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Bycatch in the NAFO Division 3M shrimp fishery, 1993-1995

by

D. W. Kulka
and
D. Power

Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1
Canada

Abstract

A fishery for shrimp (*Pandalus borealis*), in existence since the late 1970's on the Labrador Shelf, and in the Hudson and Davis Straits expanded to the Flemish Cap (NAFO Division 3M) in 1993. As with the shelf fishery, the 3M grounds overlap with the distributions of other species resulting in a bycatch consisting primarily of small fish anf invertabrates. The level and composition of this bycatch was quantified in response to the concerns raised by the Fisheries Commission of NAFO about loss of yield, particularly for redfish. A portion of the Canadian and Norwegian fleets carried fishery observers and the data collected by these individuals were used to examine the characteristics of the catch. Of the commercially important species, redfish was found to be dominant in the bycatch with lesser amounts of wolfish (striped), turbot, skates capelin, witch, plaice, cod and about 95 other species taken. Because of the use of small mesh gear, the bycatch in this fishery is primarily comprised of small fish. Redfish made up the majority, specifically 28.4%, 19.0%, and 1.1% of the catch by weight, equivalent to 138, 50 and 10 million fish in 1993, 1994 and 1995, respectively. Numbers at age are also given.
The catch of all other species combined was small, comprising less than 5% of the total catch in any year. The substantial reduction in redfish, and by-catch as a whole was due at least in part by the introduction of an excluding attachment, the Nordmore grate in 1994 and a reduction in grate size in 1995.

Introduction

A fishery for shrimp (*Pandalus borealis* and *P. montagui*) has existed on the Labrador Shelf and the Hudson and Davis Straits since the late 1970's (Parsons, 1994xxx). Shrimp were also known to be distributed on the Flemish Cap (Vasquez, 1989 and Sainza, 1995). However, it was not until 1993, the shrimp grounds were extended to include the Flemish Cap (Fig. 1). Parsons and Veitch (1995) reported that in April of that year, two Canadian vessels were granted exploratory permits to fish for *P. borealis* in NAFO Div. 3M. Those vessels located commercial concentrations of shrimp and subsequently, the fishery expanded rapidly. About 50 vessels of various countries joined in during the year. The fishery continued in 1994 and 1995 with the greater part of the activity continuing to occur

during the summer months. To date, Canada, Denmark, Faroe Islands, Greenland, Iceland, Norway, Russia, Latvia, Lithuania, Spain and St. Vincent have participated in the fishery taking an estimated 26,706 t, 24,153 t and 35,814 t in 1993, 1994 and 1995 repectively.

The gear used to capture shrimp is a modified otter trawl with small mesh gear. This configuration results in the incidental capture of fish and invertebrate species other than shrimp. Kulka (1995) from data collected by fishery observers, showed that for the Labrador Shelf and Davis Strait shrimp fisheries there was a significant bycatch of about 125 species, all of which was subsequently discarded. Because of the small mesh used, these bycatch are comprised mainly of small fish. The introduction of an excluding device, the Nordmore grate, has greatly reduced the bycatch in these Labrador Shelf and Davis Strait fisheries but where there are concentrations of very small fish (generally less than 20 cm) mixed with the shrimp, even with the grate, some of bycatch passes through the excluding device into the cod end.

In NAFO Div. 3M, reports of high bycatches from this new shrimp fishery raised concerns in STACFIS about the potential damage to the groundfish stocks, particularly redfish. The use of the grate with a maxium bar spacing of 28 mm was made mandatory in 1994 for 3M. In 1995, maxium bar spacing was reduced to 22 mm since redfish less than about 21 mm in length were still passing through the grate.

As well, the Fishery Commission requested information on the potential loss of yield due to bycatch mortality. Data collected by fishery observers deployed to a portion of the Canadian fleet in 1993 and 1994 and the Norwegian and Canadian fleet in 1995 was used to address this problem. They recorded amounts of all species in the catches and also took measurements of the redfish. The purpose of this paper is to provide available information on bycatches, particularly the redish from this new fishery on the Flemish Cap.

Methods

Fishery observers deployed to a portion of the Canadian and Norwegian vessels fishing for shrimp in NAFO Division 3M recorded details of the catches on a set by set basis and this information was used to examine discarding practices for 1993 to 1995. The observers estimated, for each set, the catches of all species, including amount kept and discarded, using the methods of Kulka and Firth (1987).

Percent of the total fishery observed amounted to 8 (all from Canadian vessels), 4 (all from Canadian vessels) and 5 (from Canadian and Norwegian vessels)% of the total fishery in 1993, 1994 and 1995. The amount of each species taken in each set was estimated by methods outlined in Kulka and Firth, 1987. Discarding of the bycatch varies among vessels and may be handled by the crew in a variety of ways on a particular vessel. Hence, instructions to observers during briefings on discard observation strategies were tailored to individual vessels and even different production shifts on the same vessel. Factors such as vessel configuration, discard sites, processing area layout, crew habits, discard practices and levels of discarding were taken into account when quantifying discards. Discard observation sites were combined where possible to minimize the number of locations at which discard observations had to be made thus maximizing the amount of fish viewed, weighed, or counted. For example if all fish to be discarded merged at one location before going overboard, this is where the fish were counted or collected for weighing. Also, time spent viewing discards was greatest where the discard rate was highest. However, observation time was allocated to each discard site and covered the entire processing period because discard rates varied among sites and over the course of processing. The objective was for the observed periods to be representative of the entire set in terms of discard practices

Estimating discards was accomplished by either weighing or counting fish, or a combination of both depending on vessel conditions and amounts discarded. The general principle was to use the most direct method possible under the circumstances to estimates amounts discarded. Weighing, the most direct method was applied where amounts were small. If the entire discarding period could not be observed, the total amount discarded was estimated by taking a count of baskets of discard fish collected for the portion of the discarding period observed then extrapolating these counts to the total processing period. A weighed sample of baskets allowed conversion of basket counts to weights.

