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MOVEMENTS OF DAB (*LIMANDA LIMANDA* L.) IN THE GERMAN BIGHT AND SOUTHERN BIGHT: RESULTS OF GERMAN AND DUTCH TAGGING EXPERIMENTS IN 1988, 1989

by

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ABSTRACT

In the course of two Dutch and one German tagging experiments conducted in 1988 and 1989, a total of 3172 dab sampled in the Southern Bight and German Bight were tagged and released. The recapture rate was 4.8 % and 2.2 %, respectively. The results reveal an elevated migrational activity in January through April, probably associated with spawning time. There was no correlation between size at release or sex and the distance covered by tagged individuals. During spawning time, recaptures of dab tagged in the Southern Bight were concentrated on positions to the south-west of the release site. No such preference seemed to exist in case of the dab tagged in the German Bight. However, there appeared to be a tendency to migrate northward from the two northernmost release

positions, but independent of the month of recapture. In case of the dab tagged off the Dutch coast, an interaction between spatial/temporal patterns of recapture positions and fishing effort by the Dutch beam trawl fleet cannot be excluded.

INTRODUCTION

Due to its high abundance and wide distribution (BOHL 1957, LOZAN 1989), dab (*Limanda limanda*) is one of the most important target species in North Sea monitoring programmes using fish as indicator organisms for the occurrence of pollution effects.
Besides investigations into contamination levels with heavy metals (CLAUSSEN 1988) and organochlorines (BÜTHER 1988), studies on embryonal malformations (CAMERON et al. 1990) and on epidemiology of external and internal diseases (DETHLEFSEN et al. 1987, MELLERGARD and NIELSEN 1987, DETHLEFSEN 1990, KRANZ and DETHLEFSEN 1990, VETHAAK and VAN DER MEER 1991) have been undertaken and the possible role of pollution in the aetiology of pathological conditions has been discussed thoroughly (DETHLEFSEN et al. 1987, VETHAAK and AP RHEINALLT 1991, WATERMANN und KRANZ 1990).

One of the main prerequisites for the suitability of a certain indicator species in studies on spatial trends of contamination and biological effects is the lack of large-scale migrations or, if present, at least the knowledge of their extent. Otherwise, mixing processes of fish populations between different sampling sites or the non-awareness of such migrations could possibly lead to biased or blurred results and misinterpretation of data.

In order to gain information on the migratory behaviour of North Sea dab, three tagging experiments were conducted in 1988 and 1989 by the Netherlands (YM2, YMN) and Germany (DHBCX). Release positions of tagged fish were off the southern coast of the Netherlands, the isle of Terschelling, and in the German Bight, respectively.

The aim of the present paper is to provide information on the results of these experiments giving details on migration direction and distance under seasonal aspects. Furthermore, differences between sexes and length groups and the influence of fishing effort on the results will be discussed.

MATERIAL AND METHODS

In the German experiment, 1947 dab were tagged on a groundfish survey with RV "Solea" in the German Bight in December 1989. Fish were caught in a bottom otter trawl with small mesh codend.
Dab were sexed and measured to the cm below, then tagged with a round red plastic flap by means of a tagging gun. They were released as soon as possible, usually after finishing the next haul.
Dab about 20 cm length and above were preferred, because they are easier to handle and because the length of the plastic wire used in the tagging was not appropriate for very small fish.

In the Dutch experiment, 1051 (YMN) and 174 (YM2) dab in the length range 15-29 cm (mainly 18-23 cm) were tagged with RV "ISIS". In the YMN experiment a 6 m beam trawl was deployed with 2 tickler chains at a towing speed of about 3 knots. In the YM2 experiment a 6 m shrimp beam trawl was deployed with one tickler chain at a towing speed of about 2-3 knots. Haul duration in both experiments was about 10-15 minutes. Dab were selected from the catch and undamaged ones were tagged with a Peterson disc with a diameter of 14 mm (YM2) or 16 mm (YMN) and released within 15 minutes after tagging.

Whenever a recapture position was recorded, it was used to calculate the covered distance, directional angle, and speed. In all cases a straight movement was assumed, though geographically this was not always quite possible. It should be reminded, however, that a large proportion of recapture positions are based on

statements on the fishing bank or the statistical rectangle, and thus the coordinates should in general not be taken too litterally. There was no evidence for gross error or deliberate misreportings of recapture data, thus no observations were excluded.

Data on Dutch beam trawl effort were available from RIVO (unpublished data), giving days at sea by quarter and statistical rectangle for two horsepower classes (≤ 300 hp and > 300 hp, respectively), for years 1989 and 1990. A combined index was derived by weighting the effort of the larger vessels by an arbitrary factor of 2, thus compensating for the higher fishing power of larger vessels. (When an estimate for 1988 or 1991 was needed, the average of 1989 and 1990 was taken.)

RESULTS

Basic data are given in Table 1. Not all data sets are complete, but there are recapture positions for 83 dab (of 105). Recapture rate was 2.2 % in the German and 4.8 % in the Dutch experiments.
A plot of calculated distance vs. the time of recapture is shown in Figure 1. Obviously, the values are not homogeneous; there is a bulking of long distances in the first months of a year.
A two-way analysis of variance was performed on the distance data, pooling monthly values irrespective of the calendar year into a 3(experiments) x 12(months) table after log-transformation.
There was a significant (5 %) effect of the month of recapture, pointing towards some seasonal pattern. Other significant effects (experiment, interaction) were not present.
Subsequently, linear contrasts (Scheffé-type, ZAR 1984) were calculated for some groupings of monthly averages, giving the highest contrast for months 1-4 grouped vs. the rest of the year. It was therefore concluded that January through April are a period of elevated migrational activity, probably associated with spawning time.

