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A Comparison of Results from Canadian Deepwater Surveys in 1991 and 1994, With Emphasis on Greenland halibut

by

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Introduction

With the development of fisheries in the deep water in the NAFO reulatory area in Div. 3KLMN, it was decided to conduct research vessel surveys in this area to learn more about the distribution and abundance of several species, particularly Greenland halibut, and to monitor changes in the populations over time. Two surveys were conducted, one by the Cape Adair in summer 1991 and the other by the Zandvoort in winter 1994. This paper compares the results of these two surveys with special emphasis on Greenland halibut.

Methods and Materials

The vessels which conducted these surveys were commercial fishing vessels chartered by the Department of Fisheries and Oceans. The Cape Adair survey was conducted from Sept. 4-30, 1991 in Div. 3KLM. Most fishing sets were in 750 to 1500m depth. A total of 106 fishing sets were completed, 27 in Div. 3K, 42 in 3L and 37 in 3M. The survey used a line transect design which was later post-stratified using a newly developed stratification scheme covering depths to 1464 m (800 fm) (Bishop, 1994).

The Zandvoort survey was conducted from Feb 3- Mar 15, 1994 in Div. 3KLMN using a stratified random design. The depth range of the survey was 500 - 1500m. A total of 131 successful fishing sets were completed, 22 in Div. 3K, 47 in 3L, 51 in 3M and 11 in 3N.

Both ships used an Engels 145 otter trawl with 18" rockhopper footgear and a 28 mm liner in the codend and net dimensions were the same for both vessels. Furuno CN net sounding equipment monitored the trawl during each tow. At touchdown of the net a standard 30 min tow started at a speed of 3.5 knots. Sets with extreme trawl damage were excluded from analyses. All tows in each survey were standardized before analyses to account for differences in tow distance.

From each fishing set, catch numbers and weights were obtained for all species along with length frequency for Greenland halibut, American plaice, witch flounder, redfish, roundnose grenadier and roughhead grenadier. Otoliths were collected from Greenland halibut.

Results and Discussion

Greenland Halibut

Total Trawlable Biomass and Abundance

Trawlable biomass of Greenland halibut in all divisions was lower in 1994 than in 1991 (Figure 1, Table 1). In 3L biomass declined from 13000 to 10000 t between 1991 and 1994. In 3M the decline in trawlable biomass was from 24000 to 10000 t. In Divisions 3L and 3M there was greater coverage in the 1994 Zandvoort survey than in the 1991 Cape Adair survey. In Div. 3K, the biomass decline was the greatest of any division in the survey area, with the estimated biomass of Greenland halibut decreasing from 32000 t in 1991 to 7000 t in 1994. There was no coverage of depths less than 1000m by the Zandvoort in Div. 3K. However, the Gadus Atlantica surveyed th 751-1000m depth zone only three months earlier in Nov. 1993. The trawlable biomass estimate for the strata in this depth zone from the Gadus survey are shown in bold italics in Table 1. Including these values in the total biomass estimate for 3K increases the estimated biomass to 10000 t. Using this estimate the biomass in Div. 3K declined from 32000 t in 1991 to 10000 t in 1994. All depth zones surveyed in Div. 3K, 3L and 3M (with the exception of 550-731m in Div. 3L) showed a decline in estimated trawlable biomass from 1991 to 1994 (Table 1).

Table 2 gives the abundance of Greenland halibut in each Division from the two surveys. Abundance decreased between 1991 and 1994 in Div. 3K and 3M, but increased in Div. 3L. In 3K

abundance declined from 20 million to 10 million fish, in 3M the decrease was from 12 million to 8 million fish, while in 3L the abundance increased from 7 million to 20 million fish.

Distribution

The distribution of Greenland halibut was similar in 1991 and 1994 (Figures 2 & 3) with fish being found througout the survey area. In both surveys, fish were found along the edge of the Grand Banks, in the Flemish Pass and in deepwater around the edge of the Flemish Cap. Although the overall distribution was similar between the two surveys, the catch per tow was generally less in 1994 throughout the survey area.

Abundance at Age and Length

The percent and absolute abundance at age and length are given in Figures 4 and 5. The absolute abundance at age 7+ was greater in all three divisions in 1991 than 1994. There was a higher abundance of ages 3-5 in all divisions in 1994 but virtually no fish older than age 9. In 1991, fish aged 9+ made up 32.7% of the catch in Div. 3K, 41.5% in Div. 3L and 44.9% in Div. 3M. In 1994, the percentages were 10.3, 2.0 and 11.0 respectively.

A similar pattern is evident from the abundance at length from the two surveys. There were few fish greater than 50 cm in length in the Zandvoort survey. In the Cape Adair survey in 1991, in 3K 55.9% of the catch consisted of fish 50 cm or greater. In 3L 59.6% of the catch was of this size and in 3M 71.0%. In 1994, 12.9%, 4.5% and 34.5% of the catch was 50 cm or greater in Div. 3K, 3L and 3M respectively. The greater overall abundance in 3L in 1994 (Table 2) is a result of an increase in smaller, younger fish.

Biomass at Age

Biomass at age in Div. 3K, 3L and 3M is shown in Figure 6 and Table 3. Biomass declined for ages 9+ for all divisions from 1991 to 1994. In 1991, age 9+ fish comprised 61.5% of the biomass in Div. 3K, 68.3% in Div. 3L and 69.5% in Div. 3M. In 1994, age 9+ fish comprised 34%, 13.6 and 31.2% of the biomass in Div. 3K, 3L, and 3M respectively.

Division 3N

The Zandvoort survey also covered part of Div. 3N. In this division, ages 3-5 were again the most abundant (Figure 7), however, there is no equivalent survey with which this result can be compared. The biomass of Greenland halibut in Div. 3N was estimated to be 2000 t (Table 1).

Conclusion

Greenland halibut has shown a marked reduction in biomass throughout the survey area between 1991 and 1994. Further, older, larger fish have all but disappeared from the area.

American Plaice

Very little A. plaice was caught during the Cape Adair survey (Figures 8 & 9) with the only catches being on the slopes of the Flemish Cap. In the Zandvoort survey, A. plaice catches were more widely distributed, especially in 3L where the estimated biomass was 7000 t (Figures 8 & 10).

Witch Flounder

The biomass estimate of witch flounder for Div. 3KLM from the 1991 survey was only 39 t and in 1994, 1900 t (Figure 8). Small catches of witch flounder were taken around the Flemish Cap and in Div. 3K in 1991 (Figure 11). Witch flounder were widely distributed throughout the area in 1994 (Figure 12) but catches were small.

Redfish

The largest biomass of redfish in the Cape Adair survey was in Div. 3K at 4000 t (Figures 8 & 13) however, this is mainly the result of one large set. Redfish were also distributed on the nose of the Grand Bank and around the Flemish Cap. In 1994, no redfish were caught in Div. 3K (Figures 8 & 14) and they were most abundant in 3M at 7700 t. The highest concentrations were on the boundary of Div. 3M, 3L and 3N.

Grenadier

Both roundnose and roughhead grenadier were caught in the two surveys in all divisions (Figure 8). The greatest biomass of roundnose grenadier was in Div. 3K in both surveys, with an estimate of 19000 t in 1991 and 21000 t in 1994. Roughhead grenadier biomass showed less variation across divisions and had a slightly higher estimated biomass in 1994 than 1991.

References

Bishop, C.A. 1994. Revisions and additions to stratification schemes used during research vessel surveys in NAFO subareas 2 and 3. NAFO SCR Doc. 94/43.

TABLE 1. Estimated biomass (tons) per stratum of G. halibut from the Cape Adair summer survey 1991 and the Zandvoort winter survey 1994. Based on the new stratification system.