Where weighing was not possible, discarded fish were counted then converted to weight by multiplying by the average weight of discarded individuals. Random sample of discarded fish from the set were weighed and measured and their mean length was calculated. A length/weight table was used to calculate average discard weight. Typical circumstances involved discarding at more than one location, thus the entire discarding period could not be observed at each site. For this situation, discard estimates were obtained by counting the discards for part of the discarding period at each site, then extrapolating these counts to the total period. This total was then multiplied by the average weight of discarded individuals to obtain total discard weight for the species. Regardless of whether the discards were weighed or counted, the amount of fish viewed, counted, or weighed was maximized, all sites were observed and observations were spread over the entire production period. Observed periods at each discard site were adjusted to the entire period then added across all sites. Appliction of these methods yielded a detailed data set on bycatch levels.

Since observed bycatch rates were used to estimate total bycatch for the fishery, this analysis assumes that the observed portion of the fishery was representative of the whole fishery. It assumes similar gear configuations and use of attachments, in this case the Nordmore grate, among fleets resulting in similar catches. Since use of the grate 28 mm bar spacing in 1994 and 22 mm in 1995 was mandatory, it is likley that use of the grate by all vesselsparticipating in the fishery was similar to the observed vessels.

Only sets where the observer estimated catch and discards were used in this study to calculate percent discarded. To account for unobserved sets, total discard amounts were estimated by multiplying the ratio of landings to observed kept weights by observed discard weight for each month (the finest breakdown available from the landing statistics). Length samples of discards were collected and these data were used to convert discard weight to numbers at length. Combined age-length keys from research vessel surveys in NAFO Div 3M were used to calculate numbers at age.
respectively.

Results and Discussion

Redfish (*Sebastes spp.*) comprised the largest bycatch of any single group for the 1993 to 1995 period in terms of weight (Table 1, Fig. 1-2). The percentage of the total catch for redfish declined from 28.4% in 1993 to 1.1% in 1995. The catch of all other species combined was small, comprising less than 5% of the total catch in any year. The Nordmore grate was implemented in 1994 with a bar spacing of 28mm. The bar spacing was reduced to 22 mm for 1995. The frequency of grate spacings by year for the observed fleets of Canada and Norway is listed in Fig. 3.

The shrimp fishing grounds from 1993-1995 consisted primarily of the Northwest and Southwest quadrants of the Flemish Cap in depths from 300-500m for the Canadian and Norwegian fleets based on the observed fishery (Fig. 4). The areas of highest bycatch were considerably reduced from 1993 to 1995, coincident with the introduction of the grate (Fig. 5-7).

Total redfish numbers at length for 1994 (Fig. 8) and 1995 (Fig. 9), based on sampling from the Canadian and Norwegian shrimp fisheries, were converted into numbers at age by a combined age length key from Canadian surveys in Div. 3M from 1978-1981. There were 11 samples of the redfish bycatch measured in 1995 and 8 samples in 1994. In the 1994 shrimp fishery it is estimated that 89 million fish were taken as bycatch with about 79% at age 6 and 7. The 1995 fishery took 4.8 million fish with about 70 % at age 6 and 7. Although there was no sampling from the 1993 fishery, if one applies the 1994 sampling to derive an estimate of the number caught the result is about 138 million fish.

It appears that the introduction of the Nordmore grate in 1994 and a subsequent reduction in the bar spacing of the grate in 1995 has had the effect of greatly reducing the bycatch of redfish in the shrimp fishery in Div. 3M between 1993 and 1995. However, the impact of changes in the population abundance of redfish in Div. 3M over this time have not been considered and there are no data without the grate from the observed fisheries of Canada and Norway in 1994 and 1995 for comparisons to draw conclusions about the efficiency of the grate in excluding by-catch of redfish or any other species.

Table 1 - List of species caught in the northern shrimp fishery in NAFO Division 3M, 1993 - 1995.

