

Northwest Atlantic



Fisheries Organization

Serial No. N1252

NAFO SCR Doc. 86/123

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1986

Results of Tagging on Winter Concentrations of Cod
in NAFO Divisions 2J, 3K and 3L During 1978-83

by

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Introduction

On the basis of inshore tagging of cod at many localities in Newfoundland and Labrador during 1962-66 it was demonstrated that in summer-autumn of years after tagging there was usually considerable homing of local populations of cod, tagged in the summer-autumn feeding season, to and near the original localities (Templeman 1979). On the basis of tagging during 1978-81 on offshore winter concentrations (Lear 1984), it was demonstrated that the cod which overwinter on the several offshore banks in Div. 2J, 3K and 3L undergo constant annual patterns of migration to inshore waters during summer and to offshore water concentrations during winter.

The aim of this paper is to examine patterns of tag returns from tagging of cod on overwintering or spawning concentrations during 1978-83. The tag returns will be analyzed to determine:

1. the degree to which cod migrate back to where they were tagged in Div. 2J, 3K and 3L based upon recaptures of tags per 1000 t of cod caught in various statistical areas during January-April for a combination of years.
2. the overall annual distribution of tags by NAFO Division or NAFO stock area to determine relative contributions of each component of the 2J, 3K, 3L cod to various NAFO Divisions and stock areas.

Materials and Methods

During February-March, 1978-83, about 33,000 adult cod (45 cm and larger) were tagged in 2J3KL (Table 1), using Petersen disc and Dangler tags, found in previous experiments to give best returns, and T-bar tags which were less labor-intensive. The tag types were applied to equal batch sizes (50) of cod randomly selected from the holding tanks. Thus any bias due to tag loss of a particular tag type should be equally distributed throughout all experiments. Taggings were conducted on the pre-spawning concentrations on Hamilton Bank, Belle Isle Bank, Funk Island Bank, and the northern slope of the Grand Bank (Fig. 1).

The cod were obtained by an Engel High Rise otter trawl. The net was not lined with a fine mesh liner except during the 1978 tagging. The sets were generally short (10-20 minute duration), but in 1981-83 frequently were of 30-minute duration depending upon the concentration of cod as deduced from echo sounding. Since the concentrations of cod were in deep water (230-350 m) and generally in ice covered areas, the net had to be taken back very slowly (8-10 m/minute) to allow the cod to acclimate to the changing pressure and to prevent suffocation from crowding of cod in the codend. Also the codend had to be hauled back in open water to prevent death of the cod from supercooling and eventual freezing. This occurred if, after being pulled through water temperatures of about -1.5 to -1.7°C, they were hauled through water filled with ice crystals. Similarly, the tagged cod had to be released in polynas or open water to prevent death from freezing in the cold water laden with ice crystals.

Only fish classified to be in excellent condition were tagged. Any fish showing signs of bruising, scale loss, injuries to fins or gills, bleeding and "pop eye" condition or with distended swim bladders were routinely culled during the tagging procedures. The cod were

held in holding tanks, with running sea water from which they were captured with dipnets, measured, examined for gill parasite (*Lernaeocera branchialis*) and tagged. The cod were then placed in tanks filled with running sea water until they fully recovered (i.e. actively swam in the tank) and were then released through the rock hatch at the level of the water line of the ship. Thus the cod were placed, not dropped, into the sea.

- 1) For the analysis of the recaptures by statistical area during January-April in years after the tagging, the recoveries for each experiment were tabulated for each fisheries statistical area (Fig. 2). Only the tags recaptured by Newfoundland-Labrador fishermen are included in this analysis since the corresponding January-April catches by statistical area were readily available only for these fishermen. In some cases there was a tag return from an area for which there was no catch and this recapture was then omitted from the calculations. In some cases the catches in an area were very small (less than 100 t) and in this case the catch was arbitrarily set at 1000 t to reduce the bias caused by a small sample size. The recapture percentages by year for each area were then averaged over all years (excluding the year of tagging) to give an overall estimate of tag distribution by area.

The tag recapture percentages by statistical area were then added (Table 2) to obtain an overall distribution and return migration to the same areas in which they were tagged, adjacent areas to that in which they were tagged and other areas.