There was no correlation of size at release or sex with the distance covered, neither over the whole data set, nor within any experiment.

Figure 2 shows the release and recapture positions from all experiments seperately by release position (note that Figure 2 j combines two closely neighbouring release sites). Recaptures from months 1-4 are marked with a delta, and it is also apparent from the maps that they are generally further apart from their release positions.

In general, dab tagged off the Dutch coast were recaptured on positions to the south-west during spawning time. There seems to be no corresponding preference in the German Bight taggings. There appears to be a tendency to migrate northward from the two northernmost positions (Figure 2 k,l), but independent of the month of recapture.

When statistically comparing the calculated directions within experiments for months 1-4 vs. those found in recaptures from the rest of the year (Test of Watson and Williams, ZAR 1984), differences were not found to be significant within neither experiment.

Any inference which is drawn from local differences in recaptures must of course consider the locally variable probability of recapture. In the given case, it is the Dutch beam trawler fleet which was responsible for the returns of almost all the Dutch and of the major part of the German tags. This makes it relatively easy to look for some interactions between the spatial/temporal patterns of fishing effort and recapture positions.

As a simple way of analysis, we chose to calculate the correlation between the calculated distance and the effort index for the respective rectangle, year and quarter. This would at least reveal, if long distances were over-emphasized by the effort distribution.

Using the recaptures from the Dutch beam trawl fleet, no such correlation could be found neither in the whole pooled data set, nor

within the German data. However, correlation was significant (1 %) in the pooled Dutch data. This points to the possibility that the effort distribution at least might exaggerate the apparent distances in this particular case.

It is interesting to see that the recaptures from the Dutch experiment were made in rectangles with an average effort index of 782 in the quarter of recapture, while it was only 303 for the German taggings. This can well explain the difference in overall recapture rate.

DISCUSSION

The experiments showed that dab is able to migrate over large distances. Also DE CLERCK (1984) and TEMMING (1989) found dab readily dispersing in their tagging experiments in the Southern Bight and the western Baltic, respectively.
On the other hand, it would be plausible, that the process of tagging and the molestation by the tag itself stimulates activity and mobility. DE VEEN (1978) discusses some outstanding tours of tagged plaice as an overcompensatory reaction to the displacement going along with the experiment.
If particularly large migrations occur directly after tagging, this might indicate such a reaction. In our data it is the dab from the German experiment which migrated most in the months right after tagging, but not so the ones tagged off the Dutch coast.
Since for both the main migrational activity was recorded for the months January-April, it is more plausible to assume a seasonal effect. Since spawning of dab starts in January with a peak from February to April (HARDING and NICHOLLS 1987, VAN DER LAND 1990), spawning migrations offer themselves for an explanation.
On the other hand. contrary evidence comes from the Belgian experiment (DE CLERCK 1984) where the largest migrations were recorded for the two quarters after tagging in June, too early for a true spawning migration, supposedly.

Seasonality in the migration pattern - animals return to the place of tagging after having wandered around - can indirectly be concluded from shorter distances after the main activity period. There is only light evidence (because of very few recaptures) that in the second winter after tagging the covered distances rose again.

In their longer-distance migrations during spawning time, dab from the German Bight preferred rather south-westerly or westerly directions rather than northerly ones. This pattern corresponds to the pattern of the mean direction of the tidal currents (Figure 3), which are known to be used by flatfish in their migrations (DE VEEN 1978, ARNOLD 1981, ARNOLD and COOK 1984). The population in the German Bight may not behave homogeneously in this respect, as it appears that specimens from the northernmore positions prefered northward movements.

Also in the Dutch experiments an southwesterly displacement prevailed for the longer distances during spawning time. However, for this data set there is evidence that concentrations of beam trawling effort in the southern Bight have favoured these particular recaptures, as shown by a correlation between an effort index and the estimated distance travelled.
No such correlation between distance and effort at the site of recapture was found in the German data set, which is probably meaningful in spite of the fact that the effort of other fleets, which contributed 1/4 of the recaptures with recorded positions, could not be considered.

According to these findings, if one assumes that tagged dab do not behave in a totally abnormal way, the conclusion must be drawn that the population south of the Dogger Bank is rather restless during spawning time, i.e. should not be used as target species for monitoring studies which require stationarity. Otherwise,

potentially existing regional differences of certain environmental parameters inducing biological effects could be masked by intermixing of fish between sampling stations due to migration.
Only comparisons on a wide geographical scale seem to be appropriate then.
The most suitable time for such studies might be in late autumn before the onset of the next migration phase, when the population has passed a period of relative stationarity. Even then, suitable minimum distances between sampling sites for regional comparisons should be taken.

