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Discards of fish at sea by northern New Brunswick draggers.<sup>1)</sup>

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Abstract

Sampling aboard northern New Brunswick draggers from 1956 to 1961 shows a substantial reduction in the percentage by numbers and by weight of the catch of cod discarded at sea. The total numbers of cod discarded in the southwestern Gulf of St. Lawrence, which amounted to about 7 million in 1956, have been reduced to an estimated 1 million in 1961. Two factors are mainly responsible for this reduction: large-mesh nets which, following an ICNAF recommendation, became effective in 1957, and reduction in sizes retained for landing. The mesh effect is believed to be 1.3 times greater than the cull effect in reducing cod discards in 1961. Discards of American plaice have increased during the same period, due to larger recruitment of young year-classes. Discards of species other than cod and plaice are negligible because they are a small part of the catch. Survival experiments show that most cod and plaice are dead when returned to the sea. The use of large-mesh codends may result in long-term increase in the total cod landings in the southwestern Gulf of St. Lawrence.

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## Introduction.

The management of groundfish fisheries in the northwest Atlantic is based on continuous investigations of the effects of fishing on stocks, catch and landings. Evaluation of the quantities, sizes and ages of fish landed is now a routine assessment for many stocks. However, the additional fishing mortality attributed to the capture of unmarketable fish which are discarded at sea has not been studied in many fisheries. This paper describes the results of a six-year study of wastage of groundfish at sea from draggers fishing off northern New Brunswick, Canada, in the southwestern Gulf of St. Lawrence (Fig. 1). Discards are found to represent a significant portion of the catch of cod and plaice. Survival studies show that a large proportion of these discarded fish die without contributing to current or future landings. The effects of gear selection, quantities and sizes of fish caught and market acceptability are examined. The results are pertinent to consideration of conservation and utilization of the groundfish resources of the Gulf of St. Lawrence.

Prior to the end of World War II the groundfish fishery of the southwestern Gulf of St. Lawrence was carried out almost entirely with baited hooks and lines and jiggers. Shortly after the war a major change took place with the introduction of otter trawls. The first small otter trawlers, commonly called draggers, began operation in 1947 in northern New Brunswick and in 1951 in Quebec. The otter-trawl fleet expanded rapidly, and in 1960 more than 130 draggers from Quebec and the Maritime Provinces were fishing in the southwestern Gulf of St. Lawrence.

Following the introduction of the otter trawl, and probably as a result of it, the annual cod landings by all countries fishing in the southwestern Gulf of St. Lawrence (ICNAF Divisions 4 T and 4 V (spring), Fig. 1) more than doubled. Annual landings averaged 61 million lb<sup>2)</sup> during the decade 1937-46 immediately preceding the introduction of draggers, compared with 133 million lb. during the 1951-60 period (Fig. 2). Prior to 1947 nearly all cod landings from the southwestern Gulf of St. Lawrence came from lines, whereas in 1960 more than 60% were caught by otter trawl, both Canadian and European (Fig. 2). About one third of the Canadian landings by all gears from the southwestern Gulf is now landed by northern New Brunswick draggers (Canada, Fisheries Statistics).

The otter trawl as a fishing gear is efficient, but it can be wasteful, especially if used with small-mesh codends. Large quantities of fish too small to be of any commercial value are brought on deck and are later discarded. It is also wasteful in time, since the discarding of small fish and other trash slows down fishing operations.

As a conservation measure the International Commission for the Northwest Atlantic Fisheries (ICNAF) at its 1955 Annual Meeting (Bates 1955) recommended that the member countries fishing for cod and haddock in Subarea 4 (Canadian Atlantic coast) use a minimum mesh size of 4 1/2 inches for manila, or its equivalent for other fibres, to replace the 3-inch or smaller mesh used during the early years of otter trawling in Subarea 4. Measurements were to be made with a wedge-shaped, flat gauge inserted in the lumen of the mesh with a pressure of 10 to 15 lb. while the net is still wet after use. Following the ICNAF recommendation, Canada passed a regulation which made the 4 1/2-inch mesh mandatory in March 1957. The years 1957 and 1958 were years of transition when part of the fleet adopted the new regulation mesh and part retained the pre-regulation one. In 1959 the conversion to the 4 1/2-inch mesh was complete.

Factors other than mesh size may determine the portion of the catch rejected at sea. The size composition of the catch, distribution of small fish and market requirements are some of them. These factors are subject to annual and long-term variations. The purpose of the present paper is to evaluate the effects of the various factors on the discards of small fish in the Gulf of St. Lawrence in recent years.

2) Unless otherwise indicated, weights are in pounds, gutted, head on. Conversion factors to round fresh weight = 1.2; to metric tons: 1 metric ton = 2204.6 lb.

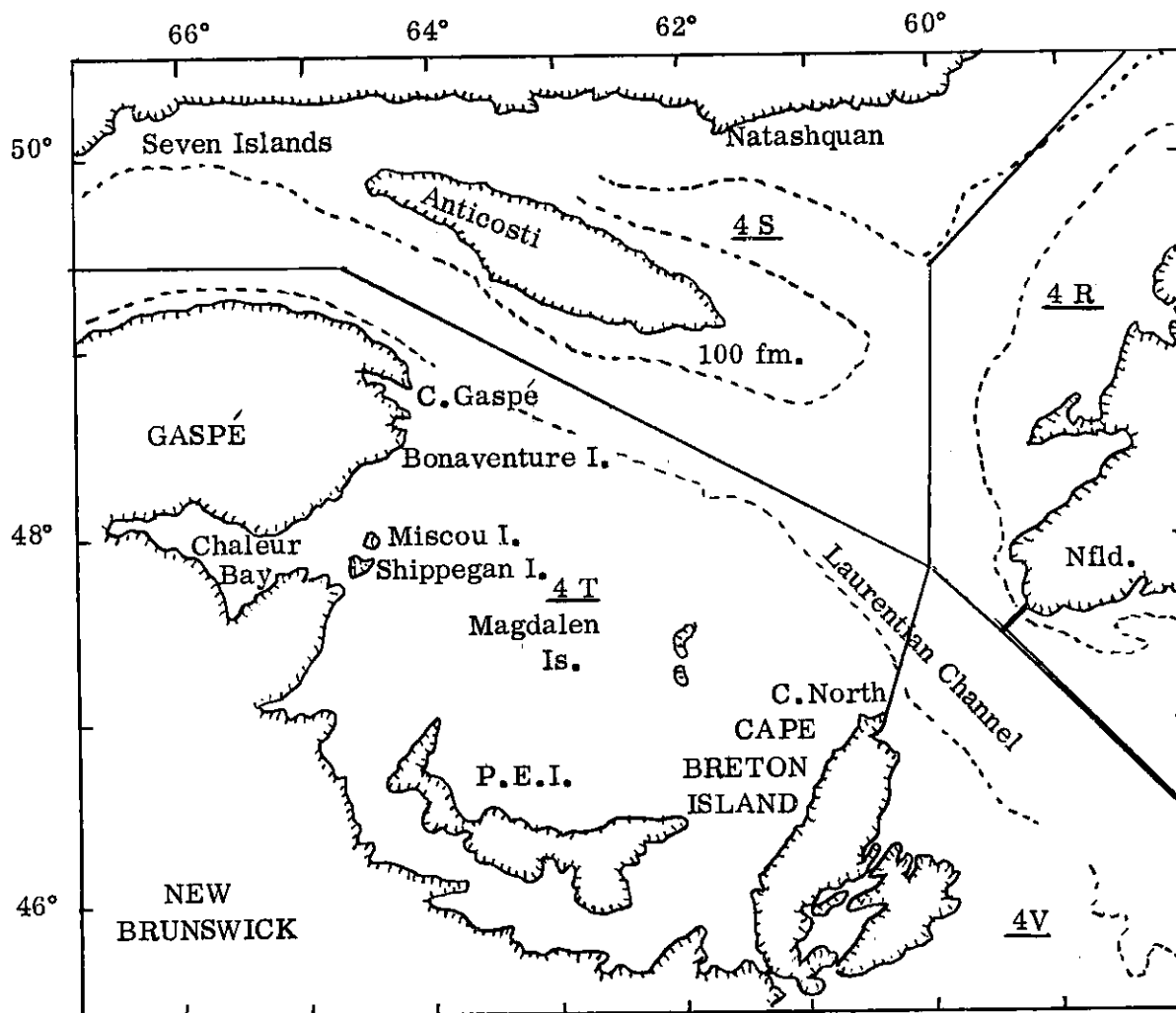


Fig. 1. Map of the Gulf of St. Lawrence showing localities mentioned in the text and ICNAF Division boundaries.

#### Acknowledgments

The author wishes to acknowledge the help of summer assistants, P. M. Powles, L. L. MacLeod, W. E. Russell, R. M. Sutherland and I. R. Woolfrey, who collected wastage data at sea during the years 1956 to 1961, and of D. N. Fitzgerald who assisted these observers in their work ashore. I would like to thank all the captains who have taken observers aboard their draggers for one or more sea trips, and also those who, on several occasions, have provided accurate counts of their cod discards at sea. Sincere thanks are due to Dr. W. R. Martin for his advice throughout this investigation, his supervision of the survival experiments and his help in preparing this paper. I wish to thank Dr. F. D. McCracken and Mr. L. R. Day who read the manuscript and offered helpful suggestions and criticisms. Two sampling trips on Gaspé draggers were arranged through Dr. A. Marcotte, Director of the Marine Biological Station at Grande-Rivière, Qué. His co-operation is much appreciated.

#### Materials and methods

##### Sampling at sea

From 1956 to 1961 our observers measured discards on 44 trips aboard commercial draggers of various sizes. The length, gross tonnage, trawl specifications and total numbers of sampling trips for each class of draggers are given in Table 1.