Div. 3K

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Biomass 1991	Biomass 1994
751-1000	647	360	27	11737	***1618***
	652	516	39	4038	***1521***
Total				15775	***3139***
1001-1250	643	733	55	4163	2118
	648	228	17	4056	2563
	653	531	40	2278	784
Total				10497	5465
1251-1500	644	474	36	2895	562
	649	212	16	2037	336
	654	479	36	1410	696
Total				6342	1594
Biomass(t)				32615	7059
95% Lower				18910	-18786
95% Upper				46320	32904

From Gadus survey, Fall 1993: Total =10178 including these values

Div. 3L

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Biomass 1991	Biomass 1994
550-731	730	170	13	-	724
	732	231	17	-	637
	734	228	17	428	112
	736	175	13	-	754
Total				428	2227
732-914	737	227	17	843	812
	741	223	17	827	399
	745	348	26	1395	1245
	748	159	12	-	457
Total				3065	2913
915-1097	738	221	17	-	399
	742	206	15	993	368
	746	392	29	2637	585
	749	126	9	-	607
Total				3630	1959
1098-1280	739	254	19	-	545
	743	211	16	1360	334
	747	724	54	2054	1245
	750	556	42	1182	447
Total				4596	2571
1281-1463	740	264	20	865	420
	744	280	21	812	-
Total				1677	420
Biomass(t)				13397	10090
95% Lower				8945	7199
95% Upper				17849	12982

Div. 3M

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Biomass 1991	Biomass 1994
367-549	537	102	8	-	0
Total					0
550-731	538	194	15	-	47
Total					47
732-914	520	525	39	2890	555
	524	253	19	-	204
	528	530	40	3587	632
	539	133	10	-	68
Total				6477	1459
915-1097	521	517	39	2185	858
	529	488	37	2667	593
	532	238	18	1778	847
	534	486	36	-	1271
Total				6630	3569
1098-1280	522	533	40	2288	953
	530	1134	85	7601	3403
	535	92	7	-	75
Total				9889	4431
1281-1463	523	284	21	-	255
	527	171	13	-	140
	531	203	15	1065	-
	536	112	8	-	122
Total				1065	517
Biomass(t)				24060	10022
95% Lower				19783	8324
95% Upper				28337	11719

Div. 3N

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Biomass 1991	Biomass 1994
550-731	728	156	12	-	324
Total					324
732- 914	752	134	10	-	554
Total					554
915-1097	753	138	10	-	296
Total					296
1098-1280	754	180	14	-	251
Total					251
1281-1463	755	385	29	-	730
Total					730
Biomass(t)					2156
95% Lower					767
95% Upper					3546

TABLE 2. Estimated numbers (000) per stratum of G. halibut from the Cape Adair summer survey 1991 and the Zandvoort winter survey 1994. Based on the new stratification system.

Div. 3K

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Abundance 1991	Abundance 1994
751-1000	647	360	27	8936	-
	652	516	39	2944	-
Total				11880	-
1001-1250	643	733	55	2678	3045
	648	228	17	1888	3834
	653	531	40	986	1408
Total				5552	8287
1251-1500	644	474	36	1361	498
	649	212	16	756	214
	654	479	36	580	557
Total				2697	1269
Abundance				20129	9557
95% Lower				11771	-31113
95% Upper				28486	50227

Div. 3L

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Abundance 1991	Abundance 1994
550-731	730	170	13	-	1608
	732	231	17	-	2488
	734	228	17	365	471
	736	175	13		2535
Total				365	7102
732-914	737	227	17	866	2650
	741	223	17	998	1122
	745	348	26	1145	2943
	748	159	12	-	937
Total				3009	7652
915-1097	738	221	17	-	705
	742	206	15	561	897
	746	392	29	1072	777
	749	126	9	-	350
Total				1633	2729
1098-1280	739	254	19	-	928
	743	211	16	449	459
	747	724	54	794	879
	750	556	42	508	292
Total				1751	2558
1281-1463	740	264	20	220	515
	744	280	21	300	-
Total				520	515
Abundance				7279	20555
95% Lower				5484	13458
95% Upper				9074	27653

Div. 3M

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Abundance 1991	Abundance 1994
367-549	537	102	8	-	0
Total					0
550-731	538	194	15	-	32
Total					32
732-914	520	525	39	2253	532
	524	253	19	-	177
	528	530	40	3358	895
	539	133	10	-	60
Total				5611	1664
915-1097	521	517	39	1411	750
	529	488	37	1513	733
	532	238	18	776	1018
	534	486	36	-	905
Total				3700	3406
1098-1280	522	533	40	974	520
	530	1134	85	2057	2564
	535	92	7	-	45
Total				3031	3129
1281-1463	523	284	21	-	160
	527	171	13	-	45
	531	203	15	250	-
	536	112	8	-	63
Total				250	268
Abundance				12591	8499
95% Lower				10520	7001
95% Upper				14663	9998

Div. 3N

Depth range (m)	Stratum	Area (sq. nm)	Trawlable Units(000)	Abundance 1991	Abundance 1994
550-731	728	156	12	-	989
Total					989
732- 914	752	134	10	-	1046
Total					1046
915-1097	753	138	10	-	119
Total					119
1098-1280	754	180	14	-	108
Total					108
1281-1463	755	385	29	-	355
Total					355
Abundance					2618
95% Lower					-7412
95% Upper					12647

Table 3. Biomass (tonnes)at age from the Cape Adair (summer 1991) and Zandvoort (winter 1994) surveys in Div. 3K, 3L and 3M.

	3K		3L		3M	
Age	1991	1994	1991	1994	1991	1994
1	0	0	0	0	0	0
2	0	0	0	8	0	0
3	0	6	0	1074	0	2
4	6	831	1	2296	0	153
5	171	1053	170	2214	72	492
6	1503	1365	781	1684	542	1437
7	3953	1032	1951	1497	2532	1718
8	6091	736	2122	693	3463	1823
9	5545	2292	3010	400	4818	1263
10	2822	91	2077	552	3194	522
11	2164	155	1894	367	1702	294
12	1998	0	1558	176	2155	461
13	2285	0	1271	0	1854	12
14	2085	0	949	0	1285	0
15	1091	64	61	0	70	0
16	651	0	0	0	0	0
17	91	0	0	0	0	0

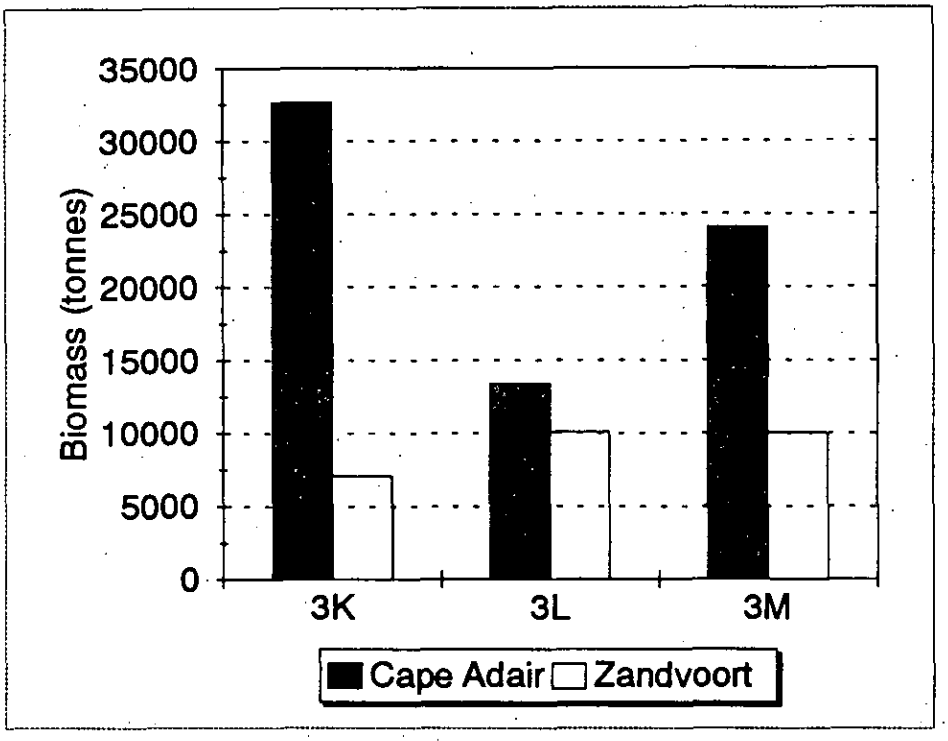

Fig. 1. Biomass (tonnes) of G. halibut in Divisions 3K, 3L, and 3M from Cape Adair (summer 1991) and Zandvoort (winter 1994).