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Table 1 : Basic data of the tagging experiments

EXP	RLL	S	RL POS	RL DATE	GR	C	RCL	RC POS	RC DATE	NM	DIR	D	NMD
DHBCX	250	F	5512 0709	13.12.89		DK	280	5623 0803	25.04.90	77	23	133	0.58
DHBCX	250	F	5455 0707	13.12.89	OT	DK	250	5714 0835	17.05.90	147	19	155	0.95
DHBCX	260	F	5405 0756	12.12.89		D	300	5405 0817	14.05.90	12	90	153	0.08
DHBCX	240	F	5405 0756	12.12.89	GN	DK		5543 0807	23.04.90	98	4	132	0.74
DHBCX	280	F	5405 0756	12.12.89		DK	290	5505 0810	24.07.90	61	8	224	0.27
DHBCX	310	F	5432 0712	14.12.89	BT	NL	305	5230 0255	07.03.90	195	233	83	2.36
DHBCX	230	F	5405 0756	12.12.89		D	235	5402 0811	03.01.90	9	109	22	0.42
DHBCX	260	F	5405 0756	12.12.89	OT	DK	278		12.01.90			31	
DHBCX	240	F	5404 0753	12.12.89	BT	NL			21.03.90			99	
DHBCX	210	F	5426 0724	14.12.89		NL	213		19.03.90			95	
DHBCX	240	F	5404 0753	12.12.89		NL	241		13.04.90			122	
DHBCX	250	F	5416 0736	16.12.89	BT	NL	255	5255 0405	20.03.90	149	239	94	1.59
DHBCX	260	F	5404 0753	12.12.89	BT	NL		5340 0505	22.02.90	102	258	72	1.42
DHBCX	290	F	5512 0709	13.12.89	BT	NL	297	5502 0730	09.05.90	16	130	147	0.11
DHBCX	240	F	5405 0756	12.12.89	PT	NL	285	5222 0320	28.04.90	195	240	137	1.42
DHBCX	260	F	5443 0715	13.12.89	BT	NL	262	5305 0410	31.01.90	147	229	49	2.99
DHBCX	270	F	5512 0709	13.12.89	BK	NL	271	5502 0700	04.04.90	11	207	112	0.10
DHBCX	260	F	5512 0709	13.12.89	BT	NL	261	5505 0710	04.04.90	7	175	112	0.06
DHBCX	260	F	5416 0736	16.12.89		D	250	5411 0749	29.07.90	9	123	225	0.04
DHBCX	280	F	5416 0736	16.12.89	OT	DK	290	5411 0747	10.11.90	8	128	329	0.02
DHBCX	230	F	5416 0736	16.12.89		D		5403 0753	06.08.90	16	142	233	0.07
DHBCX	250	F	5512 0709	13.12.89	GN	DK		5600 0745	10.05.90	52	23	148	0.35
DHBCX	260	F	5512 0709	13.12.89	BT	NL	263	5538 0645	06.06.90	29	333	175	0.17
DHBCX	240	F	5512 0709	13.12.89	BT	NL	244	5506 0703	30.05.90	7	210	168	0.04
DHBCX	250	F	5404 0753	12.12.89		NL	269						
DHBCX	250	F	5404 0753	12.12.89	BT	NL		5235 0355	12.04.90	168	240	121	1.39
DHBCX	270	F	5416 0736	16.12.89	BT	NL	274	5305 0405	20.04.90	144	242	125	1.15
DHBCX	280	F	5455 0707	13.12.89	BT	NL	249	5520 0703	28.06.90	25	355	197	0.13
DHBCX	220	F	5512 0709	13.12.89	BT	NL	221	5530 0710	28.06.90	18	2	197	0.09
DHBCX	240	F	5512 0709	13.12.89	BT	NL	247	5415 0319	10.04.90	145	248	118	1.22
DHBCX	260	F	5405 0756	12.12.89		NL	265		23.05.90			162	
DHBCX	210	F	5512 0709	13.12.89		NL	220		23.05.90			161	
DHBCX	210	F	5443 0715	13.12.89		NL	227		23.05.90			161	
DHBCX	240	M	5416 0736	16.12.89	BT	NL	240	5245 0430	04.02.90	143	232	50	2.86
DHBCX	300	F	5424 0744	16.12.89	BT	NL		5506 0700	14.06.90	49	329	180	0.27
DHBCX	250	F	5424 0744	16.12.89	BT	NL		5545 0630	13.06.90	91	333	179	0.51
DHBCX	270	F	5405 0756	12.12.89	BT	NL	268	5418 0200	25.04.90	209	276	134	1.56
DHBCX	260	F	5455 0707	13.12.89		NL	295	5513 0740	03.12.90	26	46	355	0.07
DHBCX	260	M	5447 0711	13.12.89	BT	NL	261	5508 0702	22.11.90	22	346	344	0.06
DHBCX	270	F	5424 0744	16.12.89	BT	NL	274	5250 0254	20.03.90	196	243	94	2.08
DHBCX	220	F	5455 0707	13.12.89	GN	DK		5600 0742	08.04.91	68	17	481	0.14
DHBCX	250	F	5416 0736	16.12.89		DK	250	5415 0730	23.04.90	4	254	128	0.03
DHBCX	250	F	5455 0707	13.12.89	OT	DK	250	5540 0730	04.05.90	47	16	142	0.33
DHBCX	260	F	5512 0709	13.12.89		DK	260	5530 0730	18.04.90	22	33	126	0.17

EXP : Experiment; RLL : Release length (mm); S : Sex;
RL POS : Release position (all N and E); RL DATE : Release Date;
GR : Gear (BT = Beam Trawl, OT = Otter trawl, PT = Pair trawl, SN = Seine, GN = Gill net, AN = Angling); C : Country reporting; RCL : Recapture length (mm); RC POS : Recapture Position (all N and E); RC DATE : Recapture date; NM : Nautical miles travelled; DIR : Direction travelled;
D : Days at large; NMD : Nautical miles per day

Table 1 : Basic data of the tagging experiments (ctd.)