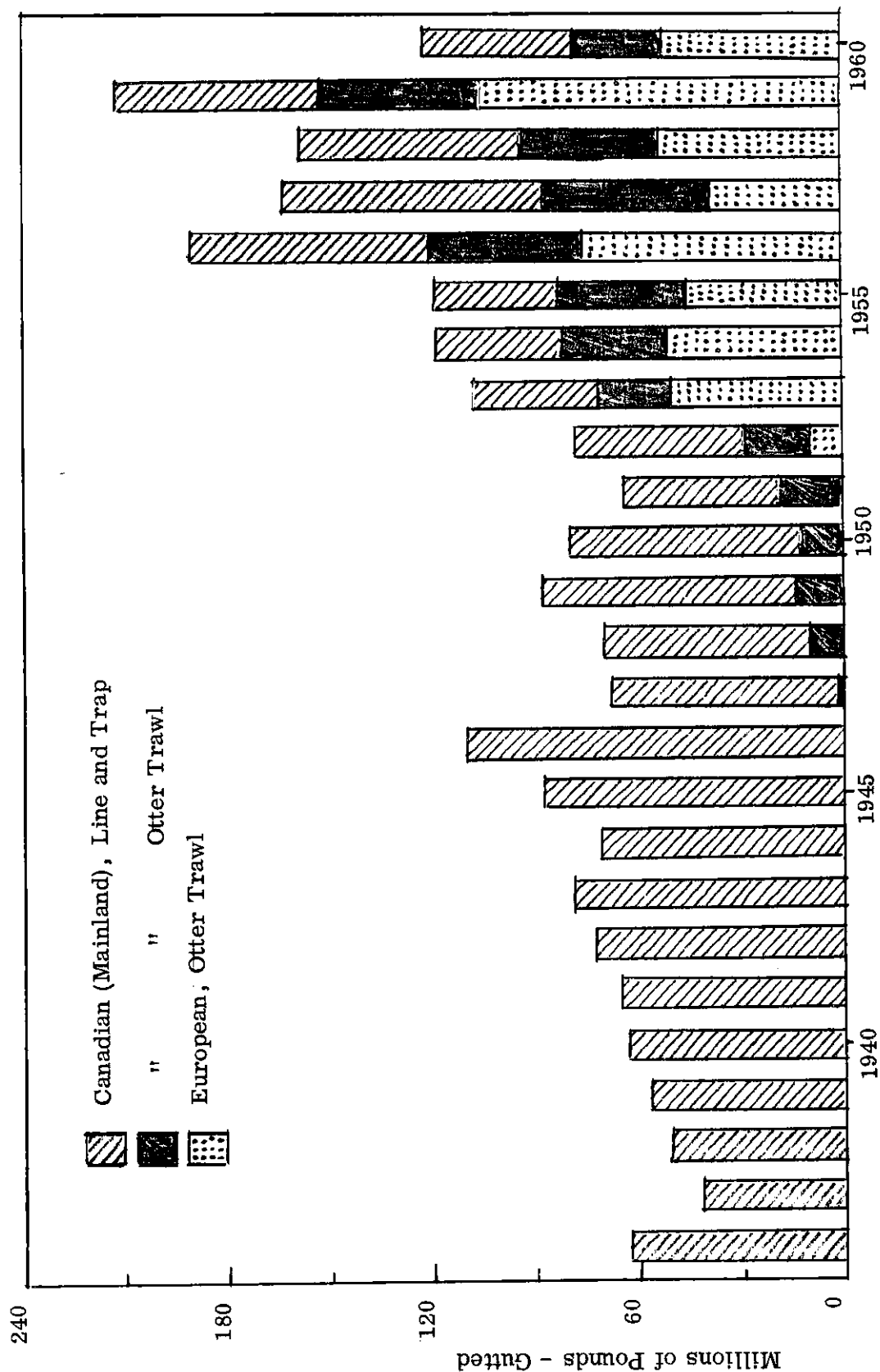


Fig. 2. Annual cod landings from the southwestern Gulf of St. Lawrence (ICNAF Divisions 4 T and 4 V (spring only)) by countries and by gears, 1936 to 1960. (From: Canada, Fisheries Statistics and ICNAF Statistical Bulletins).

Table I. Number of sampling trips made from 1956 to 1961 aboard various classes of draggers fishing in the southwestern Gulf of St. Lawrence.

Type of boat	No. of sampling trips	Length in feet	Gross tonnage	Otter trawl		
				No.	Headrope in feet	Footrope in feet
Chaleur	5	46	26 3/4	35	35	52
Gloucester	17	54-57	35-48	35	50	70
				36	60	80
"Name boats"	21	60-67	55-62	35	50	70
	1			36	60	80
				41A	76	96

A few of the larger "Name boats" changed from No. 35 or 36 to No. 41A trawls in 1960. Similarly, some Gloucester draggers replaced their No. 35 by No. 36 trawls in 1961.

The Chaleur draggers operate mainly in Chaleur Bay and in the shallow waters off Miscou and Shippegan Islands (Fig. 1). The Gloucester and 60-foot draggers fish the deeper waters off Bonaventure Island and along the western slope of the Laurentian Channel from Cape North to Cape Gaspe, as well as the shoaler waters around Miscou, Shippegan and the Magdalen Islands. In 1960 and 1961, due to the scarcity of fish in the southwestern Gulf, the Quebec and New Brunswick draggers made several trips to the north shore of the Gulf and fished the coastal waters from Seven Islands to Natashquan.

#### Methods of estimating discards

The percentage of fish discarded at sea may be calculated by one of four principal methods (Keir 1959, 1960):

1. Measuring a sample of the catch (before discards) at sea and comparing this with a sample of the landings at the wharf. The number of fish above the 100% retention length (i.e., the size at which all fish are kept for landing) are equalized in sea and wharf samples. The difference in numbers in adjusted sea and shore samples represents the numbers discarded from the sample of the catch. These are expressed in per cent of the catch. From a length-weight curve numbers discarded are converted into weights which are also expressed in per cent of the catch.

2. Measuring all discards at sea, or a sample supplemented by a count of the discards not measured, and a wharf sample of the landings. From the average weight per fish landed the total weight landed is converted into total numbers. These, plus total numbers discarded, represent total numbers caught. Per cent discards by numbers and by weight are calculated as above.

3. Measuring a sample of the catch at sea before discards and measuring all discards or a sample as in 2. In this case a length-weight relationship is used to determine the weight of the sample of the catch. From the total weight landed the sample is raised to total weight caught, i.e., weight discarded plus weight landed, and to total numbers caught. Per cent discards, by numbers and by weight, are calculated as in 1. and 2.

4. Recording estimates of weights caught and discarded after each tow in the log book. Total estimated weight caught less weight discarded during a trip should approximate the actual weight landed. Per cent discards by weight are calculated directly from the estimated catch.

The first method was the one generally used throughout this study. In 1960 and 1961 the relatively small numbers of cod discarded at sea made it possible on some trips to measure all cod discarded as well as a sample of the catch and of the landings. This provided an opportunity to compare the various methods of estimating discards.

During the period 1956-61 discards were calculated mostly for cod (Gadus morhua Linnaeus) and to a lesser extent for plaice (Hippoglossoides platessoides (Fabricius)). The number of cod measured at sea varied from 1,500 to 3,500 and those measured at the wharf varied from 300 to 700 per trip. Samples of about 400 plaice from both catch and landings of some trips were measured.

Results

Cod and plaice are the dominant species in the landings of commercial druggers fishing in the southwestern Gulf of St. Lawrence (Table II). In 1960 cod made up 57% and plaice 31% of landings by Gloucester-type druggers.

Table II. Total landings by 35 Gloucester-type druggers fishing in the southwestern Gulf of St. Lawrence in 1960.

Species	Landings <sup>a)</sup>	
	' 000 lb	%
Cod ( <u>Gadus morhua</u> Linnaeus)	9,129	57
American plaice ( <u>Hippoglossoides platessoides</u> (Febricius) )	4,919	31
Winter flounder ( <u>Pseudopleuronectes americanus</u> (Walbaum) )	473	3
Witch flounder ( <u>Glyptocephalus cynoglossus</u> Linnaeus)	440	3
Haddock ( <u>Melanogrammus aeglefinus</u> (Linnaeus) )	396	2
Hake ( <u>Urophycis</u> spp.)	336	2
Redfish ( <u>Sebastes marinus</u> (Linnaeus) )	166	1
Miscellaneous	36	< 1
Total	15,895	

a) Cod, haddock and hake gutted, head on; others round.

Cod discards

Per cent discards of cod for all sampling trips in each of the years 1956 to 1961 are given by count and by weight in Table III. These are the differences, expressed in per cent of the catch, between total catch and total landings of all sampling trips made during one year. The lowest and highest per cent discards observed during each year are also given in Table III.

Table III. Average cod discards in per cent of total catch during sampling trips aboard commercial druggers from 1956 to 1961. Minimum and maximum percentages are shown in parentheses.

Year	Trips no.	Cod discards	
		by number %	by weight %
1956	7	25 (15-59)	9 (1-29)
1957	10	24 ( 3-65)	6 (1-21)
1958	10	16(10-33)	7 (3-14)
1959	9	13 ( 1-22)	6 (<1-11)
1960	5	10 ( 6-15)	4 ( 2-6)
1961	3 <sup>a)</sup>	6 (<1-16)	2 (<1-7)

a) Data based on three sampling trips and log records of 43 commercial trips; see text.

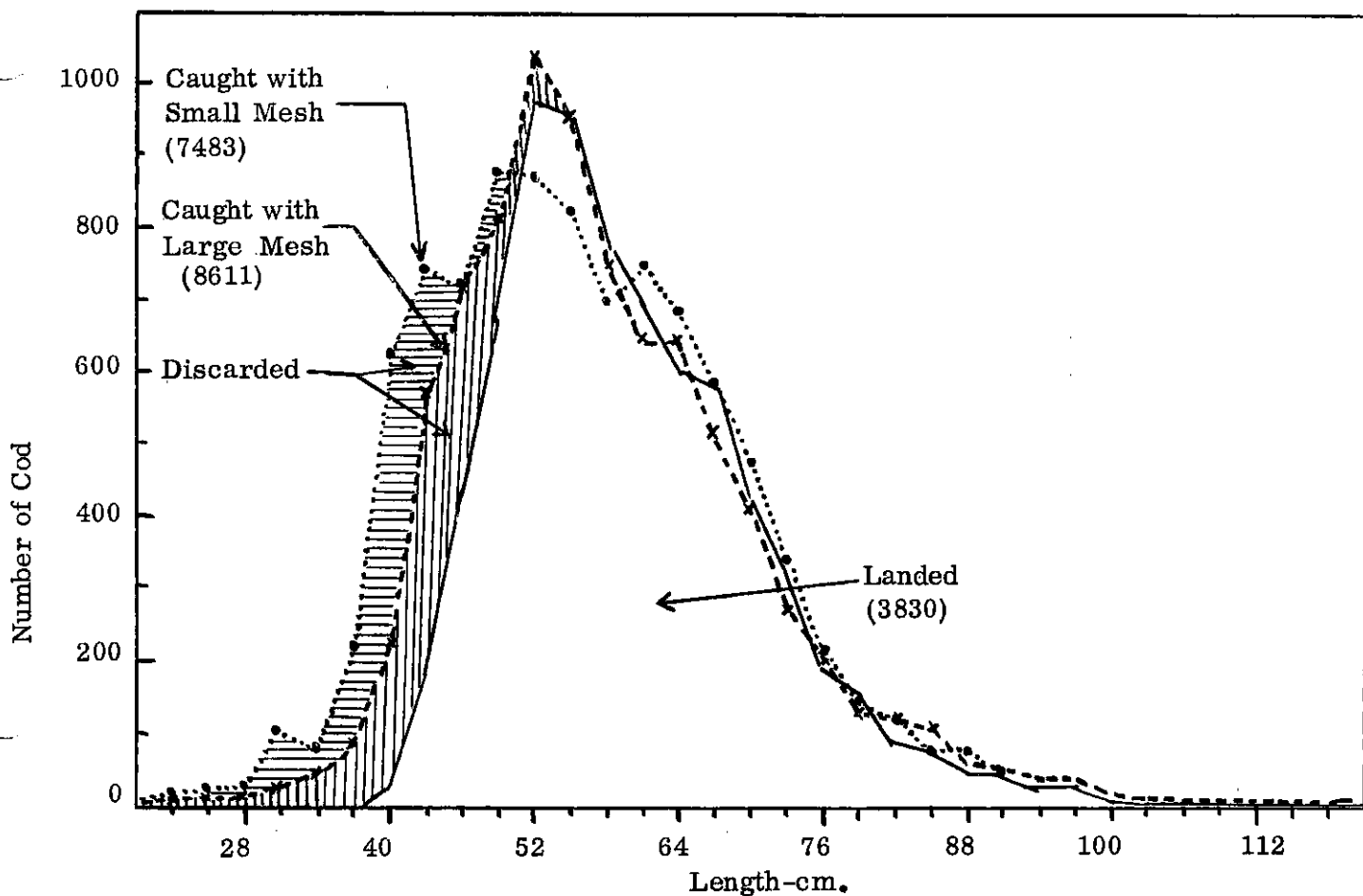


Fig. 3. Size compositions of cod caught with small-mesh (3-inch) and large-mesh (4 1/2-inch) codends and of cod landed from sampling trip aboard northern New Brunswick draggers in 1958. Numbers of fish in the samples are in parentheses.