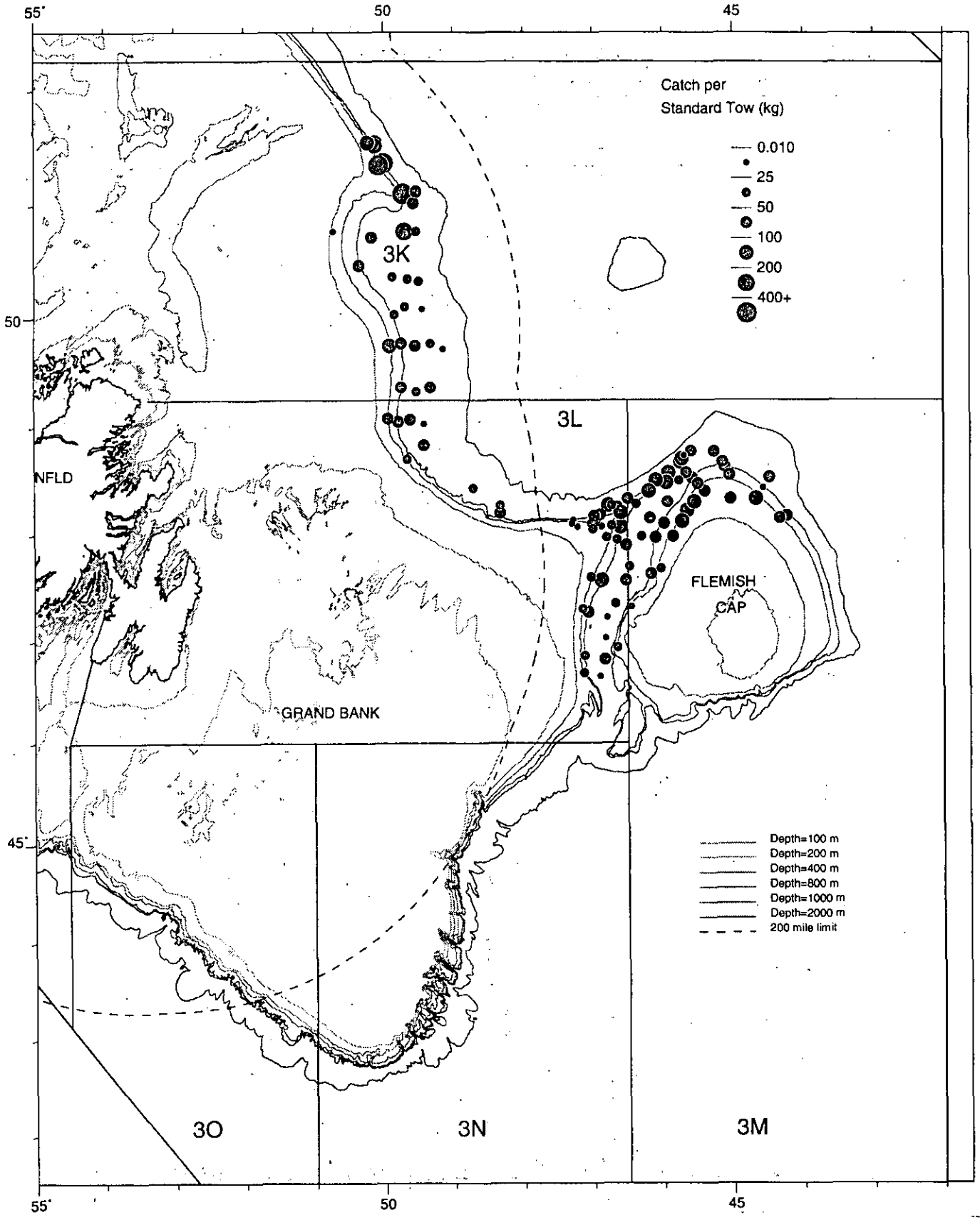

Fig. 2. Distribution of Greenland halibut catches from a Canadian survey by the Cape Adair, summer 1991, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

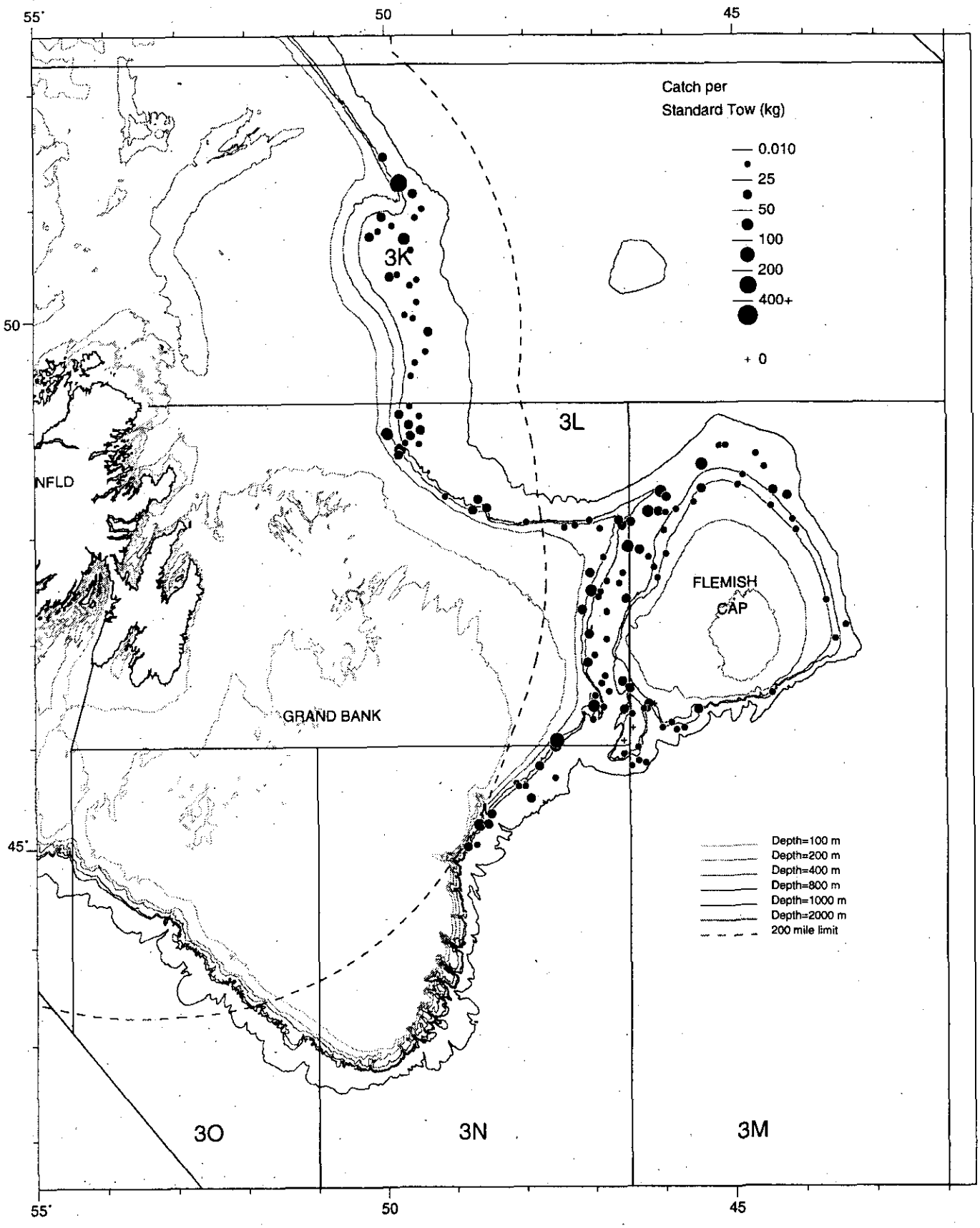

Fig. 3. Distribution of Greenland halibut catches from the vessel Zandvoort, winter 1994, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