The patterns of tag distribution during January-April by Newfoundland-Labrador fishermen are also presented by NAFO Division using as a basis the number of tags returned/1000 t of cod caught in a NAFO Division or stock area (Table 3). The various experiments for each component area were then combined to give a composite picture of tag distributions and migration of cod during January-April among NAFO Divisions from the taggings on various components by adding the percentages for each experiment of a component.

- 2) The percentages of recaptures of tagged cod by all fishermen throughout the year in various NAFO Divisions were calculated on the basis of tags/1000 t of cod caught to provide an estimate of proportions taken in the tagging Division and in other Divisions. This was done for each tagging experiment on each component. The percentages for each Division were averaged by area of recapture to obtain the distribution by NAFO Divisions.

These experiments were then grouped by component area to give a composite pattern for each component over various tagging and recapture years by averaging the percentages for each experiment by NAFO Division.

Results

The recaptures of tags/1000 t by Newfoundland-Labrador fishermen during January-April in years following the tagging (excluding the year of tagging) indicate that most of the recaptures occur in the same area or areas adjacent to the tagging area (Tables 1 and 2). One notable exception is the tagging on northeastern Hamilton Bank from which area the recaptures in the following years were on the southeastern part of Hamilton Bank but within NAFO Division 2J. In fact only 19% were taken in areas outside 2J. From the tagging on southeastern Hamilton Bank, 49% of the recaptures were from within the same area as those in which they were tagged. The Hamilton Bank component appears to vary in its winter distribution from the northern to the southern slopes of the Bank in different years. From the taggings on Belle Isle Bank which embraces the area on each side of the 2J-3K boundary, again most of the recaptures (70-97%) were from the same or adjacent areas in which they were tagged.

From the four taggings on northern Funk Island Bank, about 57-90% were recaptured in subsequent years within the same or adjacent areas. From southwestern and western Funk Island Bank, the proportions recaptured in the areas of tagging were variable (45-99%) (Table 2). On the northern Grand Bank most (52-72%) were recaptured in the vicinity of tagging. These various experiments on different components and different years and the recaptures over varying periods indicate a reasonably good degree of homing to the same general locality in which they were overwintering when they were tagged.

Recaptures by Newfoundland-Labrador fishermen during the January-April period indicate that for cod tagged in 2J, most (65%) of the recaptures were in 2J (Tables 3 and 4), with 19% in 3K and only 8% in 3L. Thus it appears that there is a good degree of homing back to the spawning and/or overwintering areas in which the cod were tagged especially for Division 2J.

For the Belle Isle Bank taggings (NAFO Divisions 2J and 3K), the recaptures were mainly from 2J and 3K with only 6% from 3L. For the northern Funk Island Bank, 35% were from the Division 3K, in which they were tagged with 44% from 2J mainly from the adjacent statistical area 204 (Table 1). About 14% were from 3L and 5% from 3NO. From the southeastern Funk Island Bank (3K), 56% of the recaptures were from 3K and 23% from 3L with only 6% from 2J.

The 15% from 3Ps is probably biased since there was only one tag recaptured from a reported catch of 1578 t which gave a larger disproportionate weight to the tag/catch ratio than from the other areas.

From the western Funk Island Bank (3K) experiments, 63% were recaptured in 3K, 20% in 2J and 14% in 3L. From the northern Grand Bank (3L) taggings, 61% were from 3L, only 9% from 3K, and 26% from 3NO indicating that there is at least an equal if not greater interaction between cod of northern 3L and Divisions 3N and 3O than there is between northern 3L and 3K. Thus it appears that for cod which overwinter on the northern slopes of the Grand Bank (Division 3L) there is very little interchange with 3K and almost none with 2J in subsequent winters following the tagging. There is evidence of some interchange with the 3NO stock.

On the basis of the percentage recaptures of cod tags by all fishermen throughout each year and then averaged over all years (including the year of tagging) from the tagging on winter concentrations during 1978-83 (Tables 5 and 6), a somewhat similar pattern emerges as that for recaptures by Newfoundland-Labrador fishermen. For Hamilton Bank (2J) taggings, 54% were caught in Subarea 2 (mainly 2J), 34% in 3K and only 7% in 3L.

