ICES meeting in the fall of 1957 the Herring Committee considered the work done and recommended that the tagging programme of 1957 should be continued in 1958 and that funds be made available for working up the results (Ref. 3). These recommendations were approved by the Council. (Loc.cit., p.23).

Medio December 1957 three experts met in Copenhagen to prepare a preliminary report on the results of the taggings. Copies of this report were circulated to the participating countries by the Secretary General and requests were sent to the various Governments for continued financial support of the tagging work. The response was positive: all the earlier participants approved.

Medio February 1958 two experts and the Secretary General met in Lysekil to discuss the further work. It was agreed in general to adhere to the 1957 plan and that the same experts (with certain amendments) should be trusted with the execution of the experiment which were subsequently carried out successfully.

At the next meeting of ICES in the autumn 1958, the Herring Committee again considered the taggings and praised their value. The general feeling, however, was that a continuation of the work was not called for at the present, but that the work should be continued in the future as requirements demanded (Ref. 4). The Committee recommended further that funds be provided to evaluate the collected material. The Council approved of the Herring Committee's recommendation and this decision brought to a close the first phase of the ICES herring tagging experiments at Bløden Ground save for the working up of results.

In the middle of May 1959 a group of four experts met in Copenhagen and prepared a preliminary report on the results from the 1958 taggings. Copies of this report were circulated to the participating countries. The whole tagging scheme was reconsidered at the next meeting of ICES in October 1959, and the Herring Committee recommended that a draft for a final report should be prepared for the following meeting and that funds be made available for this work (Ref. 5). The Council agreed to this procedure (Loc.cit., p.43) and a group of five experts were summoned by the Secretary General to meet in Copenhagen medio May 196o. The content of the present paper is the result of the work of this group, which is mainly based on the five preliminary reports presented to the Herring Committee at the various stages of the project by varying groups of experts. In Appendix 2 the names of the scientists participating in the field work are shown.

IV. The Taggings

a) 1957

In the plan of work drawn up by the expert meeting in Copenhagen November 1956 (page 4) it was recommended that: "It would be most welcome if national research programmes covered additional work in the area". This recommendation was seconded by the meeting of Delegates (Appendix 1) and consequently the participating countries were approached by the naturalist-in-charge asking if research ships could be expected to work in the Bløden Ground area during the tagging experiments. Denmark and the United Kingdom replied in the affirmative, and this provided an opportunity to carry out a pre-tagging survey for bottom temperatures and fish traces. The survey was carried out by R/S "Jens Væver" from 16th to 24th of July in the northern half, and by R/S "Platessa" from 18th to 23rd of July in the southern half. The dividing line of latitude was 55°15'N. The combined results were charted and used as a basis for planning the first stages of the tagging work (Figure 1).

Tags were released from four ships:-

1. The chartered purse-seiner M/S "Rygrunn" from Norway

24th July to 19th August. As the herring only left the bottom at night, it was found necessary to concentrate the dispersed shoals with the use of strong search-lights. Only 8 nights were the weather and tidal conditions reasonable (Figure 3), and in all 5 shots were made, 3 of which provided herring of suitable size for tagging. On the other 2 occasions only O-group herring was caught.

2. The research ship R/S "Jens Væver" from Denmark

16th July to 14th August. After the pre-tagging survey was completed this ship was primarily used as a scout ship, her job being to locate and identify echo-traces in the north-eastern part of the area.

3. The research ship R/S "Sir Lancelot" from England

loth to 26th August. This ship was used to survey the southern half of the area, locating and identifying echo-traces. After M/S "Rygrunn" left the Bløden Ground, internal and external tagging was carried out on trawl-caught fish.

4. The research ship R/S "Clupea" from Scotland

7th to 27th August. R/S "Clupea" was used to survey the north-western part of the area. After M/S "Rygrunn" left the Bløden Ground, internal and external tagging was carried out on trawl-caught fish.

A grand total of 14.519 tagged herring were released in 28 different liberations. In Table 2 the total number of tags, external and internal, released from each ship, is shown.

Table 2. Tag Release, 1957. Types of Tags:-

(I) internal
(L) Lea
(D) Danish Lea
(H) Hodgson
(S) Scottish combination.

Fishing gear :- (P) purse-seine, (T) trawl, (N) drift-net.

Ships	I		L		D	H	S		Total
	P	T	P	T	P	P	N	T	
M/S "Rygrunn"	993o	-	-	-	-	-	-	-	993o
R/S "Jens Væver"	-	5o	51	-	74	-	-	-	175
R/S "Lancelot"	-	1739	12	177	-	379	-	-	23o7
R/S "Clupea"	-	592	-	119	-	-	96	13oo	21o7
T o t a l	993o	2381	63	296	74	379	96	13oo	14519

The details of positions, dates of liberations, types of tags, fishing gear and serial numbers are given in Appendix 3. It should be mentioned that herring released at the same position and at the same date are given the same liberation number (for each ship) although the fish were released in smaller batches and to a large extent even individually.

b. 1958

From the 1957 experiments could be drawn two important conclusions with bearing on the planning of the 1958 experiment: firstly, the tagged herring did only slowly disperse from the tagging positions, or, in other words, the herring concentrations were rather stationary. Secondly, the total recovery percentage of purse-seine caught internally tagged fish were 3.5 against o.3 for the internally tagged trawl-caught fish, i.e., the tagged purse-seine caught herring had more than ten times better prospect for surviving the tagging operation than the trawl-caught one.

This second circumstance ruled out tagging of trawl-caught herring for the 1958 experiment. The purse-seiner M/S "Rygrunn" were again chartered for providing live material, and during the experiments only purse-seine caught fish were used. The first conclusion led to place more importance on the pre-tagging survey, strengthened by experimental trawling to establish the size composition of the shoals and thus avoiding areas with fish unsuitable for tagging which partly spoiled opportunity for work in 1957. Realizing the importance of the pre-tagging survey for the execution of the experiments, the participating countries placed five research ships at disposal

for the survey work. The Bløden Ground was divided into four sub-areas allotted to the five participating vessels as shown below[1]):-

"Michael Siedlecki II" (Poland)	"Jens Væver" (Denmark) "Sir Lancelot" (England)
55°35'N	
"Clupea" (Scotland) "Sir Lancelot" (England)	"Willem Beuckelsz" (Netherlands)
4°5o'E	

Lines of survey were worked with echo-sounder and hydrographic stations were placed at every lo mile. Radio contact was established twice a day.

The distribution of bottom temperatures is shown in Figure 2. In the beginning of the week of survey, the temperatures in the north-eastern part of the area were rather below normal, the conditions being, however, very instable. The survey was not favoured with good weather conditions and the wind force was 4-8. The turbulence caused by the wind was strong enough to mix the water column in the eastern part of the area, so by the end of the survey the temperature conditions were about normal as compared with former years. The discontinuity layer present over most of the area was observed in 2o-25 m depth.

The very good fishery during spring 1958 gave reason to believe that the stock of young herring was bigger than that of 1957. This was supported by the results of the pre-tagging survey. As shown on Figure 2, echo-traces were found over a very wide area. In general, the herring shoals were standing rather light on the bottom, so research trawlings were not entirely successful. This, however, is a well-known feature in the beginning of the herring season, especially when the bottom temperature undergoes rapid changes due to strong winds.

Following the pre-tagging survey the participating ships (except R/S "Clupea") met in Esbjerg together with M/S "Rygrunn" and R/S "Skagerak" on the 4th of August in order to prepare charts for the tagging ships, which were supplied with charts showing bottom temperatures and herring concentrations in the area. These charts proved very useful at least in the first fortnight when there was little difficulty in finding the herring in the localities where it was supposed to be found (Figure 2).

Tags were released from three ships:-

1. The chartered purse-seiner M/S "Rygrunn"

6th to 29th August. As in the previous summer fishing took place only in the night and the shoals were concentrated by means of strong search-lights. The weather was much more favourable than in the preceding year (see Figure 4) and in all seven successful shots were made. Only internal taggings were carried out on this ship.

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1) Co-ordinator:- the cruise-leader on the Danish ship.

2. The research ship R/S "Skagerak" from Sweden

6th to 29th August. Since only purse-seine caught live material was to be used, R/S "Skagerak" scouted for herring alongside M/S "Rygrunn" between the taggings and regular temperature measurements were performed. Batches of herring from the shots were transferred in keep nets from the seiner. Mainly externally tagged herring were released from R/S "Skagerak".

3. The research ship R/S "Sir Lancelot" from England

6th to 12th August. This ship was also used as a scout ship between the taggings which were performed on herring transported in keep nets from M/S "Rygrunn". Only externally tagged fish were released.

A grand total of 12579 tagged herring were released on seven different localities. In Table 3 the total number of tags released from each ship is shown.

Table 3. Tag Release in 1958.
Types of tags:- (I) internal
(L) Lea
(D) Danish Lea
(B) Bolster
Fishing gear: purse-seine throughout

Ships	I	L	D	B	T o t a l
M/S "Rygrunn"	6898	-	-	-	6898
R/S "Skagerak"	999	33oo	1oo	62	4461
R/S "Sir Lancelot"	-	122o	-	-	122o
T o t a l	7897	452o	1oo	62	12579

The details of positions, dates of liberations, types of tags, fishing gear, and serial numbers are given in Appendix 4.

V. Collection of Statistics

Bløden Ground 1957 and 1958

a) Danish Catch and Effort Statistics

With the herring tagging experiments in view a Danish collection of detailed statistics on catch and effort of the industrial fishery in the North Sea was started in June 1957. The work was organized by the head of the Danish Fishery Statistical Department, Mr. S.N.Sørensen. The basic information on gear, position and numbers and average duration of hauls are obtained from the fishing skippers by fishery control officers in all main landing ports. Further details on size and composition of each landing are found in the factory files. The information are compiled by the statistical department of the Ministry of Fisheries in a punch card system where all relevant data are summarized by landing port, gear, week, and statistical rectangle (c. 15 x 15 n.m.).

In the preliminary analysis of the tagging results it was found that only in Esbjerg had the number of returns reached a sufficiently high level to be of use in estimating the effect of the fishery upon the stock of young herring. Consequently, the following remarks on the further treatment of the catch and effort statistics refer especially to Esbjerg, but the methods described also apply to statistical material collected in other Danish ports.

Two problems arise in connexion with the further treatment of the material:-

1) The information (reported landings) only cover a varying part of the total catch due to the restricted amount of personnel available for this special task. It is, therefore, necessary to calculate raising factors week by week to convert reported catch and effort to totals.

2) The Danish fishery is carried out by single and pair trawling, the latter being the more important. The fraction of the total catch covered by the reported catch is different for the two methods of fishing, and raising factors have to be calculated separately. There is further a difference in fishing power between single and pair trawlers. As unit of effort is chosen one hour of pair trawling which requires a conversion factor to convert the effort of single trawlers into that of pair trawlers.

The cover fraction (reported catch/total catch) is different for the two methods of fishing because no information on a single trawler will be obtained if the skipper is not interviewed, while only one of the two skippers from a pair trawling team needs to be interviewed to obtain information on both ships. Prior to July 1958 no information were available concerning the total catch landed by single and pair trawlers, respectively. Consequently, it was not possible to calculate separate raising factors (total catch/reported catch) directly.

If, however, we assume that the skippers interviewed are chosen at random and the landing capacities of boats engaged in single and pair trawling are of the same order of size, then the following theoretical approach is possible.

If the probability of getting an interview with a skipper from a single trawler is equal to the cover fraction (reported catch/total catch) of single trawlers, and the probability of getting information on a pair trawler team likewise is expressed by the cover fraction of pair trawlers, then

$$d_p = d_s \, (2 \div d_s) \qquad (1)$$

where d_s = cover fraction of single trawlers

d_p = cover fraction of pair trawlers

Using the following notation:

C = total catch
c = total reported catch
s = reported catch of single trawlers
p = reported catch of pair trawlers
$d_c = \frac{c}{C}$ = fraction of total catch covered by total reported catch

we have

$$d_c = \frac{s + p}{\frac{s}{d_s} + \frac{p}{d_p}}$$

and by introducing (1)

$$d_s = \frac{s}{2C} + 1 \div \sqrt{\left(\frac{s}{2C}\right)^2 + 1} \div d_c \qquad (2)$$

From (1) and (2) the required raising factors for single and pair trawlers respectively are found as the reciprocals of the calculated cover fractions d_s and d_p .

Since July 1958 it is possible to divide the total catch on single and pair trawlers, respectively, and so obtain independent raising factors for each. It is further possible to compare values calculated from formulas (1) and (2) with the actual cover fractions. This was done on material from the autumn season 1958 and, as shown by Figure 5, there is sufficient agreement between the calculated and actual cover fractions to justify the use of the indirect method outlined above. The statistics from autumn 1957 and spring 1958 are treated accordingly, and it must be noted here that the stock assessment of the autumn of 1957 arrived at in the present final report is based on the total effort of both single and pair trawlers. In the preliminary report, Part III, committed to the Council in 1958, the stock assessment was based on the effort of pair trawlers only.

The total effort of pair trawlers is estimated directly by applying the raising factors calculated from the catch figures to the reported effort.

The total effort of single trawlers is calculated by applying the single trawler raising factor to the reported effort, and converted into hours of pair trawling by the following conversion factor:-

av.catch per one hour's single trawling/av. catch per one hour's pair trawling.

The conversion factor is calculated for each season by summarizing the reported catch and effort for single and pair trawlers, respectively, using only statistical rectangles where both methods are used at the same time during the six or seven best weeks of fishing.

The following conversion factors were found:-

Autumn 1957. One hour's single trawling = o.432 x one hour's pair trawling

Spring 1958. One hour's single trawling = o.424 x one hour's pair trawling

Autumn 1958. One hour's single trawling = o.567 x one hour's pair trawling

The distribution of the effort per week is shown in Appendices 5 and 6, while total catch and effort figures are found in Tables 4,5, and 6.

