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Discarding of Cod (*Gadus Morhua*) in the Northern Cod and Northern Shrimp Directed Fisheries From 1980-94

by

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Abstract

Since the 1960's, trawlers have fished for cod (*Gadus morhua)* on the offshore banks in NAFO Divisions 2J, 3K and 3L. As well, shrimp *(Pandalus borealis)* have been fished commercially since the late 1970's off Newfoundland and Labrador, including NAFO Divisions 2J and 3K. The shrimp gear captures other species, including small cod (Kulka 1995) which are of no commercial value to this sector. Cod was discarded from both of these fisheries but amounts were generally under-recorded in the fishing logs and was not accounted for in the landing statistics which are the basis for catch data as input for the assessment of the stock. Concerns have frequently been expressed about the level of discarding from the directed offshore fisheries for cod and shrimp, often as anecdotes related through the media. These fisheries have been observed since 1980 and at a level of 100% since 1987 in the cod winter (Jan. to Apr.) and shrimp fisheries providing the opportunity to quantify amounts and numbers discarded from these fisheries. This paper examines the available information from fishery observer records on discarding from the offshore shrimp and cod directed fisheries. The study based on observed sets adjusted to landings and discarded fish length samples obtained by observers provides amounts and size of fish discarded and estimates numbers at age for the period 1980 to 1994. It was found that discarding from the shrimp directed fishery was a considerably smaller component than from the cod fishery, accounting for an average of about 8% of the weight of total discards annually, peaking at 34% (1,156 t) in 1988. For both fisheries combined, total estimated discards peaked in 1986 at 9,403 t (10,211,389 fish) but had dropped to low levels by 1992 when the cod directed fishery was closed. A gear attachment, the Nordmore grate was introduced in the shrimp fishery in 1993 caused a further reduction. The total in 1994 was 57,396 fish, a fraction of the numbers from the mid 1980's.

Introduction

Northern Atlantic cod (*Gadus morhua)* located on the north-east Newfoundland and Labrador Shelves in NAFO Divisions 2J, 3K and 3L was the most important groundfish resource off Canada's Atlantic coast for over 400 years. With the introduction of an offshore fishery, there was a significant increase in fishing effort and catches during the 1960's and 1970's, with a resulting decline in biomass in the late 1970's. After some growth, it continued to be the primary resource for both the inshore and offshore fishing sectors into the 1980's. From 1980 until 1990, assessments indicated that stock size had fluctuated without trend (Baird *et al.* 1992) suggesting a stable population during this period. Bishop *et al.* (1993) noted that indications of the most recent decline first became evident from the in the fall of 1990 and from there, the biomass declined rapidly and apparently with little warning. The fishery with a peak catch of 268 677 t in 1988 was closed in 1992.

Among the many reasons that have been cited for the decline of northern cod is unreported catch, including fish discarded at sea. Discarding is the selective removal (by size or other selection criteria) of whole fish from the catch for return to the sea. Generally, it occurs because of the unmarketability of the fish that are discarded. Dumping is the non-selective process of returning whole or partial (unculled) catches to the sea and this occurs when amounts caught exceed processing capacity. Only fish rejected whole are classified as discards, not parts of fish returned to the sea during production. Throughout the rest of this paper, both dumping and discarding are referred to as discarding where not specifically differentiated.

Trawlers of many countries have fished for cod on the offshore banks since the 1960's. As well, shrimp *(Pandalus borealis)* have been fished commercially since the late 1970's off Newfoundland and Labrador, including NAFO Divisions 2J and 3K. The shrimp gear capture other species, including small cod (Kulka 1995) which are of no commercial value to this sector. Although cod was discarded from both of these fisheries, this source of mortality was not accounted for in the assessment of northern cod. Landing statistics, the basis for catch data as input into the assessment does not include amounts discarded and thus, fishing mortality is underestimated.

Since 1980, observers on a portion of the commercial offshore fleets recorded, on a set by set basis, not only amounts of fish caught but amounts returned to the sea. Mandatory use of fishery observers for both fisheries since 1987, and a specific requirement of these observers to quantify all bycatch species for each fishing set has yielded a very detailed data set on discard levels. Before the mid 1980's, there was little incentive to record discards in the fishing logs. Comparisons of log and observer data for the cod directed fishery for 1981 to 1985 (Kulka, 1986) and from the shrimp fishery, particularly in earlier years (Kulka, 1989) shows that discarded or dumped fish were greatly under-reported in fishing logs. Thus, observer data was chosen as the input for this study as the most reliable source of information on discarding.

Prior to 1980, fishing logs were the only source of information on amounts of fish discarded. Stevenson (1978) examined some of these records but concluded that these records might not be complete. Some information on discard weights collected by fishery observers from earlier years has been reported by Kulka (1982, 1984, 1885, 1989) and Kulka and Stevenson (1986). The purpose of this paper is to examine all available information on discarding of cod for the period 1980 to 1994 from the offshore shrimp and cod directed fisheries from fishery observer records. Bycatch of cod from fisheries other than shrimp and discards from the inshore sector are not included. The study provides not only amounts (weight), size of fish discarded and estimates of numbers at age but also examines the potential impact of these removals on the population.

Methods

Information gathered by fishery observers from offshore trawl fisheries directing for northern cod and northern shrimp in NAFO Divisions 2J, 3K and 3L (Figure 1) was used to examine discarding practices by those fleets from 1980 to 1994. Observers stationed on board a portion of the trawler fleets of all countries estimated, for each set, the catches of all species, including amount kept and discarded, using the methods of Kulka and Firth (1987). These data provided an estimate of the rate of discarding that was used to calculate total discards when adjusted to the landing statistics. Up to 1986, observers were deployed to a portion of the cod and shrimp fleet. Although coverage of the two fleets was mandatory after 1987, not all sets were observed since only one observer was deployed per vessel and fishing is a 24 hour operation. Also, due to logistic problems in deploying observers, not all trips were covered after 1987. Coverage was limited outside of 200 miles and is not included in this study.