EXP	RLL	S	RL POS	RL DATE	GR	C	RCL	RC POS	RC DATE	NM	DIR	D	NMD
YMN	185	M	5336 0448	04.07.89	BT	NL	192		17.05.90			317	
YMN	183	F	5336 0448	04.07.89	BT	NL	187	5310 0310	22.03.90	64	247	261	0.25
YMN	161	F	5336 0448	04.07.89	BT	NL	160		19.04.90			289	
YMN	234	F	5336 0448	04.07.89		NL	233		12.04.90			282	
YMN	195	F	5336 0448	04.07.89	BT	NL	192	5340 0440	05.12.89	6	310	154	0.04
YMN	203	F	5336 0448	04.07.89	SN	NL	201	5335 0500	27.08.89	7	98	54	0.13
YMN	245	F	5336 0448	04.07.89	BT	NL	259		24.04.90			294	
YMN	192	M	5336 0448	04.07.89	BT	NL	204	5300 0424	29.03.90	39	202	268	0.14
YMN	176	M	5336 0448	04.07.89		NL	195		28.05.90			328	
YMN	238	F	5336 0448	04.07.89			250	5330 0456	08.08.90	8	142	400	0.02
YMN	197	M	5336 0448	04.07.89	BT	NL	197	5257 0320	15.12.90	65	234	529	0.12
YMN	232	F	5336 0448	04.07.89	BT	NL	237	5210 0335	04.04.90	97	208	274	0.35
YMN	231	F	5336 0448	04.07.89	BT	NL	227	5326 0503	07.09.89	13	138	65	0.21
YMN	281	F	5336 0448	04.07.89	BT	NL	280	5324 0518	15.10.89	22	124	103	0.21
YMN	216	F	5336 0448	04.07.89	BT	NL	202	5312 0524	24.06.90	32	138	355	0.09
YMN	221	M	5336 0448	04.07.89	BT	NL	218	5335 0615	13.09.89	52	91	71	0.73
YMN	254	F	5336 0448	04.07.89	SN	NL	258	5325 0528	16.05.90	26	115	316	0.08
YMN	227	F	5338 0505	05.07.89	SN	NL	227	5325 0502	06.09.89	13	188	63	0.21
YMN	184	F	5338 0505	05.07.89	BT	NL	198	5200 0320	04.04.90	117	214	273	0.43
YMN	216	M	5338 0505	05.07.89		NL	240	5324 0518	13.07.89	16	151	8	2.00
YMN	228	F	5338 0505	05.07.89		NL	223		12.01.90			191	
YMN	277	F	5338 0505	05.07.89	BT	NL	277	5338 0615	04.10.89	42	90	91	0.46
YMN	194	F	5338 0505	05.07.89	BT	NL	201	5210 0300	19.04.90	116	221	288	0.40
YMN	245	F	5338 0505	05.07.89	BT	NL		5330 0448	14.11.89	13	232	132	0.10
YMN	193	F	5338 0505	05.07.89	SN	NL	198	5325 0501	07.09.89	13	190	64	0.21
YMN	289	F	5338 0505	05.07.89		NL	296		16.11.89			134	
YMN	216	M	5338 0505	05.07.89		NL	220		27.03.90			265	
YMN	230	F	5338 0505	05.07.89	BT	NL	237	5320 0400	26.02.90	43	245	236	0.18
YMN	194	F	5338 0505	05.07.89	BT	NL	208	5230 0315	30.01.90	95	225	209	0.45
YMN	177	F	5338 0505	05.07.89	SN	NL	181	5330 0521	27.09.89	12	130	84	0.15
YMN	178	M	5338 0505	05.07.89	BT	NL	210		23.05.90			322	
YMN	206	M	5338 0505	05.07.89	BT	NL	205	5154 0305	20.02.90	127	216	230	0.55
YMN	173	F	5338 0505	05.07.89	BT	NL	172	5345 0608	20.10.89	38	79	107	0.35
YMN	201	M	5338 0505	05.07.89		NL	217	5312 0424	16.05.90	36	223	315	0.11
YMN	221	F	5338 0505	05.07.89	SN	NL	217	5326 0500	07.09.89	12	194	64	0.19
YMN	180	F	5338 0505	05.07.89	BT	NL	176	5336 0608	05.12.89	37	93	153	0.24
YMN	196	F	5338 0505	05.07.89	BT	NL	197	5220 0330	29.03.90	97	217	267	0.36
YMN	203	F	5338 0505	05.07.89	BT	NL	202	5340 0610	09.11.89	39	87	127	0.30
YMN	204	F	5338 0505	05.07.89	BT	NL	236	5225 0402	16.08.90	82	208	407	0.20
YMN	212	F	5338 0505	05.07.89	BT	NL	240	5230 0300	28.02.91	101	229	603	0.17

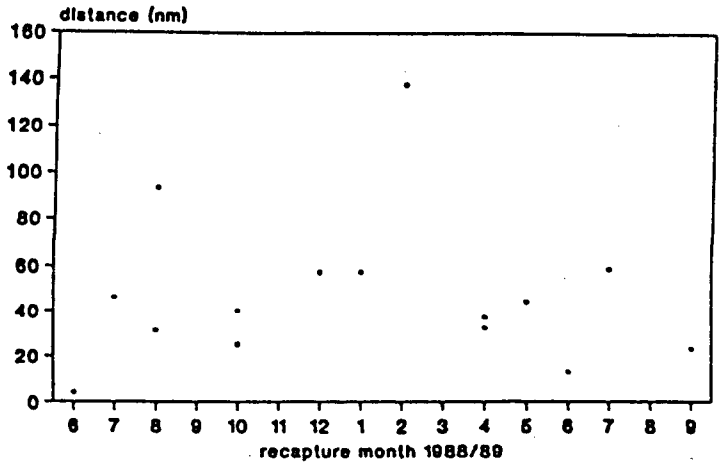
EXP : Experiment; RLL : Release length (mm); S : Sex;
RL POS : Release position (all N and E); RL DATE : Release Date;
GR : Gear (BT = Beam Trawl, OT = Otter trawl, PT = Pair trawl, SN = Seine, GN = Gill net, AN = Angling); C : Country reporting; RCL : Recapture length (mm); RC POS : Recapture Position (all N and E); RC DATE : Recapture date; NM : Nautical miles travelled; DIR : Direction travelled;
D : Days at large; NMD : Nautical miles per day

Table 1 : Basic data of the tagging experiments (ctd.)