Table 4. Total Catch and Effort per Week. Esbjerg. Autumn 1957.

Week no.	Dates	Total Catch ('ooo kg)	Total Effort (pair trawling hours)
29	14/7 - 2o/7	3,4o9	2,444
3o	21/7 - 27/7	2,5o9	2,292
31	28/7 - 3/8	3,466	2,22o
32	4/8 - 1o/8	4,733	4,387
33	11/8 - 17/8	2,o63	2,111
34	18/8 - 24/8	4,31o	2,783
35	25/8 - 31/8	2,14o	2,115
36	1/9 - 7/9	4,o61	3,284
37	8/9 - 14/9	1,545	1,317
38	15/9 - 21/9	195	174
39	22/9 - 28/9	4,913	3,o32
4o	29/9 - 5/1o	2,26o	2,343
41	6/1o - 12/1o	1,oo4	1,322
42	13/1o- 19/1o	2,214	2,9o5
43	2o/1o - 26/1o	197	223
44	27/1o - 3/11	1o8	67
47	17/11 - 23/11	2,125	2,589
T o t a l		41,252	35,6o8

Average catch per hour:- 1,159 kg.

Table 5. Total Catch and Effort per Week. Esbjerg - Spring 1958.

Week no.	Dates	Total Catch ('ooo kg)	Total Effort (pair trawling hours)
6	2/2 - 8/2	2,221	1,725
9	23/2-1/3	2,416	1,476
1o	2/3 - 8/3	3,o54	1,564
11	9/3 - 15/3	2,533	2,o34
12	16/3-22/3	3,158	2,225
13	23/3-29/3	3,514	3,21o
14	3o/3-5/4	759	54o
16	13/4-19/4	2,876	2,o35
17	2o/4-26/4	1,oo7	787
18	27/4-3/5	2,774	1,898
T o t a l		24,312	17,494

Average catch per hour:- 1,39o kg.

Table 6. Total Catch and Effort per Week. Esbjerg. Autumn 1958.

Week no.	Dates	Total Catch ('ooo kg)	Total Effort (pair trawling hours)
3o	2o/7 - 26/7	166	197
31	27/7 - 2/8	616	1,o78
32	3/8 - 9/8	3,9oo	2,692
33	1o/8 - 16/8	7,614	4,14o
34	17/8 - 23/8	4,996	2,596
35	24/8 - 3o/8	7,245	4,o87
36	31/8 - 6/9	7,o37	3,569
37	7/9 - 13/9	8,oo7	3,786
38	14/9 - 2o/9	7,512	4,569
39	21/9 - 27/9	3,348	2,284
4o	28/9 - 4/1o	1,366	857
41	5/1o - 11/1o	4,3oo	2,553
42	12/1o - 18/1o	717	435
43	19/1o - 25/1o	1,o78	4o1
44	26/1o - 1/11	4,965	2,728
45	2/11 - 8/11	4,981	2,52o
46	9/11 - 15/11	1,683	9o2
47	16/11 - 22/11	2,628	1,7o8
48	23/11 - 29/11	1,7o1	1,192
T o t a l		73,86o	42,294

Average Catch per hour:- 1,746 kg.

b.German Catch and Effort Statistics

According to the international programme a series of provisions were made in 1957 and 1958 in advance of the tagging experiments to obtain the collaboration of the fishermen as well as the managers and workers of the fish meal factories. Several meetings were arranged at which the purpose and performance of the experiment were discussed. The written instructions together with the statistical forms were distributed to the fish meal factories by kind mediation of the "Verband Deutscher Fischmehl- und Fischölfabriken e.V." and to the fishermen by the "Deutscher Fischereiverband e.V." and the fisheries co-operatives. Each reduction plant was asked to support the experiment and was provided with posters and cards for returned tags and information. Furthermore, repeated references to the tagging experiment were given in the press and broadcasting. The whole preparatory work and the collection of statistics has been organized by Dr. G.Krefft, Hamburg, German member of the ICES tagging group. The local arrangements, especially the efficiency tests for magnets in the reduction plants, were made by the local governmental biologists, Dr. C.H.Brandes, Bremerhaven, and Dr. H.Kühl, Cuxhaven, did most of this work.

Industrial herrings caught by German cutters are landed at only 4 ports, nearly all in Cuxhaven and Bremerhaven, but the ports of Hamburg and Büsum are sometimes also supplied. Thus the collection of the statistics on the catches and fishing effort as well as on the deliveries at the reduction plants could be concentrated at the two main ports. The German landings given in Table 7 comprise an unknown amount of industrial herring caught outside the Bløden area, mainly west of the Dogger Bank. On the other hand, some unimportant catches of herring made during tunny and sprat fishing are not included here. The best estimate of industrial herring landings from the true Bløden Ground may be taken for 1957 and 1958 from the data on herring reduction in the fish meal factories given in Tables 7 and 8.

In 1957 it was possible to obtain data on deliveries of industrial herring each week at nearly all factories in Cuxhaven, Bremerhaven and Büsum from the daily statistics of these plants (Table 7). Data on the number of cutters landing each week were also available, at least for Cuxhaven. Unfortunately, in 1957 the first attempt to build up detailed statistics on the catches of the oil herring cutters and their corresponding effort by rectangles did not result in data sufficient for any assessments.

The 1957 season of the German cutters started at the end of June, week 27, in the Coffee Soil area (square K 11). During July this fishery was mainly carried out at the N-Schill-Ground (square K 9), whereas during August fishing was going on in the squares I 9, K 9, and primarily G, H, I 8 (see Figure 6) At the beginning of September, about week 37, the German fleet shifted to fishing grounds further west and outside the Bløden area as Silver Pit, SW-Pit, Bruceys Garden and Shields-Blyth, where preponderantly adult herrings were caught. The proper oil herring fishery for juvenile herrings in the Bløden Ground in 1957 had ceased by the 5th of September. The total landings of about 13,5oo t were low compared with the landings of the preceding years. This is mainly due to the very bad weather conditions in 1957, and partly to the minor participation of German cutters in this fishery during this year.

In 1958 the statistics for the fish meal factories were collected in the same manner as in 1957. From the data on the daily processed quantities and number of landings in each reduction plant the weekly review given in Table 8 was prepared. The catch and effort statistics in this year were collected by the State Fishery Office of Bremen and Niedersachsen acting as fishery control authority in Bremerhaven and Cuxhaven. This proceeding proved to be suitable, so that these statistics could be prepared better than in the preceding year. The data on the reported catches and numbers of landings split up by landing harbours, weeks, and fishing gear, are also given in Table 8. The distribution of effort for each week per square 3o x 3o n.m. (statistical rectangles of ICES) is shown in Appendix 6.

In doing this, some conversions had to be made. Most of the German cutters are engaged in pair trawling. Of the reported catches 88.8 % were made by pair trawling. As the trawling with a single boat is only of minor importance, and the total amount of herring delivered each week in the factories is not statistically sub-divided by landings of single and pair trawlers, it was decided to combine the data for both types of gear. Thus, the effort of the single trawlers had to be corrected, because German investigations have shown that the pair trawlers per boat are fishing about 11 % more effectively than the single trawlers. As unit of effort for the calculations, hauls of pair trawlers were used. The formula used for the conversion of the single trawlers' effort to that of pair trawlers was:- 1 single trawler haul = o.445 double trawler haul. The reported pair trawler effort for each week was then combined with the corresponding corrected single

trawler effort. The total effort of the vessels from Cuxhaven and Bremerhaven was estimated by raising the reported effort for each harbour and each week by the ratio: total catch/reported catch. It was found that there were no differences in the fishing areas of the cutters from the two harbours. Therefore, the total German effort was estimated by adding the raised effort data for each harbour.

The proper 1958 season of the German industrial herring fishery, beginning at the end of June and ceasing not before the first week of November lasted much longer than the season in the preceding year. The total landings from the Bløden area amounting to nearly 25,4oo t were much bigger than in 1957. The better results were partly due to the more favourable weather conditions, but mainly to the strong increase in the catch per unit effort, the average of which was 19.4 t per trip in 1957 and 29.8 t in 1958. (In 1959 the mean catch per trip of the German vessels further increased to 32.5 t (Ref. 13)). Dealing with the fishing on the stock of Bløden herring it has to be considered that also in 1958 a substantial part of the landings, especially of those landed during the weeks 36-38, came from outside the Bløden area, mainly from the Middle Rough. According to investigations made on board the FRS "Anton Dohrn" the dense schools of immature herring found in October 1958 in that area did certainly not belong to the same stock as the immatures from the Bløden Ground as they were quite different in composition and meristic characters.

Table 7. Landings of the Industrial Herring Fishery from the Bløden Ground Area to the Fish Meal Factories in Germany in 1957

A. Bremerhaven

Week	Dates	Landings (t)	No. of Landings cutters [1]
27	3o/6 - 6/7	9o.o	(+)
28	7/7 - 13/7	484.7	(1o)
29	14/7 - 2o/7	532.1	(12)
3o	21/7 - 27/7	566.9	(18)
31	28/7 - 3/8	118.2	(8)
32	4/8 - 1o/8	1,46o.7	(24)
33	11/8 - 17/8	459.o	(6)
34	18/8 - 24/8	767.2	(22)
35	25/8 - 31/8	437.o	(11)
36	1/9 - 7/9	13o o	(3)
Grand Total		5,o45.8	(114)

1) not fully recorded.

B. Cuxhaven

Week	Dates	Landings (t)	No. of Landings cutters
27	3o/6 - 6/7	91.o	6
28	7/7 - 13/7	1,o74.9	61
29	14/7 - 2o/7	5o1.9	28
3o	21/7 - 27/7	1,o42.1	5o
31	28/7 - 3/8	226.7	14
32	4/8 - 1o/8	2,o74.4	89
33	11/8 - 17/8	667.3	52
34	18/8 - 24/8	1,56o.3	74
35	25/8 - 31/8	3o5.1	18
36	1/9 - 7/9	172.3	7
Grand Total		7,716.o	399

C. Hamburg

No landings.

D. Büsum

Week	Dates	Landings (t)	No. of Landings cutters
27	3o/6 - 6/7	-	
28	7/7 - 13/7	-	
29	14/7 - 2o/7	31.o	
3o	21/7 - 27/7	144.o	
31	28/7 - 3/8	-	
32	4/8 - 1o/8	169.o	
33	11/8 - 17/8	116.o	
34	18/8 - 24/8	74.o	
35	25/8 - 31/8	57.o	
36	1/9 - 7/9	-	
Grand Total		591.o	

Not recorded

Grand Total of landings in all ports (A + B + C + D) = 13,352.8 tons

Table 8. Landings of the Industrial Herring Fishery from the Bløden Ground Area to the Fish Meal Factories in Germany and Catches Reported from the German Ships in 1958.

(Data in Brackets: no. of reporting ships)

A. Bremerhaven

Week	Dates	Landings to Factories		Catches reported from Ships	
		Landings (t)	No. of Landings cutters	Single Trawlers (t)	Pair Trawlers (t)
28	6/7 - 12/7	71.4	4	-	71.4
29	13/7 - 19/7	-	-	-	95.5
3o	2o/7 - 26/7	323.1	13	12.9	2o9.1
31	27/7 - 2/8	-	-	-	187.9
32	3/8 - 9/8	295.4	14	-	259.5
33	1o/8 - 16/8	893.8	28	-	72o.6
34	17/8 - 23/8	7oo.7	18	79.5	1,o44.5
35	24/8 - 3o/8	951.4	22	25.7	917.7
36	31/8 - 6/9	1,oo2.1	3o	28.1	75o.6
37	7/9 - 13/9	982.2	22	56.2	1,236.6
38	14/9 - 2o/9	1,578.7	33	5.o	1,114.9
39	21/9 - 27/9	71o.6	16	-	331.8
4o	28/9 - 4/1o	193.1	8	9.o	891.7
41	5/1o - 11/1o	898.6	27	2o.7	2o6.8
42	12/1o - 18/1o	334.8	16	-	194.o
43	19/1o - 25/1o	-	-	21.2	286.3
44	26/1o - 1/11	274.3	6	-	-
45	2/11 - 8/11	4.1	1	-	-
Grand Total		9,214.3	258	258.3(14)	8,518.9 (234)

Grand Total of catches reported from ships:- 8,777.2 tons = 95.3 % of total landings.
Total number of reporting ships 248 = 96.1 % of number of landings.

B. Cuxhaven

Week	Dates	Landings to Factories: Landings (t)	Landings to Factories: No. of Landings cutters	Catches reported from Ships: Single Trawlers (t)	Catches reported from Ships: Pair Trawlers (t)
28	6/7 - 12/7	43.o	2	-	45.o
29	13/7 - 19/7	-	-	-	1o2.5
3o	2o/7 - 26/7	346.o	2o	-	141.o
31	27/7 - 2/8	115.o	7	-	243.o
32	3/8 - 9/8	5oo.o	29	3.o	339.6
33	1o/8 - 16/8	1,691.o	5o	136.o	655.5
34	17/8 - 23/8	1,132.o	42	85.o	1,424.o
35	24/8 - 3o/8	1,77o.o	51	113.o	1,o57.3
36	31/8 - 6/9	1,83o.o	57	2o7.o	57o.6
37	7/9 - 13/9	2,32o.o	68	336.o	1,4oo.o
38	14/9 - 2o/9	2,248.o	57	651.o	1,29o.o
39	21/9 - 27/9	1,178.o	4o	15.o	95.o
4o	28/9 - 4/1o	632.o	27	166.o	583.o
41	5/1o - 11/1o	948.o	35	73.o	134.5
42	12/1o - 18/1o	387.o	21	-	45.o
43	19/1o - 25/1o	3.o	1	-	-
44	26/1o - 1/11	42.o	1	-	-
45	2/11 - 8/11	72.o	4	-	-
46	9/11 - 15/11	7.o	1	-	-
47	16/11 - 22/11	-	-	-	-
48	23/11 - 29/11	47.o	1	-	-
Grand Total		15,311.o	514	1,785.o(62)	8,126.o(252)

Grand Total of catches reported from ships:- 9,911.o tons = 64.7 % of total landings.
Total number of reporting ships 314 = 61.1 % of number of landings.