Species	1993 Catch	Percent	1994 Catch	Percent	1995 Catch	Percent	Average Catch	Percent
Shrimp	26,706.0	66.74	24,153.0	78.15	35,814.0	97.41	28,891.0	80.8
Redfish	11,381.0	28.44	5,861.0	18.96	406.4	1.11	5,882.8	16.2
Turbot	294.0	0.73	96.0	0.31	35.0	0.10	141.7	0.4
Spotted Wolfish	373.2	0.93	20.2	0.07	13.5	0.04	135.6	0.3
[1]Skates	336.8	0.84	22.6	0.07	13.2	0.04	124.2	0.3
Striped. Wolfish	168.1	0.42	68.5	0.22	61.3	0.17	99.3	0.3
Lanternfish	66.7	0.17	63.1	0.20	157.1	0.43	95.6	0.3
Eelpout	36.6	0.09	81.8	0.26	82.4	0.22	66.9	0.2
Common Grenadier	5.3	0.01	79.2	0.26	29.6	0.08	38.0	0.1
Roughhead Grenadier	15.0	0.04	75.3	0.24	8.5	0.02	32.9	0.1
Greenland Shark	44.3	0.11	49.8	0.16	0.0	0.00	31.4	0.1
Capelin	62.3	0.16	12.7	0.04	2.9	0.01	25.9	0.1
Plaice	57.0	0.14	11.0	0.04	6.9	0.02	25.0	0.1
Northern Wolfish	66.3	0.17	0.2	0.00	0.1	0.00	22.2	0.1
Witch	30.3	0.08	12.0	0.04	5.8	0.02	16.0	0.0
Longfin Hake	13.4	0.03	24.4	0.08	6.2	0.02	14.7	0.0
Viperfish	9.6	0.02	19.5	0.06	6.2	0.02	11.8	0.0
Basking Shark	33.6	0.08	0.0	0.00	0.0	0.00	11.2	0.0
Lancetfish	23.3	0.06	3.0	0.01	6.6	0.02	11.0	0.0
Snipe Eel	9.9	0.02	15.8	0.05	2.2	0.01	9.3	0.0
Barracudina	3.8	0.01	15.8	0.05	7.9	0.02	9.2	0.0
Cod	18.0	0.04	2.3	0.01	0.3	0.00	6.9	0.0
Roundnose Grenadier	9.9	0.02	10.2	0.03	0.1	0.00	6.7	0.0
Silver Hake	0.1	0.00	17.3	0.06	0.0	0.00	5.8	0.0
Halibut	7.6	0.02	0.0	0.00	0.0	0.00	2.5	0.0
[2]Other	243.0	0.61	191.0	0.62	100.0	0.27	178.0	0.5
Sum	40,015.2	100.00	30,905.8	100.0	36,766.2	100.00	35,895.7	

[1]Consists of approximately 95% percent Thorny Skate

[2]Other - comprises all other species caught in varying amounts

Table 2. Estimated numbers at age for redfish bycatch from the 1994 shrimp fishery in Div. 3M.

Length	#'s	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Percent
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
12	26,280	0	0	2,167	15,443	8,128	542	0	0	0	0	0	0	0	0	0.03
13	477,885	0	0	0	178,603	270,319	28,963	0	0	0	0	0	0	0	0	0.54
14	1,380,375	0	0	0	106,183	915,825	358,366	0	0	0	0	0	0	0	0	1.55
15	3,139,177	0	0	0	30,477	1,005,756	1,859,124	243,820	0	0	0	0	0	0	0	3.52
16	10,260,961	0	0	0	58,971	707,652	7,371,380	2,122,957	0	0	0	0	0	0	0	11.51
17	24,542,009	0	0	0	0	0	12,816,382	10,225,837	1,499,789	0	0	0	0	0	0	27.54
18	29,801,805	0	0	0	0	153,618	7,066,407	17,358,783	4,915,762	307,235	0	0	0	0	0	33.44
19	15,600,449	0	0	0	0	0	1,306,844	8,004,419	5,145,698	980,133	163,355	0	0	0	0	17.51
20	3,279,393	0	0	0	0	0	32,959	1,433,704	1,417,225	346,067	49,438	0	0	0	0	3.68
21	450,137	0	0	0	0	0	2,273	86,390	252,349	90,937	15,914	2,273	0	0	0	0.51
22	160,740	0	0	0	0	0	0	12,428	84,513	43,914	14,914	4,971	0	0	0	0.18
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	89,119,209	0	0	2,167	389,677	3,061,298	30,843,241	39,488,339	13,315,336	1,768,285	243,622	7,245	0	0	0	100
	100.00	0.00	0.00	0.00	0.44	3.44	34.61	44.31	14.94	1.98	0.27	0.01	0.00	0.00	0.00	