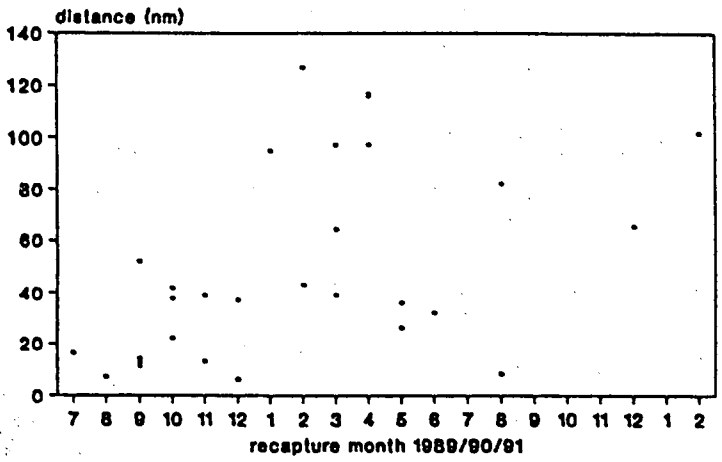
EXP	RLL	S	RL POS	RL DATE	GR	C	RCL	RC POS	RC DATE	NM	DIR	D	NMD
YM2	225	F	5137 0335	08.06.88	BT	NL	248	5200 0320	03.10.88	25	338	117	0.21
YM2	259		5137 0335	08.06.88	BT	NL	269	5310 0320	30.08.88	93	354	83	1.13
YM2	206		5137 0335	08.06.88	BT	NL	275		14.04.89			310	
YM2	226	F	5215 0415	10.06.88	BT	NL	275	5238 0420	07.09.89	23	8	454	0.05
YM2	173	F	5215 0415	10.06.88	BT	NL	213	5154 0336	27.04.89	32	229	321	0.10
YM2	253		5215 0415	10.06.88		DK			15.02.89			250	
YM2	196		5215 0415	10.06.88		F	210	5045 0130	23.02.89	137	230	258	0.53
YM2	213	F	5215 0415	10.06.88	BT	NL	262	5305 0328	05.07.89	58	331	390	0.15
YM2	164		5215 0415	10.06.88	BT	NL		5312 0424	17.01.89	57	5	221	0.26
YM2	236	F	5215 0415	10.06.88		NL	252	5312 0424	03.12.88	57	5	176	0.33
YM2	220	F	5215 0415	10.06.88		NL	217	5212 0418	22.06.88	4	148	12	0.29
YM2	181	F	5215 0415	10.06.88	BT	NL	225	5250 0330	02.05.89	44	322	326	0.14
YM2	212	F	5215 0415	10.06.88	BT	NL	235	5211 0310	04.10.88	40	265	116	0.35
YM2	216	M	5215 0415	10.06.88		NL	200		01.07.88			21	
YM2	217	F	5215 0415	10.06.88	BT	NL	230	5230 0330	25.08.88	31	299	76	0.41
YM2	202		5215 0415	10.06.88	AN	NL	210		26.11.88			169	
YM2	236	F	5215 0415	10.06.88		NL	232	5212 0418	24.06.88	4	148	14	0.25
YM2	189	M	5215 0415	10.06.88		NL	187		24.06.88			14	
YM2	193	F	5215 0415	10.06.88	BT	NL	192	5225 0302	07.07.88	46	283	27	1.69
YM2	233	F	5215 0415	10.06.88		NL	275	5224 0430	12.06.89	13	45	367	0.04
YM2	183	F	5215 0415	10.06.88	BT	NL	239	5200 0320	06.04.89	37	246	300	0.12

EXP : Experiment; RLL : Release length (mm); S : Sex;
RL POS : Release position (all N and E); RL DATE : Release Date;
GR : Gear (BT = Beam Trawl, OT = Otter trawl, PT = Pair trawl, SN = Seine, GN = Gill net, AN = Angling); C : Country reporting; RCL : Recapture length (mm); RC POS : Recapture Position (all N and E); RC DATE : Recapture date; NM : Nautical miles travelled; DIR : Direction travelled;
D : Days at large; NMD : Nautical miles per day