C. Hamburg

Month	Landings to Factories: Landings (t)	Landings to Factories: No. of Landings cutters	Catches reported from Ships: Single Trawlers (t)	Catches reported from Ships: Pair Trawlers (t)
August	2o6.7	8	-	-
September	368.o	2o	-	-
October	28o.4	1o	-	-
Grand Total	855.1	38	- (-)	- (-)

D. Büsum. No landings.

All ports (A - D):-

Total landings to A - D = 25,38o.5 tons
Total reported catches = 18,688.2 tons = 73.6 %
Total no. of landings A - D = 81o cutters
Total no. of reporting ships = 562 (cutters) = 69.4 %

VI. The Returns

a) Tagging Mortality

Obviously it is impossible to guarantee that all fish tagged survive the shock of being tagged. At the same time it was equally impossible to measure such mortality directly. The recovery of two tags in the stomach of whiting suggests that one form of tagging mortality during the Bløden experiment was due to predators while the herring are recovering from the shock of marking and are less active. In fact, considering how slight must be the chances of finding a tag in the stomach while gutting a whiting, this form of mortality might well be considerable. If it does occur it probably would be higher among those fish kept longest in the live nets.

In Appendix 7 the total recaptures from each liberation have been summarized according to the tagging team and the time between capture and tagging. For the latter, the fish tagged by each team have been divided into ten groups:- group 1 are the first fish tagged, group 1o the last, up to five hours after group 1. It will be seen that especially for the 1958 experiment there are big differences in recaptures both between tagging teams and between groups of fish. In all 1958 liberations the highest percentage of recaptures was from team 1, though the ratio of recaptures from the different teams was not the same in all experiments. There were also more returns from the fish tagged earlier in each liberation (groups 1-5) than those for which there was some delay in tagging (6-1o), though again the differences varied from liberation to liberation, being greatest for liberation I.

For the 1957 experiment there was no significant difference between fish kept for different length of time, though there are differences between tagging teams. These latter are not so clear as in 1958, because the same tagging teams were not maintained from one experiment to another.

It is reasonable to assume that these differences are due to losses at tagging, either because of bad handling, incorrect placing of the tag in the body cavity (causing death or loss of tag), or loss of condition while in the keep net. All these factors will reduce the effective number of fish tagged.

While it is impossible to determine the extent of these losses, some estimates, which will make some correction for the effects, can be made. For the 1957 experiment no correction is made for the time between capture and tagging, but it will be assumed that the differences between the best team for any one liberation, and the other teams are due to mortality or loss of tags, so that the effective number of fish tagged will be as given below:-

Liberation	I	II	III
% returned by best team (A)	7.2	9.2	2.7
Total tags returned (B)	215	162	82
Effective no. tagged B/A x 1oo	3ooo	176o	3ooo

For the 1958 experiment team 1 is taken as standard, except for liberation S VI. In Figure 7 the returns of this team have been plotted against time between capture and tagging. These points show a very close relation, and the line fitted by least squares has been plotted. The intercept on the y-axis (= 23.5) may be taken as a fair estimate of the returns to be expected from a group of fish tagged with no delay at all between capture and tagging. Thus the returns to be expected

if there was no delay for any of the 10 groups of fish is 235, compared with an observed total of 172; the "expected" returns of fish tagged by team 1 are therefore 235/172 = 1.366 times the observed number.

A different formula has to be used for liberation S VI, in which team 1 did not participate. For this liberation team 3 has been taken as standard, and the"efficiency" of this team estimated from percentage returns of teams 1 and 3 from all other liberations, viz. for team 1, 2100 fish tagged, 172 recaptures = 8.19 %, for team 3, 2300 fish tagged, 124 recaptures = 5.39 %. From team 3's liberations in liberation S VI 40 % were returned; this is, therefore, equivalent to 4.0 x 8.19/5.39 = 6.08 % from team 1, or 6.08 x 1.366 % = 8,305 % corrected for delay in tagging.

The tagging conditions for liberation S VI were, in fact, rather different from the other liberations, the fish being tagged on board after being transferred from the live net to buckets with water. The actual mortality at tagging is likely to be different from that estimated here, and probably larger. This might explain the rather low value of number of tags/100 hours' fishing per square/1000 tags for liberation S VI, as estimated later in this report.

The estimates for all liberations can, therefore, be determined as in Table 9.

Table 9

Liberation	Fish tagged by standard team			All fish		
	Tagged	% Recaptured	% Recaptured(A) corrected for delay	Actually tagged	Recaptured (B)	Effective no. tagged (B/A x 100)
I	550	9.5	13.0	1500	120	930
II	450	11.1	15.2	1507	103	680
III	250	13.2	18.0	1094	91	500
S VI	600	6.1	8.3	1000	39	470
IV	850	4.3	5.9	2800	90	1510
			T o t a l	7901	443	4090

b) Efficiency of Magnets

Not all the tags from recaptured fish will be returned, some fish being processed at factories not equipped with magnets, and some tags not being detected by the magnets. This loss was measured by measuring the returns from a known number of tagged fish introduced into each factory. The efficiency of return for each factory, weighted by the quantity of fish processed by the factory gives the average efficiency for that port or country. This factor is then applied to the number of tags (or tags per unit effort) reported, to give an estimate of the actual numbers caught. The estimated percentages of recaptured tags actually returned were as follows:-

Esbjerg	1957	88%
Germany	1957	74%
Esbjerg	1958	91%
Germany	1958	64%

c) Early Returns from Esbjerg

Appendix 8 shows that the total returns and their distribution by weeks and between ports vary greatly from liberation to liberation. The most reasonable explanation is that during the couple of months concerned, there is relatively little mixing between the groups of fish tagged. The internal tags cannot show this directly, because the tag may not reach the magnet and be recovered until some time has passed, and cannot with certainty be allocated to a particular day of landing, still less to a particular cutter. There are exceptions for which movement can be clearly shown where a tag is returned from a port whose fleet does not fish in the tagging area. However, for the bulk of the returns from ports whose ships have been fishing both in the marking area and elsewhere, we may strongly suspect that the tags coming back in the first few weeks are nearly all caught close to the tagging position, but from the evidence of internal tags alone, there is no direct way of proving it.

The analysis of the results, therefore, depends largely on calculating the local fishing intensity on each group of tagged fish. This requires detailed effort statistics by areas of the commercial fishery, and some assumption about the movements and dispersal of the tagged fish.

For the Esbjerg statistics, which are given for areas 15 miles square, the average effort per square was calculated for 4 areas of differing sizes (1, 2, 4, and 12 squares) surrounding the tagging position. (For liberation I of 1957, which was nearly on the border between two squares, the smallest area was not used). The particular squares used are shown in Figures 8a-h, the choice being determined by the probable general movement from the liberation position.

Finally, the best estimate of the fishing intensity on the tagged fish is found as the weighted mean of the intensities in the 4 areas. In the first week after tagging greatest weight is given to the single square covering the marking area, and in later weeks increasing weight to the other areas. With our present information the weights used must be purely arbitrary, and those actually used are given in Table 1o. The weights for liberation I of 1957 for which no single square region was used, were obtained by adding the first two weights.

Table 1o. Weighting Factors Used to Determine Average Fishing Intensity

Week after tagging:	1	2	3	4	5	6	7	8
1.-square region	o.8	o.6	o.3	o.1	o.1	o.1	o.o	o.o
2.-square region	o.1	o.2	o.3	o.3	o.1	o.1	o.1	o.1
4.-square region	o.o5	o.1	o.2	o.3	o.3	o.2	o.1	o.1
12.-square region	o.o5	o.1	o.2	o.3	o.5	o.6	o.8	o.8

These weighting factors define the dispersal of fish from the tagging position, and the assumed pattern of distribution of 1o,ooo tagged fish is shown on page 21:-

42	42	42
42	667	167
42	8667	167
42	42	42

1 week

83	83	83
83	1333	333
83	7333	333
83	83	83

2 week

167	167	167
167	2167	667
167	5167	667
167	167	167

3 week

25o	25o	25o
25o	25oo	1ooo
25o	35oo	1ooo
25o	25o	25o

4 week

417	417	417
417	1667	1167
417	2667	1167
417	417	417

5 week

5oo	5oo	5oo
5oo	15oo	1ooo
5oo	25oo	1ooo
5oo	5oo	5oo

6 week

667	667	667
667	1417	917
667	1417	917
667	667	667

7 week

667	667	667
667	1417	917
667	1417	917
667	667	667

8 week

The number of tags returned per unit fishing intensity (1oo hours' fishing per square) per 1ooo fish tagged can be calculated for each liberation for each week. The figure used for the number of fish tagged was that derived above, corrected as far as possible for loss at tagging. These calculations are given in detail in Appendix 9. For all, except the first week after tagging, the data have been lightly smoothed by using the mean of the effort in the week of reported recapture and in the previous week; this, in part, corrects for the delay which, as shown by the tests, often occurs between the tagged fish entering the factory, and the appearance of the tags at the magnets. The results are summarized in Table 11.

Table 11. Number of Tags returned per Unit Fishing Intensity per 1oooFish Effectively Tagged

	1957			1958				
Week	I	II	III	I	II	III	S VI	IV
32	(8.9)	-	-	-	-	-	-	-
33	24.6	-	-	(2.5)	(o)	-	-	-
34	26.7	(1o.6)	16.7	17.8	o	(25.o)	-	-
35	6.7	3.1	22.2	2.o	o	1o.9	8.9	(o)
36	3.3	1.6	48.5	7.2	4.8	14.3	15.o	26.1
37	5.8	2.7	16.7	7.3	2o.1	14.o	6.6	7.4
38	-	o	-	4.3	11.4	14.2	18.5	o
39	22.o	34.1	-	5.9	61.9	19.2	6.8	2o.4
4o	-	-	-	9.8	o	12.9	o	2.o
41	-	-	-	-	-	44.4	o	39.1
42	-	-	-	-	-	-	-	-
Total) for 8) weeks)	15.o2	9.82	31.37	8.7o	19.45	15.76	7.16	14.8o

The figures in brackets denote the values for the week in which tagging took place, and in which, therefore, the tagged fish was not subject to the full effort. A single estimate (bottom tow) for each liberation was obtained by adding the number of tags and fishing intensity for the 8 weeks and is given by:-

$$p = \frac{\sum n}{N \sum f}$$

where p = returns per unit intensity per looo fish tagged
n = number of tags returned each week
N = total number of fish effectively tagged
f = fishing intensity in each week.

This shows a fair degree of agreement between the liberations and between years. A single figure for tags per fishing intensity can be given as the simple mean of all liberations (in the year) or, probably better, as the weighted mean, weighted by the effective number of fish tagged in each liberation x the total fishing effort on those fish, that is, the mean value for all experiments in the year is:-

$$p = \frac{\sum (\sum n)}{\sum (N \sum f)}$$

This gives values of 12.8 for the 1957 experiment and 11.4 for 1958.

Strictly, some allowance should be made for mortality (other than that caused directly by tagging) between the time of tagging and recapture. This should appear as a decrease in the number caught per unit effort with time. The data are too variable to detect such a decrease with any certainty, but there are some suggestions of it, at least for liberations I/1957 and I/1958. To the extent that it does occur, then the present estimates are underestimates of the actual rate of capture immediately following tagging.

Using the weighted means for all weeks the expected number of recaptures from each liberation each week can be calculated, and in Table 12 below these are being compared with the numbers actually observed.

Table 12. Number of Recaptures Observed and Expected each Week from Each Liberation

Week	1957 liberations					
	I		II		III	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
32	(21)	(3o)	-	-	-	-
33	53	25	-	-	-	-
34	48	21	(79)	(96)	(3)	(2.3)
35	8	lo	12	3	3	1.2
36	4	22	2	28	8	3.1
37	7	9	3	o	2	o
38	o	o	o	1	o	o
39	lo	12	3	2	o	o

(continue page 23)

Week	1958 liberations									
	I		II		III		S VI		IV	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
33	(13)	(58)	(o)	(o.1)	-	-	-	-	-	-
34	65	25	o	o	(1)	(o.5)	-	-	-	-
35	4	2o	o	o.6	6	12	(1)	1	(o)	(o.3)
36	8	5	1	4	11	5	3	3	12	1o
37	4	7	8	5	7	6	1	o.2	4	2
38	5	19	4	3	14	16	1	1	o	2
39	6	4	12	1	16	3	1	2	8	7
4o	2	1	o	o.5	2	1	o	1	1	4
41	-	-	-	-	8	3	o	1	13	3
42	-	-	-	-	-	-	-	-	-	-

Though the differences between "observed" and "expected" are larger than would be expected by random variation alone, the general agreement is good, considering methods used and the inevitable inaccuracies in the original data, such as fishing positions, etc. The most serious differences are in liberation I, 1958, whose number returned, particularly in the later weeks, are well below expectation, and in the last two weeks for liberation II, 1958. These differences are probably due to the dispersion of the fish from the tagging position being different from the rather simple pattern assumed. Liberation I, 1958, was made on the edge of the main Bløden Ground. It is possible that these fish, instead of moving mainly north and west from the tagging area, moved north-east. This would take them out of the area fished by the Esbjerg fleet. That this may have happened is supported by the 4 returns from this liberation by the Thyborøn fishery in weeks 35, 36, 39, and 41. If this explanation is accepted, and the estimate for Liberation I, 1958, is too low, then a better estimate for the whole year is the mean of the estimates for liberations II, III, S VI, and IV = 15.1 tags/loo hours/looo tags.

