Gillnet Dropout in the Roe Herring Gillnet Fishery in British Columbia

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ABSTRACT

Hay, D. E., K. D. Cooke, and C. V. Gissing. 1982. Gillnet dropout in the roe herring gillnet fishery in British Columbia. Can. Ind. Rep. Fish. Aquat. Sci. 131: iv + 21 p.

Two different methods were used to estimate dropout, or the quantity of fish falling from gillnets prior to landing, in the 1981 Lambert Channel roe fishery. (1) The quantity of fish falling into an experimental dropout net attached to a commercial gillnet punt was compared with the quantity of fish actually landed in the punt. (2) SCUBA diver surveys estimated the average density of fish (per m^2) on the bottom after the fishery. Then total dropout from the entire fishery was calculated by multiplying the average density by an estimate of the total area fished (estimated at about 4.5 km2 from aerial photographs taken during the fishery). This was compared to the total landed catch taken during the fishery.

The first estimate of dropout using the dropout net was approximately 12-13%; that is, about 12-13% of the fish which were entrained in a 2 1/4-in gillnet dropped out, into the dropout net, prior to being landed on the punt. The second estimate of dropout was much lower, 1.7%, and is based on a maximum observed density of dead fish on the bottom of 0.118 per m^2, observed in an area of the most intense fishing activity. The density of dead fish on the bottom throughout the entire area fished was probably lower and therefore an estimate of 1.7% probably is a maximum or inflated estimate of the actual density of dead dropout fish.

The explanation for the difference between the two estimates is simple: most fish falling from gillnets remain alive and do not die on the bottom. Most of the fish in the dropout net sustained little or no injury and many spawned in the dropout net. The estimate of dropout based on diver observations represents a <u>lethal</u> dropout rate or fish actually killed in the capture and dropout processes.

Similar estimates of dropout into the dropout net were obtained from experimental sets using 1 3/4- and 2 3/8-in gillnets. The size, age, and sex composition of the dropout fish from all mesh sizes were similar to the landed portions of the catch.

Key words: dropout, roe herring, gillnet.

RESUME

Hay, D. E., K. D. Cooke, and C. V. Gissing. 1982. Gillnet dropout in the roe herring gillnet fishery in British Columbia. Can. Ind. Rep. Fish. Aquat. Sci. 131: iv + 21 p.

Deux méthodes différentes ont été utilisées pour évaluer le taux d'échappement, ou la quantité de poissons tombant des filets maillants avant le hissage sur le pont au cours de la pêche du hareng rogué dans le chenal Lambert en 1981. (1) La quantité de poissons tombant dans un filet d'échappement expérimental attaché à un bachot de pêche commerciale aux filets maillants est comparée à la quantité amenée à bord du bachot. (2) Des plongeurs en scaphandre autonome ont évalué la densité moyenne des poissons (par m^2) sur le fond après le pêche. L'échappement total de la pêche fut ensuite calculé en multipliant la densité moyenne par l'évaluation de l'aire totale pêchée (estimée à environ 4,5 km^2 à partir de photographies aériennes prises au cours de la pêche). Cette valeur est comparée à la prise totale débarquée.

La première estimation du taux d'échappement, où un filet d'échappement a été utilisé, variait de 12 à 13 %, c'est-à-dire qu'environ 12 à 13 % des poissons entraînés dans un filet maillant à mailles de 2 1/4 po se sont échappés dans le filet d'échappement avant d'être amenés à bord du bachot. La deuxième estimation du taux d'échappement, 1,7 %, était beaucoup moins éevée et est basée sur une densité maximale observée de 0,118 poisson mort par m^2 de fond. Ce relevé a été fait dans la zone de pêche la plus intensive. la densité de poissons morts dur le fond à travers toute la zone pêchée était probablement moins élevée et par conséquent l'estimation de 1,7 % est probablement le maximum ou une estimation exagérée de la densité réelle de poissons échappés morts.

La différence entre les deux estimations peut être expliquée de façon simple: la plupart des poissons tombant des filets maillants sont vivants et ne meurent pas sur le fond. La plupart des poissons dans le filet d'échappement ont subi peu ou aucume blessure et beaucoup ont frayé dans le filet. L'estimation du taux d'échappement basée sur les observations des plongeurs représente un taux d'échappement léthal, ou la quantité réelle de poissons tués au cours de la capture et de l'échappement.