Migration distance of tagged *L.limanda*
Experiment YM2, tagging in 06.1988



Migration distance of tagged *L.limanda*
Experiment YMN, tagging in 06.1989



Migration distance of tagged *L.limanda*
Experiment DHBCX, tagging in 12.1989

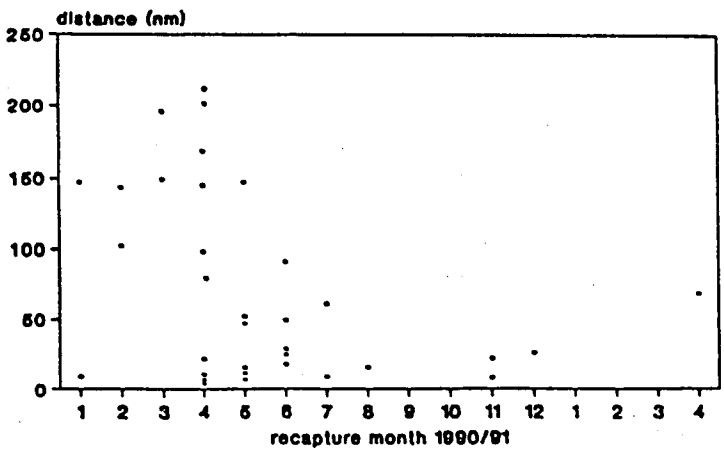


Figure 1: Migration distance vs. recapture month of tagged dab

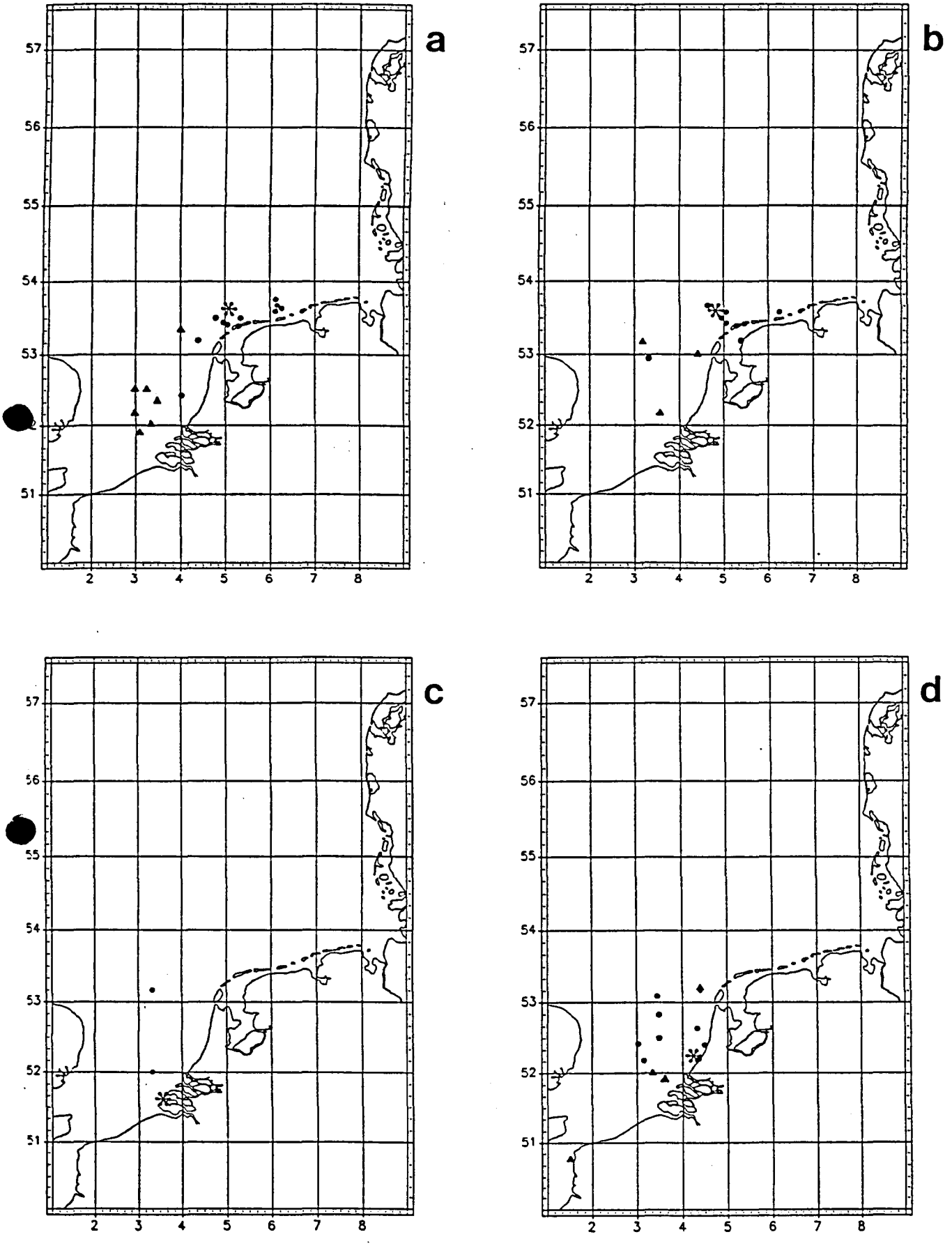


Figure 2: Release and recapture position of tagged dab
(a,b: Experiment YMN; c,d: Experiment YM2)