Table 3. Estimated numbers at age for redfish bycatch from the 1995 shrimp fishery in Div. 3M.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total	Percent
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
7	366	5,371	0	0	0	0	0	0	0	0	0	0	0	0	5,737	0.12
8	0	7,347	612	0	0	0	0	0	0	0	0	0	0	0	7,959	0.16
9	0	1,957	3,718	294	0	0	0	0	0	0	0	0	0	0	5,969	0.12
10	0	0	2,538	1,393	50	0	0	0	0	0	0	0	0	0	3,981	0.08
11	0	0	6,335	8,830	2,496	0	0	0	0	0	0	0	0	0	17,660	0.37
12	0	0	3,562	25,376	13,356	890	0	0	0	0	0	0	0	0	43,184	0.89
13	0	0	0	15,252	23,084	2,473	0	0	0	0	0	0	0	0	40,809	0.85
14	0	0	0	5,864	50,577	19,791	0	0	0	0	0	0	0	0	76,232	1.58
15	0	0	0	2,868	94,642	174,945	22,944	0	0	0	0	0	0	0	295,399	6.12
16	0	0	0	2,960	35,521	370,008	106,562	0	0	0	0	0	0	0	515,051	10.67
17	0	0	0	0	0	474,001	378,192	55,468	0	0	0	0	0	0	907,661	18.81
18	0	0	0	0	6,090	280,125	688,134	194,870	12,179	0	0	0	0	0	1,181,398	24.48
19	0	0	0	0	0	82,368	504,507	324,326	61,776	10,296	0	0	0	0	983,273	20.37
20	0	0	0	0	0	5,144	223,751	221,179	54,009	7,716	0	0	0	0	511,797	10.60
21	0	0	0	0	0	770	29,258	85,463	30,798	5,390	770	0	0	0	152,448	3.16
22	0	0	0	0	0	0	2,496	16,976	8,821	2,996	999	0	0	0	32,288	0.67
23	0	0	0	0	0	0	303	2,641	3,074	1,472	693	130	0	0	8,313	0.17
24	0	0	0	0	0	0	14	360	1,122	590	374	144	58	14	2,676	0.06
25	0	0	0	0	0	0	0	397	1,482	1,561	847	503	159	132	5,081	0.11
26	0	0	0	0	0	0	0	134	1,049	1,587	753	995	592	242	5,351	0.11
27	0	0	0	0	0	0	0	23	185	718	811	741	927	1,251	4,657	0.10
28	0	0	0	0	0	0	0	0	41	869	911	1,449	1,283	3,683	8,236	0.17
29	0	0	0	0	0	0	0	0	38	115	459	1,146	1,146	4,814	7,718	0.16
30	0	0	0	0	0	0	0	0	0	0	73	132	219	2,486	2,910	0.06
31	0	0	0	0	0	0	0	0	0	0	0	6	18	558	582	0.01
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	366	14,675	16,765	62,837	225,815	1,410,515	1,956,160	901,837	174,575	33,309	6,688	5,245	4,401	13,182	4,826,373	100

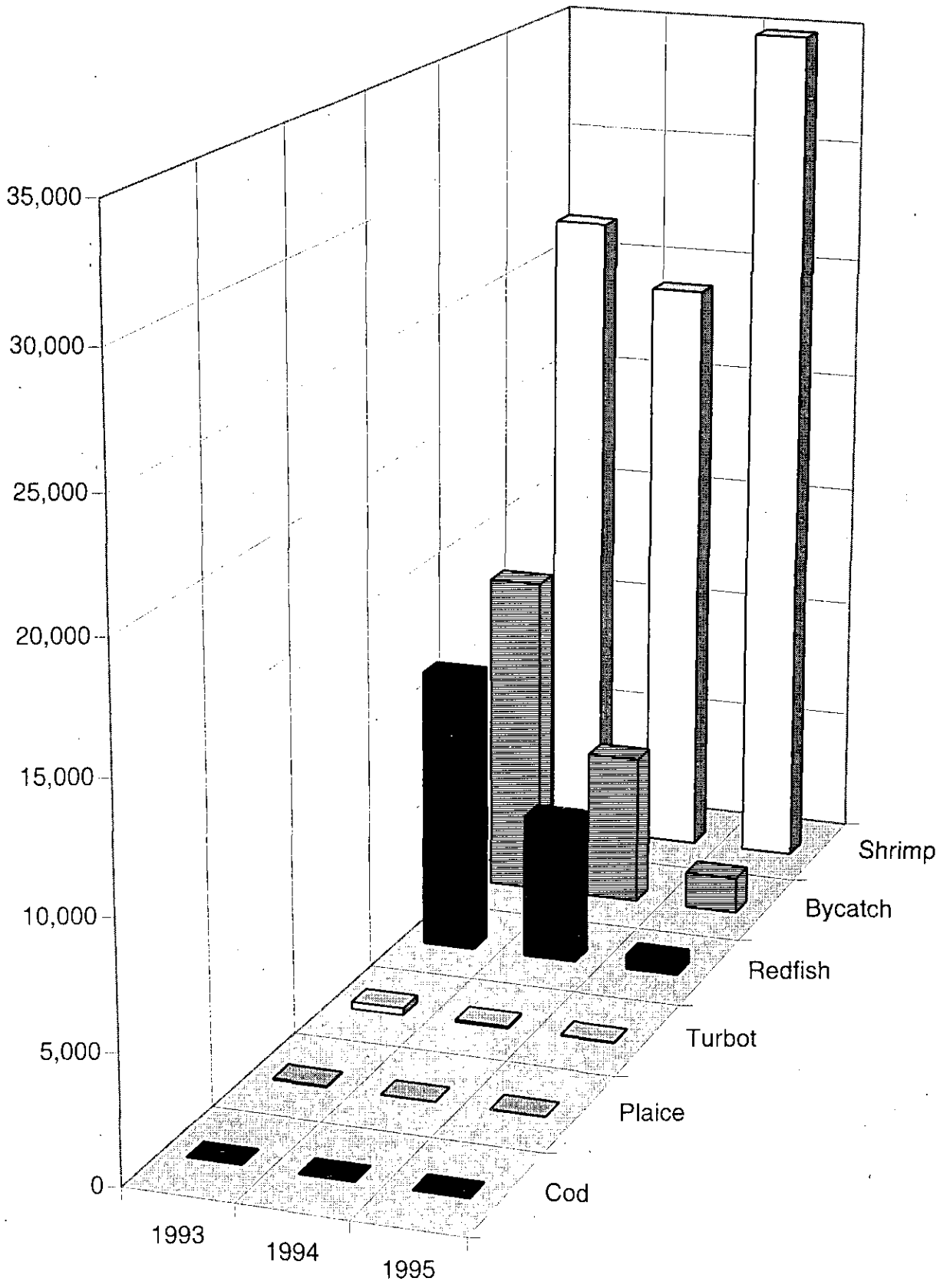

Fig. 1. Bycatches from the shrimp fishery in NAFO Division 3M.