Des estimations semblables du taux d'échappement dans le filet d'échappement ont été obtenues à partir de mouillages expérimentaux de filets maillants à mailles de 1 3/4 et 2 3/8 po. La répartition des longueurs, des âges et des sexes des poissons échappés pris dans toutes les grandeurs de mailles sont semblables à celles des poissons hissés à bord.

Mots-clés: échappement, hareng rougé, filet maillant.

INTRODUCTION

The British Columbia gillnet fishery for roe herring occurs in March and April, usually in the immediate vicinity of herring spawning areas. In recent years, some segments of industry and government have been concerned that this fishery is deleterious to the resource, perhaps through some qualitative degradation of the spawning grounds. The hauling and shaking of a gillnet usually results in some fish falling back into the water. If these "dropout" fish are killed, then their carcasses would likely be deposited on or near a spawning area and the subsequent decay could be deleterious to incubating eggs.

Earlier studies conducted in 1975 in Barkley Sound (Humphreys 1975) and in 1979 in the Strait of Georgia (Edwards 1981) concluded that the quantity of dead fish on the bottom after a fishery was not significant. Edwards estimated mortality from dropout at 2.2% based on total numbers of fish caught and a density rate of one fish per m^2 observed on the bottom. In an independent study, Gissing (1979) estimated total dropout to be 8.6%. This estimate was determined by attaching an experimental dropout net to the side of a commercial vessel and recapturing most of the dropout fish. The quantity of dropout fish was then compared to the landed catch to determine percent of dropout.

The objectives of this study were to investigate these discrepancies in estimated dropout rate by:

1) repeating the tests by Gissing using regular commercial fishing gear and determining if dropout catch differs from landed catch in terms of length, weight, age composition, sex ratio and roe yield;

2) comparing rates of dropout obtained using various gillnet mesh sizes;

3) quantifying the numbers of dead fish on the bottom after a commercial fishery through SCUBA diver observations and comparing that estimate with total estimated dropout to determine "lethal" dropout rate.

MATERIAL AND METHODS

FISHING GEAR AND METHODS

Fishing operations were conducted from the commercial gillnet vessel, HI FOXY. This punt is a standard aluminum herring skiff that has been lengthened 6 ft to accommodate 120 mesh nets and widened 3 ft to allow for three additional bins amidships. The punt is equipped with a 40-hp outboard motor, Furuno recording sounder and a power shaker (Fig. 1a-c). The M/V SHAULA was utilized as a support vessel. Both vessels are owned and operated by C. V. Gissing.

Four experimental dropout tests were carried out from March 4-6, 1981 during the commercial roe herring gillnet fishery in Lambert Channel (Fig. 2a-b). Mesh size and gear type, duration of set, location of gear and method of shaking are summarized in Table 1. The nets were checked periodically to determine their fishing success. All nets were set with the leadline on the bottom and corklines submerged with the exception of periods of low tide when some of the corklines floated on the surface.

SAMPLING METHODS AND ANALYSIS OF CATCHES

Upon completion of each set, the gear was hauled aboard using the power shaker. (While hauling, a malfunction with the power shaker required that Set 1 be shaken by hand.) Fish falling from the net prior to being brought aboard and recaptured in the dropout net were termed "dropout catch"; fish released in the punt were designated as "net catch."

Size of samples varied with available catch. The entire net catch was retained from the 2 3/8-inch net (Set 3) and 1 3/4-inch net (Set 4) whereas larger volume catches with the 2 1/4-inch net (Sets 1 and 2) required subsampling. Any remaining catch was delivered to a cash buyer for sale. In all cases, the total "dropout catch" was sampled. Collected samples were placed in plastic buckets, labelled and stored for laboratory analysis.

Laboratory analysis of 100 fish from each of the dropout and net portions of the catch determined length, body weight, roe weight, sex and age composition (determined from scale readings). To obtain a representative size frequency of the total catch for tested mesh sizes, additional samples were measured for length only. Samples from the 2 3/8-in mesh net (March 5) were analyzed for length only.

DIVER SURVEYS OF FISHED GROUNDS

Within 2 hr of closure of the roe fishery on March 6, 1981, diver surveys were conducted in areas of intensive fishing (Fig. 2a-b). Transect 1 began approximately 400 m north of Longbeak Point and continued in a northerly direction for 200 m. Transect 2 was located approximately 140 m off Longbeak Point and extended for 200 m. A third transect of 200 m was located 2 km north of Fillongley Park.

The dates of surveys on each transect are summarized in Table 5. Visibility varied throughout the surveys and, as a consequence, the estimated observable width varied between 4-7 m. Divers recorded numbers of dead fish, made observations on scavengers eating carcasses and noted any damage to the substrate caused by gillnets.