#### Factors affecting discards

Table III shows a wide range in per cent discards each year and a gradual decrease between the years 1956 to 1961. Large variations in the portion of the catch discarded at sea have been observed from trip to trip throughout this study. Before discussing the decrease in cod wastage in the Gulf of St. Lawrence in recent years, let us examine the various factors affecting the proportion of the catch discarded at sea by commercial draggers.

**Mesh size.** The size of the mesh used, especially in the codend, obviously affects discards: the larger the mesh the smaller the number of undersized cod retained and the lower the percentage discarded. This was shown by Martin and Jean (1958) who compared data collected in 1957 during three sampling trips with small-mesh codends (about 3-inch) with data from three trips with large-mesh (about 4 1/2-inch) manila codends. They found that discards of cod with small-mesh codends were 31% by number and 10% by weight compared to 12% and 5%, respectively, with large-mesh codends.

The year 1958, the second year of conversion to large-mesh nets, provided another opportunity to compare discards from small- and large-mesh nets. From May 26 to August 16, nine comparable trips were made on the Bonaventure Island grounds (Fig. 1), four on draggers using small-mesh (3-inch) and five on draggers using large-mesh (4 1/2-inch) manila codends. The size composition of cod caught with small-mesh and large-mesh codends is compared in Fig. 3. Cod discards with small-mesh codends were 23% by number and 9% by weight compared with 12% by number and 5% by weight with larger-mesh codends. The 1958 observations confirm those of Martin and Jean (1958) in showing that discards with small-mesh codends were about double those with large-mesh codends on the same fishing grounds.

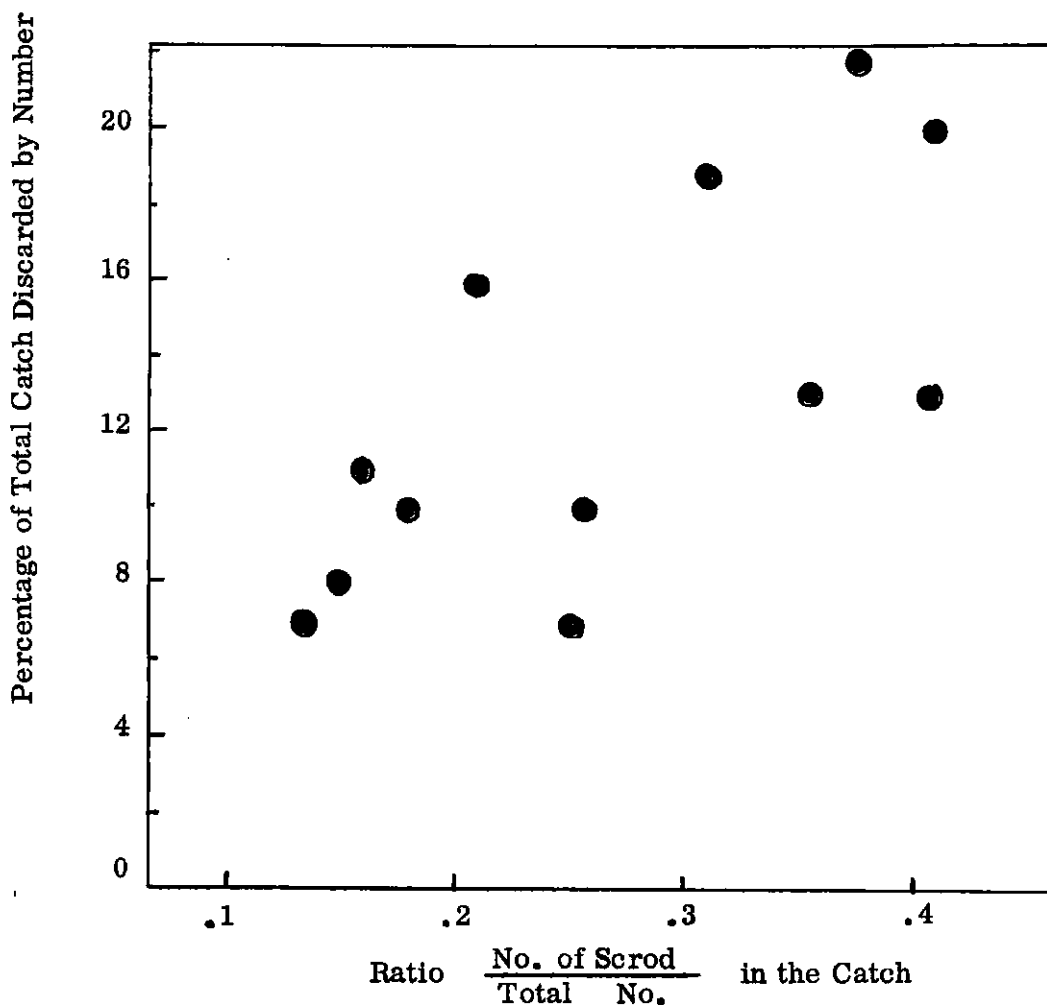


Fig. 4. Relationship between the proportion of scrod (below 51 cm) in the catch and the percentage discarded. Each point represents one trip.

**Abundance of scrod.** The relative abundance of scrod (cod below 51 cm in length and 2 lb in weight) in the catch also affects the percentage discarded. This is shown in Fig. 4 where per cent discards by numbers are plotted against the ratio of numbers of scrod/total cod in the catch. To eliminate the effects of area fished and mesh size on discards only trips made in the Bonaventure Island area aboard draggers with large-mesh (4 1/2-inch) codends were considered. Twelve trips made during the years 1957 to 1959 were selected on that basis. Large-mesh nets were not introduced until 1957 and no manila codends were used on the sample trips made in 1960 and 1961. As seen in Fig. 4, larger percentages were discarded when small fish formed a higher proportion of the total catch. Presumably the larger the proportion of scrod in the catch, the greater is the incentive for the crew to discard low-priced, fast-spoiling, small cod.

**Concentrations of small cod.** The percentage of the catch discarded at sea also varies with local concentrations of small cod. Trips made on grounds where small cod are relatively more abundant generally show larger percentages of discards. Recent cod taggings in the Gulf of St. Lawrence in summer (McCracken 1959, 1961) and off the east coast of Cape Breton in winter (Martin 1961) have shown that cod migrate into deep water and out of the Gulf in late fall and return to the Gulf in late spring. Annual groundfish surveys carried out in the Gulf of St. Lawrence and east of Cape Breton since 1957 (Jean 1960) indicate that small cod (40 cm and smaller) are concentrated in shoal waters in the spring and to a still greater extent in the fall. In winter these small cod migrate into deeper water but not as far south along the Laurentian Channel as the larger ones. The seasonal concentration of small fish in shoal waters of the Gulf is likely due to the fact that the small cod are the first ones to move inshore in the spring and the last ones to leave in the fall. These small fish are found in spring and autumn at depths of 20 fathoms or less southeast of Shippegan and Miscou Flats (Fir



and in Chaleur Bay (Marcotte 1959). Draggers fishing on these grounds catch and discard large numbers of small cod. This is shown in Table IV where discards on the Chaleur Bay and Shippegan Island grounds are compared with those off Bonaventure Island during the years for which comparable data are available. Per cent discards were from two to three times higher in the Chaleur Bay-Shippegan Island area.

Table IV. Comparison of per cent discards of cod in the Chaleur Bay, Shippegan Island and the Bonaventure Island areas during the years 1956 and 1958.

Year	Average mesh size	Trips	Discards			
			By number		By weight	
			Chaleur Bay-Shippegan Is.	Bonaventure Is.	Chaleur Bay-Shippegan Is.	Bonaventure Is.
	<u>In.</u>	<u>No.</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
1956	3	7	55	18	14	4
1958	4 1/2	6	26	12	10	5

Sizes retained for landing. The wastage data collected in 1959 provided an opportunity to observe how sizes selected for landing (cull at sea) may affect the percentage of cod discarded. Cull at sea in turn is affected by such factors as grading at the plant, as was the case in 1959. This was the first year when all northern New Brunswick draggers used large-mesh (about 4 1/2-inch) codends. Consequently all sampling trips were made on draggers with large-mesh nets and were comparable. This was also a year when the sampling trips covered the longest period, from early June to early September. The percentages by number discarded on nine sampling trips in 1959 are shown in Fig. 5B. From the first part of the summer until about July 24 discards were low, averaging about 3%. Toward the end of July discards increased sharply and averaged about 20% until September. The size composition of cod caught during these two periods did not differ markedly, and was not responsible for the sudden increase in discards. The 50% retention length for landing, i.e., the length at which half the fish caught are retained and half are discarded, on the other hand, increased from 41 cm prior to July 24 to 45 cm after that date. The change in cull at sea, which resulted in higher discards, followed a change in grading at the Caraquet shore plant (Fig. 5A). Early in the season less than 10% of the cod landed by Caraquet draggers were graded as low-priced scrod. This percentage rose to about 30% during the latter part of July. The change in grading at the plant coincided with the peak in summer air temperatures (Fig. 5B) which caused small fish to spoil more rapidly. As a result of stricter grading at the plant, fishermen changed their cull at sea. Discards of small, fast-spoiling fish increased accordingly. Wastage remained high until September, the end of the observation period in 1959.

The above analysis shows that size of mesh, relative abundance of scrod in the catch, local concentrations of small cod and sizes retained for landing are important factors affecting per cent discards. Other factors, such as distances from fishing grounds to landing port and individual differences in grading by the crew at sea, were mentioned in observers' reports as influencing discards. The data, however, are insufficient to show the effects of these factors.

#### Comparison of results by various methods of estimating discards

Actual numbers of cod discarded at sea in 1960 and 1961 were relatively small. This provided an opportunity to measure all discards in addition to samples of the catch and of the landings on two trips in 1960 and two trips in 1961 (Table V).