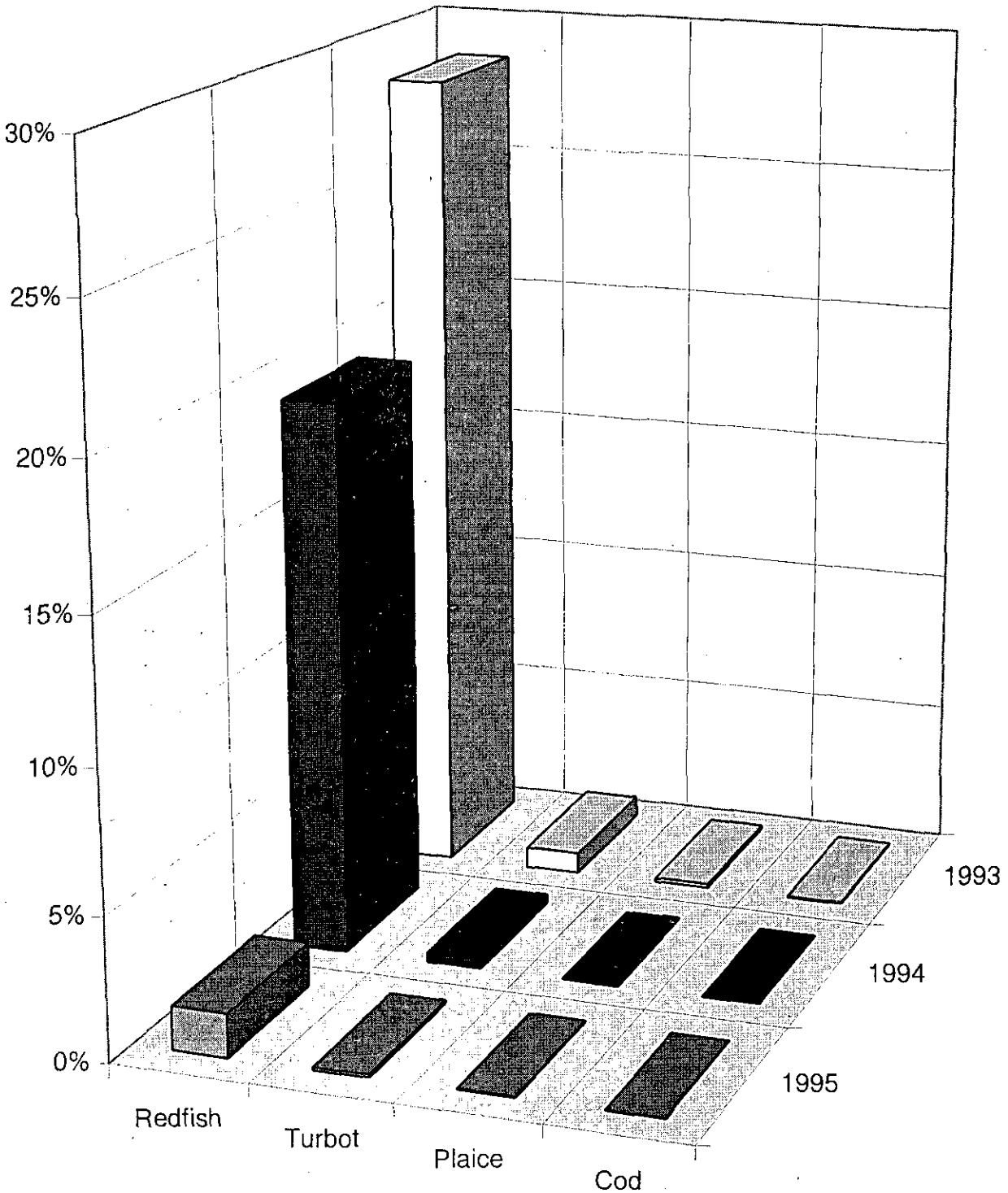

Fig. 2. Percentage bycatch of redfish, Greenland halibut, American plaice and cod from the shrimp fishery in NAFO Division 3M.