For Belle Isle Bank (2J-3K) the percentages caught in 2GHJ and 3K were about equal (44 and 43%, respectively) and only 4% in 3L with 9% in 3Pn, 4RS, mainly in 4R during the summer inshore fishery.

For the cod of the northern Funk Island Bank (3K), 43% were caught in 3K, 30% in 2GHJ (mainly 2J), and 18% in 3L.

The cod of southeastern Funk Island Bank (3K) contribute at a higher percentage to the fishery in 3L than do the cod of northern Funk Island Bank (40% compared to 18% respectively). Only 4% of the cod from southeastern Funk Island Bank were caught in 2J.

From the western Funk Island Bank (3K) taggings, about 58% were recaptured in 3K, 15% in 2J, and 25% in 3L.

From the northern Grand Bank (3L) taggings, only 1% went to 2J, 14% to 3K while 63% were caught within 3L. About 18% were caught in 3NO. When it is considered that these two taggings were conducted in the deep water (deeper than 200 m) along the northern slopes of the Grand Bank and in close proximity to the 3K boundary, it illustrates the great degree of interaction which the cod of the northern Grand Bank and Division 3L in particular must have with the neighboring cod stock in Divisions 3N and 3O.

Conclusions

- 1) On the basis of tag recaptures by Newfoundland-Labrador fishermen during January-April from taggings on winter concentrations, there was evidence of a significant degree of homing in years following the tagging to the same or adjacent areas in which the cod were originally tagged.
- 2) On the basis of tag returns from all fishermen throughout the year there was evidence that most of the cod tagged in NAFO Div. 2J were caught within 2J, similarly 43-58% of the recaptures of cod tagged in 3K were caught in 3K while 63% of the recaptured cod which were tagged in 3L were eventually caught in 3L.
- 3) Based upon the taggings of cod in northern 3L there appears to be a great deal of interaction between cod of 3L and 3NO.

References

- Lear, W. H. 1984. Discrimination of the stock complex of Atlantic cod (*Gadus morhua*) off southern Labrador and eastern Newfoundland, as inferred from tagging studies. *J. Northw. Atl. Fish. Sci.* Vol. 5: 143-159.
- Templeman, W. 1979. Migrations and intermingling of stocks of Atlantic cod, *Gadus morhua*, of the Newfoundland and adjacent areas from tagging in 1962-66. *ICNAF Res. Bull.*, No. 14, 5-50.

Table 1. Percentage recaptures of cod for January-April, by Newfoundland-Labrador fishermen, from various statistical areas from taggings on winter concentrations in various statistical areas during 1978-83. Based upon overall averages of percentages by year from tags/1000 + of cod caught.

Expt. no.	Tagging locality	Tagging areas	No. tagged	Percentage recaptures (Ave. of percentages by year)															
				202	203	204	206	207	211	301	302	303	309	310	314	319			
20	NE Hamilton Bank	211	3305		42.6	26.6	10.5		1.8										
30	SE Hamilton Bank	203, 206	2992		36.4	26.2	12.7										4.0		
1	Belle Isle Bank	203, 204, 343, 347	4455	5.9	8.4	12.8	0.4	2.0	0.9										
42	Belle Isle Bank	203, 343	3142		8.2	7.9													
7	North Funk Island Bank	345, 347	5008		11.4	26.4	3.1		0.9	0.3		4.8				12.3			
22	North Funk Island Bank	347	3139		20.9	24.1	2.7		0.9							4.0			
31	North Funk Island Bank	347	2383		7.4	12.3													
41	North Funk Island Bank	347	1996		4.2	30.8													
13B	SE Funk Island Bank	345, 346	2259			2.8	2.0												
19	SW Funk Island Bank	344, 345	1195		0.6														
13C	West Funk Island Bank	344, 345	2158		20.7	23.5	4.9					3.0							
14	North Cape of Grand Bank	330	1994		0.3	0.9										5.2		20.0	
40	NE Grand Bank	330	1984															24.3	24.3