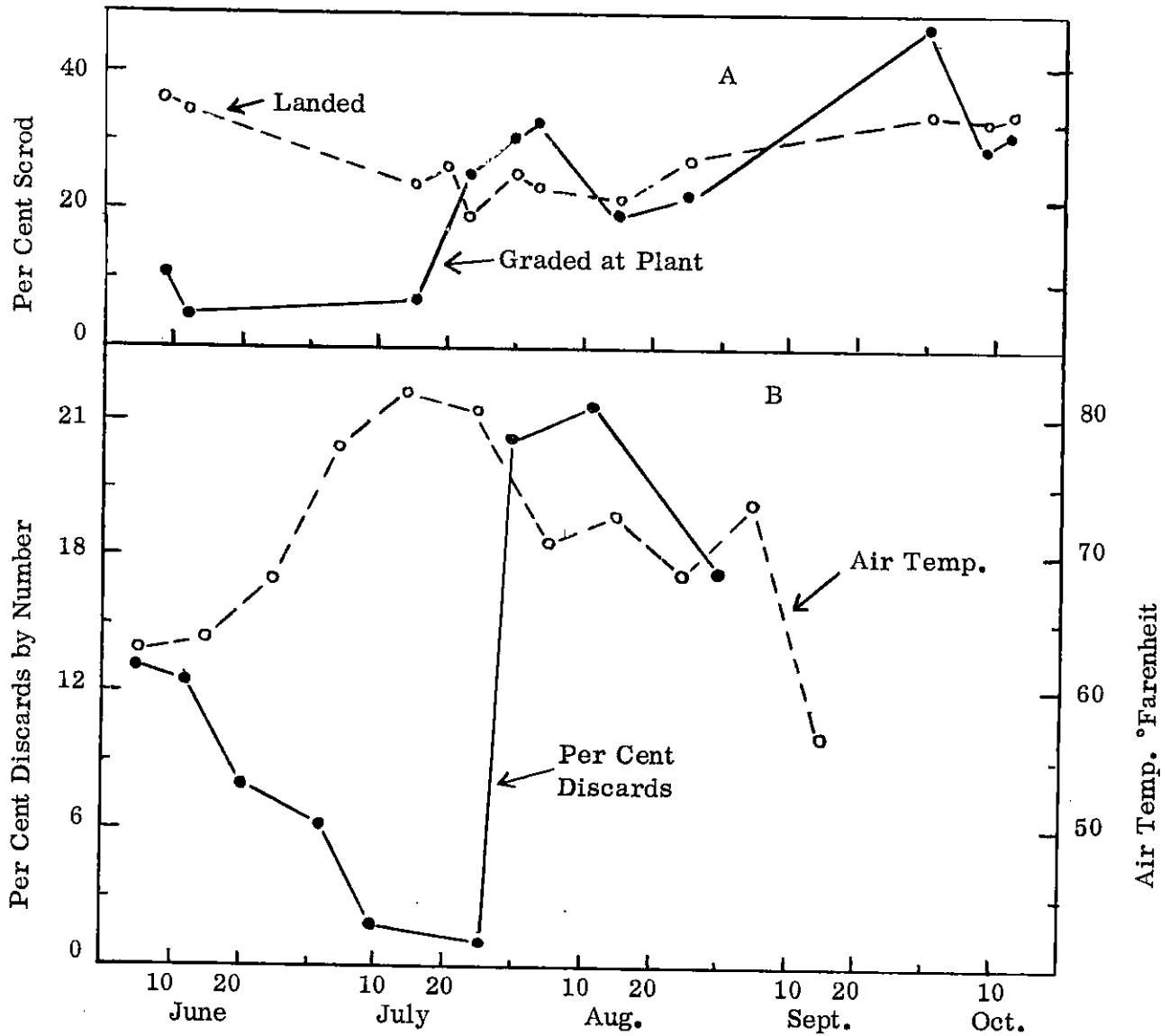


Fig. 5A. Percentage of scrod cod landed by northern New Brunswick draggers and percentage graded as scrod at a local plant at Caraquet, N.B., in 1959.  
 B. Per cent discards of cod aboard commercial draggers and maximum air temperatures in 10-day averages at Miscou Island in 1959. (Temperatures from Canada, Department of Transport).

Table V. Summary of cod sampling aboard New Brunswick draggers in 1960-61 on trips where catch, discards and landings were measured.

Year	Trips	Tows	Tows samples for catch	Cod measured before discards	Discards measured	Cod measured at wharf
	<u>no.</u>	<u>no.</u>	<u>no.</u>	<u>no.</u>	<u>no.</u>	<u>no.</u>
1960	2	30	12	1,620	1,422	563
	4	26	13	1,605	1,568	727
1961	1	23	13	1,470	250	423
	2	37	14	1,807	197	395

From these data a comparison of the four methods of calculating discards (described on page 5) was made. The results are summarized in Table VI. For the sake of clarity, only discards by weight are given.

Table VI. Per cent discards by weight of cod taken during four sampling trips made in 1960 and 1961. Discards were calculated using four methods as follows  
 1 = catch and landings; 2 = discards and landings;  
 3 = catch and discards; 4 = observer's log-book estimate;  
 see text, p. 5.

Year	Trips	Total weight landed	Total weight discarded	Discards by weight using methods			
				1	2	3	4
	no.	lb	lb	%	%	%	%
1960	2	25,455	1,394	6	5	4	3
	4	21,615	1,882	8	8	7	6
1961	1	18,130	243	1	1	2	2
	2	34,340	154	1	1	1	1

Method 2, based on actual numbers discarded and actual total landings, is the most direct (Keir 1959) and probably the most reliable. However, Table VI shows that the results obtained by the other methods do not differ appreciably from those obtained by Method 2. Although all four methods of calculating discards are subject to errors in sampling (Methods 1 to 3) or in estimating weights of catch and discards (Method 4), the results are in fairly close agreement.

Based on the 1960 results, a variant of Method 2 (discards and landings) was introduced in 1961. A number of dragger captains were asked to record on special forms the actual numbers of cod discarded at sea after each tow. The total landings were obtained from purchase slips at the end of the trip. A small fee was given to the crew member who counted the discards. In addition, sampling of discards (brought ashore by commercial draggers or measured at sea by our observer) and of landings was carried out at regular intervals. The size compositions of discards and landings provided the necessary data to convert numbers discarded into weight, and weight landed into numbers.

Dragger captains contacted before 50 trips brought in reliable discard records from 47 trips. Data from 43 of these log records were used and included in Table III in calculating the 1961 discards. The remaining four were not used because of a lack of data on the size composition of discards in the Chaleur Bay area where the trips were made.

The results given in Table VI show that comparable discard figures are derived from sampling any combination of catch, discards or landings. They also show that the actual count of discards by fishermen, plus occasional sampling of discards and landings, allow a greater coverage of the fishing fleet. Log-book estimates of discards by weight, supplemented by actual sampling of catch, discards and landings, would also provide an adequate coverage of the fleet.

#### Size composition of cod discards

A knowledge of the size and age compositions of the catch is essential for the assessment of fish stocks. Such parameters as fishing mortality, recruitment and age at first capture are estimated from catch data. Most sampling, however, is done on landings. If sizes and quantities discarded are known, sizes and quantities caught can be derived from those of the landings.

Data on the size composition of discards in the southwestern Gulf of St. Lawrence were collected on two trips in 1960 and three trips in 1961. On two of the 1961 trips samples of discards are brought ashore by the dragger captains and measured at the wharf by our observer. Total cod discards were measured at sea by observers during all other trips. The percentage size composition of discards is given in Table VII.

Table VII. Percentage size composition of cod discarded at sea by northern New Brunswick draggers using 4 1/2 - inch mesh codends in 1960 and 1961.

Length groups	Percentage	
	1960	1961
<u>cm</u>		
22	0.3	...
25	0.7	...
28	3.5	0.3
31	6.2	4.0
34	9.1	11.6
37	18.6	15.6
40	30.5	34.7
43	24.1	29.5
46	6.5	4.0
49	0.5	...
No. of fish	1,525	351
Mean length cm	38.9	39.5
Mean weight lb	1.0	1.0

The size composition of cod discarded at sea during these two years did not vary markedly. Few fish below 28 cm were caught and discarded. Almost all cod caught above 46 cm were retained. In both years the mean length of discards was about 39 cm. The mean weight, estimated from a length-weight relationship, was 1 lb.

Discards of species other than cod

Although cod is the main commercial species caught and landed by northern New Brunswick draggers, other species represent an appreciable portion of the total landings (Table II).

Plaice

American plaice, which accounted for 31% of the total 1960 landings, is the second most important species landed by draggers fishing in the southwestern Gulf of St. Lawrence. This species also occupied second rank in the catches of research-vessel hauls (ca. 3-inch mesh codend) in the Miscou-Bonaventure Island area in 1953 (Jean 1954).

On most sampling trips the weight of plaice caught and of plaice discarded, as estimated in consultation with the skipper, was entered in the observer's log book after each haul. An estimate of total discards by weight was obtained for each trip. From the actual weight landed and the log-book estimate of discards, the total weight caught was calculated. Total catch and total landings from the sampling trips of one year were added. From these data annual per cent discards by weight were calculated (Table VIII).

Table VIII. Observers' log-book estimates of American plaice discarded by northern New Brunswick draggers, 1956 to 1961.

Year	Sampling trips	Estimated catch	Actual landings	Discards by weight
	no.	lb	lb	%
1956	4	32,339	26,718	17
1957	8	19,096	16,603	13
1958	10	48,421	39,850	18
1959	9	37,044	29,520	20
1960	3	8,960	5,816	34
1961	2	5,076	2,500	51

The sea-and wharf-sampling method used throughout this investigation in estimating cod discards is sometimes inapplicable to the American plaice. This was the case in 1960 when large plaice, well above the 100% retention length, were discarded because of the "jellied" condition of their flesh (Templeman and Andrews 1956; Powles 1961). In this case, it was impossible to equalize sea and shore samples in order to calculate numbers and weight of small fish discarded. The jellied condition was not observed during the plaice-sampling trips made in 1958 and 1959. It is reasonable to assume that no large plaice were discarded during these trips. The sea-and shore-sampling method indicates that plaice discards by weight in the southwestern Gulf of St. Lawrence amounted to 34% in 1958 and 64% in 1959. By applying theoretical selection curves to survey data, Powles (1960) estimated that plaice discards by numbers were 70% in 1957, 74% in 1958 and 81% in 1959. These would correspond to per cent weights of about 40 in 1957 and 60 in 1959. On the basis of research-vessel catch, Jean (1954) estimated that 87% by count of plaice caught in 1953 on the Bonaventure and Miscou Islands grounds were discarded. The corresponding figure by weight is estimated at about 60%.

The above percentages by weight of plaice discarded are considerably higher than the observer's log-book estimates given in Table VIII. This may be due to the fact that it is rather difficult to estimate the quantities of plaice in the codend or in deck checkers partly filled with cod and other species. The observer's log-book data probably underestimated the quantities of plaice discarded at sea. Figures in Table VIII, however, indicate, that in contrast to cod (Table III), plaice discards increased from 1956 to 1961, despite larger mesh sizes. Based on data from surveys with fine-mesh codends, Powles (1960) attributed the increase in wastage of plaice to an increase in the relative number of plaice below 35 cm in the catch.

#### Incidental marketable species

Incidental species of commercial interest, i.e., species other than cod and plaice, which in 1960 made up about 12% of the total landings (Table II), were discarded to a varying extent. This is shown in Table IX, based on our observer's log-book entries for 1959, the year with the largest number of sea trips aboard large-mesh draggers.