RESULTS AND DISCUSSION

DROPOUT ESTIMATED FROM DROPOUT NET

Dropout was estimated as a percentage of the total available catch (i.e. landed or net catch plus dropout catch) as well as a proportion of landed catch only (Table 2). In each case, the dropout rate indicates the proportion of fish released from the net prior to being brought aboard. The latter estimate of dropout is useful for comparison with dropout estimates based on diver surveys and is discussed later. Dropout rates, relative to total (net plus dropout) catch, varied from 12.1% with the 1 3/4-in mesh net and 12.6% and 12.3% with the 2 1/4-in mesh nets to 15.2% in the 2 3/8-in mesh net. Fish weights were not taken for the 2 3/8-in mesh net samples and, therefore, dropout rate was determined only from numbers of fish.

ANALYSIS OF CATCHES

Dropout and net fish were compared for differences in length, weight and roe weight (Table 3). A chi square test (corrected for continuity when df=1) was used to compare age frequencies and sex ratios (Steel and Torrie 1960). Although some of the statistical differences between net and dropout fish were significant, the absolute differences between net and dropout fish for length, weight, roe weight, and age were generally slight. For instance, in the March 4 test comparing net and dropout catches, the net fish were significantly longer and older ($p<0.01$) but the dropout fish were significantly heavier ($p<0.05$). The March 5 tests with the same mesh size gear showed no differences between net and dropout fish in any of the comparisons. The March 6 test using 1 3/4 inch mesh nets showed that the net fish were slightly longer ($p<0.05$) but all other comparisons were insignificant. Perhaps the only simple and useful conclusion that can be made from these apparently contradictory results is that there is really little, if any, difference between the net and dropout fish. For instance, Fig. 3 shows that when net and dropout catches are compared among tests using different mesh sizes, the similarities between net and dropout length frequencies are more striking than the differences. The fact that some tests show statistical differences is puzzling but probably unimportant because the magnitude of the differences are small and the direction of the differences is inconsistent. It is possible that some of these differences might reflect slight artifacts generated during the handling and storage period. For instance, some portions of the samples had to be frozen for later analyses. The freezing process, through dehydration of specimens might have induced some of the apparent differences between net and dropout fish.

DROPOUT ESTIMATED FROM DIVER SURVEYS

Diver observations of Transects 1 and 2 (Fig. 2a-b) indicate an increase in numbers of dead fish for a short period following closure of the fishery (Table 5). On Transect 1, the numbers of dead fish increased from a total of 10 on March 6 to 42 on March 9, or a density of 0.048 fish per m^2 over an area of 880 m^2. On Transect 2, an initial count of 74 fish on March 8 increased to a maximum of 115 on March 11. The maximum density of 0.118 fish per m^2 over an area of 800 m^2 was recorded on March 9. Transect 3 was surveyed on March 6 and had a density of 0.042 fish per m^2 over an area of 1540 m^2.

In the week following the closure of the fishery, divers noted an increase in numbers of predators, particularly starfish, crabs, urchins and snails into the area and a corresponding elimination and decomposition of herring carcasses. Densities of dead fish on the bottom declined from the maximum of 0.118 fish per m^2 (March 9) to 0.005 fish per m^2 (March 26). No physical damage to the vegetation was observed.

A maximum estimate of the density of dead fish on the bottom after the 1981 Lambert Channel fishery was 0.118 fish/m^2 (Transect 3, March 9 - see Table 5). The total area of the fishery, determined from aerial photographs (Fig. 2a-b), was estimated at 4.5×10^6 m^2. Therefore, a maximum estimate of the total number of dead fish on the bottom after the fishery is obtained by multiplying the density of dead fish (maximum estimate of 0.118 per m^2 - Table 5) by the area of the fishery. This gives a total of 5.31×10^5 fish. Based on an average weight per fish of 0.35 lb (Table 2), this represents a total weight of 185,850 lb or 92.9 tons. The total 1981 gillnet catch in Lambert Channel was approximately 5583 tons (Hourston and Haist, in press), so the maximum dropout rate is estimated at 1.66% (i.e. total dropout/catch + "lethal" dropout).