Discarding of fish varies greatly among vessels and may be handled by the crew in a variety of ways on a particular vessel. Hence, based on prior knowledge of vessel production and layout, 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 (Figure 2) 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.

Only sets where the observer estimated catch and discards were used in this study to calculate percent of cod 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 the cod directed fishery, this was done by NAFO Division by month (the finest breakdown available from the landing statistics) and for the shrimp fishery, it was done by shrimp ground (refer to Figure 1 and Table 1). Where observed catch exceeded reported landings, observed figures were used. Length samples of discards

were collected from each vessel and these data were used to convert discard weight to numbers at length. Age-length keys from research vessel surveys were used to calculate numbers at age since commercial landing keys did not cover the lower end of the discard sizes.

Results

Table 1 summarizes catch and discard amounts for the directed cod and shrimp fisheries, for 1980 to 1994. It shows that discarding increased up to 1987 then declined to low levels by 1992. For the cod fishery, discarding was generally highest in the winter months in NAFO Div. 3K corresponding to times and areas where catch per set were greatest and where fish were generally smaller. Cod directed discarding peaked in 1986 at 9,330 t or 10,097,621 fish.

Cod bycatch from the shrimp fishery is categorized by fishing ground within NAFO Divs. 2J and 3K. The fishery for shrimp was limited before 1986 to the more northerly areas, namely Cartwright and Hawke Channels located in NAFO Div. 2J (refer to Fig. 1). Discards increased proportionately with the catches of shrimp and peaked in 1988 as the shrimp fishery spread to more southerly locations. The cod bycatches were highest in Hawke Channel and Funk Island Deep contributing to most of the shrimp fishery discarding, particularly between 1987 and 1991. Nearly all bycaught cod in this fishery were discarded in later years but some (about 15 to 20% representing the larger fish), was kept in earlier years before 1988. Discarding from both fisheries dropped off sharply after 1991 as the cod fishery was closed (Feb. 1992) and gear attachments on shrimp nets were used to exclude cod bycatch. Only 22 t (small cod from the shrimp fishery) were observed to have discarded in 1994. Preliminary results for 1995 show a similar level.

Figure 3 shows numbers of discarded cod at length by year from the two fisheries for 1980 to 1992. Most of the fish discarded from the directed cod fishery were in the range of 25 to 50 cm, primarily 4 and 5 year olds. In every year except 1987, cod directed discards were larger than the discards from the shrimp fishery. Shrimp was a minor component before 1988 and consisted of a mix of smaller fish averaging 28 cm. and ranging from 15 to 40 cm. (mostly 2 to 4 year olds).

Size of shrimp fishery discards was fairly consistent over time with the exception of 1987 when larger fish were caught and discarded. Average size of discards from the cod directed fishery (Fig. 4) varied over time, increasing during the early 1980's then declining after 1987. This pattern was likely partly related to a corresponding increase then decrease in dumping since dumping meant the rejection of fish of all sizes, including larger fish in the catch.

Numbers of cod discarded at age from both fisheries is shown in Fig. 5. Older fish, mainly 4 and five year olds dominated in the years prior to 1992. An increasing shrimp fishery and closure of the cod fishery led to a greater proportion of 2 and 3 year olds in the later years. Table 2 and Fig. 6 summarizes the numbers at age combined for both fisheries. Fig. 6a shows that average dropped over time as the shrimp fishery discard component became an increasingly important component. Overall, the majority, 74% of discards were aged 4 and 5 and nearly all (98%) were less than 6 years old. Figure 6b compares Adapt population numbers and total catch numbers to the amounts discarded from the offshore directed cod and shrimp fisheries. In the peak year, they represented 6.5% of total catch and 1% of the population.

Discussion

Throughout the early 1980's, increasing size of catch and decreasing size of fish resulted in an increase in the discard rate on most Canadian vessels and some foreign vessels. Increasingly dense schools of fish encountered in the directed winter fishery led to greater catch rates. Catch per set increased from 1981 and peaked in 1984 in NAFO Div. 2J and in 1985 in 2J, often exceeding the processing capacity of the vessels during that period. On some vessels, portions of some sets were dumped if the previous set was not completely processed before the next set was brought aboard. Although it varied among vessels, average optimum catch per set for processing was 12 t (to allow production of one set to be completed before the next set was completed) but catches exceeding 25 t were not uncommon for limited areas and times, particularly in 2J in the mid 1980's. Percent of sets exceeding 12 t rose rapidly from about 2.5% of sets in 1980 and peaked in 1985 at 18%. The result was increased dumping during the winter and to the north, a consequence of greater catch to processing capacity ratio. The summer fishery, prosecuted less dense concentrations of fish that were dispersing shoreward. The fleets also fished the southern part of 3L where the fish were larger and catch rates were low. The lower catch rates and larger fish in these summer catches resulted in lower discard rates. As well, many foreign vessels, active in the early 1980's, did not discard small fish. Their on board cutting and filleting machinery could handle small fish and their processing capacity could handle very large catches. On some vessels, small fish were reduced to fish meal.

A greater portion of small, unmarketable fish taken by the Canadian fleet particularly in 2J and the northern part of 3K during the mid 1980's contributed to the increasing observed discard rate. Fish plant machinery generally could not handle fish less than about 18 inches (45 cm.) and there was no market for these fish. As well, a new fishery for shrimp, starting in the early late 1970's expanded southward in 2J and 3K particularly after 1987. The small mesh shrimp gear captured small cod that was of no commercial value to the shrimp industry and nearly all was discarded.