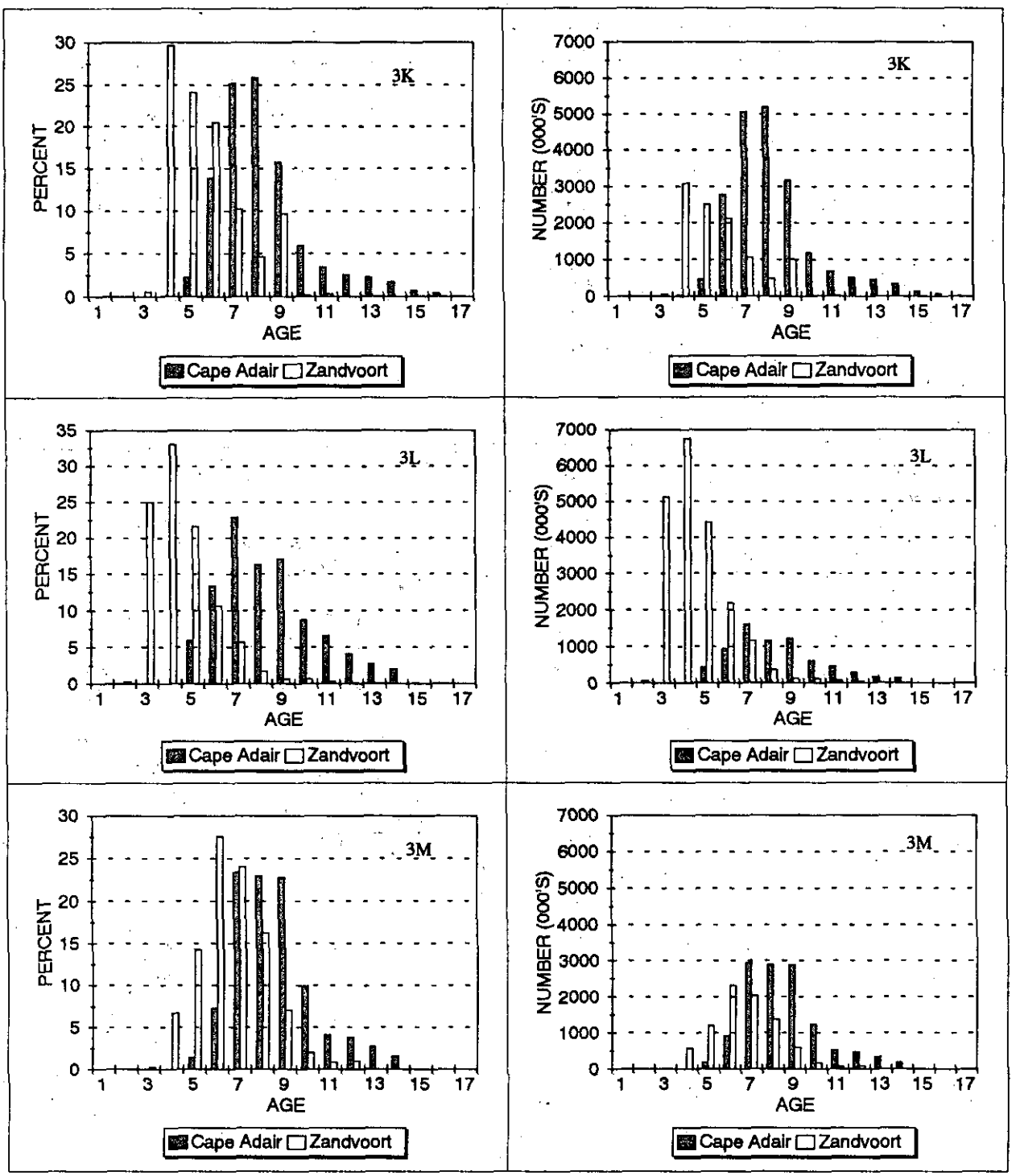

Fig. 4. Percent occurrence and absolute abundance (000's) at age of G. halibut from Cape Adair (summer 1991) and Zandvoort (winter 1994) surveys.

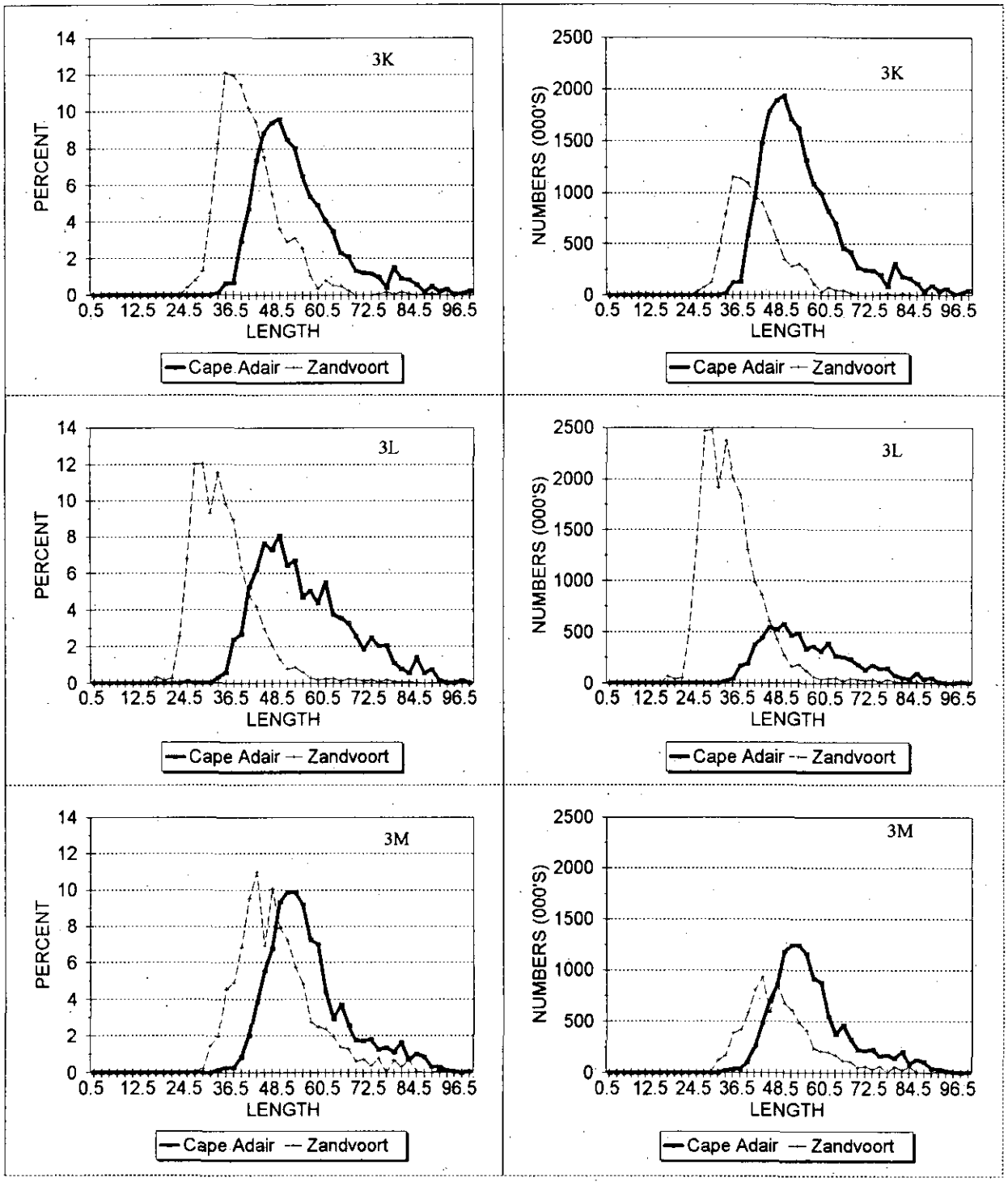

Fig. 5. Percent occurrence and absolute abundance (000's) at length of G. halibut from Cape Adair (summer 1991) and Zandvoort (winter 1994) surveys.