These estimates must be corrected for the efficiency of the Esbjerg magnets (see page 19). These revised estimates are as follows:-

1957 = 12.8/o.88 = 14.6 tags/loo hours/looo tags

1958 (all liberations) = 11.4/o.91 = 12.5 tags/loo hours/looo tags

1958 (liberations II, III, SVI and IV) = 15.1/o.91 = 16.6 tags/loo hours/looo tags

These figures show that a fishing intensity of loo hours/square will catch probably between 1.25 % and 1.66 % of the stock present. During the periods of tagging, weeks 32-34 in 1957 and 33-35 in 1958, the average catches per loo hours' fishing were 122 tons and 184 tons, respectively. These represent 1.46 % and 1.25 % (1.66 %) of the stock present per square. The estimates of the density of the stock are therefore:-

1957 = 122/1.46 x loo = 8,4oo tons/square

1958 (all liberations) = 184/1.25 x loo =14,7oo tons/square

1958 (liberations II, III, S VI and IV) = 184/1.66 x loo =11,1oo tons/square

Immediately before the tagging, echo-surveys were made over the Bløden Ground (see Figures 1 and 2). Although there might have been fish where no traces were observed, and some traces might not have belonged to the Bløden stock proper (e.g., to O-group fish), these surveys do provide a fair guide to the extent of the area covered by the stock. This gives a value of about 5o squares. The total number of squares fished at any time during the season (probably an overestimate of the extent of the stock at anyone time) was about 6o, while the greatest number fished in a single week (almost certainly an underestimate of the extent) was 35; these agree reasonably well with the figure of 5o squares. If the density throughout these 5o squares was the same, then the estimated sizes of the stocks at the time of tagging are:-

1957	=	5o x 8,4oo = 42o,ooo tons
1958 (all liberations)	=	5o x 14,7oo = 735,ooo tons
1958 (liberations II, III, S VI and IV)	=	5o x 11,1oo = 555,ooo tons

d) Other Danish Ports

Only few tags (31 in all) were returned from Danish ports other than Esbjerg (mainly Thyborøn) in the period soon after tagging. These are too few for detailed analysis, but being predominantly from liberation I/1957 with a few from I/1958 are in agreement with the general picture of the movements and slow dispersal of the groups of tagged fish.

e) German Recaptures

Detailed German statistics of catch and effort are available only for 1958 in 3o x 3o miles squares. These cannot be combined directly with the Esbjerg figures in 15 x 15 miles squares, nor can the same areas round the liberation position be used to estimate fishing intensity. Instead the fishing effort, in terms of number of hauls, in the square in which the fish were liberated, was used for the 8 weeks following liberation. The data are given in Table 13.

Table 13. Number of Hauls by German Cutters in the 3o x 3o m.sq. of Liberation, and Number of Tags Returned

Week	Liberations 1958									
	I		II		III		S VI		IV	
	Hauls	Tags	Hauls	Tags	Hauls	Tags	Hauls	Tags	Hauls	Tags
33	-	-	-	-	-	-	-	-	-	-
34	-	-	-	-	22	-	-	-	-	-
35	-	-	-	-	-	-	591	-	38	2
36	-	-	16	-	11	-	22o	2o	1o1	15
37	-	-	-	-	-	-	16	-	14	5
38	-	-	-	-	-	-	1o4	-	68	2
39	-	-	-	-	-	-	-	1	23	7
4o	-	-	-	1	-	-	1o3	-	11	-

As may be expected from these data the results are much more variable than those for the Esbjerg fleet. Pooling the data for the whole period (weeks 35-4o) the last two liberations give usable results as follows:-

	Liberation S VI	Liberation IV
Hauls	1o33	255
Tags recovered	21	31
Tags/1oo hauls	2.o	12.o
Fish effectively tagged	47o	151o
Tags/1oo hauls/1ooo tags	4.33	8.o5

The mean of these is 5.97 tags/1oo hauls/1ooo tags. This figure may be too low, as the low value for liberation S VI is due to the high effort in week 35, which was probably not in exactly the same area as the liberation. Tests of magnets showed that 64 % of all tags landed in Germany should be returned (see page 19). That is, the corrected number of tags is 7.8/o.64 = 9.33 tags/1oo hauls/1ooo tags. During the tagging period (week 35) the average catch per 1oo hauls of the German cutters was 367 tons. The estimated density of stock at that time is therefore

$$367 \times \frac{1ooo}{9.33} = 39,4oo \text{ tons per } 3o \times 3o \text{ miles square,}$$

or, in the same units as the Esbjerg estimate, 9,85o tons per 15 x 15 miles square, and 5o x 9,85o = 492,ooo tons for the whole stock.

f) Late Autumn Recaptures

After more than 8 weeks from tagging the fish have probably moved too far from the tagging position to allow a local fishing intensity on them to be calculated by the previous methods. However, the various groups of fish had still not mixed very much, as is shown by the difference in the returns from the different liberations. This is clearer for the 1958 season, which continued longer than in 1957. It is impossible to determine exactly how the fish had moved. If the distributior of fishing (Appendix 6) are compared with the returns (Appendix 8), it will be seen that the fishing effort and number of returns agree, if the movements of each group of fish in 1958 were roughly as follows:-

Liberation I:- mainly north and east, perhaps as far as the entrance to the Skagerak.

Liberation II:-north to the Tail End of the Dogger.

Liberation III: - no great movement; dispersion to the north-west and north-east.

Liberation SVI: - north-east along the south edge of the Dogger Bank, and directly, or round the Tail-End, to the north-west side of the Dogger Bank.

Liberation IV: - north and north-east.

It is not suggested that these are necessarily the movements of the fish, only that such movements would explain the pattern of returns, and are consistent with our present knowledge of the movements of the immature herring. Lacking reliable data on local fishing intensity, a reasonable estimate of the stock size at the time of tagging can be obtained by combining the data of all liberations, using a modification of the simple Petersen-method. In Figure 9 the number of tags returned each week have been plotted against the weight of herring landed in that week. These data have been fitted by a simple proportional line, giving 1000 tons landed = 5.4 tags, or correcting for magnet efficiency 1000 tons = 5.4/0.911 = 5.9 tags. The individual fish may have grown since the time of tagging, so that the 1000 tons of fish in the late autumn represent less than 1000 tons at the time of tagging. However, data from market samples (Popp Madsen, verbal information) show no significant change in the number of fish per ton, suggesting that the growth in length has been balanced by a decrease in fatness. For the present, therefore, no correction has been made for possible change in weight of individual fish.

The number of herring effectively tagged was 4090. The estimated stock at the time of tagging was, therefore, 4090 x 1000/5.9 = 695,000 tons. In the corresponding period of 1957, fishing was light, and only 5 tags were returned. The catches were mixed with a large amount of other species and with small herring. True Bløden herring only amounted to 300 tons. This gives 16.7 tags per 1000 tons, and an estimated population at tagging of 7760/16.7 x 1000 = 465,000 tons.

g) Spring Recaptures

As shown in Appendix 8, substantial numbers of tags from the 1957 and 1958 experiments were recaptured in the spring seasons of 1958 and 1959. Because a proportion of the tagged fish will have left the Bløden area, and because the catches include a large number of small fish newly recruited to the stock, it is not easy to use these data for quantitative estimation of the size of stock. Therefore, these tags (and also a few later recaptures) have not been analyzed further in this report.

h) The Effect of Fishing

The various estimates of stock size can be summarized as follows:-

1957

Esbjerg recaptures within 8 weeks	420,000 tons
Later Esbjerg recaptures	465,000 tons

1958

Esbjerg reacptures within 8 weeks	555,000-735,000 tons
Later Esbjerg recaptures	695,000 tons
German recaptures	492,000 tons

These estimates are not equally accurate, the early Esbjerg recaptures probably being best. Reasonable mean estimates are:-

1957	420,000 tons
1958	600,000 tons

The difference between the two years agree well with the changes in catch per unit effort. The Danish catch per hour increased from 1.16 tons per hour in the autumn 1957 to 1.75 tons per hour in 1958 (an increase of 51 %), and the German catch per trip increased from 19.4 tons to 29.8 tons (an increase of 53 %).

In estimating the effect of fishing on this stock only the catches of this stock must be taken into account. These will be rather smaller to those given in Tables 4-8. In 1957 the tagged population consisted of fish mostly from 17-2o cm in length, and this group of fish made up most of the landings at Esbjerg for the weeks 29-38. At the beginning and end of the season the catches included also a large number of smaller fish; as a working approximation we will take only half the Esbjerg catch during this period as coming from the tagged population. The landings at Thyborøn will be taken as having the same composition as the Esbjerg catch and the landings at Hirtshals as being taken from outside the tagged population (mostly in the Skagerak). The German catch, taken almost entirely in July and August, will be assumed to be entirely from the tagged stock. The total catch from the tagged stock is, therefore, as follows:-

Half the Esbjerg and Thyborøn catch before 13/7	3,567 tons
Esbjerg and Thyborøn catch 14/7 - 21/9	37,553 tons
Half the Esbjerg and Thyborøn catch after 22/9	5,667 tons
German catch	15,ooo tons
Total	61,787 tons

In 1957 the total catch during the period 2o/7 to 3/12 is shown below:-

Thyborøn	11,535 tons
Esbjerg	75,191 "
Hamburg	885 "
Cuxhaven	15,311 "
Bremerhaven	9,214 "
T o t a l	112,1o6 tons

As in 1957 a small amount of herring landed at Hirtshals was almost certainly not part of the Bløden Ground stock and has been omitted. Unlike 1957 there did not appear to be any great number of smaller fish in the later Esbjerg catches for 1958, so that all these catches have been included. However, a quantity of some 9oo tons taken very far from the Bløden area (Fladen Ground etc.) has been omitted. The best estimate of the catch taken in 1958 is, therefore, 111,2oo tons. Expressed as percentage of the stock at time of tagging these are:-

1957 61.8/42o x 1oo = 14.7 %

1958 111.2/6oo x 1oo = 18.5 %

VII. Summary

The present paper is an account of the ICES Herring Tagging Experiments at Bløden Ground in 1957 and 1958. A short description of the background for these experiments is given together with an outline of the history of the project. The execution of the field work is described in more details, and full particulars of the different liberations are given in Appendices 3 and 4. Only the returns of the internal tags have been considered, and these only for recaptures during the autumn season of the year of tagging. Corrections are made for efficiency of return of tags from the factories, and for the estimated tagging mortality. Large differences between the pattern of returns from different liberations were found. These were, however, to a large extent eliminated by calculating the local fishing intensity on each liberation from the detailed statistics of fishing effort. Independent estimates of stock size were obtained from Esbjerg catches within 8 weeks of tagging, later Esbjerg and German catches. These were in good agreement, and the best estimates of stock size at the time of tagging were:- 42o,ooo tons in 1957, and 6oo,ooo tons in 1958. The catches in the autumn in 1957 was equal to 14.7 % of the stock, and in 1958 to 18.5 % of the stock.

VIII. References

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Appendix 1.

IX. Appendices

Executive Bodies of ICES Herring Tagging Experiments

Participating Countries	Delegates at Meeting in Copenhagen, February 18th and 19th, 1957	Working Group appointed by Delegates
	Convener: Dr. Árni Fridriksson	
Denmark	Dr. Å. Vedel Tåning	Dr. Erik Bertelsen
Germany	Dr. G.Krefft	Dr. G.Krefft
Netherlands	Mr. G.J.Lienesch	Mr. J.Zijlstra
Poland	Mr. J.Popiel	Mr. J.Popiel
Sweden	Dr. H.Höglund	Dr. H.Höglund
United Kingdom	Dr. D.Cushing	Dr. D.Cushing
U.S.S.R.	Not present	Dr. Ju.Ju.Marty
Norway	Mr. Olav Aasen[1)]	Mr. Olav Aasen

Other appointments by Delegates:-

Naturalist-in-charge:- Chairman of Herring Committee
Financial Administrator:- Secretary General of ICES.

Duties of Naturalist-in-charge:-

1. To charter a purse-seiner with its skipper and crew.
2. To provide gear and equipment.
3. To write a guide on testing the efficiency of magnets in factories to be distributed to the members of the working group and to provide them with unnumbered tags for that purpose.
4. To design a poster giving information on the experiment; this would be translated in each participating country and copies distributed to factories and other centres.
5. He will be responsible to the ICES for executing the plan.

Duties of Working Group:-

1. To take care of the efficiency of magnets in the factories.
2. The collection of tags and their transmission to ICES.
3. To ensure that adequate statistics were collected.
4. To advertise the experiment on national information services, including radio.

1) Norway did not participate in the scheme by direct financial contribution, but agreed to support the work by giving technical assistance in personnel and equipment. Mr. Aasen was invited on strength of chairmanship in the Herring Committee.