There are a number of reasons that discarding diminished after 1986 in the cod directed fishery as outlined in (Kulka, 1989). Very large catches slowed production. To compensate for increased size of catch, tow length was reduced from an average 5.05 hours in 1980 to 1.47 hours in 1987-88. Catch (and percent exceeding 12 t) then diminished over time due to the shortening of sets, decreasing density of the schools to the north and technology changes designed to limit catch size and decrease the capture of small fish (discussed below). Coupled with the full observer coverage and the regulation requiring that discarded fish be deducted from the quota, the smaller catch per set resulted in a diminished incentive to dump fish. After 1986, most larger fish that came on board were kept because catch per set did not exceed processing capacity and all of the catch, not just the landings were deducted from the quota. On the other hand, about 2-3% of the catch continued to consist of fish too small for the plant machinery and the markets and these continued to be discarded.

Technology changes contributed significantly to the lower catch per set with time. The industry changed its gear, vessel production capacity and marketing to accommodate large catches and regulatory changes. There was an increased use of windows in the codend over time starting in 1983 and increasing to 78% in 1988. These gear modifications were designed to release a portion of the catch beyond a certain level while the gear was still in the water. Mesh size was increased over time from 128 mm in 1980 to 137 mm in 1987-88. A change to square mesh from primarily diamond before 1985 facilitated the release of more small fish. Introduction of SCANMAR to detect when the net was full to capacity likely led to the shorter tow lengths observed. Increased processing capacity through containerization increased optimum catch size and allowed larger catches to be retained. All of these changes occurred through the mid 1980's.

Regulations requiring 100% observer coverage and inclusion of discards against the quota in 1987 (it also became mandatory that cod discards be reported in the fishing logs). Coupled with the decreasing catch per set due shorter sets, technological changes and less dense schools of fish reduced the incentive to dump, and discard. While vessels used shorter tows and introduced windows to reduce catch size, plants found a way to market smaller fish because if it was not utilized it was lost quota. Increased observer coverage made it more difficult discard without those discards being applied to the quota. Following the moratorium on the directed fishery for cod, amounts discarded were low since the shrimp fishery was the lesser contributor. Introduction of the Nordmore grate in 1993 and its extensive use in subsequent years allowed the live escapement of most cod from the shrimp gear (Kulka, 1995).

Since not all sets were observed particularly during the years prior to 1987, the numbers presented in this paper are regarded as minimum estimates. However, it is the best source of information on discarding from the offshore directed cod and shrimp fisheries. Two further sources of discarding remain unquantified. First, for the bycatch from other trawl fisheries, a portion of cod bycatch was discarded. It is expected that for most fisheries the discard rate and absolute amounts would be low because cod was usually more valuable than the directed species and amounts bycaught were relatively low. Some data exists for these non-cod directed trawl fisheries and these amounts should be quantified. Second, for the inshore sector, a very complex set of fisheries made up of a variety of gears and extending along the coast from St. Marys Bay to White Bay, there exists no reliable source of data. Less direct methods will be required to attempt estimate discarding practises for these fisheries.

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Table 1 - Summary discard amounts and numbers for the directed cod and shrimp fisheries in NAFO Divisions 2J, 3K and 3L.

	Cod Directed (tonnes)				Shrimp Directed (tonnes)						
					Cartwright	Hawke	St. Anth.	St. Anth.	Funk Isl.		
	2J	3K	3L	Total	Channel	Channel	East	West	Deep	Total	Both
1994				0.0	9.6	8.7	2.8		0.9	22.0	22.0
1993				0.0	2.8	40.9	2.3	0.5	0.0	46.5	46.5
1992	0.0	73.1	377.9	451.0	7.6	124.4	10.6	18.8	70.9	232.3	683.3
1991	23.0	492.0	444.0	959.0	6.4	383.7	35.8	68.0	64.1	558.0	1,517.0
1990	950.6	573.5	1,339.8	2,864.0	14.7	24.0	60.8	61.9	227.1	388.4	3,252.4
1989	1,088.5	973.2	519.8	2,581.5	26.2	103.5	36.4	53.5	280.7	500.3	3,081.8
1988	1,310.7	967.8	560.5	2,839.0	1.3	121.8	23.1	14.9	257.9	419.0	3,258.0
1987	1,747.0	2,013.5	665.1	4,425.6	4.6	215.5		91.5		311.6	4,737.3
1986	529.3	6,054.9	2,746.0	9,330.1	72.8					72.8	9,402.9
1985	83.3	5,545.7	1,333.7	6,962.7	0.4					0.4	6,963.2
1984	528.5	3,185.0	1,740.5	5,453.9	1.1					1.1	5,455.0
1983	1,577.2	1,344.9	641.6	3,563.7	0.0					0.0	3,563.7
1982	965.1	581.9	236.7	1,783.7	5.9					5.9	1,789.6
1981	329.9	241.8	65.5	637.2	18.9	47.6				66.5	703.7
1980	55.7	76.2	22.8	154.7	31.7					31.7	186.4
Avg.	**706.8**	**1,701.8**	**822.6**	**2,800.4**	**13.6**	**118.9**	**24.5**	**44.2**	**128.8**	**177.1**	**2,977.5**

Table 2 - Numbers of discards from the cod and shrimp directed fisheries in NAFO Divisions 2J, 3K and 3L, by age.