Expt. no.	Tagging locality																No. of tags	Tagging year	Recapture years
	326	328	329	330	331	332	333	337	339	343	344	345	346	347	404				
20				0.6	2.9								5.6	9.6		85	1981	1982-85	
30				9.3						0.7			1.0	9.3	0.5	57	1982	1983-85	
1				0.8	1.4					13.3	11.5	8.3	0.8	33.3		96	1978	1979-85	
42	1.6	8.1		1.2	2.0						8.1	3.7	17.4	42.1		51	1983	1984-85	
7				2.9					2.2	7.5	9.1		3.1	15.7	0.5	124	1979	1980-85	
22				0.7			2.0			2.1		15.0	2.2	25.5		85	1981	1982-85	
31		19.0		1.1	3.1		1.8			1.8		5.8	4.5	43.2		43	1982	1983-85	
41	2.4		24.5	5.9		10.3							9.6	12.5		38	1983	1984-85	
13B		13.1		0.9		15.6				3.4	3.8	6.0	12.2	40.1		14	1980	1981-85	
19				1.8							11.3	11.3	25.0	50.0		10	1981	1982-85	
13C	2.7			5.5	9.1		3.0				3.7		2.3	21.6		36	1980	1981-85	
14	3.4			33.3	13.6							21.8		1.6		29	1980	1981-85	
40	4.9		25.8	19.4									1.5			6	1983	1984-85	

Table 2. Percentages of recaptures of cod for January-April by Newfoundland-Labrador fishermen, from the same, adjacent and other statistical areas based on taggings on winter concentrations in various statistical areas during 1978-83. Based upon overall average percentages by year.

Expt. no.	Tagging locality	Tagging areas	No. tagged	Percentage recaptures (Ave. of percentages by year)				Total	Same and adjacent	No. of tags
				Same	Adjacent	Other (same Div.)	Other (other Div.)			
20	NE Hamilton Bank	211	3305	1.8	10.5	69.2	18.7	100.2	12.3	85
30	SE Hamilton Bank	203, 206	2992	49.1	36.2		14.8	100.1	85.3	57
1	Belle Isle Bank	203, 204, 343, 347	4455	67.8	28.9	0.9	2.2	99.8	96.7	96
42	Belle Isle Bank	203, 343	3142	8.2	61.8	17.4	12.9	100.3	70.0	51
7	North Funk Island Bank	345, 347	5008	15.7	57.5	2.2	24.8	100.2	73.2	124
22	North Funk Island Bank	347	3139	25.5	64.3		10.3	100.1	89.8	85
31	North Funk Island Bank	347	2383	43.2	30.0	1.8	25.0	100.0	73.2	43
41	North Funk Island Bank	347	1996	12.5	44.6		43.1	100.2	57.1	38
13B	SE Funk Island Bank	345, 346	2259	18.2	48.2		33.5	99.9	66.4	14
19	SW Funk Island Bank	344, 345	1195	22.6	76.8		0.6	100.0	99.4	10
13C	West Funk Island Bank	344, 345	2158	3.7	41.5		54.8	100.0	45.2	36
14	North Cape of Grand Bank	330	1994	33.3	38.8		28.0	100.1	72.1	29
40	NE Grand Bank	330	1984	19.4	32.2		48.6	100.2	51.6	6

Table 3. Percentage of recaptures of cod for January-April by Newfoundland-Labrador fishermen, from various NAFO Divisions from taggings on winter concentrations during 1978-83. Based upon averages of percentages by year.

Expt. no.	Tagging locality	NAFO Div.	No. tagged	Percentage recaptures (Ave. of percentages by year)						Total	No. of tags	Tagging year	Recap. years
				2J	3K	3L	3N0	3Ps	3Pn4RS				
20	NE Hamilton Bank	2J	3305	66.8	18.8	2.6		11.9		100.1	88	1981	82-85
30	SE Hamilton Bank	2J	2992	63.9	18.6	14.0	2.0		1.5	100.0	58	1982	83-85
1	Belle Isle Bank	2J-3K	4455	30.7	61.9	7.4				100.0	97	1978	79-85
42	Belle Isle Bank	2J-3K	3142	30.1	64.9	5.1				100.1	51	1983	84-85
7	North Funk Island Bank	3K	5008	27.0	30.0	20.6	12.9	7.6	1.9	100.0	127	1979	80-85
22	North Funk Island Bank	3K	3139	54.5	34.9	3.5	7.1			100.0	85	1981	82-85
31	North Funk Island Bank	3K	2383	45.4	47.8	6.7				99.9	45	1982	83-85
41	North Funk Island Bank	3K	1996	48.7	27.8	23.5				100.0	38	1983	84-85
138	SE Funk Island Bank	3K	2259	5.7	55.6	23.3		15.4		100.0	15	1980	81-85
19	SW Funk Island Bank	3K	1195	1.6	92.0	6.4				100.0	10	1981	82-85
130	West Funk Island Bank	3K	2158	38.8	33.3	22.7		5.2		100.0	37	1980	81-85
14	North Cape of Grand Bank	3L	1994	0.7	14.7	71.7	5.8	7.1		100.0	31	1980	81-85
40	NE Grand Bank	3L	1984	0.0	4.3	50.0	45.8			100.1	6	1983	84-85