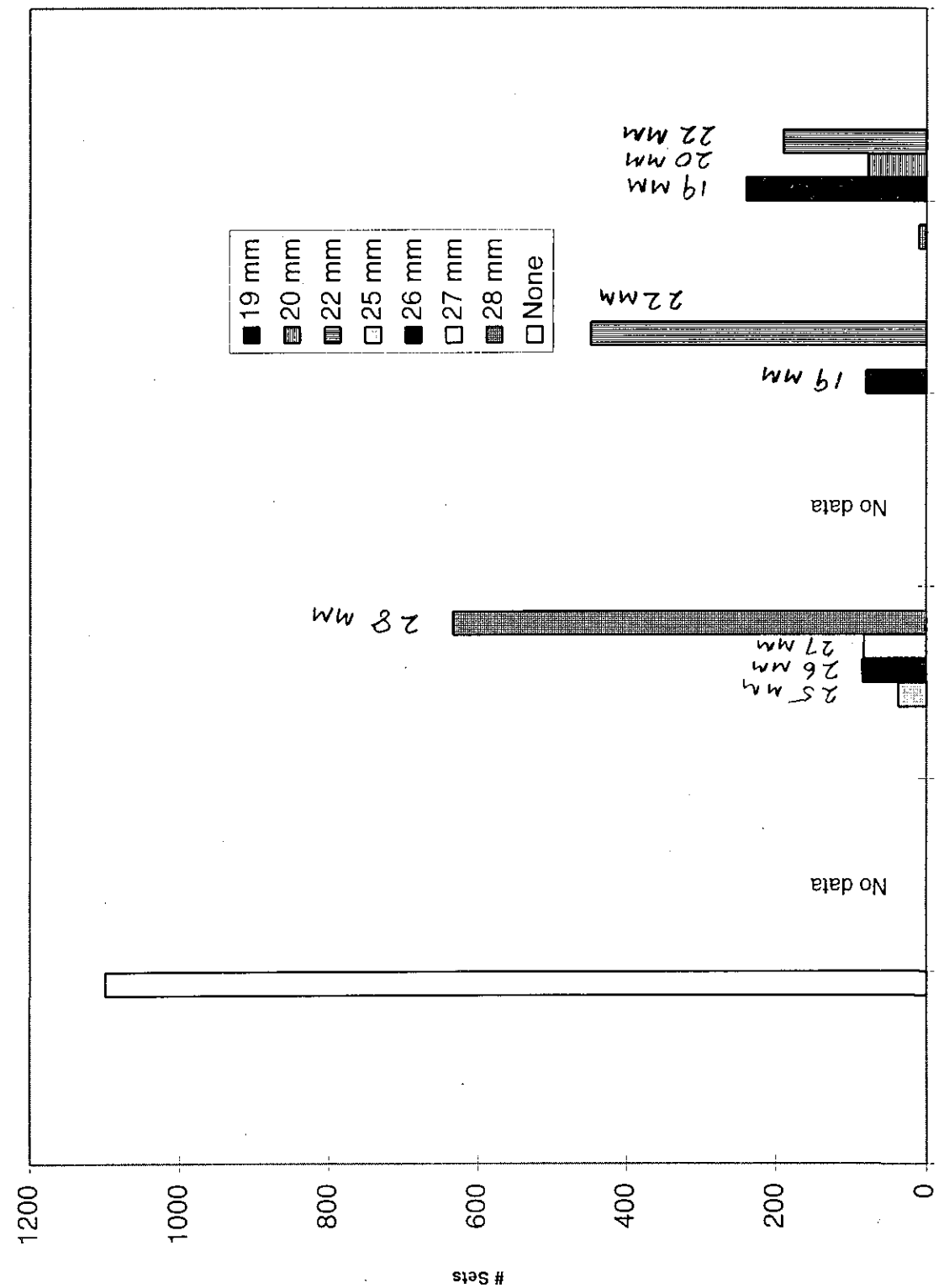

Fig. 3. Frequency of sets with various bar spacings in Nordmore grates from 1993-1995 from the observed fishery.