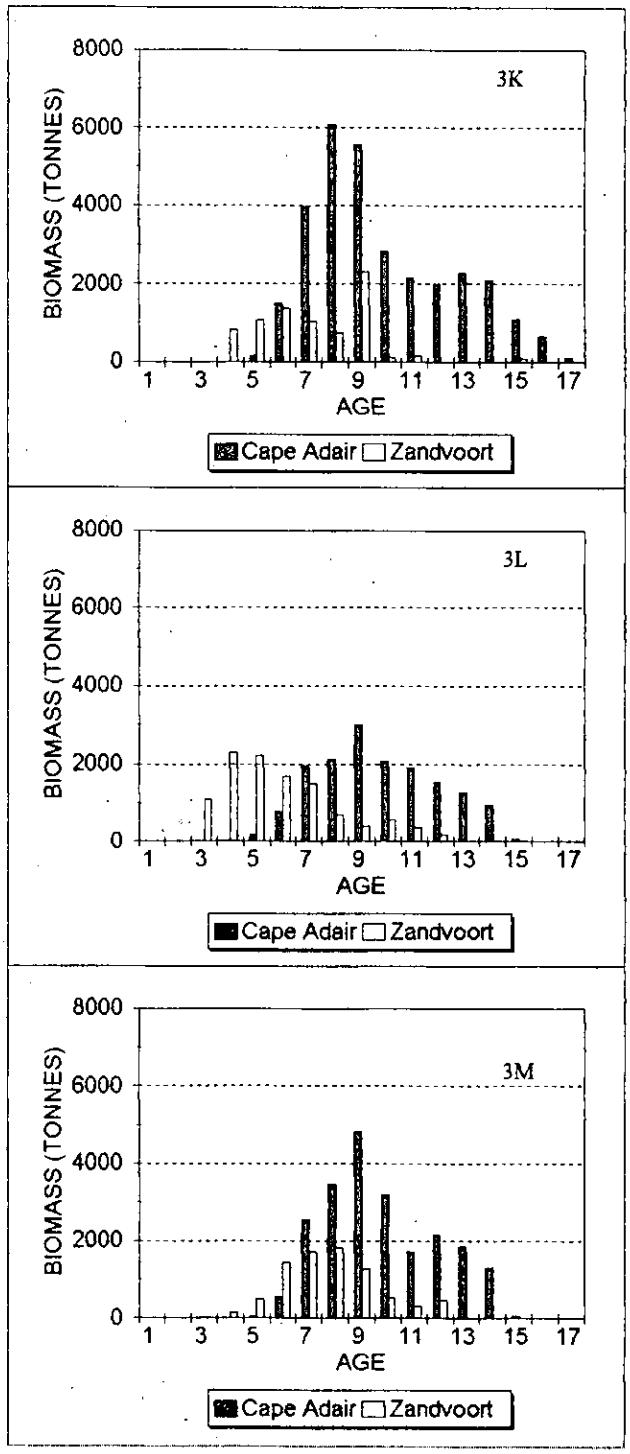

Fig. 6. Biomass (tonnes) at age of G. halibut from Cape Adair (summer 1991) and Zandvoort (winter 1994) surveys in Divisions 3K, 3L and 3M.

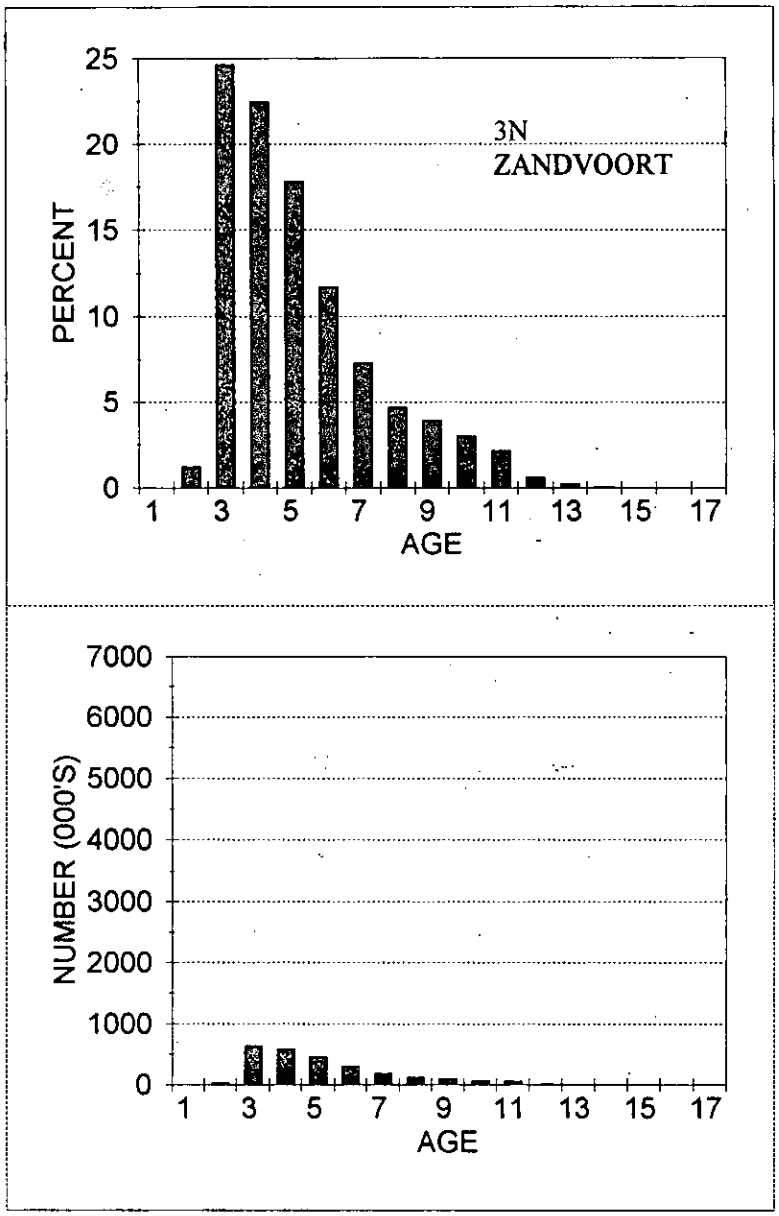

Fig. 7. Percent occurrence and absolute abundance at age of G. halibut in Div. 3N from Zandvoort survey.

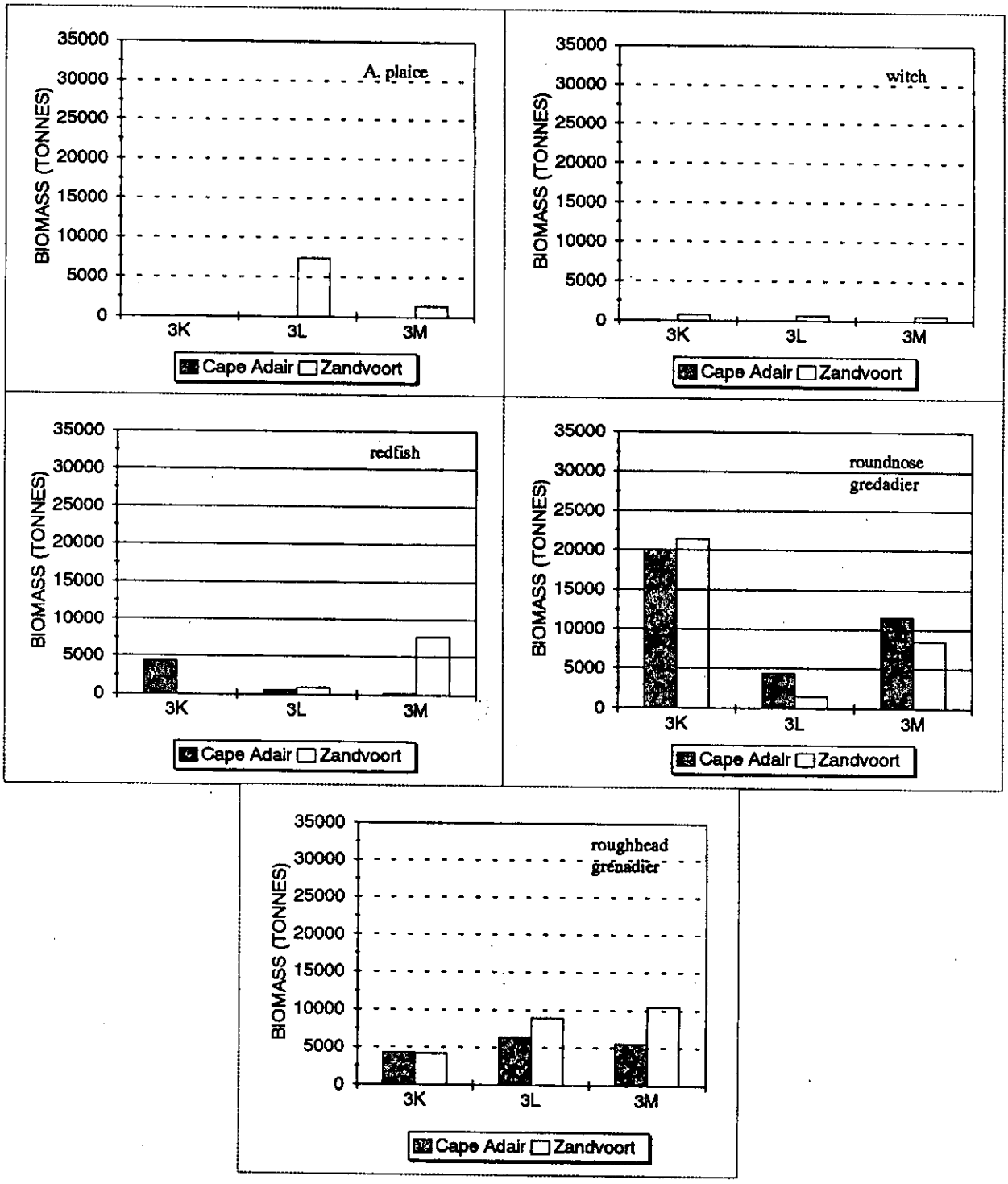

Fig. 8. Biomass (tonnes) of groundfish species caught in the Cape Adair (summer 1991) and Zandvoort (winter 1994) surveys in Divisions 3K, 3L, and 3M.