In contrast, Edwards (1981) estimated total dropout for the 1979 Strait of Georgia fishery at 2.2%. There are, however, some errors and potentially misleading assumptions in the Edwards calculations. Edwards' estimated weight of 33 fish/lb was corrected to 3.3 fish/lb and his maximum density of dead fish was adjusted from 1.0 fish/m^2 to 0.133 fish/m^2. This latter estimate is consistent with his own reported observations as well as the diver estimates reported in this study. The lethal dropout rate, then, is recalculated at 0.31%, which represents a total of approximately 18 tons for the 1979 Strait of Georgia fishery. This lethal dropout estimate of 0.31% is then comparable to the estimated 1.66% rate for the 1981 Lambert Channel fishery. It is important to appreciate that 1981 Lambert Channel figures are based on maximum densities of dead fish and so are representative of the "worst" situation. It is likely that actual densities are substantially lower.

A comparison of the maximum net dropout rate for 2 1/4" mesh nets (14.5%) and the lethal dropout rate (1.66%) indicates a high proportion of fish falling from the net survive and observations made during the collection of samples confirmed that most fish in the dropout net were alive and appeared undamaged. Humphreys (1975) concludes that most fish falling back into the water are apparently recaptured or remain alive to spawn. The results of these tests concur with his conclusions.

COMPARISON OF METHODS AND ESTIMATES OF DROPOUT

The difference between the dropout rate of 8% determined by Gissing (1979) and the 2.2% estimated by Edwards (1981) can largely be attributed to the different methodology that each employed. Gissing measured the total dropout, (i.e., the amount of fish which are released from the net and retained by the dropout net); Edwards estimated the numbers of fish which drop from the gillnets and subsequently die on the bottom, (i.e., the lethal dropout rate). Gissing's estimate was based on individual hauls with the net during a commercial fishery, whereas Edwards estimated dropout from a specific site following the closure of the fishery and applied this estimate to broader areas. The differences between the two estimates can be explained if most of the dropout fish are not killed, but swim away to spawn or perhaps be recaptured.

There is also an approximate 50% difference between the 8% dropout determined by Gissing (1979) and the 12-13% determined in the present report. This difference can probably be attributed to different types of net construction. The 1979 tests used deeper (120 mesh) nets with two shaker panels which, when hauled, were not stretched as tightly as the shallower nets used for the 1981 tests.

FACTORS AFFECTING DROPOUT

Fishing intensity and duration of set

During a commercial fishery the duration of a set is largely dependent upon the availability of fish - if fish are plentiful most fishermen would haul their nets frequently. The amount of dropout probably depends on the combined effects of the duration of a set and the availability of fish.

Dropout is probably highest from short sets catching few fish and long sets catching many fish. A recently set net is relatively slack and, if hauled shortly after setting the webbing may stretch, thereby allowing incompletely gilled fish to drop out. Likewise dropout from an extremely full net, fished for a long duration could be high because little flexibility would remain in the webbing. Fish encountering such a net during the later stages of a set might not gill completely and would be more susceptible to dropping out. Between the extremes of a very slack, empty net and a taut, full net, a condition of maximum efficiency exists when dropout will be minimized.

Method of shaking

Observations during the roe herring fishery indicate the method of shaking does not significantly affect the amount of dropout. Set 1 (March 4) of the 2 1/4-in gillnet was hauled and shaken manually by inexperienced shakers while the second set of the 2 1/4-in net (March 5) was cleared using the power shaker. Dropout rates for these sets are similar; 12.6% and 12.3%, respectively. This observation is corroborated by Edwards (1981) who concluded that power shaking causes no more dropout loss than manual shaking. The likely explanation for this is that the power shaker facilitates removal of fish from sections of the net that are over the punt but most dropout occurs as the net is being lifted or pulled from the water to the punt rail.

Fish size and gillnet mesh size

Although each mesh size of gillnet retained different sizes of fish, there were relatively few differences between individual catches of net and dropout fish in terms of length, weight, roe yield, age or sex frequency. The net fish were slightly longer and older in March 4 (2 1/4-inch) samples, but this tendency was not seen in the other test sets (Table 3).

Edwards (1981) compared size, sex and roe yield between net fish and dead dropout fish retrieved from the bottom and found no significant differences between the two groups. His observations are consistent with those of this study and we conclude that, dropout fish, alive and dead, do not markedly differ by size, sex and age from netted fish. It also seems that this holds for all of the mesh sizes tested.

RECOMMENDATIONS

Although there is no evidence indicating a high mortality attributable to gillnet dropout, there is undoubtedly some damage to individual fish. Therefore, it would be advantageous to the roe herring gillnet fishery to minimize dropout by incorporating dropout nets on all commercial herring punts. Although the specific design of the dropout net utilized during the experimental fishing may not be acceptable to all punts, with minor modifications it would be possible to utilize dropout nets throughout the gillnet fleet and some consideration should be given to making the inclusion of dropout nets mandatory. The inclusion of a dropout net to a punt could increase individual catch rates by approximately 12%.