1957

Pre-tagging Survey

		Date
R/S "Jens Væver":-		
Mr. K.Popp Madsen,	Denmark	16/7 - 23/7
R/S "Platessa":-		
Mr. A.C.Burd	England	18/7 - 24/7
Mr. Gordon White	England	" "
Mr. John Riley	England	" "

Tagging Work

		Date
R/S"Jens Væver":-		
Mr. K.Popp Madsen	Denmark	24/7 - 14/8
M/S "Rygrunn":-		
Mr. Olav Aasen	Norway	24/7 - 19/8
Dr. E.Bertelsen	Denmark	24/7 - 31/7
Mr. J.Zijlstra	Netherlands	9/8 - 19/8
Mr. Harry Knudsen	Denmark	4/8 - 19/8
Mr. J.Popiel	Poland	1/8 - 14/8
Mr. D.Cushing	England	24/7 - 9/8
Mr. G.Bolster	England	9/8 - 19/8
Dr. G.Krefft	Germany	24/7 - 9/8
R/S "Sir Lancelot":-		
Mr. A.C.Burd	England	1o/8 - 26/8
Mr. Don Rout	England	" "
Mr. Gordon White	England	" "
Mr. Reg.Calver	England	" "
R/S "Clupea":-		
Mr. B.B.Parrish	Scotland	7/8 - 17/8
Mr. G.McPherson	Scotland	7/8 - 27/8
Mr. F.Holiday	Scotland	18/8 - 27/8
Mr. T.Bruce	Scotland	7/8 - 27/8

1958

Pre-tagging Survey

		Date
R/S "Jens Væver":-		
Mr. K.Popp Madsen,	Denmark	24/7 - 3/8
R/S "Sir Lancelot":-		
Mr. D.S.Raitt	England	24/7 - 3/8
Mr. V.Bainbridge	England	" "
Mr. John Bridger	England	" "
Mr. I.Parmenter	England	" "
R/S "Clupea":-		
Mr. Jan Baxter	Scotland	22/7 - 31/7
Mr. Robert Watt	Scotland	" "
R/S "Willem Beuckelsz":-		
Mr. K.H.Postuma	Netherlands	24/7 - 3/8
Mr. M.A.Binsbergen	Netherlands	" "
Mr. S.Schaap	Netherlands	" "
R/S "Michael Siedlecki II":-		
Mr. S.Sadowski	Poland	24/7 - 3/8
Mr. A.Góra	Poland	" "
Mr. J.Kochanowski	Poland	" "

Tagging work

		Date
M/S "Rygrunn":-		
Mr. Olav Aasen	Norway	6/8 - 29/8
Dr. E.Bertelsen	Denmark	" "
Mr. J.Zijlstra	Netherlands	" "
Mr. A.Revheim	Norway	" "
R/S "Skagerak":-		
Dr. H.Höglund	Sweden	6/8 - 29/8
Mr. A.Lindquist	Sweden	" "
Dr. G.Krefft	Germany	" "
Mr. K.Postuma	Netherlands	6/8 - 15/8
Mr. G.McPherson	Scotland	6/8 - 29/8
Mr. G.Bolster	England	" "
Mr. J.Popiel	Poland	15/8 - 29/8
R/S "Sir Lancelot":-		
Mr. V.Bainbridge	England	6/8 - 12/8
Mr. D.S.Raitt	England	" "
Mr. J.Bridger	England	" "
Mr. I.Parmenter	England	" "

Appendix 2.

Appendix 3.

Details of Liberations at Bløden Ground in 1957. Types of Tags:- (I) internal, (L) Lea, (D) Danish Lea, (H) Hodgson, (S) Scottish Combination with Scottish Bridles. Mode of Catch:- (P) Purse-seine, (T) Trawl, (N) Drift-net. The Totals are Sums of Figures in Brackets.

Liberation No.	Mode of Catch	Date	Position N ° '	Position E ° '	Type of Tag	Serial Numbers	Not used (see below)	Total
						R/S "Jens Væver"		175
1	T	28.7	56 17	06 18	I	C8001-8050(50)		50
2	P	5.8	56 04	05 57	L,D	12488-12538(51),3251-3325(74)	1	125
						M/S "Rygrunn"		9930
I	P	5.8	56 07	05 57	I	C1-1000(997),C4001-6000(1996),8051-9100(1048)	9	4041
II	P	14.8	55 10	04 12	I	C1001-2000(1000),7501-8000(489),9101-9600(500)	11	1989
III	P	17.8	54 39	04 14	I	C2001-4000(2000),6001-7500(1500),9601-10000(400)		3900
						R/S "Sir Lancelot"		2307
1	P	15.8	54 39	04 14	L,H	5485-5500(12),8E221-3000(79),9E301-5000(200),10E901-1000(100)	5	391
2	T	20.8	54 41	04 00	I	C12001-12050(50)		50
3	T	20.8	54 33	04 00	I	C12051-12150(100)		100
4	T	20.8	54 41	04 11	L	12920-12991(72)		72
5	T	21.8	54 45	03 38	L	12896-12919(24)		24
6	T	21.8	54 45	03 58	I	C12151-12500(350)		350
7	T	22.8	54 48	04 37	I	C12501-12551(51),12553-12582(30),12584,12599(2),12601-12700(100)		183
8	T	22.8	54 46	04 39	L	12867-12873(7),12885-12892(8),12894-12895(2)		17
9	T	23.8	54 40	04 16	L	12815-12866(52),12874-12884(11),12893(1)		64
10	T	23.8	54 40	04 06	I	C12552,12583(2),12585-12600(15),12701-13450(750),13464-13556(89),13801-14000(200)	5	1056

Appendix 3(continued)

Liberation No.	Mode of Catch	Date	Position N ° '	Position E ° '	Type of Tag		Not used (see below)	Total
						R/S "Clupea"		21o7
1	N	8.8	55 o8	o4 45	S	AH2o1-29o(9o),295-3oo(6)		96
2	T	8.8	55 o8	o4 41	S	AH291-294(4),3o1-6oo(3oo)		3o4
3	T	8.8	55 o9	o5 23	S	AH6o1-62o(2o)		2o
4	T	2o.8	55 o1	o4 22	S	AH621-76o(14o)		14o
5	T	2o.8	55 44	o4 o4	S	AH762-766(5),768-78o(13)		18
6	T	21.8	54 44	o3 52	I,S	C14o45(1),14o83-1415o(68),AH761,767(2),781-8oo(2o)		91
7	T	21.8	54 42	o3 56	I	C14oo1-14o44(44),14o46-14o82(37)		81
8	T	21.8	54 44	o3 53	I	C14151-142oo(5o)		5o
9	T	21.8	54 47	o3 57	I	C142o1-14221(21)		21
1o	T	21.8	54 44	o3 51	I	C14222-14253(32)		32
11	T	22.8	54 43	o3 55	I,L	C14254-143oo(47),12992-13o74(83)		13o
12	T	22.8	54 45	o4 1o	I,S,L	C143o1-1445o(15o),AH8o1-1ooo(2oo),AJoo1-2oo(2oo),3o1-4oo(1oo),C13o75-1311o(36)		686
13	T	22.8	54 43	o4 o2	I,S	C14451-14593(142),AJ2o1-3oo(1oo),AJ4o1-6oo(196)	5	438
							Total	14519

Serial Numbers not used:- "Jens Væver", Lib.2(D)3289.

"Sir Lancelot", Lib.1(L)5486,5488,5489,549o,(H)8E291; Lib.1o (I)C12599, 13481,13497,13554,13555.

"Rygrunn", Lib.I, C142,146,221,4o67,4943,5197,5273,8o51,8112; Lib.II.,C7551,7557,7558,7561,7566,7574,7578,76oo,7787, 7791,7794.

"Clupea", Lib.13,C14465,AJ424,525,563,59o.

Appendix 4.

Details of Liberations at Bløden Ground in 1958. Types of Tags:- (I) internal, (L) Lea, (D) Danish Lea, (B) Bolster. Catching Gear:- purse-seine throughout. The Totals are Sums of Figures in Brackets. 1, 2, 3, 4 = Tagging Teams.

Liberation No.	Date	Position N °	'	Position E °	'	Types of Tags	Serial Numbers	Not used (see below)	Totals
							M/S "Rygrunn"		6898
I	9.8	55	53½	06	24	I	1.C25001-25550(550),2.C.29001-29500,29951-30000(550),3.C33001-33400(400)		1500
II	12.8	54	43	05	20½	I	1.C25551-26000(450),2.C29501-29950,30001-30007(457),3.C33401-34000(600)		1507
III	22.8	55	49½	05	32	I	1.C26051-26300(250),2.C30008-30350(343),3.C34001-34500(500)		1093
IV	25.8	54	36	04	14	I	1.C26701-27550(850),2.C31001-31800,31851-32000(950),3.C34501-35500(1000)	2	2798
							R/S "Skagerak"		4461
SI	8.8	56	05½	05	36	L,B	1921-2217,2241-2324(381),1-50,52,54,56,69,70,72,76,83-86,100(62)		443
SII	9.8	55	53½	06	24	L	2218-2240,2561-2759,2325-2506(403)		403
SIII	12.8	54	43	05	20½	L,D	2507-2560,3521-3625,2761-2880,3201-3503(582),1-100(100)		682
SIV	13.8	55	22	03	19	L	3141-3200,3504-3520,3626-3689,3841-3876(177)		177
SV	22.8	55	49	05	32	L	3877-4112,3690-3840,4161-4300,4301-4329(556)		556
SVI	24.8	54	52	03	23	I,L	4113-4160,4481-4722,4330-4480,4741-5000(701),4.C26301-26700(400), 2.C30401-31000(599)	1	1700
SVII	25.8	54	39	04	17	L	4723-4740,1601-1742,9601-1300(500)		500
							R/S "Sir Lancelot"		1220
LI	8.8	56	05	05	36	L	1-300(300)		300
LII	9.8	55	53½	06	24	L	301-640(340)		340
LIII	12.8	54	43	05	20½	L	641-960,2881-3140(580)		580
							Total		12579

Serial Numbers not used:- "Skagerak", Lib.SVI (I), C30639.

"Rygrunn", Lib.IV (I), C31787,C32000.

Appendix 5.

Distribution of Effort. Esbjerg 1957.
Key to Effort Data in Figure 1o. (Data outside the Young Herring Area are omitted).

	J	K	L	M
12				
		15	162	
11		19	1o1	422 76
		71	578	52
1o		174	227	169
	32		53	4o
9	28			

Week 31.

	H	J	K	L
12				
				42
11				9o 34
			51	243 297 31
1o		3o	75	155 497 24o
	5o			264 398 73 144
9	5o	85	1o4	1o9 26o 17
	51	186	565	
8				
7				86

Week 32.

	H	J	K	L	M
12			34		
				45	
11				81	1o6
				62	77
1o				34 212	1o4
			32	82 114	
9		193 157	43		
	43	238 56		13	
8	4o 148	42			
	94				

Week 33.

	H		J		K		L		M	
11						15		55	417	
							62	78	124	
1o					71	21		9		
					49	52				
9			226	3o6	63	41		6		
	46	97	472	76	42		14			
8	68	52	216							
		15								
7		11		9						

Week 34.

	J		K		L		M	
12								
						18		
11			177	316		35	142	
			11o	4o3				
1o			126	511	11			
			8o	464				
9	1o7		138	98				
	178	16o						
8		39						

Week 36.

	H		J		K		L		M	
12										
								9		
11									1oo	
						29	41	31		
1o					2o1	118				
			9		45o	343				
9				361	148					
8		148		61						

Week 35.

	G		H		J		K	
12								
							75	3
11							99	
							66	22o
1o							2●2	2o5
		5o					133	4o

Week 37.

	G	H	J	K
11				
			27	
	36			33
1o		13	65	

Week 38.

	F	G	H	J
12				
	232			
11			244	23 538
				295 53
1o			193 522	243

Week 4o.

	G	H	J	K	L	M
14						
		39				
13		26		37		
			51			
	57 67	52		12o	64	
12	12 88	219		28		
	34 45	86	4	197	71	
11	49	66	41	153	1o3 6	77
	59 2o7	25		41	234 13	
1o	77 168 124	43		64	22	42
		59		45	17	
9						

Week 39.

Distribution of Effort in 1958

Data from outside the Young Herring Area are omitted.
Key to Effort Data in Figure 1o.

A = Danish Effort (Esbjerg) (15 x 15 n.sq.miles) - Hours' Fishing.

B = German Effort (Bremerhaven and Cuxhaven) (3o x 3o n.sq.miles) - Number of Hauls.

	J		K		L	
12			119	59		
			153	13	57	
11		13	183	144	149	18
			263	158	813	25
1o	33	8o	138	5o9	161	86
	71			142	18o	
9				311	182	29

Week 33 A.

	F	G	H	J	K
1o	2			1o3	31
9		23	64	116	21o
8			3	13	

Week 33 B.

	J		K		L		M
							15
12			1o1	9			42
			13o	264	74	26	
11		42	331	297	131	41	
			149	1o1	265		
1o	87	77	23	145	156		
				31	9		
9							

Week 34 A.

	G	H	J	K
12	5			
11	6	7		
1o		73	256	22
9		51	118	
8		289	87	

Week 34 B.

	G	H	J	K	L	M
12				153		36
11				147	36	
			224	483	5o9	186
	45		49o	155	153	165
1o			12	83	1o9	195	47	33	14
9	36		79	22	1o8		12		
		24	24	1o			161		
	35	97			24		47		
		41							

Week 35 A.

	G	H	J	K	L
13					1o
12	4				
11	13				
1o		28			
9		31	49		
8		591	38		

Week 35 B.

	G	H	J	K	L	M
12				62		
				9o	8	14
11					5o	
					19o	95	53		
				69	25	99			
		116	135	86		464	11		
9	9	41	122		122	32	38		36	
				174	86	279	39	116		
8		53	1o7	178	215	35		45		
			32	33	72					
7									26	

Week 36 A.

	G	H	J	K
12	5			
11	48	24		
1o	22	67		11
9	8	29	37	9
8		22o	1o1	16

Week 36 B.

	F	G	H	J	K	L
12				55	9	
						13
11					25	151
			88		1o4	1o6
1o		1o5	62	46	98	13o 42
	13	31	92	285	122	67 233
9		41	66	17	57 14	17 23 387 166
					26	224 527 1o7
8				5o	8o	

Week 37 A.

	G	H	J	K
11	7	47		
1o	4o	318	51	
9	57	89	12o	12
8	94	16	14	

Week 37 B.

	F	G	H	J	K	L
12					67	28 124
		62			69	94
11		97 21		29	321	64o 38
	27		65	11	293	267 34
1o		39 319	53	14	223	578
				75		46 13 25
9				1oo	38	58 213
					27o	46 88
8	42					
	44					
7						

Week 38 A.

	G	H	J
1o	97	111	38
9	23	59	35o
8		1o4	68

Week 38 B.