Year/Age	1	2	3	4	5	6	7	8	9	10	11+	Sum
80	0	0	6,540	60,369	49,273	7,831	68	0	0	0	0	124,081
81	0	3,026	249,251	408,524	96,194	19,547	3,599	0	0	0	0	780,141
82	0	0	447,424	1,284,176	302,991	67,290	5,209	134	0	0	0	2,107,224
83	0	45	157,092	1,939,526	989,955	118,733	14,518	3,475	1,136	228	0	3,224,708
84	0	925	396,004	3,154,599	1,430,782	251,973	1,073	9,285	100	0	0	5,244,741
85	0	62	84,133	1,936,741	3,232,521	573,057	107,142	14,570	2,360	3,215	0	5,953,800
86	0	9,674	537,680	4,075,233	4,406,498	1,053,066	108,652	6,769	273	634	118	10,198,597
87	11,759	39,204	96,809	673,300	2,723,640	1,107,711	80,670	20,805	7,240	2,543	1,412	4,765,093
88	17,257	535,703	545,495	1,092,489	1,131,458	678,534	148,652	6,227	2,028	402	182	4,158,427
89	187,669	887,234	622,664	1,666,380	869,880	179,174	31,761	8,557	484	127	59	4,453,989
90	284,928	511,453	709,224	2,114,216	1,027,604	85,363	5,580	3,626	1,868	217	70	4,744,150
91	80,388	468,579	363,299	615,885	609,638	112,240	7,255	675	244	95	51	2,258,349
92	14,189	315,446	180,622	386,419	201,927	26,336	1,260	254	3	0	0	1,126,455
93	3,469	117,247	45,367	12,113	1,207	1,144	124	51	0	0	0	180,723
94	2,668	33,911	14,896	3,952	1,751	82	120	16	0	0	0	57,396
	602,326	2,922,509	4,456,501	19,423,922	17,075,318	4,282,081	515,684	74,445	15,735	7,462	1,892	49,377,875
% of Total	1.22%	5.92%	9.03%	39.34%	34.58%	8.67%	1.04%	0.15%	0.03%	0.02%	0.00%	

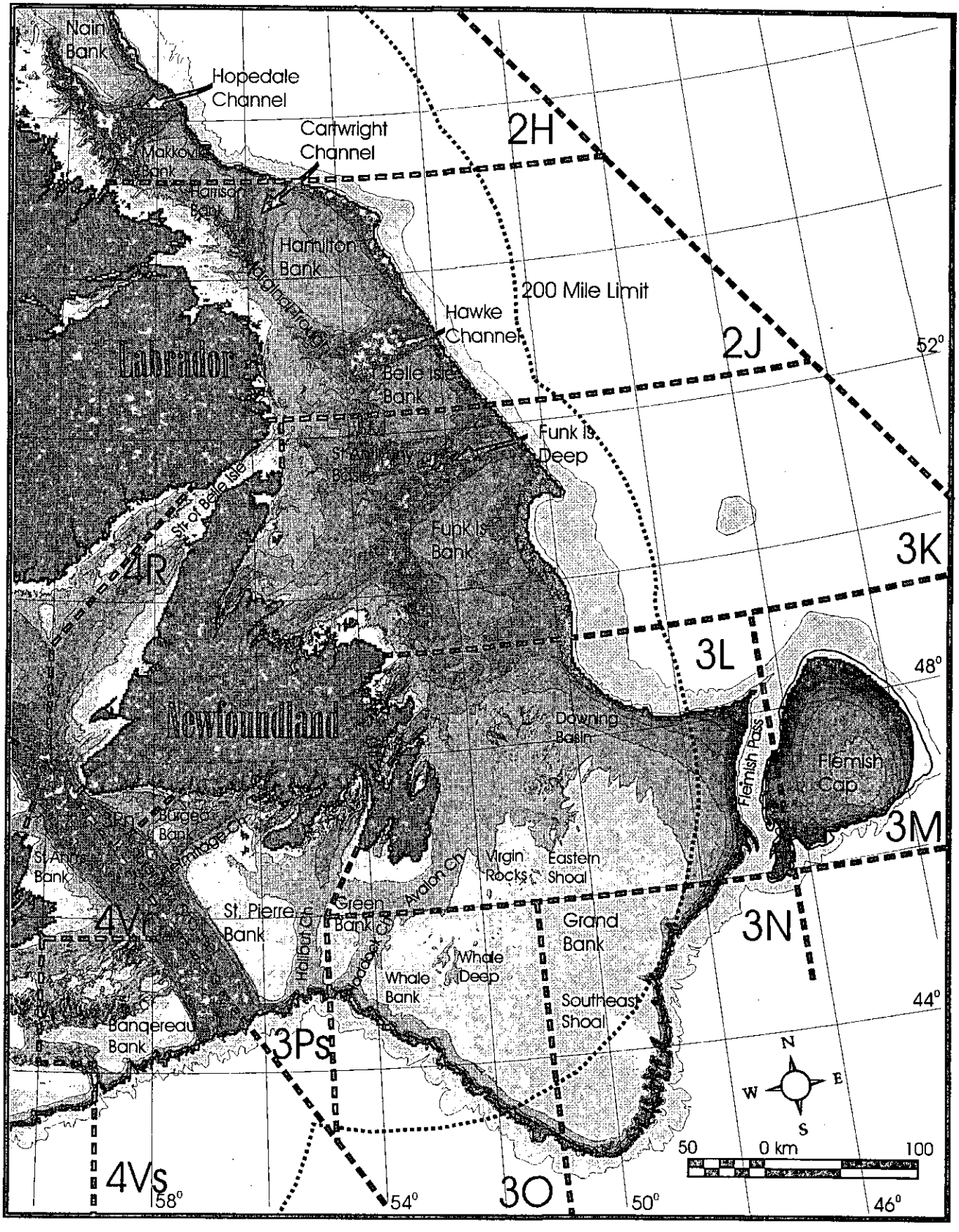

Figure 1 - Map of the area fished showing NAFO Divisions and shrimp fishing grounds.