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Table 1. Location and time of test sets for each mesh size.

Mesh size	Date	Location	Depth (fm)	Set time	Haul time	Duration (hr)	Shaking method
2 1/4"	4/3/81	1 km S. Fillongley Park	4-5	1830	2330	5.0	Manual
2 1/4"	5/3/81	1 km S. Fillongley Park	4-5	0800	1200	4.0	Power
2 3/8"	5/3/81	1 km S. Fillongley Park	4-5	1330	1630	3.0	Power
1 3/4"	6/3/81	2 km N. Fillongley Park	3	1300	1500	2.0	Power

Table 2. Analysis of catch weights and determination of dropout (D. O.). The percent D. O. is shown as a proportion of (i) the landed or net catch and (ii) the proportion of the total catch (net-weight plus D. O. weight).

Mesh size	Date	Fish in net sample	Mean wt. net fish (lb)	Wt. net sample (lb)	Wt. net catch sold (lb)	Total wt. net catch (lb)	Fish in dropout sample	Mean wt. D.O. fish (lb)	Wt. D.O. sample (lb)	Wt. D.O. catch sold (lb)	Total wt. D.O. catch (lb)	Total catch (Net+D.O.) (lb)	(i) % D.O. / Net	(ii) % D.O. / Total
2 1/4"	Mar. 4/81	344	0.34	117	3600	3717	1541	0.35	539	-	539	4256	14.5	12.6
2 1/4"	Mar. 5/81	338	0.36	122	2720	2842	1106	0.36	398	-	398	3240	14.0	12.3
2 3/8"[a]	Mar. 5/81	1068	-	-	-	-	191	-	-	-	-	1259	17.9	15.2
1 3/4"	Mar. 6/81	354	0.23	80	253	333	207	0.23	47	-	47	380	13.8	12.1

[a]Percent of dropout based on numbers of fish caught.

Table 3. Statistical comparisons of captured (net) and dropout (D.O.) fish. Difference of means for length, weight, and roe weight were compared using a t-test and difference in age frequency and sex composition were compared by chi square analyses (Steel and Torrie, 1960). Significant differences at the 0.05 and 0.01 probability levels are indicated by one or two asterisks, respectively, at each of means.

		Mean length (mm)				Mean body weight (gm)			
Mesh size	Date	Net fish	S. E.	D.O. fish	S. E.	Net fish	S. E.	D.O. fish	S. E.
2 1/4"	Mar. 4/81	224.5 (N=344)	0.52	222.4 (N=1537)	0.26	156.5 (N=100)	1.81	162.2 (N=199)	1.790
			t=3.50**				t=2.01**		
2 1/4"	Mar. 5/81	225.2 (N=338)	0.55	225.2 (N=1105)	0.27	164.2 (N=100)	1.82	163.4 (N=99)	1.861
			t=0.0				t=0.31		
2 3/8"	Mar. 5/81	231.3 (N=407)	0.33	231.4 (N=191)	0.59	-	-	-	-
			t=0.25						
1 3/4"	Mar. 6/81	196.6 (N=354)	0.42	200.1 (N=207)	0.60	102.7 (N=99)	1.17	102.5 (N=100)	1.250
			t=2.58*				t=0.12		

Table 3. cont'd.

Mesh size	Date	Mean roe weight (gm)				Mean age		% ♀	
		Net fish	S. E.	D.O. fish	S. E.	Net fish	D.O. fish	Net fish	D.O. Fish
2 1/4"	Mar. 4/81	40.8 (N=47)	0.95	44.6 (N=117)	0.84	5.82 (N=56)	5.15 (N=125)	47.0 (N=100)	59.8 (N=199)
			t=1.78			x2=26.2**	(3df)	x2=1.77	(1df)
2 1/4"	Mar. 5/81	43.3 (N=44)	1.060	42.9 (N=50)	1.126	5.50 (N=53)	5.25 (N=68)	44.0 (N=100)	51.0 (N=99)
			t=0.26			x2=3.86	(3df)	x2=0.45	(1df)
2 3/8"	Mar. 5/81	-	-	-	-	-	-	-	-
1 3/4"	Mar. 6/81	23.7 (N=34)	0.69	25.0 (N=30)	0.90	3.08 (N=78)	3.12 (N=79)	35.1 (N=99)	30.0 (N=100)
			t=1.16			x2=0.07	(3df)	x2=0.27	(1df)

Table 4. Age frequency of net vs. dropout catch for each mesh size.