Table IX. Log-book estimates of discards of marketable species other than cod and plaice caught during nine sea trips in the southwestern Gulf of St. Lawrence in 1959.

Species	Average catch per hour <sup>a)</sup>	Discards by weight
	lb	%
Winter flounder	5	5
Witch flounder	17	0
Haddock	12	2
Hake	4	95
Redfish	1	100 (discarded on cod trips)

a) from commercial log records.

Commercial log records indicate that northern New Brunswick draggers fish about 1,600 hours (800 hauls) during a normal fishing season. From the data shown in Table IX, the total discards per boat per fishing season in 1959 were about 400 lb of winter flounder and 380 lb of haddock. Discards of hake (Urophycis spp.) were around 6,000 lb. All witch flounder caught were of marketable size and none were discarded. It is estimated that about 10% by weight of the incidental commercial species caught are discarded.

#### Incidental unmarketable species

Other species of no commercial value are discarded. These include: skates (Raja spp.), eelpouts (Macrozoarces americanus (Bloch and Schneider) and Lycodes spp.), lumpfish (Cyclopterus lumpus Linnaeus), sea ravens (Hemitripterus americanus (Gmelin)), sculpins (Myoxocephalus spp.) and spiny dogfish (Squalus acanthias Linnaeus). Except for skates, which have an average frequency of occurrence of about three per haul, the above non-commercial species

occur at the rate of five to eight fish per 10 hauls. On the basis of 800 hauls per fishing season, the average number of individual fish of non-commercial species discarded at sea in 1959 was about 3,000 fish per boat. At 2 lb per fish, as roughly estimated by our observer, the total weight of non-commercial species discarded was about 6,000 lb per boat per fishing season.

The occasional halibut (Hippoglossus hippoglossus (Linnaeus) ), turbot (Reinhardtius hippoglossoides (Walbaum) ) and shad (Alosa sapidissima (Wilson) ) are kept and consumed by the crew.

In summary, observations collected at sea aboard northern New Brunswick draggers show that cod discards have decreased from 9 to 2% by weight during the period 1956-61. Plaice discards, based on log-book estimates, have increased from about 13 to 50% during the same period. It is estimated that about 10% by weight of the catch of incidental species of commercial value caught are discarded. The other unmarketable fish species caught are discarded.

#### Survival of discarded cod and plaice

Undersized cod and plaice remain on deck from 15 to 30 minutes before being shovelled overboard. According to our observers' reports, most of the discarded fish are dead by the time they are discarded. To obtain information on the survival of cod and plaice left on deck, a series of tests were carried out during night fishing from the research vessel A. T. Cameron in October 1960. Four series of tests, two on cod and two on plaice, were made on four different nights. Cod were divided into four lots and plaice into three lots, according to size. Different lots were left on deck for periods of time varying from less than 5 to 45 minutes. After exposure the fish were placed in tanks filled with sea water. The numbers of fish alive were noted after they had been in the tank for one hour (except for one series with plaice when they were kept in tanks from 1 to 2 hours). Bottom temperatures as well as air and tank temperatures were recorded.

#### Cod

The results of two series of experiments conducted on cod on October 6 and 8, 1960, are summarized in Table X. Small cod (40 cm and smaller) had a lower survival than the larger ones. In the first series of tests none of the small cod survived a 30-minute exposure on deck, whereas up to 13% of the larger ones survived. In the second series of tests, 20% of the small ones compared to 80% of the larger ones survived.

Table X. Survival of cod after exposure on deck of C.G.S. A. T. Cameron for varying periods of time in October 1960; for air temperature, high = 4.4° to 7.8°C and low = -1.1 to 0.6°C.

Exposure <u>min.</u>	< 5		5		15		30		45	
	Series		Series		Series		Series		Series	
	1	2	1	2	1	2	1	2	1	2
Air temperature	High	Low	High	Low	High	Low	High	Low	High	Low
Tank temp. °C	11.4	...	11.5	6.6	11.6	6.7	11.6	6.5	...	6.4
Bottom temp. °C	1.9	...	3.8	3.6	10.6	2.0	4.4	1.1	...	1.0
Size groups <u>cm</u>	Survival %									
20-29	20	...	10	70	20	60	0	20	...	0
30-39	50	...	60	78	40	40	0	20	...	0
40-49	50	...	70	90	70	90	10	50	...	10
50-59	100	...	67	87	50	90	13	80	...	20
All sizes	51	...	50	81	45	70	6	43	...	8

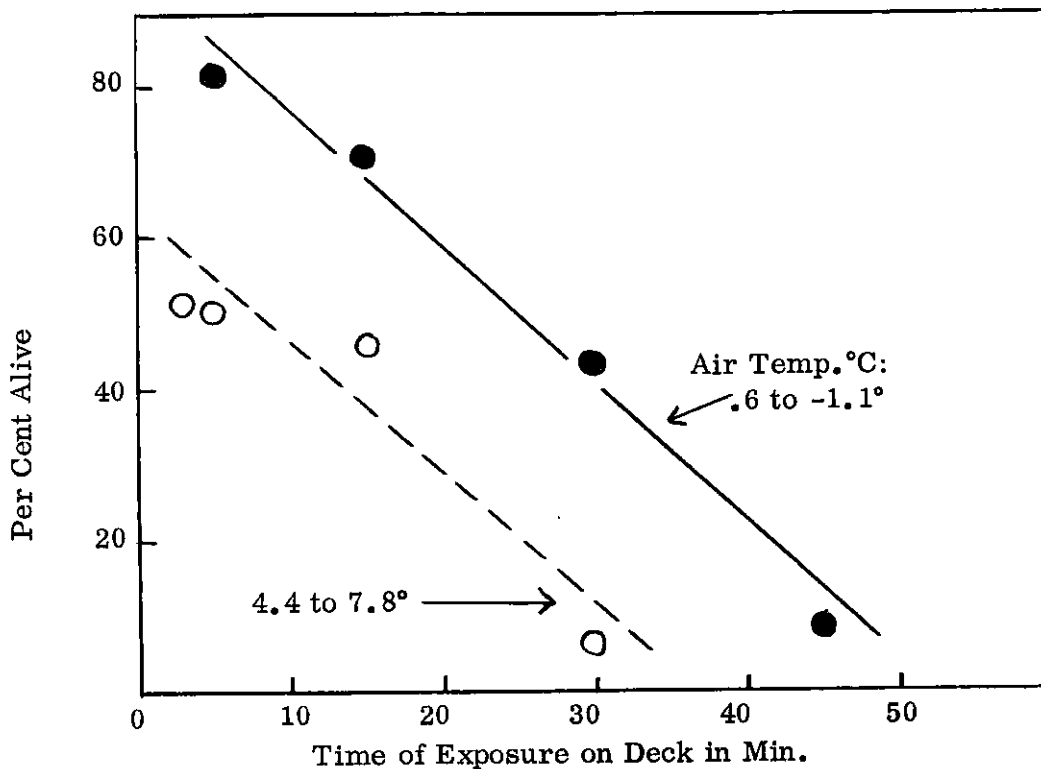


Fig. 6. Effects of time of exposure on deck and air temperature on survival of cod 20 to 59 cm long.

Air temperature (and possibly water temperature in the tanks) affected survival of cod after exposure on deck. The first series of tests were carried out at air temperatures varying from 4.4° to 7.8°C (the mean water temperature in the tanks being about 11.5°C). The second series of experiments were conducted at air temperatures of 0.6° to -1.1°C (tank temperature of about 6.5°C). As seen in Table X, the survival of cod exposed to warmer air temperatures was consistently lower than that of cod of the same size exposed to colder air temperatures. The same results were obtained when all sizes were lumped together (Fig. 6). These observations show that a greater percentage of cod survive a given length of exposure on deck when the air temperature (and possibly the tank temperature) is lower.

**Plaice**

Experiments on survival of plaice after exposure on deck were carried out on October 4 and 5, 1960. The results are summarized in Table XI.

Table XI. Survival of plaice after exposure on deck of C.G.S. A. T. Cameron for varying periods of time in October 1960.

Exposure <u>min.</u>	<10		15		30		45	
	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2
Air temperature °C	4.4	7.2	4.4	4.4	2.8	4.4	2.2	5.0
Tank temp. °Ca)	10.6	10.0	10.0	10.2	9.7	10.1	10.0	9.7
Bottom temp. °C	1.5	0.7	1.8	0.6	1.6	0.7	1.6	0.7
Size groups <u>cm</u>	Survival %							
10-19	40	27	13	0	0	0	0	0
20-29	78	100	40	20	0	10	30	0
30-39	78	92	78	40	20	20	0	0
All sizes	64	74	44	27	7	10	17	0

a) fish kept in tank from 1 to 2 hours in Series 1 and 1 hour in Series 2.

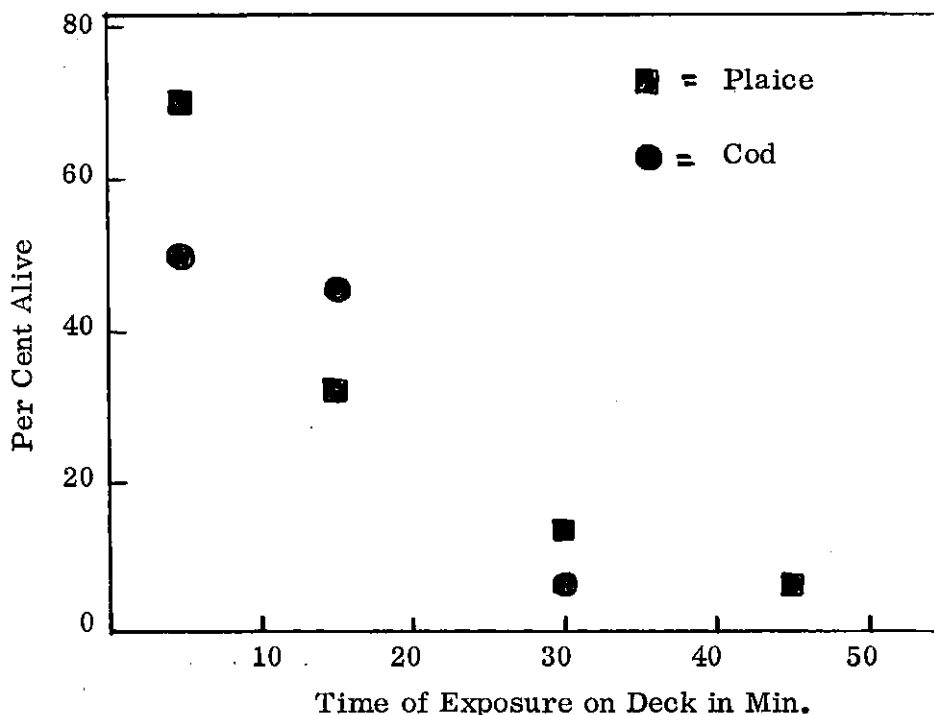


Fig. 7. Survival of cod and plaice after exposure on deck for varying periods of time.

As in the case of cod, small plaice (30 cm and smaller) generally had lower survival than the larger ones. Less than 10% of the small plaice compared to 20% of the larger ones survived a 30-minute exposure. Differences in air temperatures during the two series of tests on plaice survival were not as large as in the case of cod. This may account for the fact that no consistent differences in survival rates of plaice were observed between the two series of tests (Table XI).