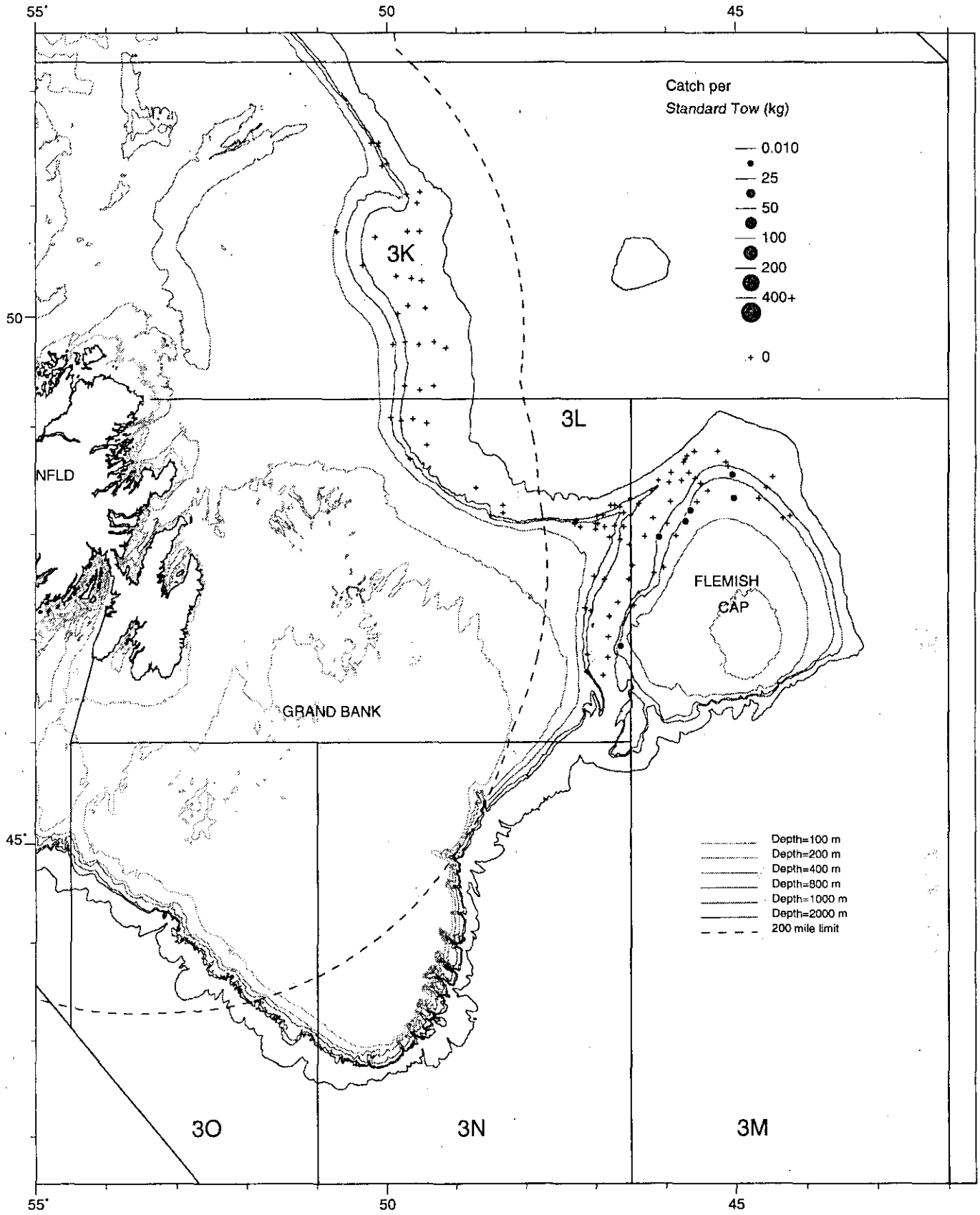

Fig. 9. Distribution of American plaice catches from a Canadian survey by the Cape Adair, summer 1991, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

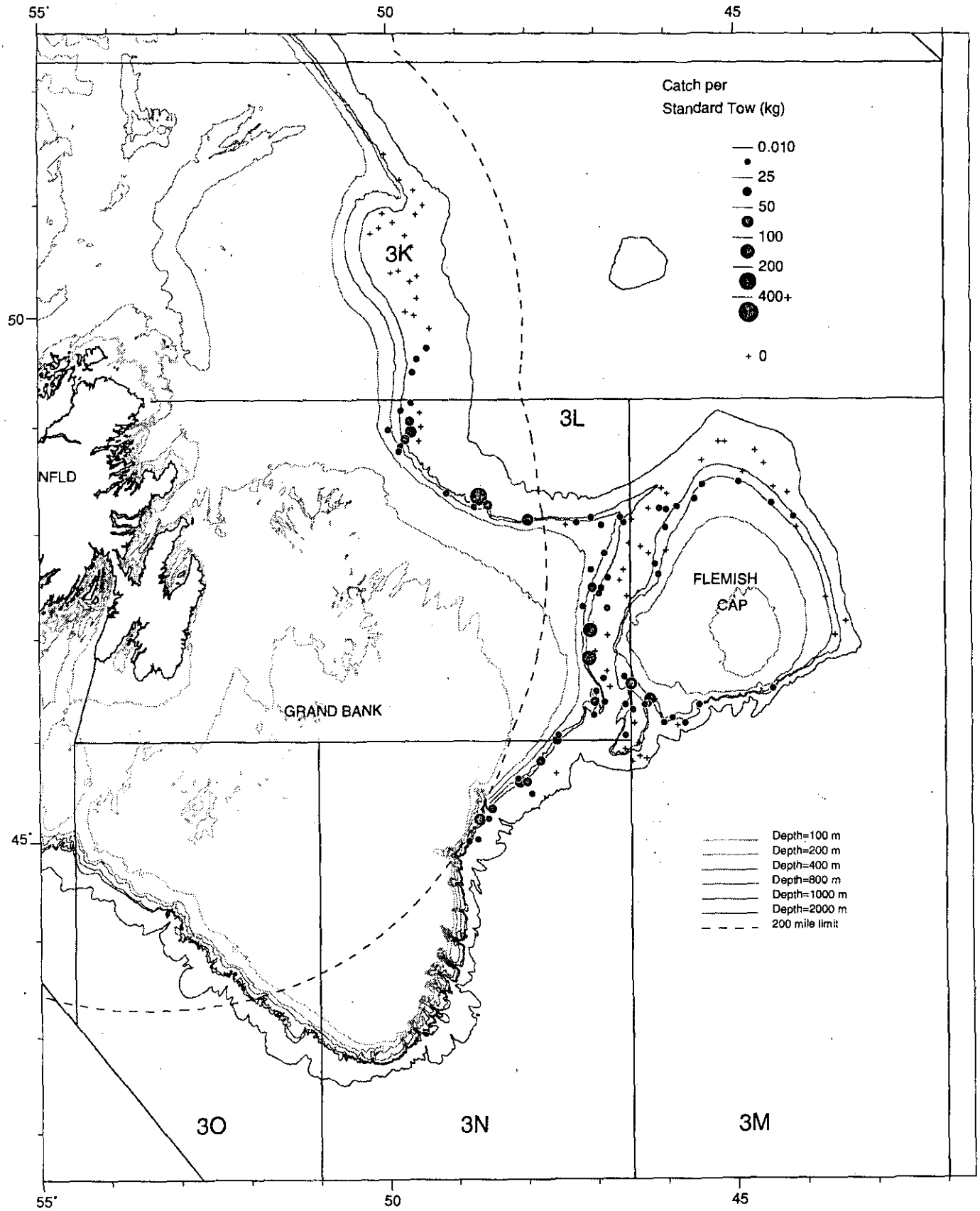

Fig. 10. Distribution of American plaice catches from the vessel Zandvoort, winter 1994, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