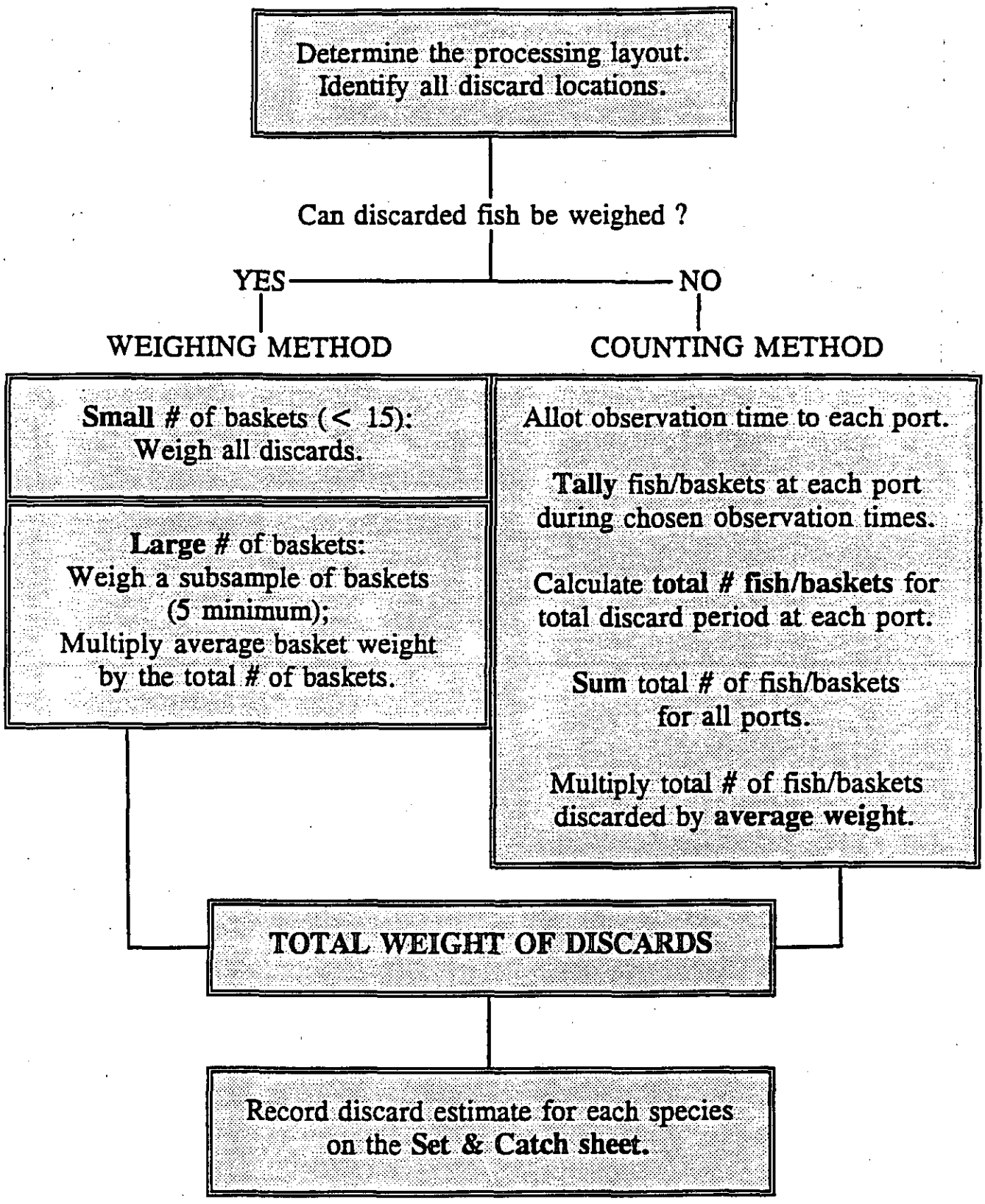

Fig. 2. Discard Estimation Strategy flow chart.