	F		G		H		J		K		L	
12												
						142	44	121	26			
11					16	7		16		23		
					156	192	31		65	55		
1o		89		43	93	31				48		
					16				254	52		
9						42				58		
						73	47			13	124	
8					23	84	1o3	146				
7						57						

Week 39 A.

	H	J
9	9	7o
8		23

Week 39 B.

	H		J		K	
		41				
11	24	31	62			
				77	133	
1o						
					87	
9		167	112			
8		122				

Week 4o A.

	G	H	J
12	3		
11			
1o	3	26	8
9		237	221
8		1o3	11

Week 4o B.

	H	J		K		L
11	75	57	28	99		23
		155	87		43	
1o		8o	116	52	294	
	2o9		39		132	45
9	87			43	212	44
			149	29	64	
8			19			

Week 41 A.

	H	J
1o	13	11
9		53
8	71	34

Week 41 B.

11	H	J		K	
			52		33
1o				161	
				67	88
9					
	34				

Week 42 A.

	J
9	5o
8	12

Week 42 B.

	H	J		K	
				1o6	
11	25		18	9	92	
					112	2o
1o					19	

Week 43 A.

	H	J
9	39	8
8	4o	

Week 43 B.

Note:- No German Data for Weeks 44-49.

	F		G		H		J		K	
								142	301	42
11		61						70	157	71
		193					60	171	268	73
10			330			72		21	222	45
							26	29	43	
9								236		
								6		
8										

Week 44 A.

	F		G		H		J		K	
12		14								
	24									
		27	14	14					26	99
11			225						24	
		13	24						11	44
10			36						182	70
							109	340	150	45
9						21	249	578	61	
						33		69		
8										

Week 45 A.

	F		G		H		J		K	
		35								
12	14	55	6							
		86							118	98
11									64	8
									53	16
1o										147
									35	
9							34	1o5		

Week 46 A.

	F		G		H		J		K		L	
		288										
12		99										
		315					18		1o9	39		
11		49					81	2o	4o			
							77	1o8	45	97		
1o								62	1o7			
							33	21				17
9												

Week 47 A.

	F	G	H	J	K
12	137		27		
	148				
11					
	117				58
1o		57			3oo 84
					94 111
9					15

Week 48 A.

	F	G	H	J	K
12					
	32				78
11	252				97 17o
					142
1o					14 7o

Week 49 A.

Appendix 7. Total Number of Tags Returned from each Liberation up to the End of 1958, separated according to Team and Order of Tagging, i.e., Column Head 1 are the Numbers of Tags Returned from the First Tenth of the Fish Tagged(e.g., 8 out of 55 for Team 3, Liberation I, 1958).

a) 1957

Order of Tagging	1	2	3	4	5	6	7	8	9	1o	Total	Total tagged	% returned
Liberation I.													
Tagging Team													
1	7	2	4	9	7	6	7	3	4	5	54	997	5.4
2	4	11	1o	1o	1o	7	9	7	8	1o	86	1996	4.3
3	9	14	8	8	1o	5	6	5	4	6	75	1o48	7.2
	2o	27	22	27	27	18	22	15	16	21	215	4o41	5.3
Liberation II.													
4	5	8	1o	5	11	8	7	9	5	6	74	1ooo	7.4
5	5	6	3	1	8	3	7	3	6	3	45	489	9.2
6	1	o	7	5	2	4	6	6	11	1	43	5oo	8.6
	11	14	2o	11	21	15	2o	18	22	1o	162	1989	8.1
Liberation III.													
7	6	6	2	3	1	3	2	6	6	2	37	2ooo	1.8
8	6	3	2	6	6	3	o	1o	3	2	41	15oo	2.7
9	1	1	o	o	o	1	1	o	o	o	4	4oo	1.o
	13	1o	4	9	7	7	3	16	9	4	82	39oo	2.1

b) 1958

Order of Tagging	1	2	3	4	5	6	7	8	9	1o	Total	Total tagged	% returned
Liberation I.													
Tagging Team													
1	5	11	11	4	2	1	2	4	6	6	52	55o	9.5
3	8	11	11	2	8	4	3	3	o	2	52	55o	9.5
4	3	1	o	o	2	2	o	3	3	2	16	4oo	4.o
	16	23	22	6	12	7	5	1o	9	1o	12o	1,5oo	8.o
Liberation II.													
1	6	5	5	7	3	6	5	5	5	3	5o	45o	11.1
3	2	1	4	3	1	o	o	o	2	o	13	457	2.8
4	7	5	2	9	5	2	5	2	o	3	4o	6oo	6.7
	15	11	11	19	9	8	1o	7	7	6	1o3	1,5o7	6.8
Liberation III.													
1	2	6	2	4	7	3	3	3	1	2	33	25o	13.2
3	4	2	3	4	2	1	2	o	5	5	28	344	8.1
4	4	3	3	3	5	2	2	2	2	4	3o	5oo	6.o
	1o	11	8	11	14	6	7	5	8	11	91	1,o94	8.3

(continued on page 47)

b) 1958 (continued)

Liberation S VI.

Order of Tagging	1	2	3	4	5	6	7	8	9	1o	Total	Total tagged	% recapt.
Tagging Team													
2	2	o	3	3	1	2	o	2	o	2	15	4oo	3.7
3	4	4	2	o	4	1	3	3	1	2	24	6oo	4.o
	6	4	5	3	5	3	3	5	1	4	39	1,ooo	3.9

Liberation IV.

1	7	1	2	5	7	5	6	2	1	1	37	85o	4.3
3	2	3	2	7	2	3	4	5	o	3	31	95o	3.3
4	6	o	1	2	2	3	1	3	2	2	22	1,ooo	2.2
	15	4	5	14	11	11	11	1o	3	6	9o	2,8oo	3.2

Appendix 8.

a) Recaptures from the 1957 Experiment until 31/12 1959

Recaptures in 1957

Week	Esbjerg			Other Danish Ports			Germany			Other Recaptures			Total
	I	II	III	I	II	III	I	II	III	I	II	III	
32	21	-	-	1	-	-	-	-	-	-	-	-	22
33	53	-	-	2	-	-	-	-	1	-	-	-	56
34	48	79	3	12	-	-	-	31	26	-	-	-	199
35	8	12	3	2	-	-	-	6	8	1[1]	-	2[2]	42
36	4	2	8	2	-	1	-	1	4	-	-	-	22
37	7	3	2	1	-	-	-	-	1	-	-	-	14
38	-	-	-	-	-	-	-	-	-	-	-	-	o
39	1o	3	-	1	1	-	1	-	-	-	-	-	16
4o	-	-	-	-	-	-	-	-	-	-	-	-	o
41	-	-	-	-	1	-	-	-	-	-	-	-	1
42	3	-	-	-	-	-	-	-	-	-	-	-	3
43	-	-	-	-	-	-	-	-	-	-	-	-	o
44	-	-	-	1	-	-	-	-	-	-	-	-	1
45	-	-	-	-	-	-	-	-	-	-	-	-	o
46	-	-	-	-	-	-	-	-	-	-	-	-	o
47	-	-	-	1	-	-	-	-	-	-	-	-	1
48	-	-	-	-	-	-	-	-	-	-	-	-	o
49	-	2	-	-	-	-	-	1	-	-	-	-	3
5o	-	2	1	-	-	-	-	-	-	-	-	-	3
51	-	-	-	1	-	-	-	-	2	-	-	-	3
52	-	-	-	-	-	-	-	-	-	-	-	-	o
Total	154	1o3	17	24	2	1	1	39	42	1	-	2	386
Recaptures in 1958													
	14	12	14	7	2	3	5	-	3	2	-	-	62
Recaptures in 1959													
	-	2	-	1	-	-	6	2	-	-	-	-	11

1) from Norway.

2) found in the stomach of whitings.

b) Recaptures from the 1958 Experiment until 31/12 1958

Recaptures in 1958

Week	Esbjerg					Thyborøn					Germany					Total
	I	II	III	SVI	IV	I	II	III	SVI	IV	I	II	III	SVI	IV	
33	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13
34	65	-	1	-	-	-	-	-	-	-	-	-	-	-	-	66
35	4	-	6	1	-	1	-	-	-	-	-	-	-	-	2	14
36	8	1	11	3	12	1	-	-	-	-	-	-	-	2o	15	71
37	4	8	7	1	4	-	-	1(1)	-	-	-	-	-	-	5	3o (1)
38	5	4	14	1	-	-	-	-	-	-	-	-	-	1	2	27
39	6	12	16	1	8	1	-	-	-	-	-	-	-	-	7	51
4o	2	-	2	-	1	-	-	1	-	-	-	1	-	-	-	7
41	5	8	8	-	13	1	-	-	-	-	-	-	-	1	-	36
42	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	3
43	-	4	1	-	1	-	-	-	-	-	-	-	-	-	-	6
44	2	19	5	-	1	-	-	-	-	-	-	-	-	-	-(1)	27 (1)
45	1	15	1	1	7	-	-	-	-	-	-	-	-	-	-(1)	25 (1)
46	-	7	1	-	3	-	-	-	-	-	-	-	-	-	-	11
47	1	1o	3	-	1	-	-	-	-	-	-	-	-	-	-	15
48	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	3
49	-	7	5	-	1	-	-	-	-	-	-	-	-	-	-	13
5o	-	4	2	4	1	-	-	-	-	-	-	-	-	-	-	11
Unknown	-	1	3	3	3	-	-	-	-	-	-	-	-	1	- ++)	11
Total	116	1o2	88	15	56	4	-	2(1 +)	-	-	-	1	-	24	32(2)	44o (3)

+) 1 from Skagen.

++) 2 from Hamburg.

Appendix 9.

Distribution of Tags and Effort for the 1957 and 1958 Experiments arranged according to Weeks. Numbers in Brackets denote Figures reduced in Accordance to such Efforts during the Week of Tagging which is supposed to be effective on the Tagged Stock.

a) 1957

Liberation I

Effective number of tags 3ooo.

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo Tags per Square
32	21	2	164		
		4	9o		
		12	123		
		Weighted mean	158 (79)	o.266	8.9
33	53	2	7o		
		4	35		
		12	52		
		Weighted mean	64	o.828	27.6
34	48	2	7o		
		4	49		
		12	18		
		Weighted mean	55	o.873	29.1
35	8	2	36		
		4	18		
		12	19		
		Weighted mean	26	o.3o8	lo.3
36	4	2	-		
		4	9		
		12	lo8		
		Weighted mean	56	o.o71	2.4
37	7	2	-		
		4	-		
		12	41		
		Weighted mean	24	o.292	9.7
38	o	2	-		
		4	-		
		12	-		
		Weighted mean	-	-	-
39	lo	2	3		
		4	2		
		12	38		
		Weighted mean	31	o.323	lo.8

Liberation II

Effective number of tags 176o

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo Tags per Square
34	79	1	472		
		2	349		
		4	27o		
		12	12o		
		Weighted mean	432 (423)	o.187	lo.6
35	12	1	-		
		2	-		
		4	9o		
		12	48		
		Weighted mean	14	o.857	48.7
36	2	1	178		
		2	142		
		4	111		
		12	4o		
		Weighted mean	126	o.ol6	o.9
37	3	1	-		
		2	-		
		4	-		
		12	-		
		Weighted mean	-	-	-
38	o	1	-		
		2	-		
		4	-		
		12	5		
		Weighted mean	3	-	-
39	3	1	-		
		2	-		
		4	-		
		12	8		
		Weighted mean	7	o.429	24.4

Liberation III

Effective number of tags 3ooo

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo Tags per Square
34	3	1	-		
		2	-		
		4	54		
		12	97		
		Weighted mean	8 (6)	o.5oo	16.7
35	3	1	-		
		2	-		
		4	15		
		12	17		
		Weighted mean	3	1.ooo	33.3
36	8	1	-		
		2	-		
		4	lo		
		12	28		
		Weighted mean	8	1.ooo	33.3
37	2	1	-		
		2	-		
		4	-		
		12	-		
		Weighted mean	-	-	-
38	o	1	-		
		2	-		
		4	-		
		12	-		
		Weighted mean	-	-	-
39	o	1	-		
		2	-		
		4	-		
		12	-		
		Weighted mean	-	-	-

b) 1958

Liberation I

Effective number of tags 93o

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo tags per Square
33	13	1	813		
		2	481		
		4	316		
		12	228		
		Weighted mean	726 (552)	o.o24	2.5
34	65	1	265		
		2	198		
		4	198		
		12	172		
		Weighted mean	235	o.277	29.7
35	4	1	165		
		2	176		
		4	253		
		12	182		
		Weighted mean	189	o.o21	2.3
36	8	1	-		
		2	27		
		4	62		
		12	82		
		Weighted mean	51	o.157	16.9
37	4	1	42		
		2	21		
		4	69		
		12	8o		
		Weighted mean	67	o.o6o	6.4
38	5	1	34		
		2	36		
		4	244		
		12	213		
		Weighted mean	184	o.o27	2.9
39	6	1	-		
		2	-		
		4	26		
		12	41		
		Weighted mean	35	o.171	18.4
4o	2	1	-		
		2	-		
		4	-		
		12	11		
		Weighted mean	9	o.222	24.9

Liberation II

Effective number of tags 68o

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo tags per Square
33	o	1	-		
		2	-		
		4	-		
		12	38		
		Weighted mean	2 (1)	-	-
34	o	1	-		
		2	-		
		4	-		
		12	3		
		Weighted mean	o	-	-
35	o	1	-		
		2	12		
		4	6		
		12	14		
		Weighted mean	8	-	-
36	1	1	-		
		2	18		
		4	81		
		12	77		
		Weighted mean	53	o.o19	2.8
37	8	1	-		
		2	4o		
		4	2o		
		12	1o7		
		Weighted mean	64	o.125	18.4
38	4	1	-		
		2	23		
		4	79		
		12	35		
		Weighted mean	39	o.1o3	15.1
39	12	1	-		
		2	-		
		4	36		
		12	18		
		Weighted mean	18	o.667	98.o
4o	o	1	-		
		2	-		
		4	-		
		12	7		
		Weighted mean	6	-	-