	2 1/4" Mar. 4/81		2 1/4" Mar. 5/81		1 3/4" Mar. 6/81	
Age	Net	Dropout	Net	Dropout	Net	Dropout
1						
2						1
3		2		1	72	71
4	3	33	7	17	6	6
5	18	57	23	21		1
6	23	17	18	22		
7	10	11	4	7		
8	2	3	1			
9		2				
Non-aged	44	75	47	32	22	21
Mean age	5.82	5.15	5.50	5.25	3.08	3.12

Table 5. Summary of transect dimensions, diver counts of dead fish, and estimated density of dead fish following the Lambert Channel gillnet fishery.

	No. of fish	Transect length (m)	Transect width (m)	Transect area (m2)	Fish m2
Transect 1					
March 6	10	220	4	880	0.011
March 9	42	220	4	880	0.048
Transect 2					
March 8	74	200	4	800	0.093
March 9	94	200	4	800	0.118
March 11	115	200	6	1200	0.096
March 18	44	200	4	800	0.055
March 26	4	200	4	800	0.005
Transect 3					
March 6	65	220	7	1540	0.042

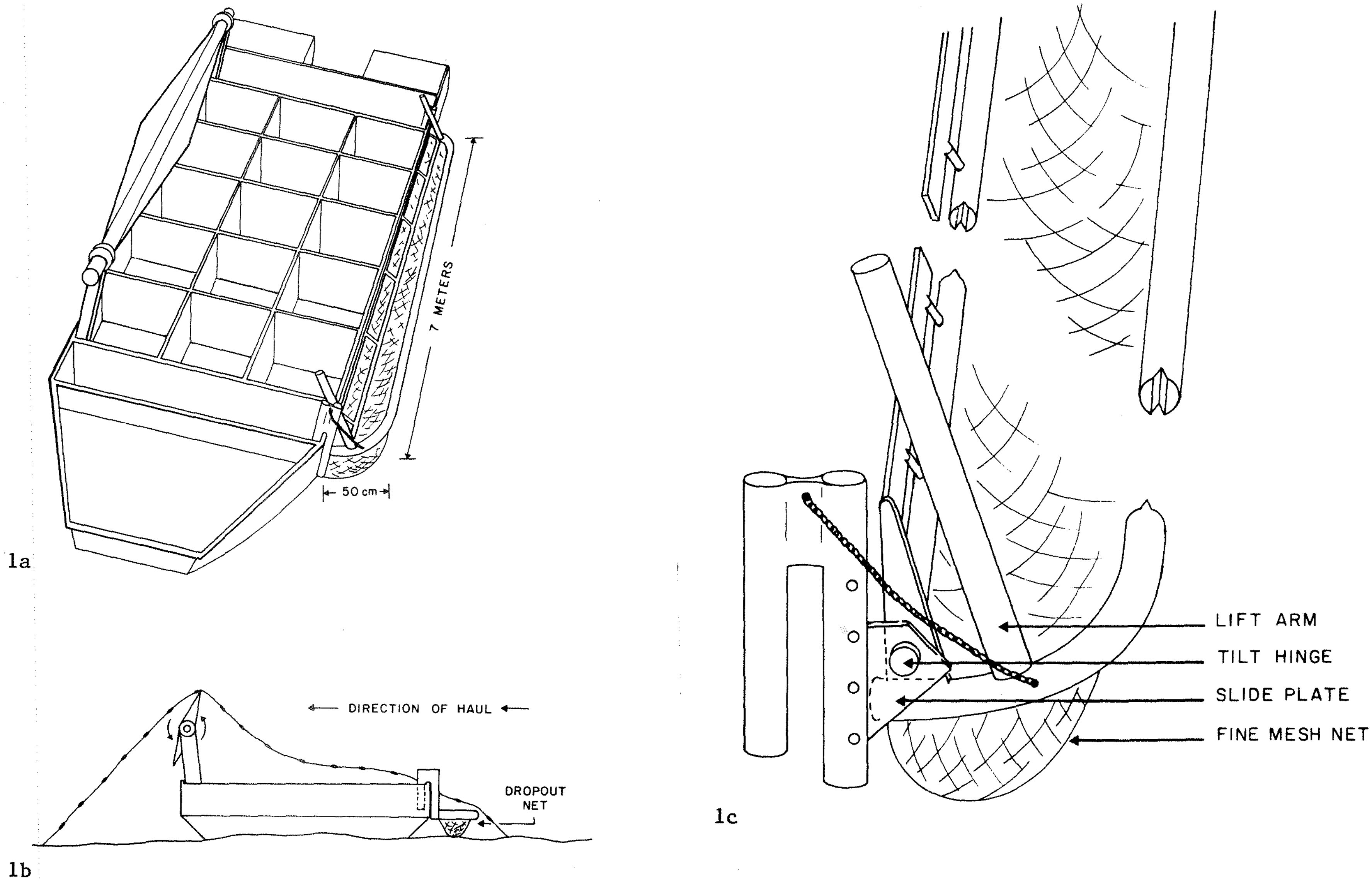

Fig. 1. Chartered commercial punt. (a) experimental dropout net attachment. (b) operational view of the dropout net. (c) exploded view of the lift and tilt mechanism of the dropout net.

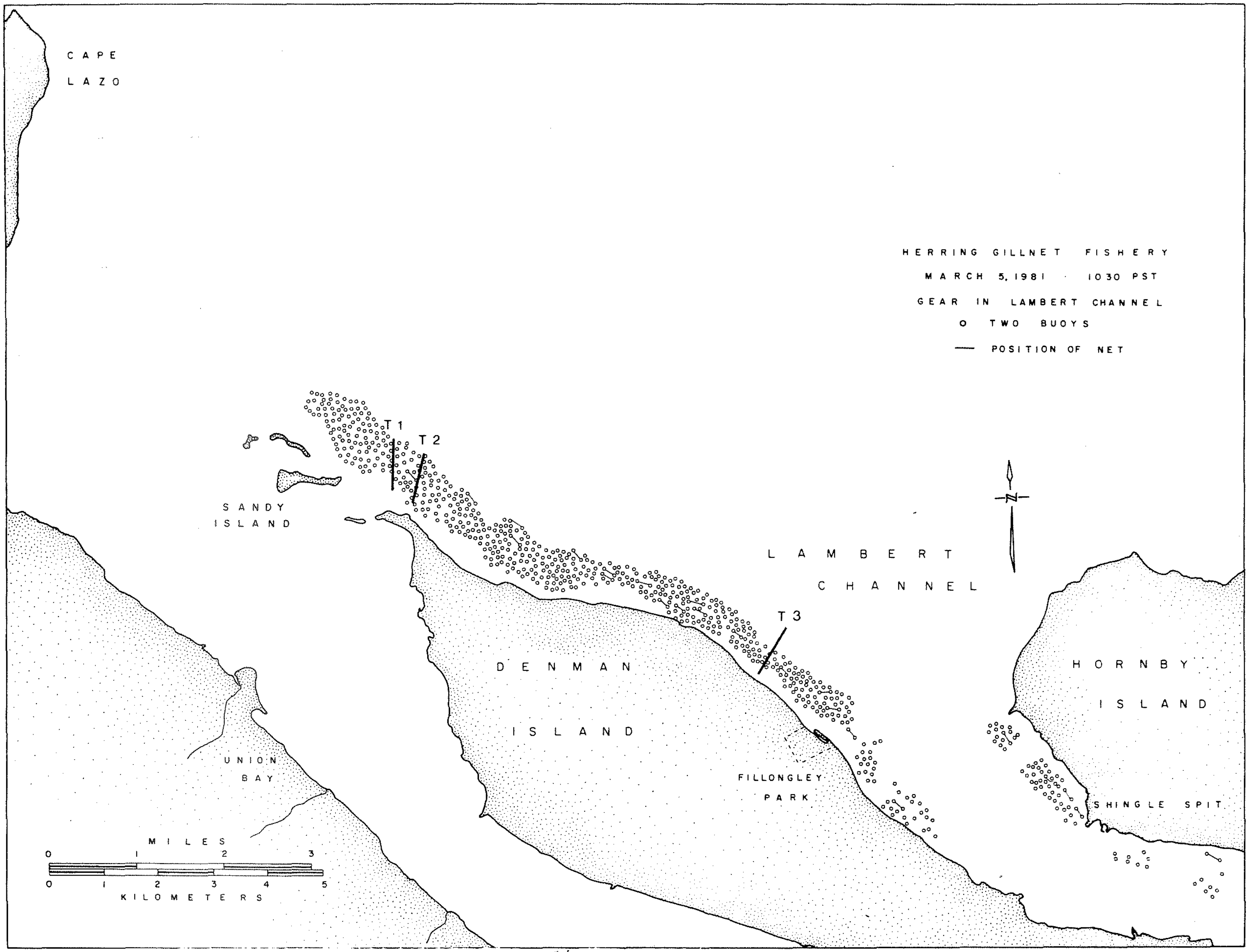

Fig. 2a. The location of gillnets on March 5, 1981 in Lambert Channel. The position of diver survey transects are indicated by the solid lines T-1, T-2, and T-3.