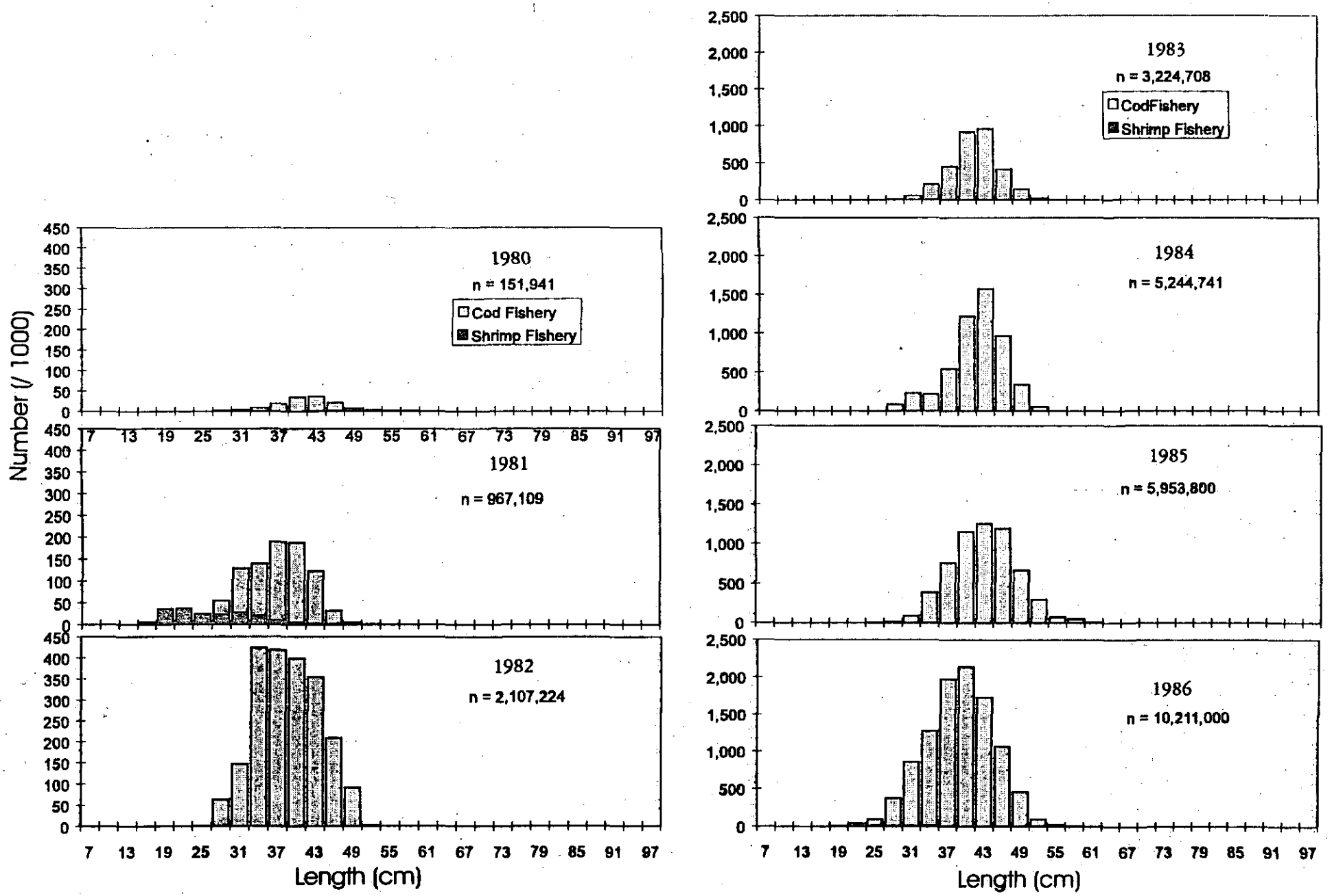

Figure 3a - Numbers of fish discarded from the cod and shrimp directed fisheries at length.

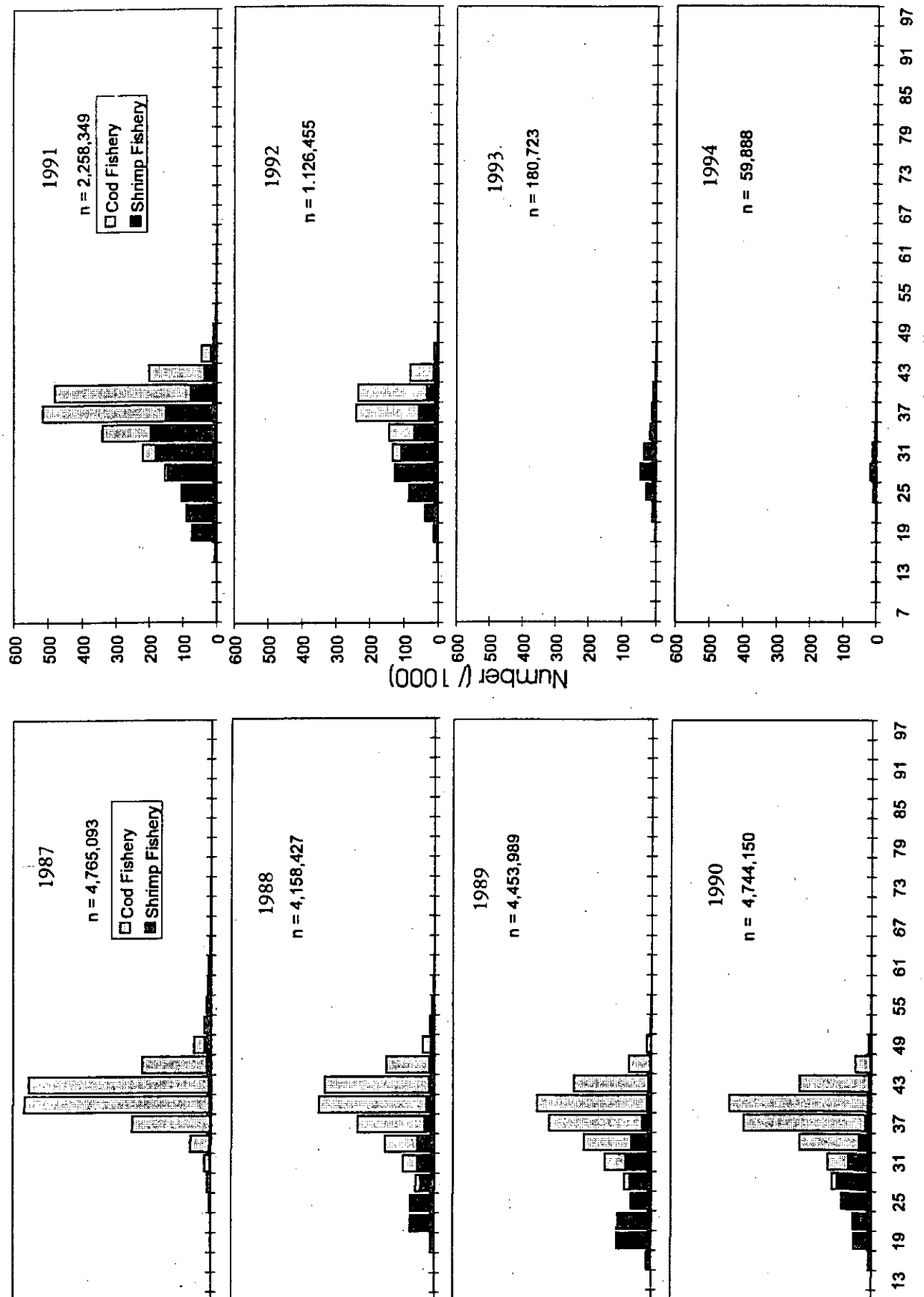

Figure 3b - Numbers of fish discarded from the cod and shrimp directed fisheries at length.