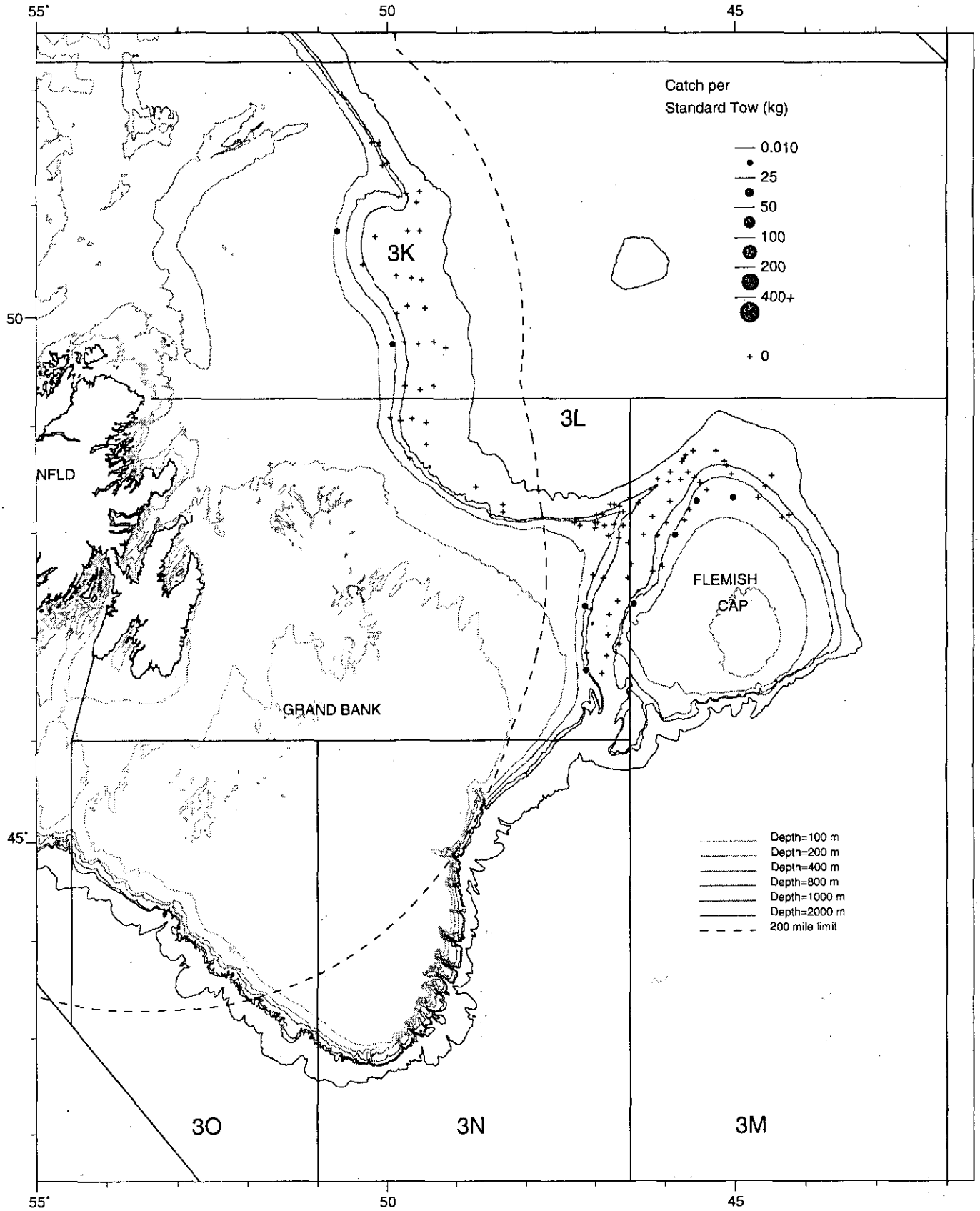

Fig. 11. Distribution of Witch catches from a Canadian survey by the Cape Adair, summer 1991, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

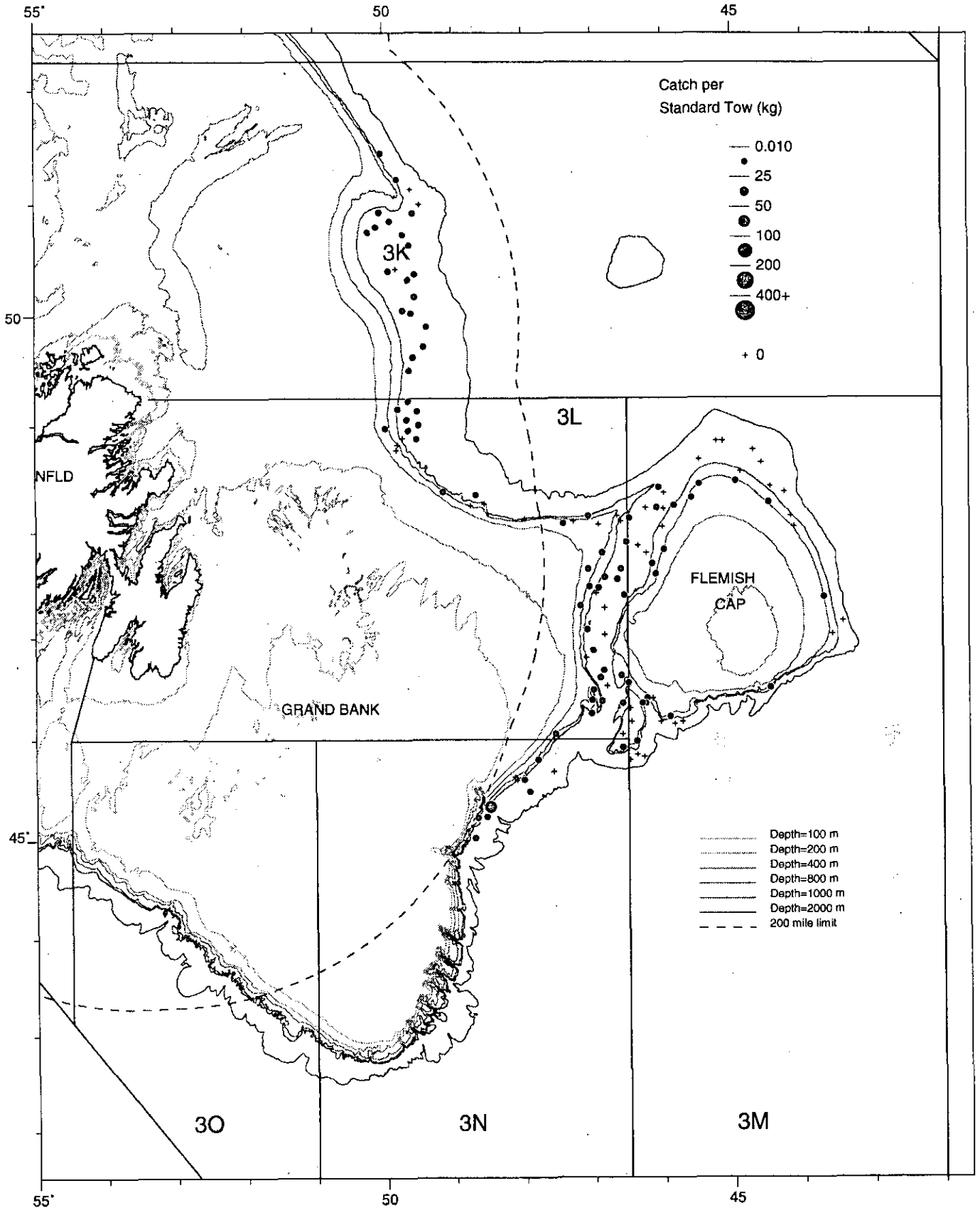

Fig. 12. Distribution of Witch catches from the vessel Zandvoort, winter 1994, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