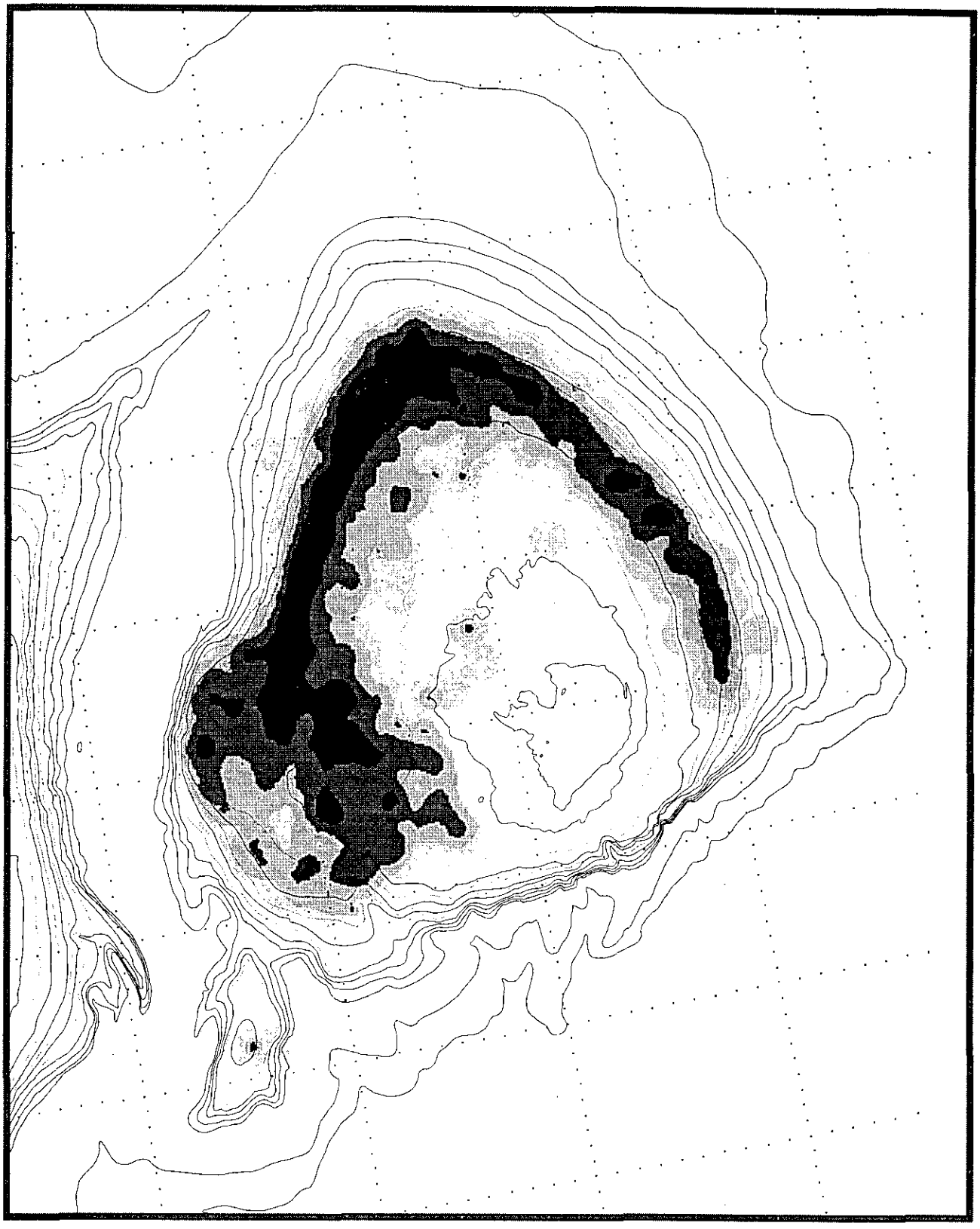

Fig. 4. Shrimp fishing grounds from 1993-1995 in Div. 3M based on the observed fishery of Canada and Norway. Darker areas denote more densily fished areas. Black = 0.2 sets per square mile, Greyshades = 0.07-0.2, 0.02-0.07, less than 0.02.

Fig. 5. Areas of redfish bycatch in 1993 shrimp fishery in Div. 3M. Darker areas denote higher bycatch rates. Black = greater than 200 kg/hr.

Fig. 6. Areas of redfish bycatch in 1994 shrimp fishery in Div. 3M. Darker areas denote higher bycatch rates. Black = greater than 200 kg/hr.

Fig. 7. Areas of redfish bycatch in 1995 shrimp fishery in Div. 3M. Darker areas denote higher bycatch rates. Black = greater than 200 kg/hr.