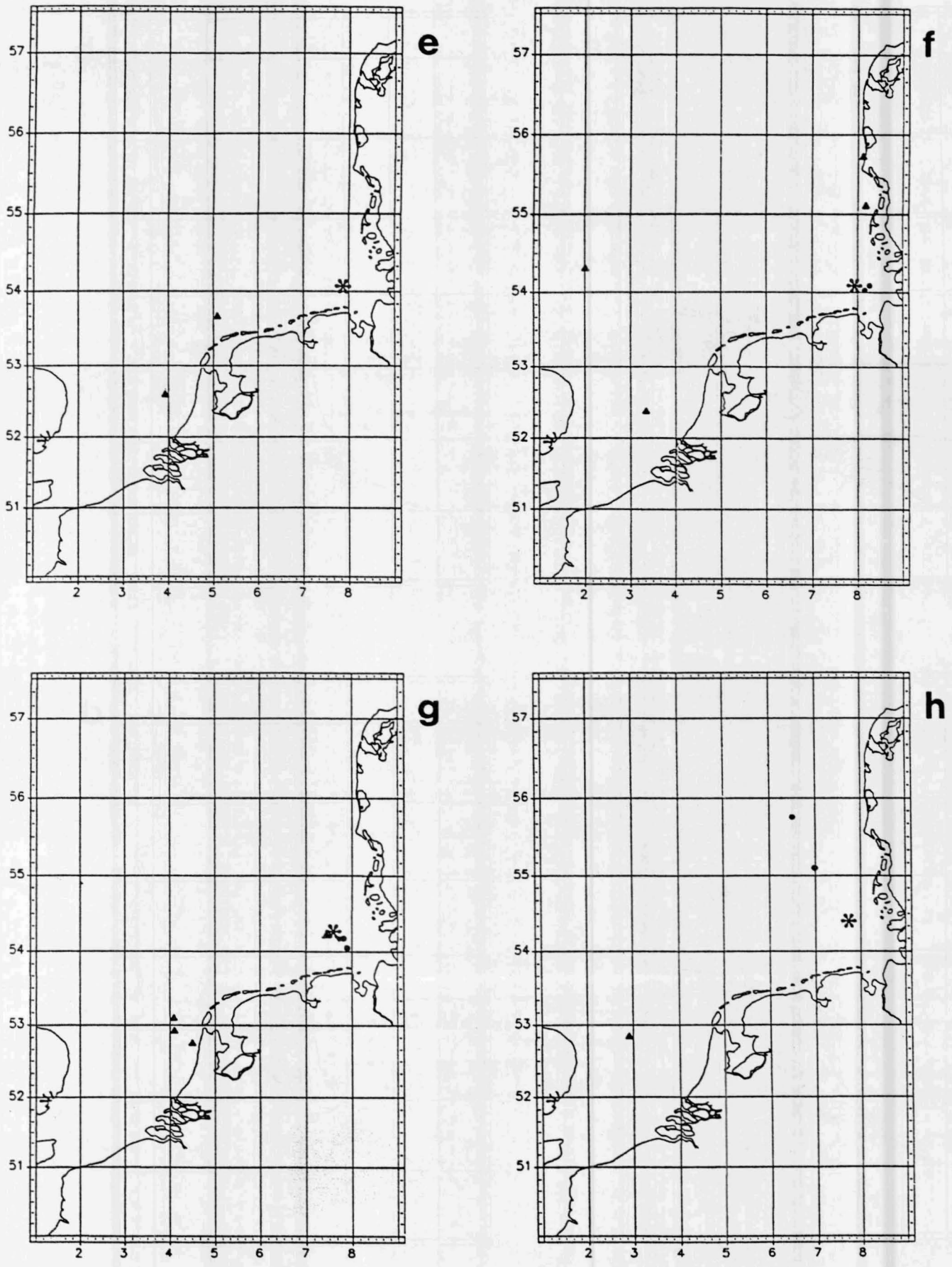


Figure 2 (cont.): Experiment DHBCX, part 1

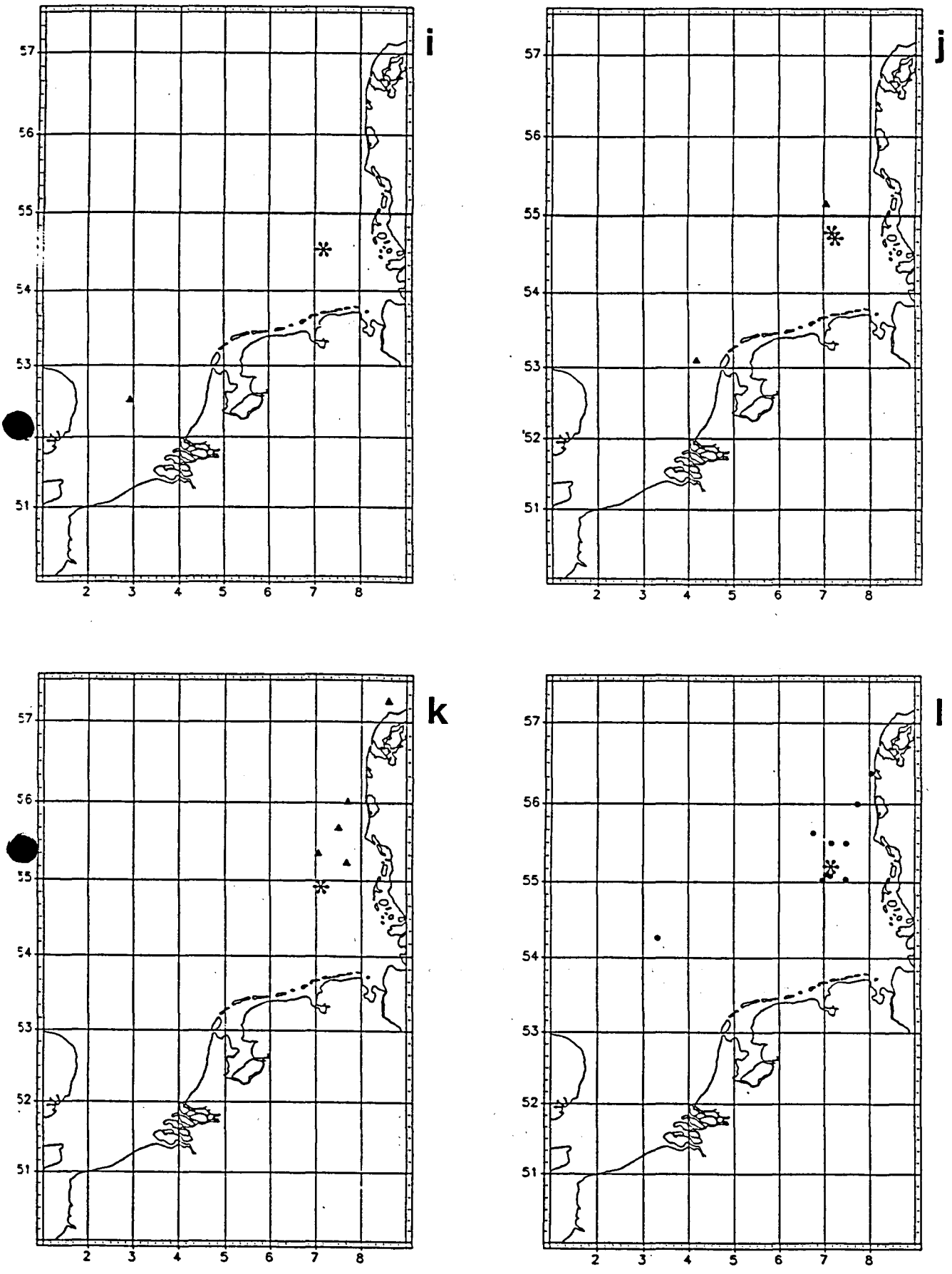


Figure 2 (cont.): Experiment DHBCX, part 2