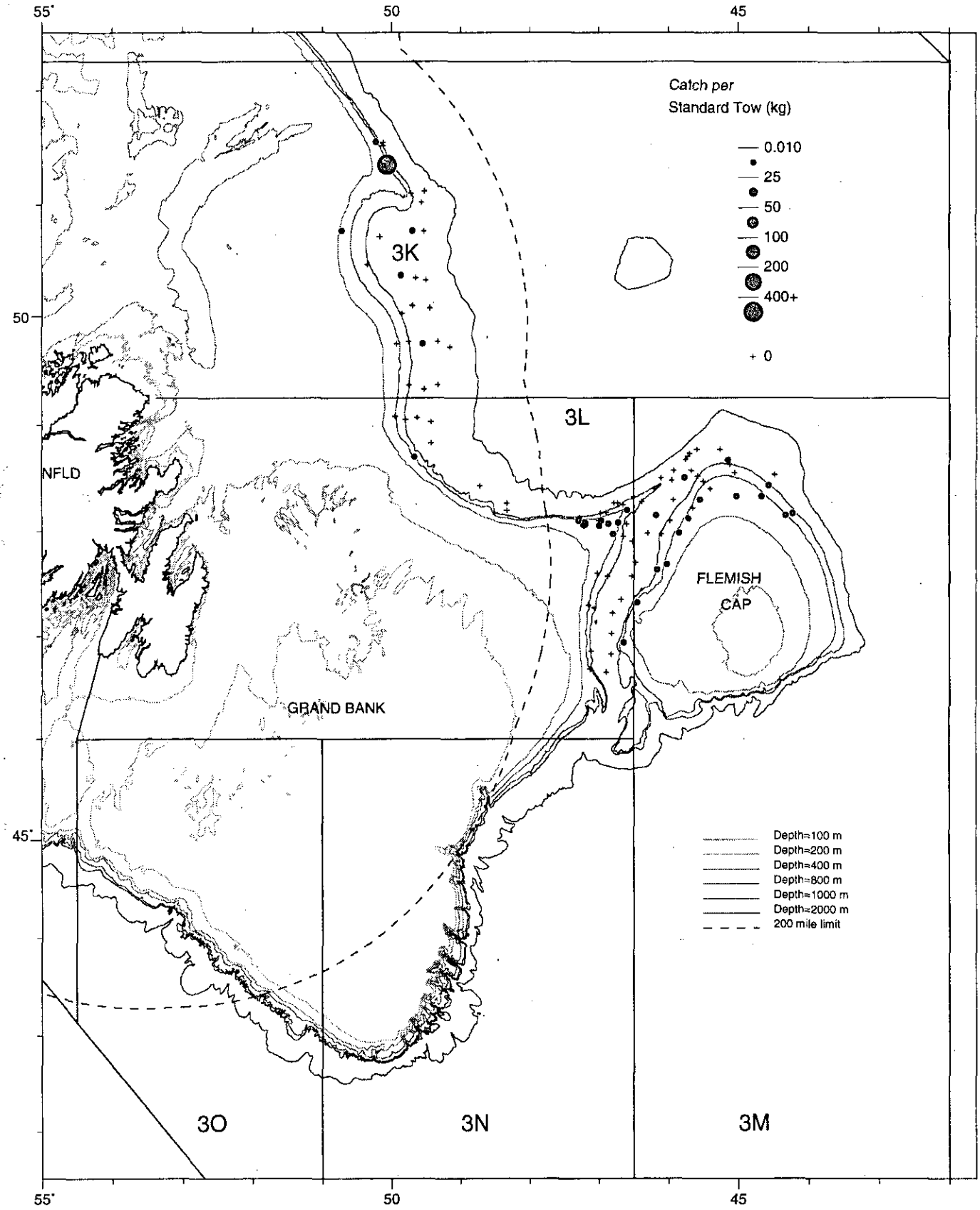

Fig. 13. Distribution of Redfish catches from a Canadian survey by the Cape Adair, summer 1991, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.

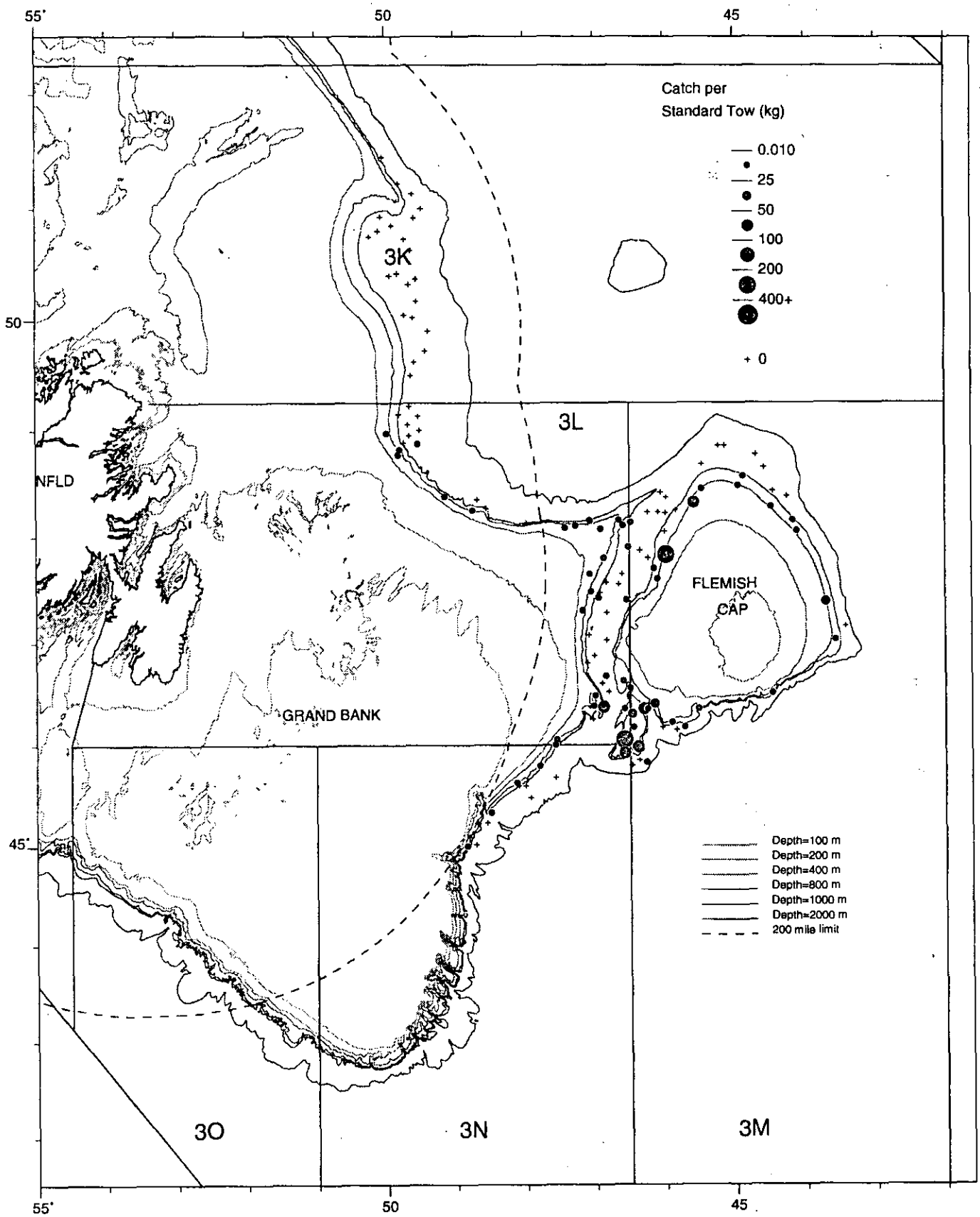

Fig. 14. Distribution of Redfish catches from the vessel Zandvoort, winter 1994, to NAFO Divisions 3KLMN. All survey tows standardized to 1.75 nautical miles.