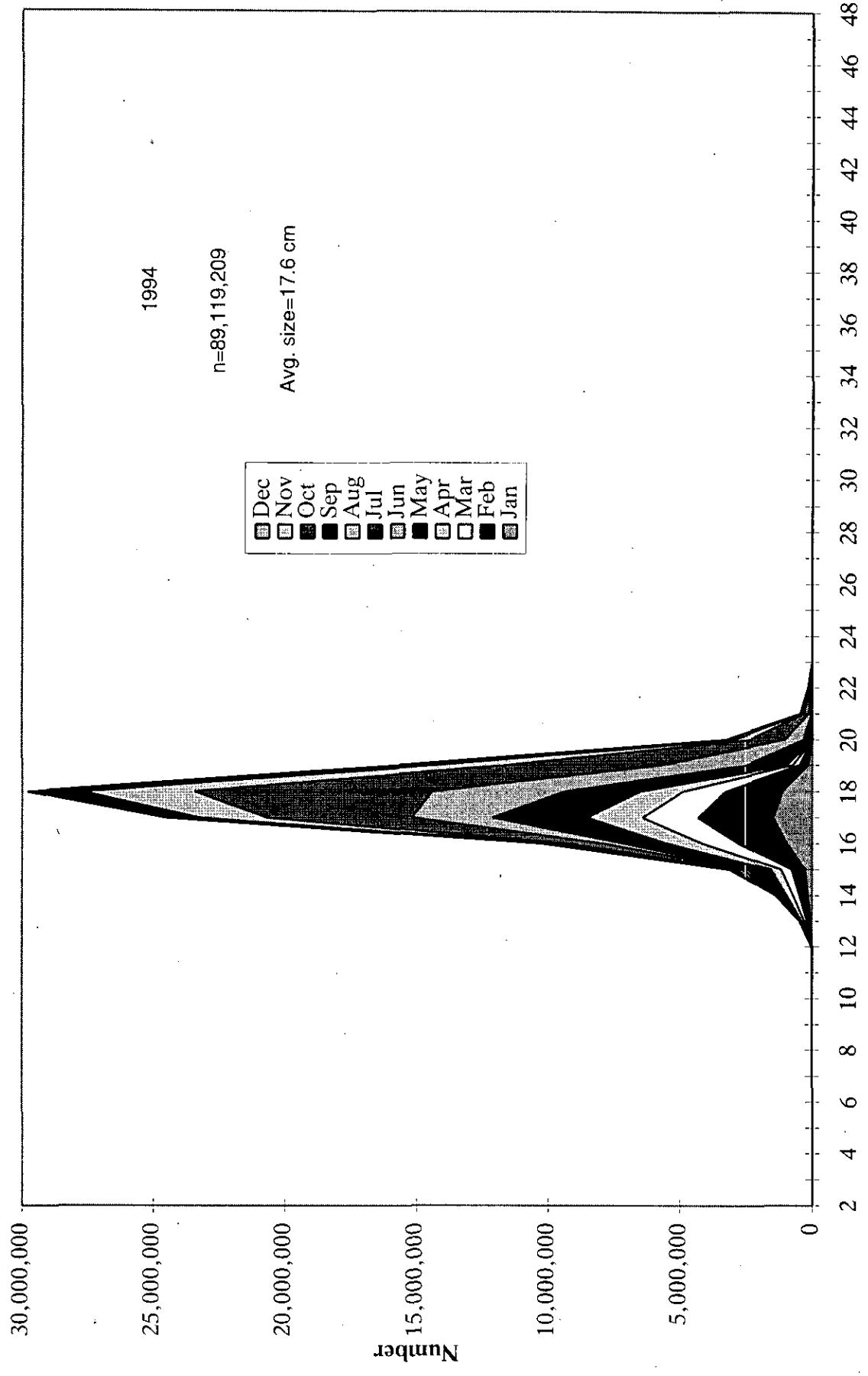

Fig. 8. Redfish bycatch in the shrimp fishery in NAFO Div. 3M in 1994.

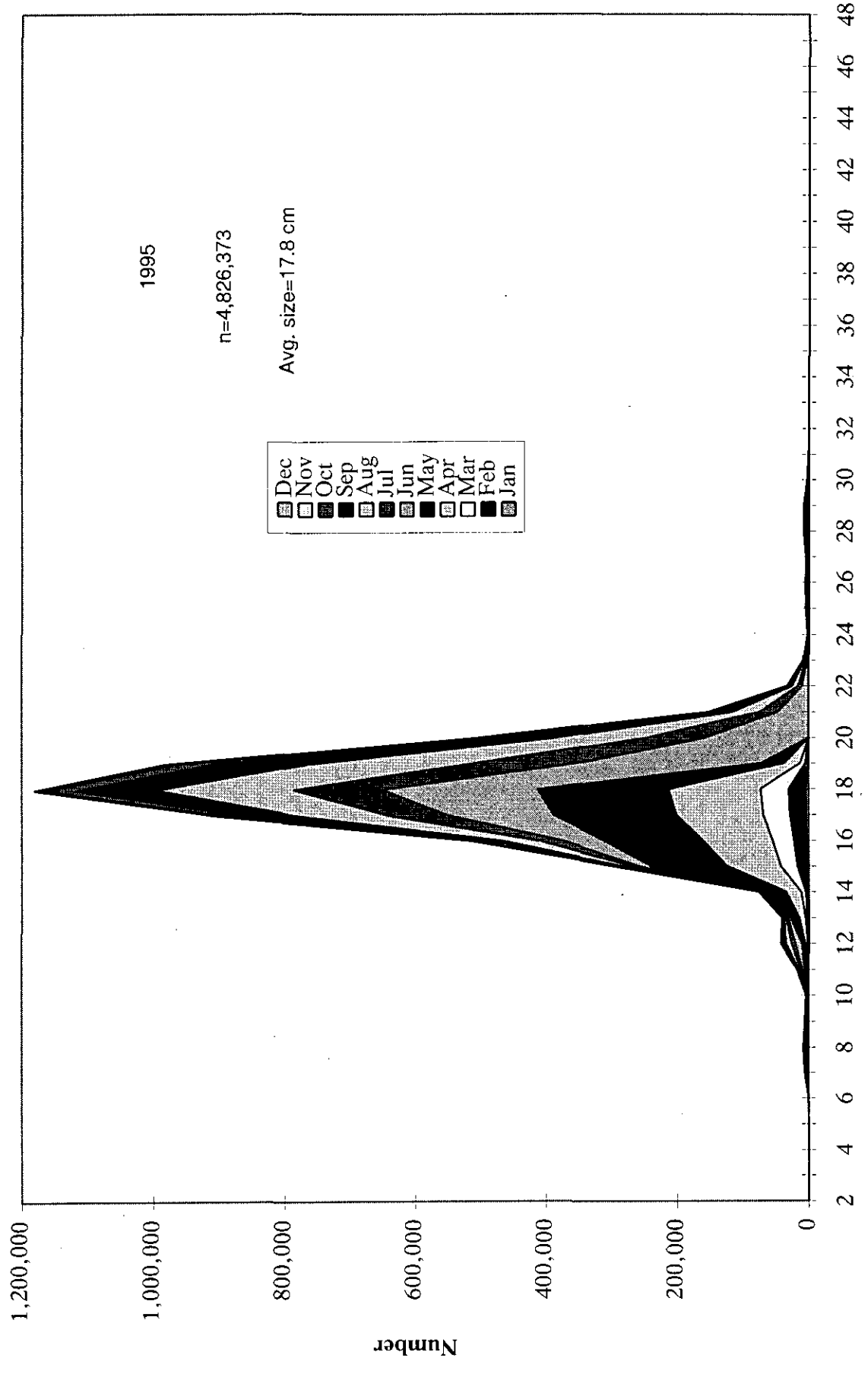

Fig. 9. Redfish bycatch in the shrimp fishery in NAFO Div. 3M in 1995.