Cod and plaice appear to be equally vulnerable to exposure on deck. One series of tests on cod and two on plaice were carried out at roughly comparable air temperatures, i.e., from 2.2° to 7.8° C (Tables X and XI). Survival of cod and plaice of all sizes after varying exposures on deck are compared in Fig. 7. No consistent differences in the percentages of fish which survived exposure were observed between the two species.

Results of these experiments show that the chances of survival of small cod and plaice discarded at sea aboard commercial draggers are rather poor. All cod below 40 cm (Table X) and most of the plaice below 30 cm (Table XI) died after a 30-minute exposure on deck when the air temperature was below 8°C. It is unlikely that small cod and plaice would survive even shorter exposures when summer air temperatures reach an average of 22°C (Fig. 5B). It is concluded that the majority of cod and plaice discarded at sea by northern New Brunswick draggers are dead when thrown overboard.

#### Discussion

Selection studies summarized by Clark, McCracken and Templeman (1958) show that the selective properties vary quite widely with different gear and, within one gear, with mesh or hook size. McCracken (1957) using Marcotte's (1952) data showed that the 50% selection length of No. 14 hooks, generally used by line fishermen in the Gulf of St. Lawrence, was about 48 cm, corresponding to a weight of about 1 3/4 lb. Small-mesh (3-inch) manila codends in use in the Gulf fishery for about 10 years prior to mesh regulation have a 50% retention length of less than 30 cm (about 1/2 lb). Larger-mesh manila codends (4 1/2-inch) introduced in 1957 have a 50% retention length of 40 cm (1 1/4 lb). Synthetic codends of the same mesh size have a slightly higher selection, 43 cm, corresponding to a weight of about 1 1/2 lb.



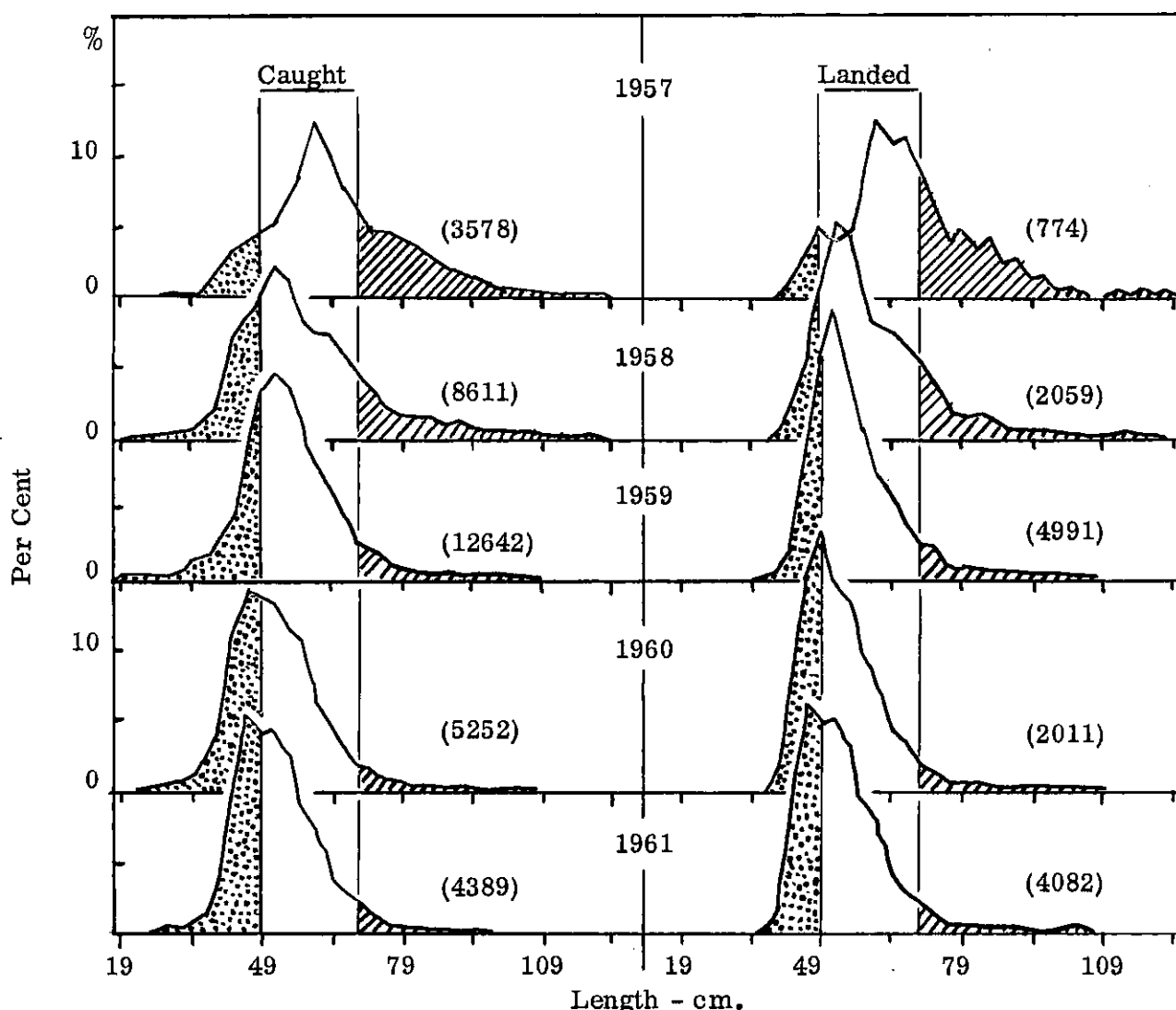


Fig. 8. Size compositions of cod caught and landed by northern New Brunswick draggers fishing in the southwestern Gulf of St. Lawrence with large-mesh (4 1/2-inch) codends, 1957 to 1961.

On theoretical grounds one would expect that the introduction of otter trawling in the southwestern Gulf of St. Lawrence in 1947 resulted in smaller fish being caught and landed. That this is the case is indicated by the decline in salt-fish production which depends on large fish. During the decade 1930-39 about 90% of the total southwestern Gulf cod landings were salted (Canada, Fisheries Statistics). During the decade 1950-59 this figure has decreased to 62%. In the year 1959 alone, salt-fish production amounted to only 39% of the total landings.

The gradual shift toward smaller fish in the catch and landings of cod has continued even after the introduction of large-mesh nets in the Gulf, as shown in Fig. 8. The percentage size compositions of cod caught and landed by draggers using large-mesh codends during the years 1957 to 1961 are compared. An increase in percentage of scrod and a decrease in percentage of large cod in both catch and landings are evident from Fig. 8. Smaller fish are now caught and retained for landing. This is further evident when selection curves for landing are compared for the years 1957 to 1961 (Fig. 9). The 50% retention length for landing with large mesh has decreased from about 45 cm in 1957 to 40 cm in 1961.

The preceding section has shown that mesh size, relative abundance of scrod in the catch, area fished and sizes selected for landing (cull) are important factors affecting discards. From the above discussion it is evident that an increase in mesh size and a reduction in cull size have played a major part in reducing cod discards in the southwestern Gulf of St. Lawrence in recent years (Table III). Of the other factors known to affect discards, area fished may be ruled out. There is no evidence from commercial log records that the northern New Brunswick fleet, when fishing in the southwestern Gulf, has recently been concentrating on different fishing grounds. The reduction in cod discards cannot be attributed to avoidance of concentrations of small cod.

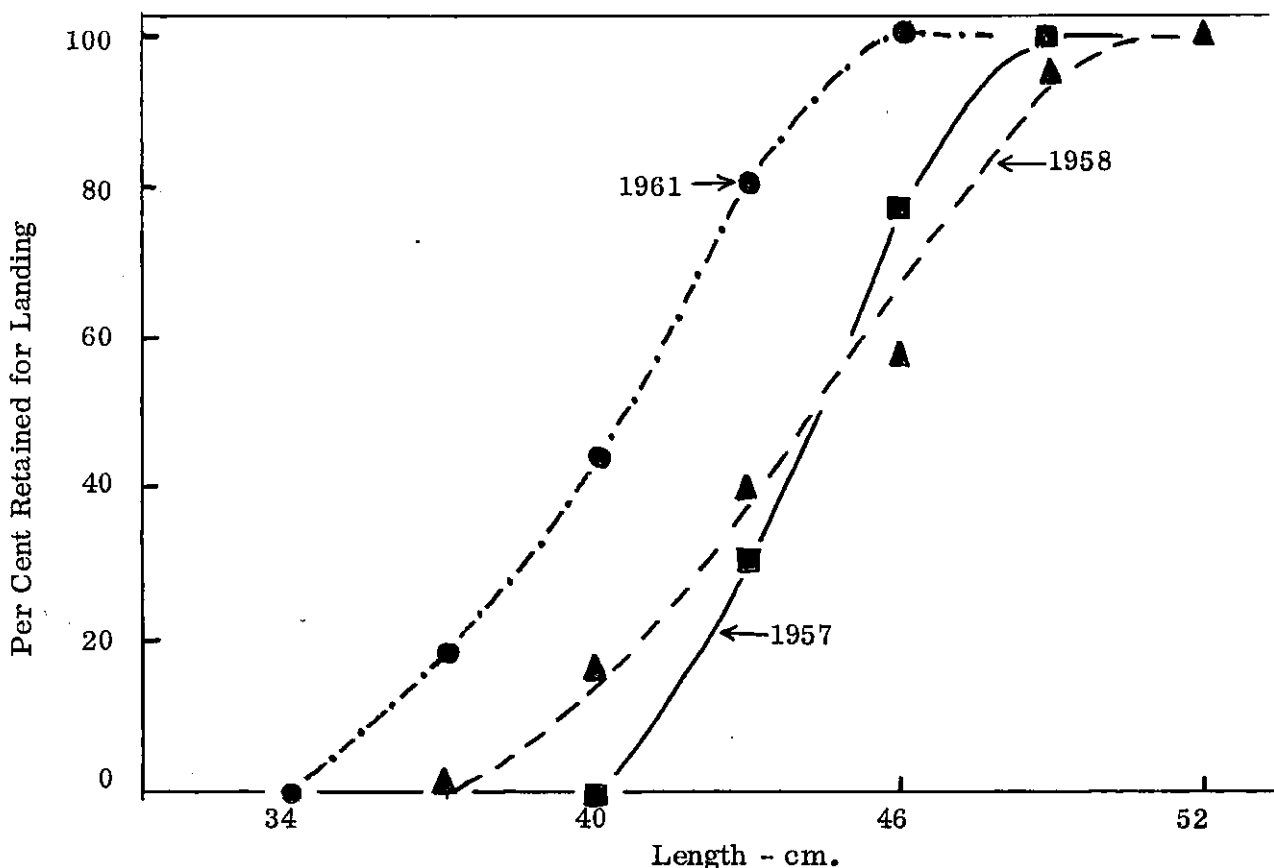


Fig. 9. Selection curves for landing (cull) based on sea and wharf samples from commercial draggers fishing in the southwestern Gulf of St. Lawrence with large-mesh codends (4 1/2-inch), 1957 to 1961. The curves for 1959 and 1960, omitted from the graph, fall between the 1957 and 1961 curves.