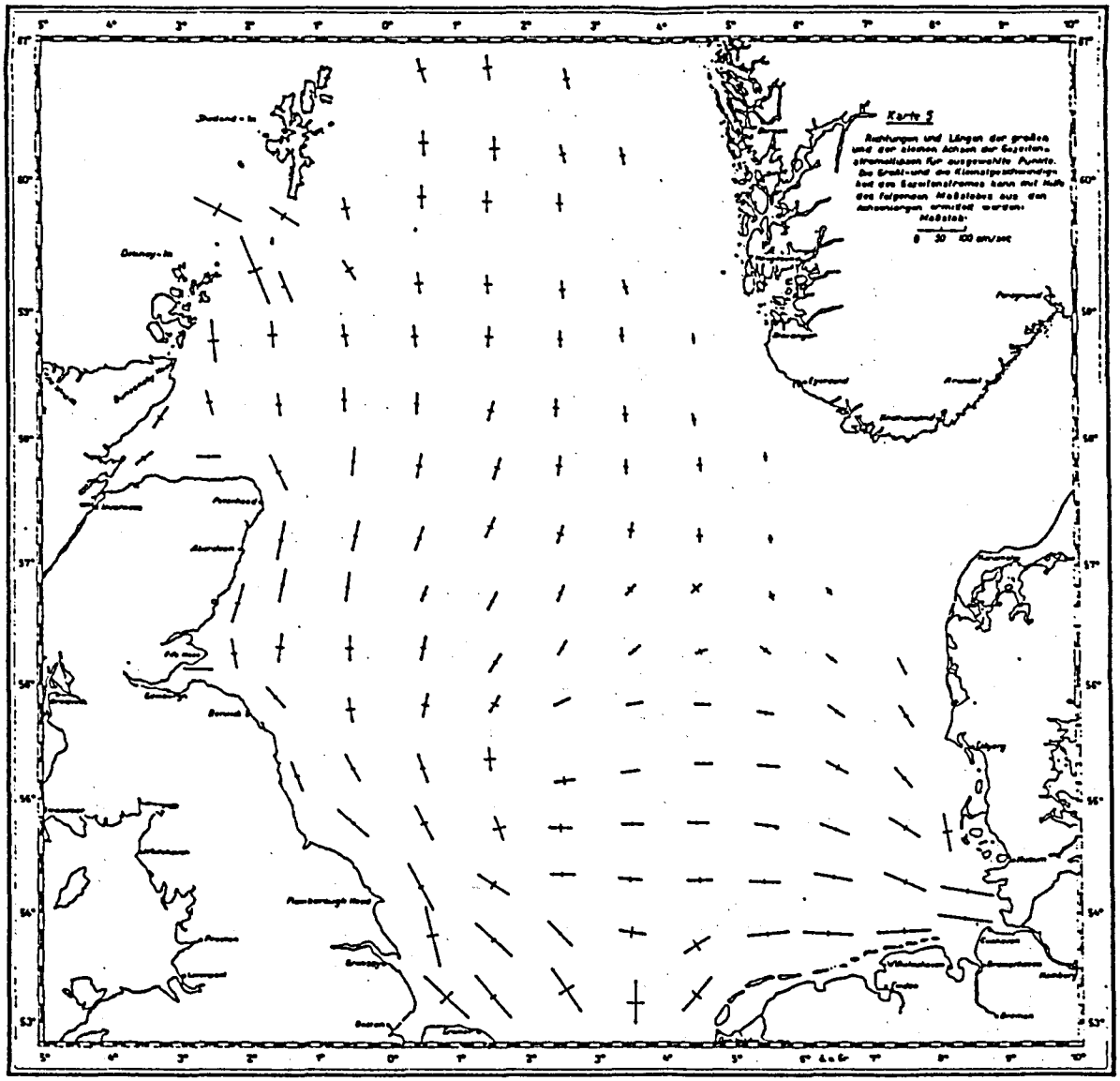


Figure 3: Theoretical directions and intensities of tidal currents in the North Sea (from HANSEN 1952)