Liberation III

Effective number of tags 5oo

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo tags per Square
34	1	1	lol		
		2	199		
		4	22o		
		12	13o		
		Weighted mean	118 (8)	o.125	25.o
35	6	1	153		
		2	331		
		4	325		
		12	215		
		Weighted mean	212	o.o28	5.7
36	11	1	99		
		2	97		
		4	lo2		
		12	84		
		Weighted mean	96	o.115	22.9
37	7	1	13o		
		2	118		
		4	llo		
		12	76		
		Weighted mean	lo4	o.o67	13.5
38	14	1	267		
		2	453		
		4	38o		
		12	2o7		
		Weighted mean	289	o.o48	9.7
39	16	1	48		
		2	51		
		4	42		
		12	43		
		Weighted mean	44	o.364	72.7
4o	2	1	-		
		2	-		
		4	33		
		12	18		
		Weighted mean	18	o.111	22.2
41	8	1	-		
		2	21		
		4	84		
		12	55		
		Weighted mean	54	o.148	29.6

Liberation S VI

Effective number of tags 47o

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per loo hrs. per looo tags per Square
35	1	1	35		
		2	66		
		4	39		
		12	24		
		Weighted mean	37 (24)	o.o42	8.9
36	3	1	53		
		2	8o		
		4	4o		
		12	92		
		Weighted mean	61	o.o49	1o.5
37	1	1	-		
		2	-		
		4	-		
		12	15		
		Weighted mean	3	o.333	7o.9
38	1	1	-		
		2	-		
		4	25		
		12	4o		
		Weighted mean	2o	o.o5o	1o.6
39	1	1	23		
		2	54		
		4	45		
		12	43		
		Weighted mean	43	o.o23	4.9
4o	o	1	-		
		2	-		
		4	42		
		12	23		
		Weighted mean	22	-	-
41	o	1	-		
		2	-		
		4	-		
		12	27		
		Weighted mean	22	-	-

Liberation IV

Effective number of tags 1510

Week	Tags	No. of Squares	Total Effort per Square	Tags per Unit Effort	Tags per 100 hrs. per 1000 tags per Square
35	0	1	-		
		2	-		
		4	34		
		12	25		
		Weighted mean	3 (2)	-	-
36	12	1	33		
		2	105		
		4	87		
		12	95		
		Weighted mean	59	0.203	13.5
37	4	1	-		
		2	25		
		4	12		
		12	14		
		Weighted mean	13	0.308	20.4
38	0	1	-		
		2	-		
		4	-		
		12	40		
		Weighted mean	12	-	-
39	8	1	-		
		2	51		
		4	47		
		12	41		
		Weighted mean	40	0.200	13.2
40	1	1	-		
		2	-		
		4	30		
		12	33		
		Weighted mean	26	0.038	2.5
41	13	1	-		
		2	10		
		4	5		
		12	20		
		Weighted mean	18	0.722	47.8

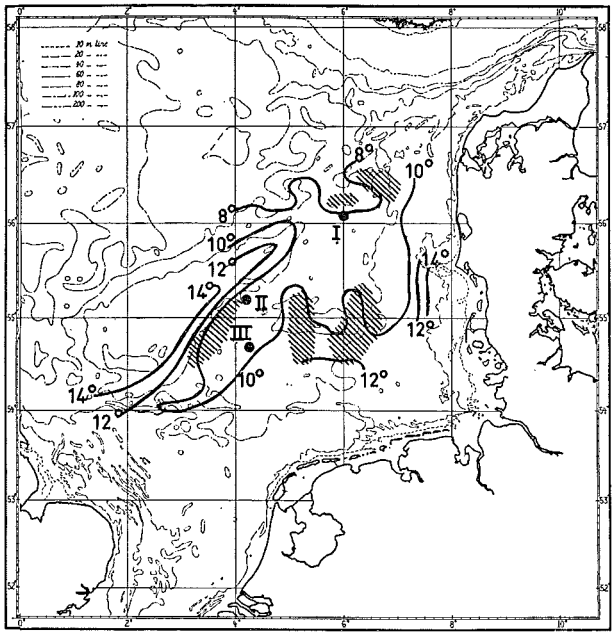


Figure 1. Pretagging survey in 1957.
Bottom temperatures in °C.
Hatched areas: echo-traces.
Roman numerals: position of liberations.

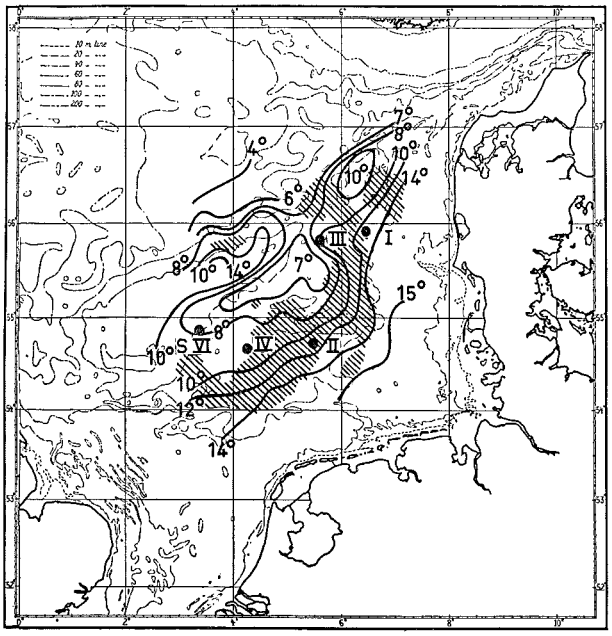


Figure 2. Pretagging survey in 1958.
Bottom temperatures in °C.
Hatched areas: echo-traces.
Roman numerals: position of liberations.

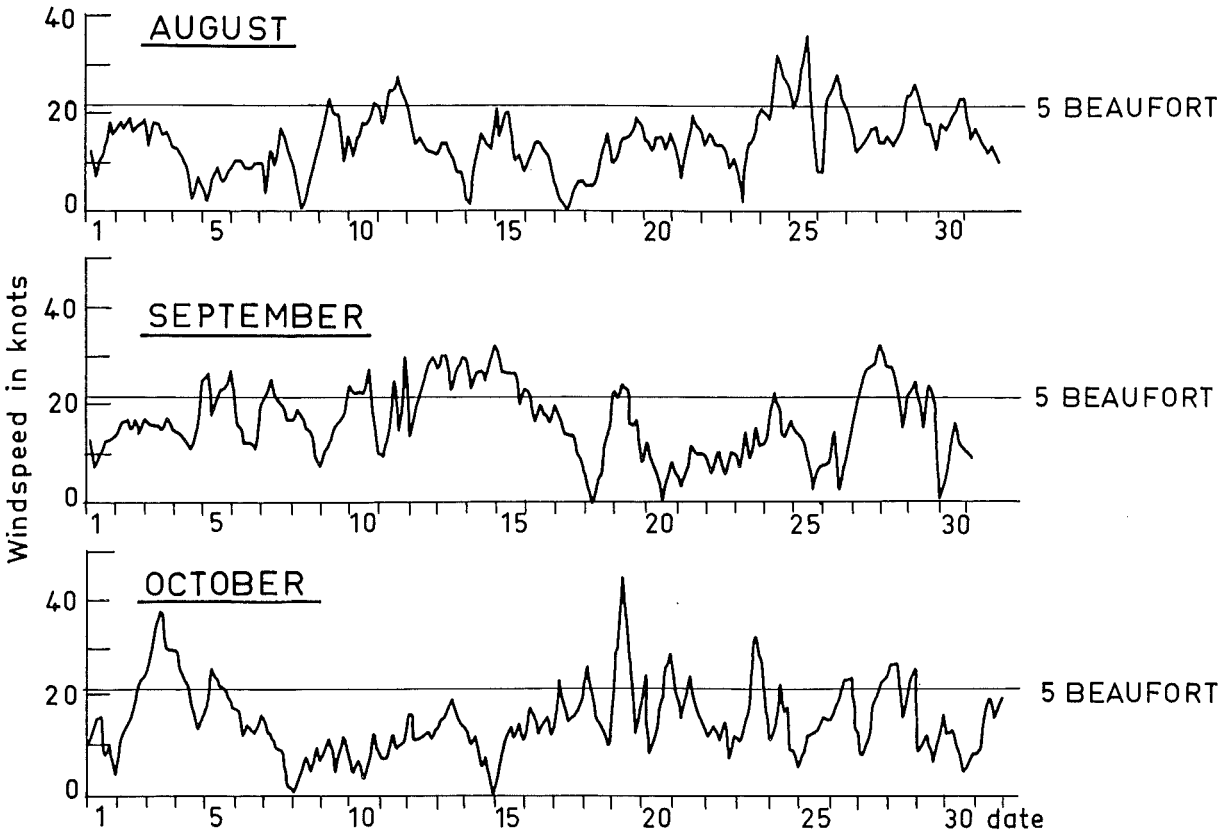


Figure 3. Daily windspeeds (in knots) at E. R. lightship (55°23′N–6°57′E) during the autumn fishing season of 1957.

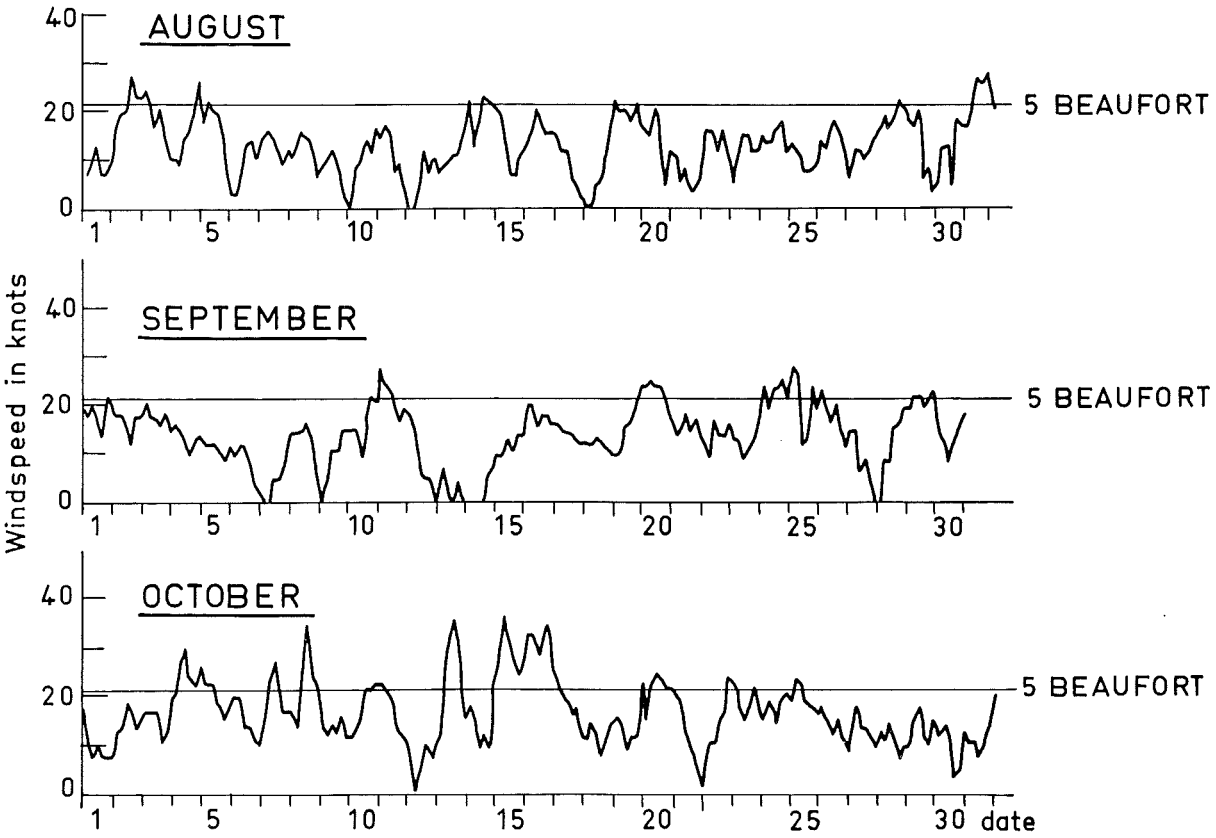


Figure 4. Daily windspeeds (in knots) at E. R. lightship (55°23′N–6°57′E) during the autumn fishing season of 1958.

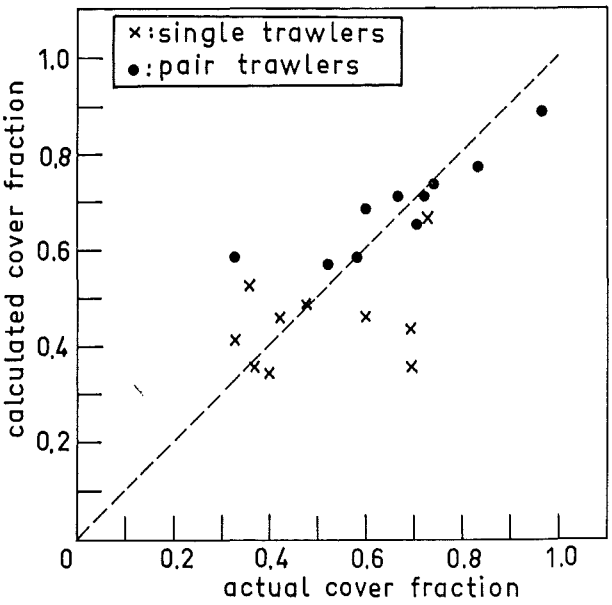


Figure 5. Comparison between calculated and actual cover fractions. Esbjerg. Autumn 1958. For explanation: see text.