An increase from 1957 to 1961 in the proportion of scrod in the catch (Fig. 8) would normally result in a greater percentage being discarded (Fig. 4). Obviously, the "scrod effect" has been masked by the more important mesh and cull effects, and discards have declined in spite of an increase in relative abundance of scrod in the catch.

Theoretical considerations, presented later, and based on 1961 data, suggest that the use of a 3-inch mesh in 1961 (Fig. 9) would have increased the ratio  $\frac{\text{number of scrod}}{\text{total numbers caught}}$  from about 0.5 to 0.6. These ratios are much higher than the ones shown in Fig. 4. It is doubtful if in that range a difference of 10% in the relative abundance of scrod in the catch would affect discards measurably.

In the following discussion, the effect of abundance of scrod in the catch is considered to be negligible, at least in 1961.

#### Relative effects of mesh size and selection for landing on discards

To measure the relative effects on discards of an increase in mesh size and a decrease in sizes selected for landing, a theoretical catch curve for a 3-inch manila codend was derived from the 1961 survey catches. This was done by first comparing actual catch using 3-inch mesh with actual survey catches in 1957, the year when surveys with fine-mesh codends were started in the southwestern Gulf. The selection curve obtained was then applied to the 1961 survey catches on the assumption that the distribution of cod within the 3-inch mesh selection range did not differ appreciably during these two years.

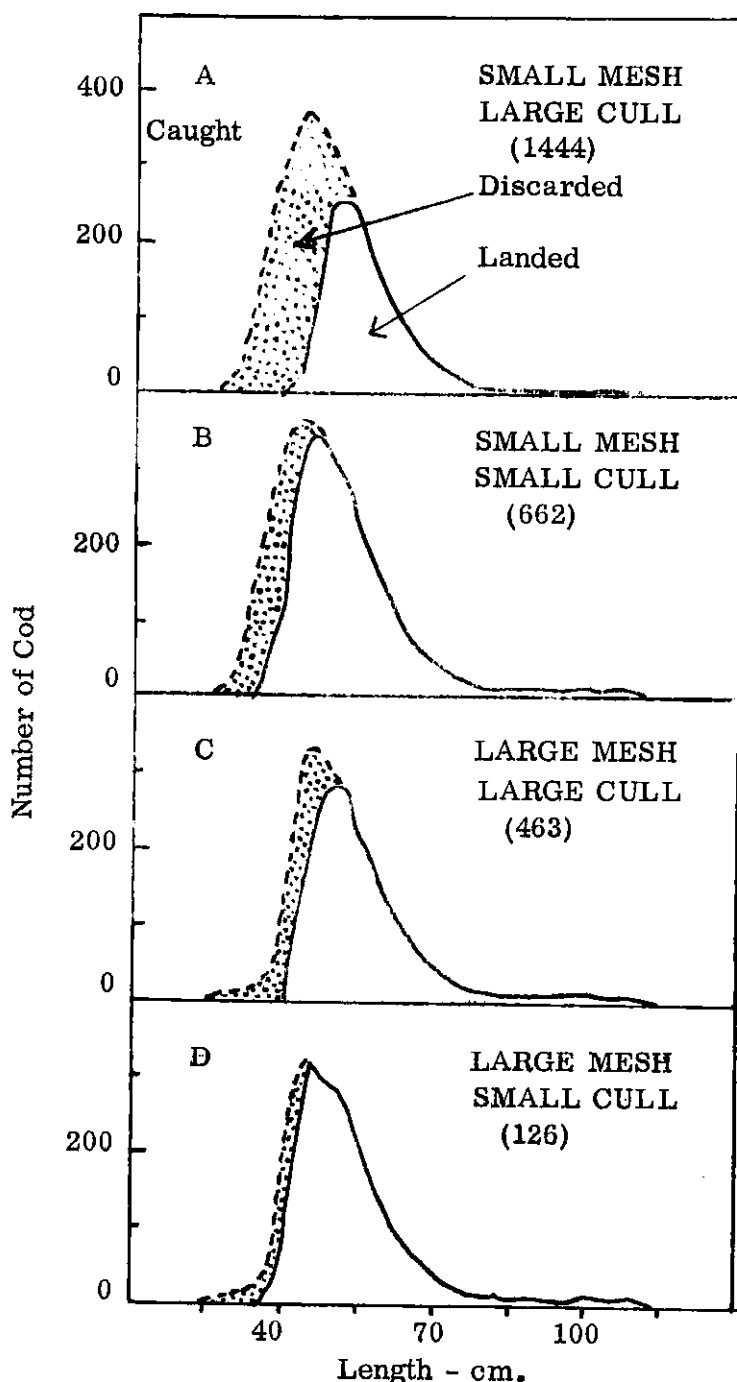


Fig. 10. Size compositions of cod caught and landed by northern New Brunswick draggers with various mesh and cull sizes. D is based on actual 1961 samplings; others are theoretical. Numbers discarded are in parentheses.

To the theoretical 1961 small-mesh catch the large-(1956) and small-(1961) cull curves were applied, resulting in the landing curves shown in Fig. 10A and B. Discards were calculated by subtracting numbers landed from numbers caught. These represent the theoretical discards in 1961, had small-mesh codends been used and had the small and large culls been in effect. In the next step a large-cull curve was applied to the actual catch with large-mesh codends in 1961 (Fig. 10C), and discards were calculated. Figure 10D shows the actual sizes landed with the large mesh and the small cull in effect in 1961. All frequencies were adjusted above 50 cm. The numbers of cod discarded (in brackets in Fig. 10) in each case are therefore comparable.

If A, B, C and D represent the numbers discarded with the various combinations of mesh and cull shown in Fig. 10, then:

$$A-C = \text{reduction in discards due to mesh} = 1,444-463 = 981$$

$$A-B = \text{reduction in discards due to cull} = 1,444-662 = 782$$

$$A-D = \text{reduction in discards due to both mesh and cull} = 1,444-126 = 1,318$$

These are relative numbers based on the numbers of fish sampled at the wharf.

The relation between mesh and cull effects may be expressed as the ratio:

$$\frac{981}{782} = 1.3$$

It is concluded that an increase in mesh size has contributed more toward reducing discards in 1961 than the selection of small sizes (cull) for landing by a ratio of about 1.3 to 1.

Observations made in 1957, the first year of conversion to large-mesh nets (Martin and Jean 1958), provided actual catch data with small- and large-mesh nets and landings with large cull. These data, when submitted to a similar analysis, show that in 1957 the mesh effect would have been about 1.5 times greater than the cull effect had the 1961 small cull been in effect that year.

#### Cod discards by the New Brunswick dragger fleet

The total cod discards by the New Brunswick dragger fleet were estimated from the data collected on sampling trips from 1956 to 1960. (Total 1961 landings were not available at the time of writing). Regular wharf sampling of the dragger landings provided yearly average weight per fish landed during these years. The total numbers landed were calculated from the total weights landed. Applying the discard figures listed in Table III to total weights and total numbers landed, the yearly total discards by the New Brunswick fleet were calculated (Table XII).

Table XII. Total cod discards by the northern New Brunswick dragger fleet from 1956 to 1960.

Year	Boats	Total weight landed	Av. weight per fish landed	Total no. landed	Discards		Total Discards	
					by weight	by number	by weight	by number
	no.	million lb	lb	million	%	%	million lb	million
1956	58	32.3	5.6	5.6	9	25	3.2	1.9
1957	59	30.4	5.5	5.5	6	24	1.9	1.7
1958	59	26.0	3.8	6.8	7	16	2.0	1.3
1959	62	30.6	2.9	10.5	6	13	2.0	1.6
1960	65	16.4	2.9	5.7	4	10	0.7	0.6

The total weight of cod discarded at sea by New Brunswick draggers has decreased from 3.2 in 1956 to 0.7 million lb per year in 1960. The total number discarded has decreased from 1.9 to 0.6 million per year during the same period.

The use of larger mesh and smaller retention length for landing has resulted in a reduction of about 75% by number and 65% by weight in the wastage of small cod at sea by northern New Brunswick draggers.

#### Total cod discards in the southwestern Gulf of St. Lawrence

Total cod discards in the southwestern Gulf of St. Lawrence may be estimated from total landings, using the discard percentages given in Table III, provided the following assumptions are correct. First, line fishermen do not discard cod at sea. Second, the discarding practices observed aboard northern New Brunswick draggers also apply to other small otter trawlers fishing in the southwestern Gulf in summer. Third, the European otter-trawl fleet fishing off the Cape Breton coast (Fig. 1) in the spring discard the same proportion of their catch as the northern New Brunswick draggers.

No observations are available on discards of small cod at sea by line fishermen. McCracken (1957) showed that the 50% retention length for cod by No. 14 hooks was about 48 cm. According to Jean and Marcotte (1959), the 50% selection length for No. 14 hooks may be as high as 53 cm. As seen in Fig. 9, almost all cod larger than 44 cm caught by draggers in 1961 were landed. Presumably the acceptable sizes for landing by draggers applied to lines as well. In such a case the number of fish smaller than 44 cm caught by lines would be quite small. This suggests that even in 1961 when the size of fish landed by lines (Table XIII) was lower than average and more likely to be discarded, all fish caught by lines were landed. Discards, if any, were negligible. In the following calculations it is assumed that line fishermen do not discard cod at sea.

Little is known of cod discards by draggers other than those operating from northern New Brunswick ports. During the period under study, two sampling trips were made on Gaspé draggers, one in July, 1959 and the other in August, 1961. The latter was a redfish trip and few cod were caught. Cod discards on the July 1959 trip were 1% by number and less than 1% by weight. At about the same time New Brunswick draggers were discarding 3% by number and 1% by weight of their catch. This comparison suggests that Quebec draggers may discard a smaller proportion of their catch than the New Brunswick draggers. However, both sets of figures are estimates. For the purpose of this discussion it is assumed that there is no appreciable difference in discards by small otter trawlers fishing in the southwestern Gulf of St. Lawrence.

Finally, it is also assumed that cod discards by European trawlers fishing in Divisions 4 T and 4 V in the spring do not differ markedly in percentage and size from those of northern New Brunswick draggers. McCracken and Clark (1958) measured a sample of discards aboard a French trawler fishing off the Cape Breton coast in March 1958 (McCracken 1958). The average length of these discards was 42.5 cm (ICNAF 1959). The same authors estimated that about 10% by weight of the catch was discarded during that trip. Sampling trips in the southwestern Gulf during the summer of 1958 indicated that the mean length of cod discarded by New Brunswick draggers was 41.5 cm. The overall per cent discards of the New Brunswick draggers was 7%. These observations suggest no large differences in the sizes and percentages of the catch discarded by the two fleets. The discard data collected from northern New Brunswick draggers were therefore applied to European trawlers.

On the above assumptions, total cod discards were calculated from total landings from the southwestern Gulf of St. Lawrence (including the Cape Breton coast in the spring) during the years 1956 to 1960 (Table XIII).

Table XIII. Total weights and numbers of cod landed and discarded at sea in the southwestern Gulf of St. Lawrence, 1956 to 1961. (From ICNAF Statistical Bulletins).