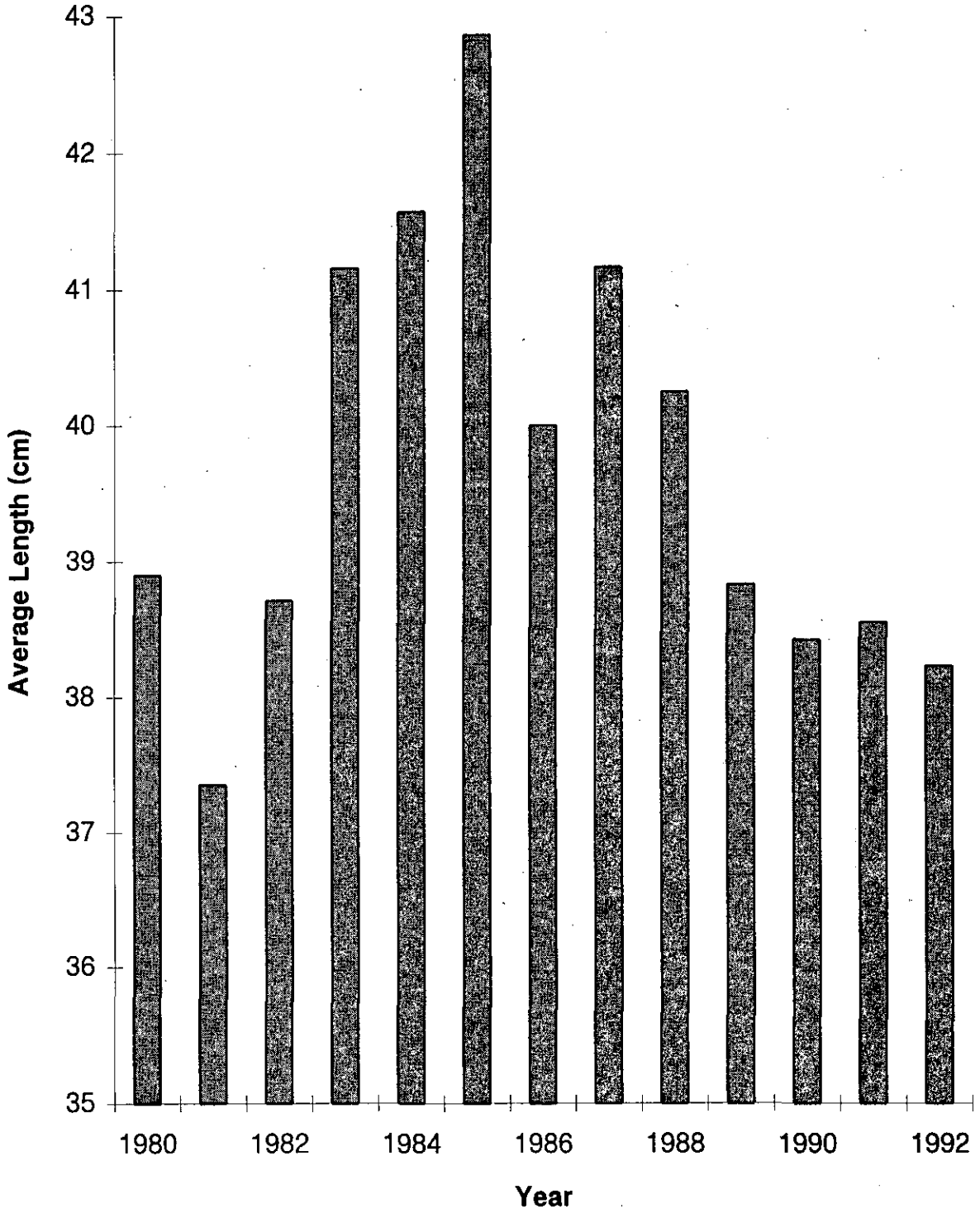

Figure 4 - Averge size of discards for the directed cod fishery in NAFO Divisions 2J, 3K and 3L.