Table 4. Percentages of recaptures of cod by Newfoundland-Labrador fishermen, during January-April in various NAFO Divisions from taggings on winter concentrations in NAFO Div. 2J, 3K and 3L during 1978-83. Percentages are based upon tags recaptured per 1000 t of cod caught. Annual percentages are averaged to obtain overall percentage averages.

Area	NAFO Div.	No. of expts.	2J	3K	3L	3N0	3Ps	3Pn4RS	Total
Hamilton Bank	2J	2	65	19	8	1	6	1	100
Belle Island Bank	2J-3K	2	31	63	6	0	0	0	100
N Funk Island Bank	3K	4	44	35	14	5	2	+	100
SE Funk Island Bank	3K	1	6	56	23	0	15	0	100
W Funk Island Bank	3K	2	20	63	14	0	3	0	100
N Grand Bank	3L	2	+	9	61	26	4	0	100

Table 5. Percentage recaptures of cod by all fishermen throughout the year in various NAFO Divisions from taggings on winter concentrations in NAFO Divisions 2J, 3K, and 3L during 1978-83. Based upon overall averages of percentages from tags/1000 t of cod caught by year.

Expt. no.	Tagging locality	NAFO Div.	Percentage recaptures (Ave. of percentages by year)								Total
			2GHJ	3K	3L	3NO	3Ps	3M	3Pn4Rs	4TVWX	
20	NE Hamilton Bank	2J	52.9	35.6	6.6	1.1	1.1	0	2.8	0	100.1
30	SE Hamilton Bank	2J	54.4	33.3	7.8	1.1	0	0.2	3.3	0	100.1
1	Belle Isle Bank	2J-3K	47.4	39.2	4.0	0	0.1	0.7	7.7	0.9	100.0
42	Belle Isle Bank	2J-3K	40.7	46.0	3.5	0	0.4	0	9.4	0	100.0
7	North Funk Island Bank	3K	37.4	39.0	14.1	4.5	0.9	0	4.0	0.1	100.0
22	North Funk Island Bank	3K	39.5	37.0	15.2	1.4	0.5	0	6.5	0	100.1
31	North Funk Island Bank	3K	15.7	46.2	26.7	1.9	2.2	3.7	3.1	0.5	100.0
41	North Funk Island Bank	3K	26.1	48.8	16.6	2.0	0	0	6.5	0	100.0
13B	SE Funk Island Bank	3K	4.4	43.3	39.9	0	5.9	0	6.5	0	100.0
19	SW Funk Island Bank	3K	13.1	65.6	19.6	0	0	0	1.7	0	100.0
13C	West Funk Island Bank	3K	17.6	49.9	30.2	0	0.5	0	1.9	0	100.1
14	North Cape of Grand Bank	3L	2.9	8.7	66.1	14.8	7.4	0	0	0.1	100.0
40	NE Grand Bank	3L	0	19.8	59.7	20.6	0	0	0	0	100.1

Table 6. Percentage recaptures of cod by all fishermen throughout the year in various NAFO Divisions from taggings on winter concentrations in NAFO Div. 2J, 3K, and 3L during 1978-83. Percentages are based upon tags recaptured per 1000 t of cod caught. Annual percentages are averaged to obtain overall percentage average.