Year	1956	1957	1958	1959	1960	1961 <sup>a)</sup>
Weight landed ('000,000 lb)						
Canadian, lines	71.1	76.1	64.7	59.0	43.2	...
otter trawl	43.5	47.8	40.2	45.9	25.2	...
European, otter trawl	77.2	39.9	54.0	107.5	53.3	...
Total	191.8	163.8	158.9	212.4	121.7	...
Average weight per fish landed (lb)						
Lines	8.54	9.76	9.76	9.76	5.11	4.85
Otter trawl	5.82	5.47	3.78	2.92	2.89	2.65
Numbers landed ('000,000 fish)						
Canadian, lines	8.3	7.8	6.6	6.0	8.5	...
otter trawl	7.5	8.7	10.6	15.7	8.7	...
European, otter trawl	13.3	7.3	14.2	37.0	18.3	...
Total	29.1	23.8	31.4	58.7	35.5	...
Weight discarded ('000,000 lb)						
Canadian, lines	Nil	Nil	Nil	Nil	Nil	Nil
otter trawl	4.3	3.1	3.0	2.9	1.1	0.6
European, otter trawl	7.6	2.5	4.1	6.3	2.2	0.4
Total	11.9	5.6	7.1	9.2	3.3	1.0
Numbers discarded ('000,000 fish)						
Canadian, lines	Nil	Nil	Nil	Nil	Nil	Nil
otter trawl	2.5	2.7	2.0	2.3	1.0	0.6
European, otter trawl	4.4	2.3	2.7	5.5	2.0	0.4
Total	6.9	5.0	4.7	7.8	3.0	1.0

a) Discards estimated.

Discards for the year 1961 were estimated. The table shows that total discards by weight have decreased from about 12 million lb per year in 1956 to 3 million lb in 1960 and an estimated 1 million lb in 1961. Discards by numbers have been reduced from about 7 million fish in 1956 to 3 million in 1960 and an estimated 1 million in 1961. These figures suggest that about 6 million fish which would have been discarded in 1956 were either released by a larger mesh or caught and landed in 1961. It was estimated that the mesh effect was 1.3 times that of cull effect in reducing cod discards in 1961. This would indicate that from 1956 to 1961 large-mesh codends were responsible for a reduction in discards of about 3.5 million fish in numbers in the southwestern Gulf of St. Lawrence. A further reduction of 2.5 million fish resulted from the smaller cull size for landing.

Immediate effects of 5- and 5 1/2-inch mesh on catch, discards and landings

Beginning in 1959 nylon and other synthetic fibres replaced manila in the codends and cotton in the body of the nets used by northern New Brunswick draggers. In 1961 nearly all nets were of synthetic fibres, such as nylon, terylene, courlene, anzalón, etc. Even with synthetic fibres the codends had a mesh size of about 4 1/2 inches, equivalent to about 5 inches manila (McCrae, Clark and Templeman 1958), i. e., about 1/2-inch larger than the regulation mesh.

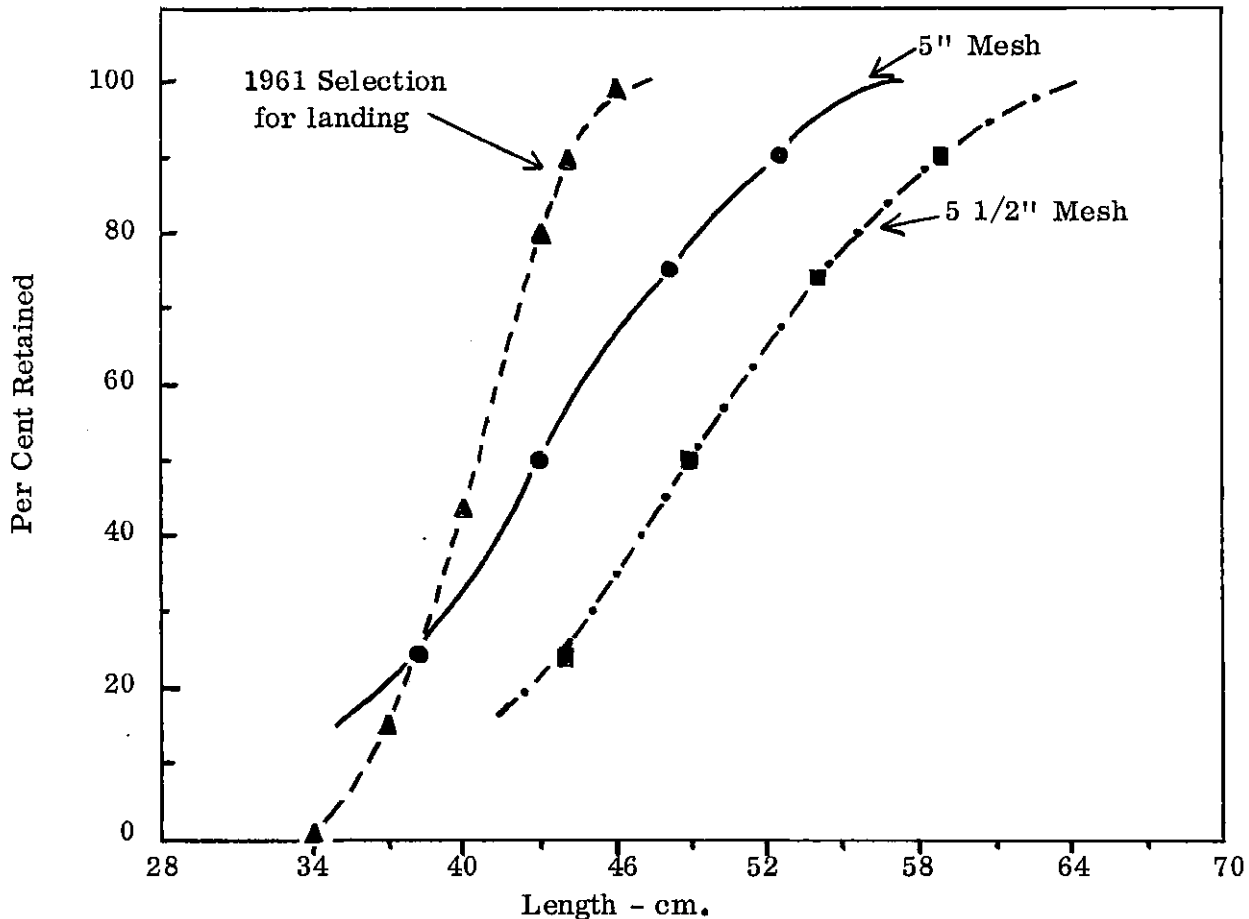


Fig. 11. Selection curves for cod of 5- and 5 1/2-inch manila codends plotted against the 1961 selection curve for landing.

In order to evaluate the effects of 5- and 5 1/2-inch mesh (manila equivalent) on catch, discards and landings of cod, the selection curves for these mesh sizes were plotted against the 1961 selection curve for landings (Fig. 11). A selection factor  $\left( \frac{50\% \text{ retention length}}{\text{mesh size}} \right)$  of 3.5 for manila and 3.8 for synthetics (McCracken, Clark and Templeman 1958) was used in calculating the 25, 50 and 75% retention lengths of 5- and 5 1/2-inch mesh manila codends.

The immediate effect of 5-inch (manila equivalent) mesh, as discussed earlier, has been a reduction in discards by about 3.5 million cod in the southwestern Gulf of St. Lawrence between the years 1956 and 1961. Another immediate effect has been the release of some cod which normally would have been landed (Fig. 11). Some of these released fish, however, were caught again and landed after growing to a larger size.

A more efficient fishing operation resulting from a 5-inch mesh may more than compensate for the temporary loss of cod of marketable size. Firstly, the release of small unmarketable fish and other trash reduces work on deck and contributes toward a more rapid operation. Secondly, as shown by Graham and Premetz (1955) and Clark and Nechy (1957a, 1957b) for Georges Bank haddock, large-mesh nets are more efficient in catching large fish. Because of inadequate catch statistics prior to mesh regulation, the effect of large-mesh nets on total cod landings in the southwestern Gulf of St. Lawrence is difficult to measure, especially if the increase is of the same order (5%) as the one observed for haddock. Martin and Jean (1958) could not detect any reduced landings per trip in northern New Brunswick draggers which had adopted the regulation mesh in 1957.

From statistics and sampling data collected from commercial and research vessels, the ICNAF Working Group of Scientists on Fishery Assessment in relation to Regulation Problems (ICNAF Working Group 1962) evaluated the long-term benefits of large-mesh nets in the Convention Area. They estimated that the use of 5-inch mesh nets in the southwestern Gulf of St. Lawrence would result in a 2 to 4 % increase over the 1956 and 1958 cod landings by all gears.

The immediate effects of 5 1/2-inch mesh would be a further reduction and possibly complete elimination of discards (Fig. 11). It would also release a larger quantity of marketable cod. The long-term effect, on the other hand, would be a greater benefit than the one caused by 5-inch mesh (ICNAF Working Group (1962)). These authors estimate that 5 1/2-inch mesh would eventually increase weights of cod landed by 3 to 8 % over those of 1956 and 1958 in the southwestern Gulf of St. Lawrence.

#### Summary

1. This study is based on 44 sampling trips from 1956 to 1961 aboard commercial draggers fishing in the southwestern Gulf of St. Lawrence, mainly from northern New Brunswick ports.
2. Important factors affecting cod discards at sea are:  
codend mesh size, relative abundance of small fish in the catch, area fished and sizes selected for landing.
3. From 1956 to 1961 cod discards in the southwestern Gulf of St. Lawrence have been reduced from 25% to 6% by numbers and from 9% to 6% by weight.
4. Two factors are mainly responsible for the reduction in cod discards:  
large-mesh nets which, following an ICNAF recommendation, became effective in 1957, and reduction in sizes retained for landing (cull). The mesh effect is believed to be about 1.3 times greater than the cull effect in the reduction of discards in 1961.
5. These results were applied to the southwestern Gulf fishery as a whole. It is estimated that total discards of cod have been reduced by about 6 million fish, from 7 million per year in 1956 to 1 million in 1961. An increase in mesh size is believed to be responsible for a 3.5 million reduction. The decrease in sizes selected for landing resulted in a further reduction of 2.5 million in the numbers of fish discarded.
6. Log-book estimates indicate that, in contrast to cod, plaice discards have increased from about 17 to about 50% by weight in recent years. This is due to an increase in the abundance of small fish in the catch.
7. The discards of incidental species in the southwestern Gulf are considered to be unimportant since these species are a small part of the catch.
8. Experiments carried out on a research vessel indicate that cod and plaice are dead when discarded.
9. The use of 5-inch mesh nets (manila equivalent), besides reducing discards, has released some fish of marketable size. Increase in fishing efficiency, although difficult to measure, may compensate for the temporary loss. The long-term benefits (ICNAF Working Group 1962) would be a 2 to 4% increase in total cod landings by all gears. A 5 1/2-inch mesh would eliminate cod discards. It would also release a larger quantity of cod of marketable size. The long-term benefits (ICNAF Working Group 1962) would be an increase of 3 to 8 % in the total cod landings over those of 1956 and 1958 in the southwestern Gulf of St. Lawrence.



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