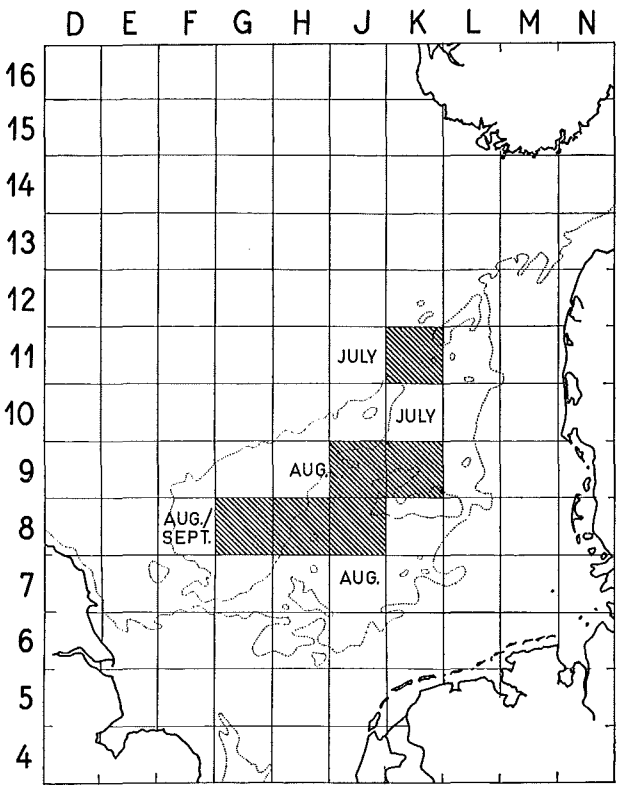


Figure 6. Main areas of the German fishery for industrial herring during the Bløden Ground season 1957.

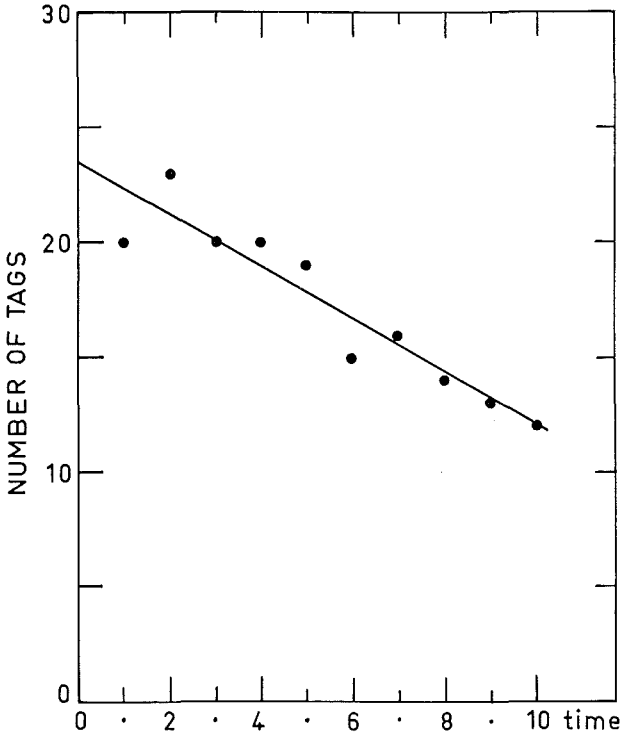
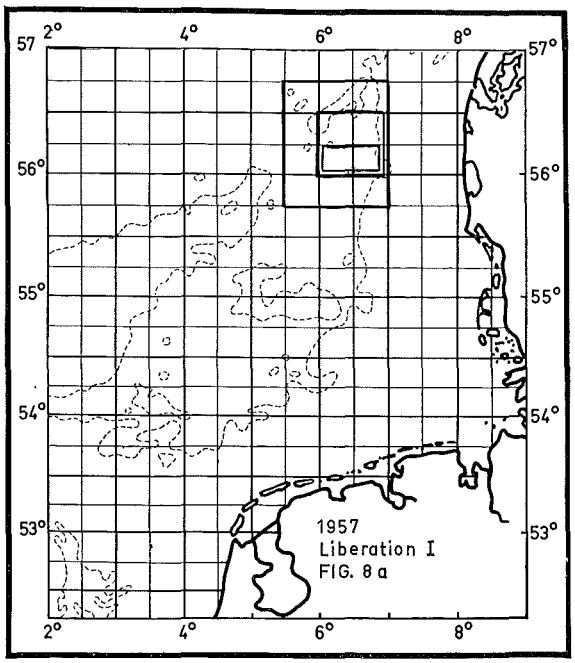
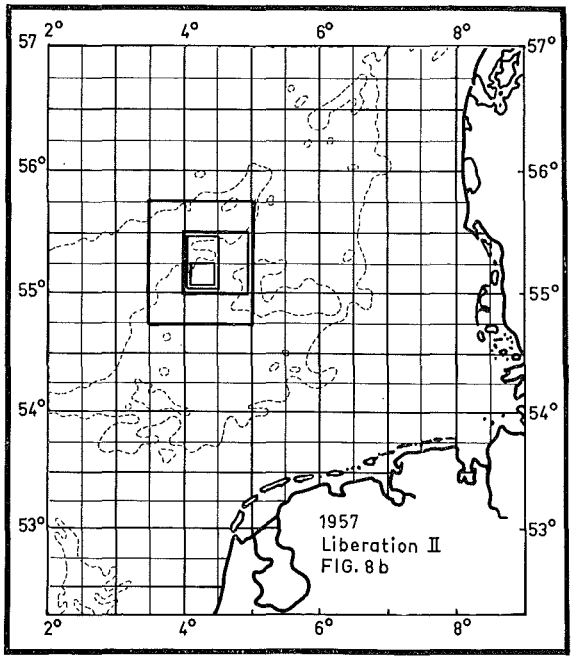
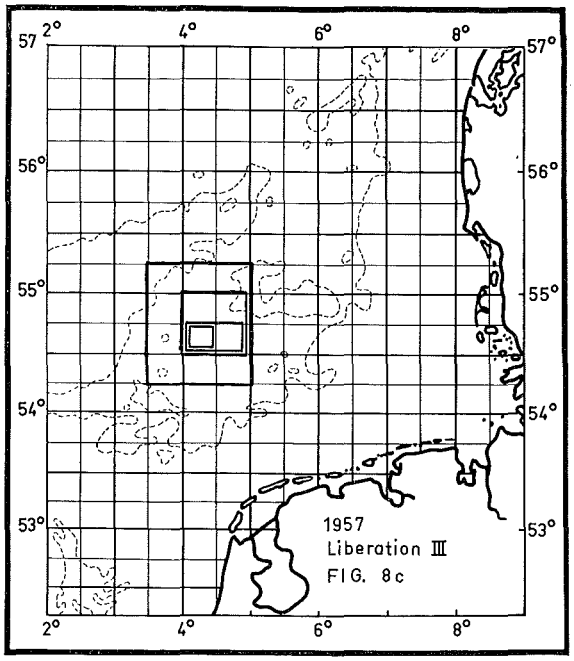


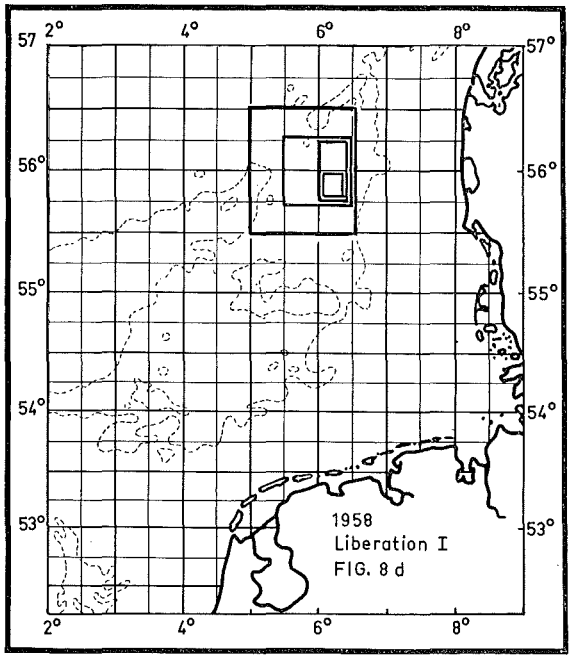
Figure 7. Returns of team 1 plotted against time between capture and tagging.

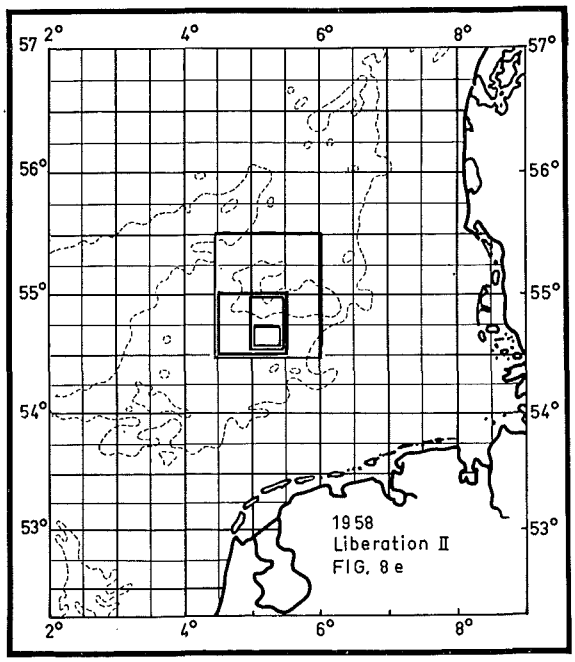
Figures 8 a-h. The regions of 1, 2, 4, and 12 squares used in calculating the fishing intensity on each liberation of tags.

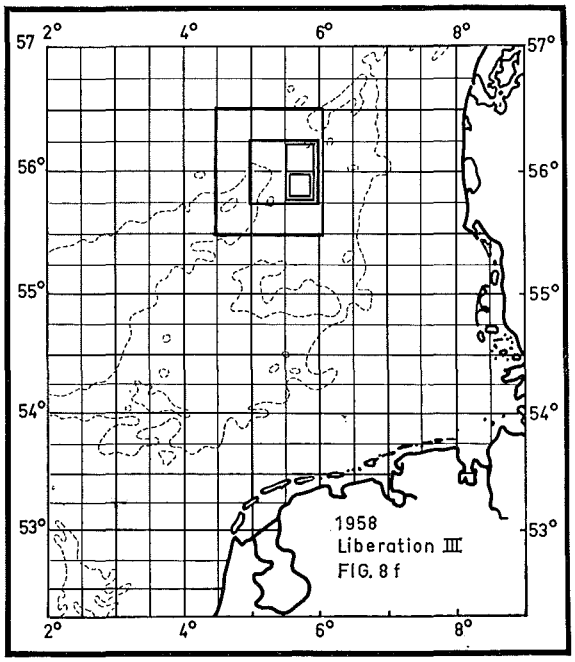


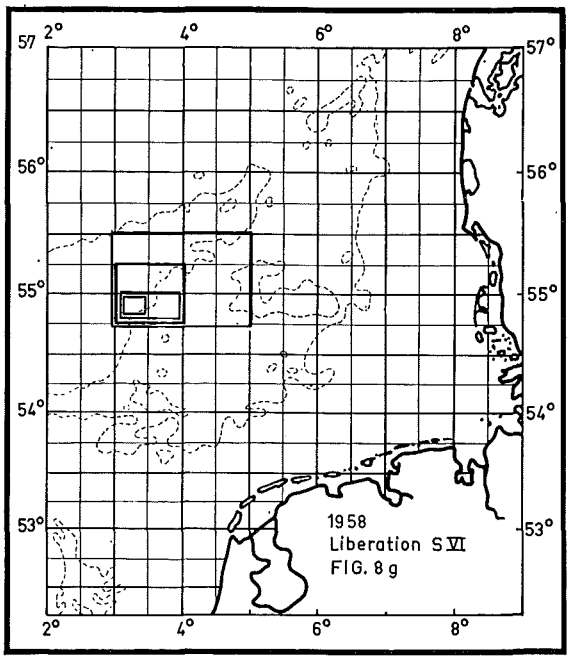


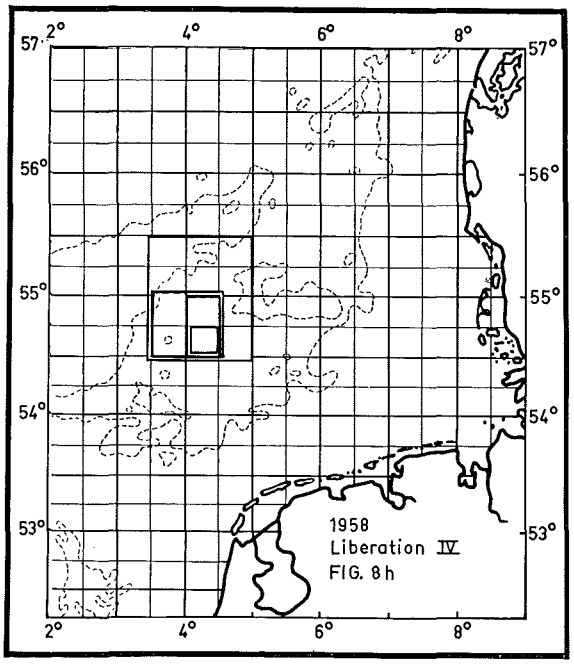





57
2°
4°
6°
8°
56°
55°
54°
53°
1958
Liberation II
FIG. 8 e


57
2°
4°
6°
8°
56°
55°
54°
53°
1958
Liberation III
FIG. 8 f


57
2°
4°
6°
8°
56°
55°
54°
53°
1958
Liberation S VI
FIG. 8 g


57
2°
4°
6°
8°
56°
55°
54°
53°
1958
Liberation IV
FIG. 8 h