Area	NAFO Div.	No. of Expt.	2GHJ	3K	3L	3NO	3Ps	3M	3Pn4RS	4TVWX	Total
Hamilton Bank	2J	2	54	34	7	1	1	+	3	0	100
Belle Isle Bank	2J-3K	2	44	43	4	0	+	+	9	+	100
N Funk Island Bank	3K	4	30	43	18	2	1	1	5	+	100
SE Funk Island Bank	3K	1	4	43	40	0	6	0	7	0	100
W Funk Island Bank	3K	2	15	58	25	0	+	0	2	0	100
N Grand Bank	3L	2	1	14	63	18	4	0	0	+	100

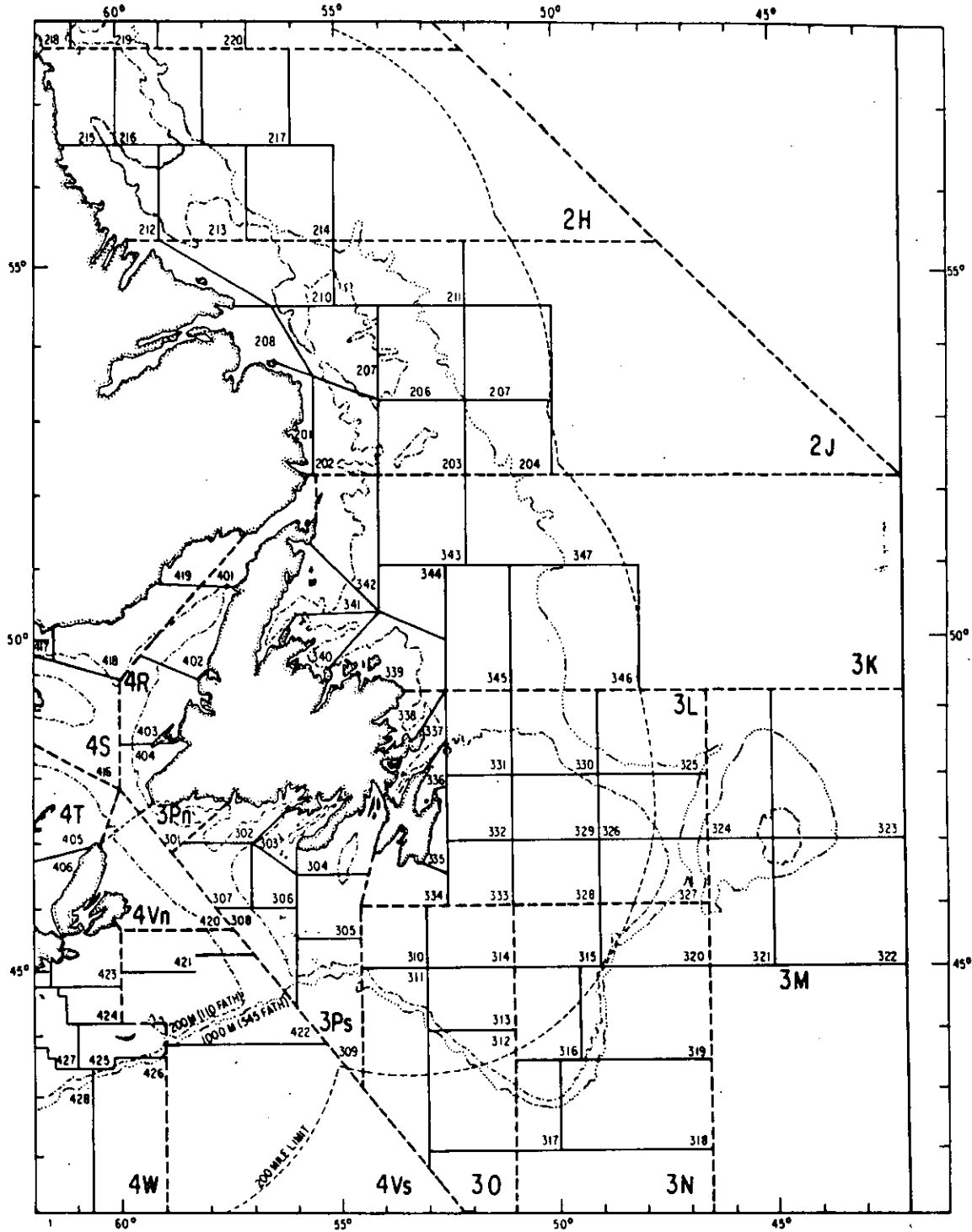


Fig. 2. NAFO Divisions and Fisheries Statistical Areas.