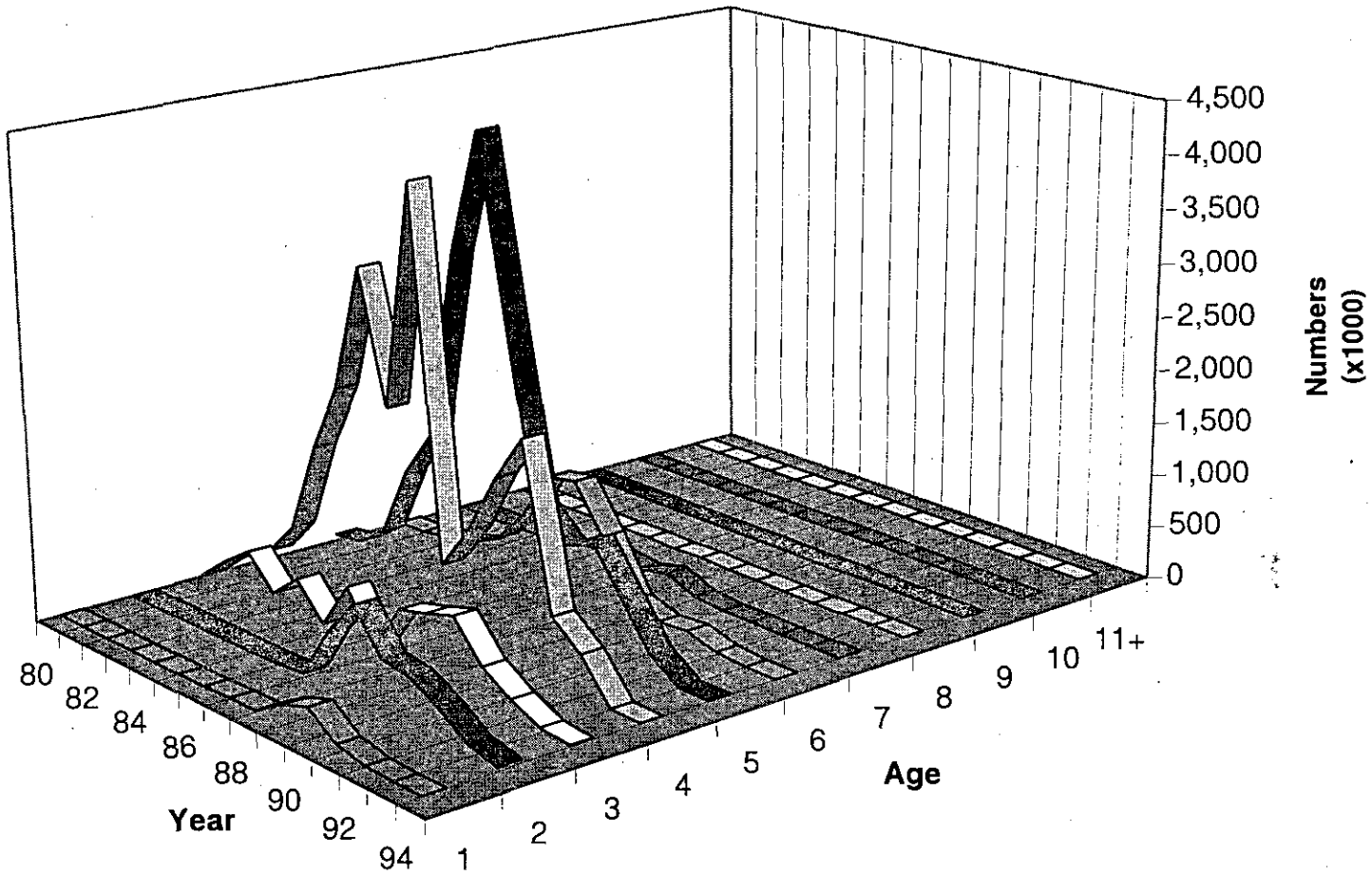

Figure 5 - Numbers of cod discarded at age for the directed cod and shrimp fisheries in NAFO Divisions 2J, #k and 3L.

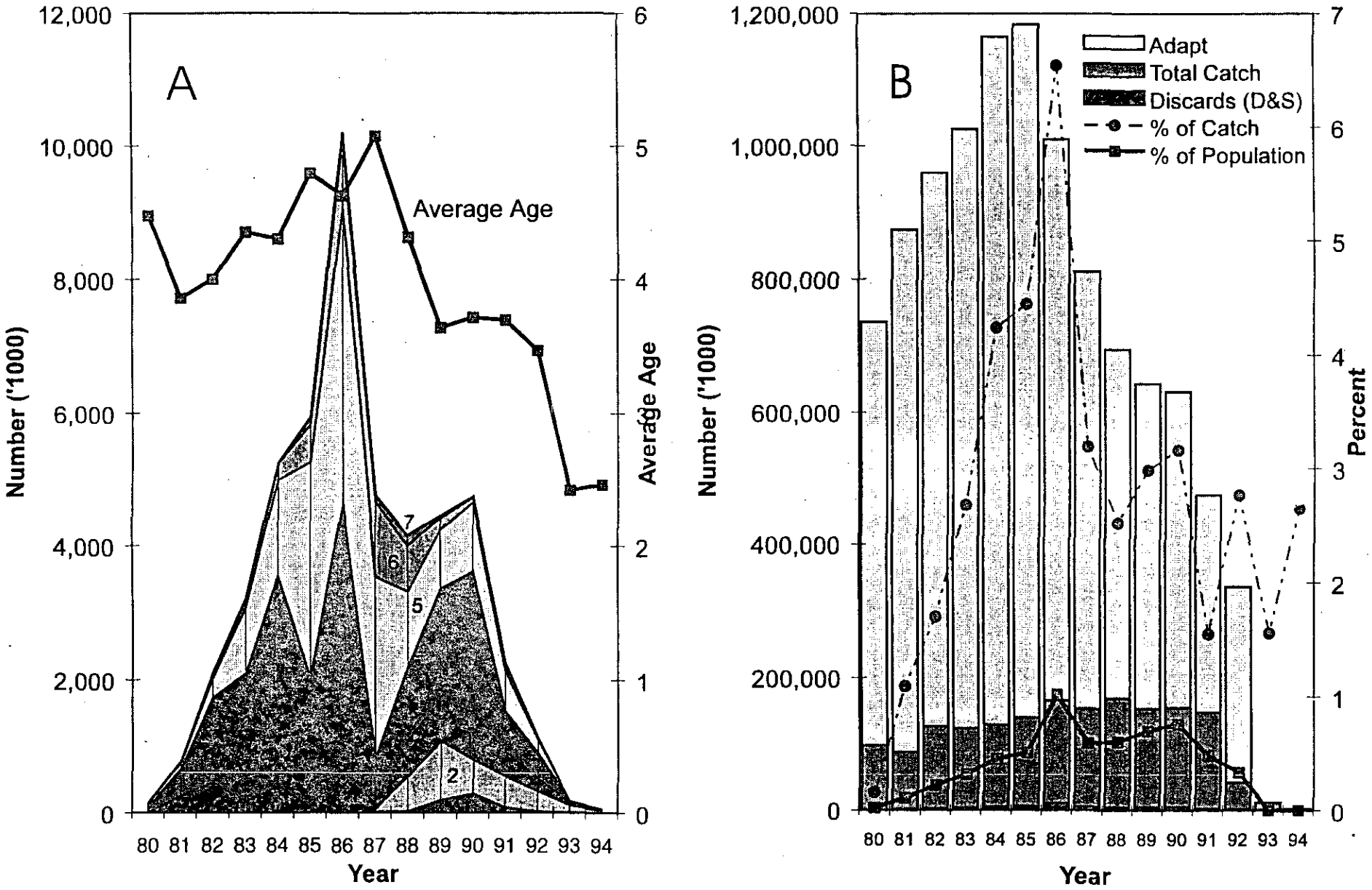

Figure 6 - Discards from the offshore Northern Cod and Northern Shrimp Directed fisheries. Fig. a shows numbers discarded by year. Sub-portions of the area graph denote fish ages. The line graph shows average of discards by year. The bar graph in Fig. b shows numbers discarded in comparison to populations numbers from Adapt and total catches of cod while the line graphs show percentages of the same.