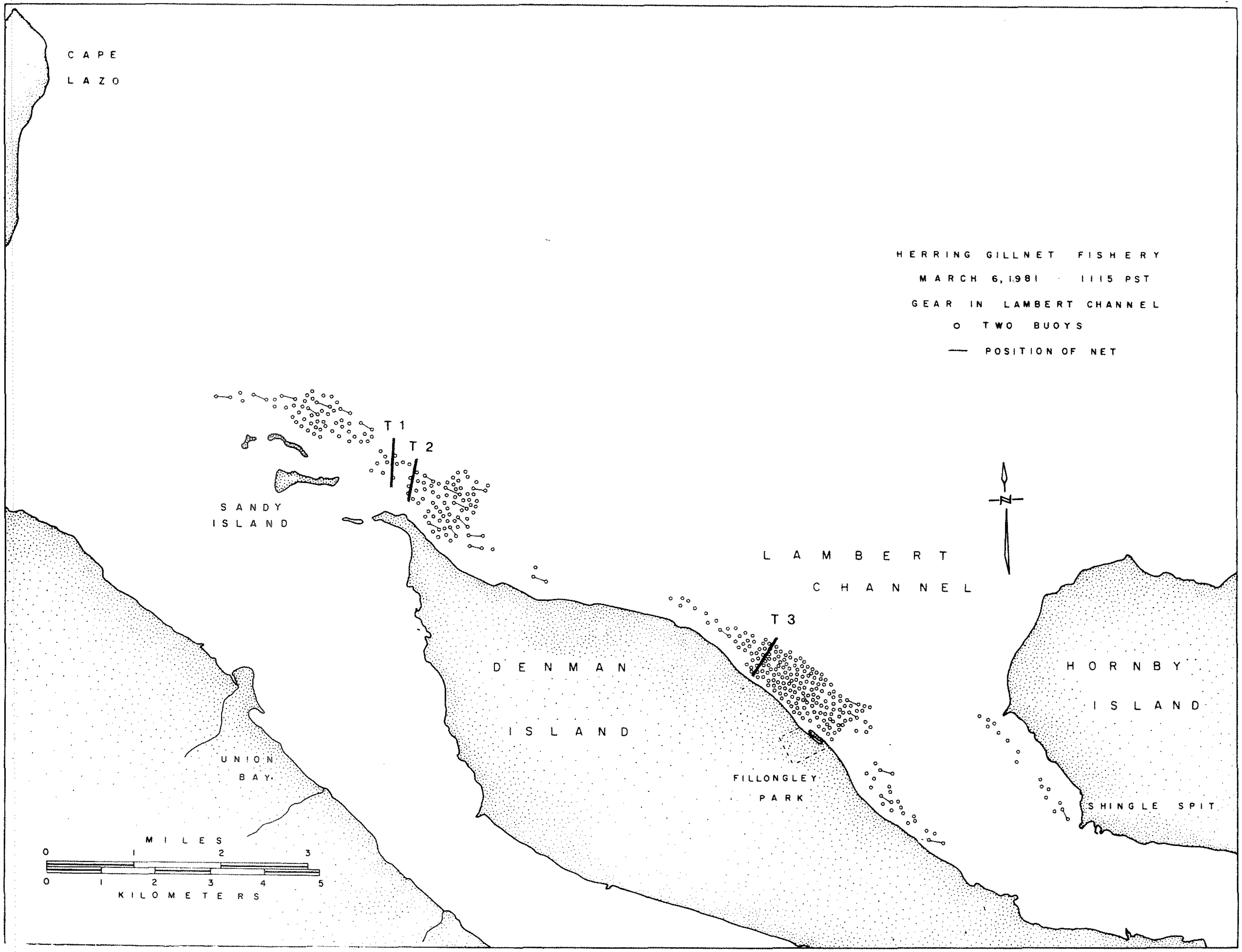

Fig. 2b. The location of gillnets on March 6, 1981 in Lambert Channel. The position of diver survey transects are indicated by the solid lines T-1, T-2, and T-3.

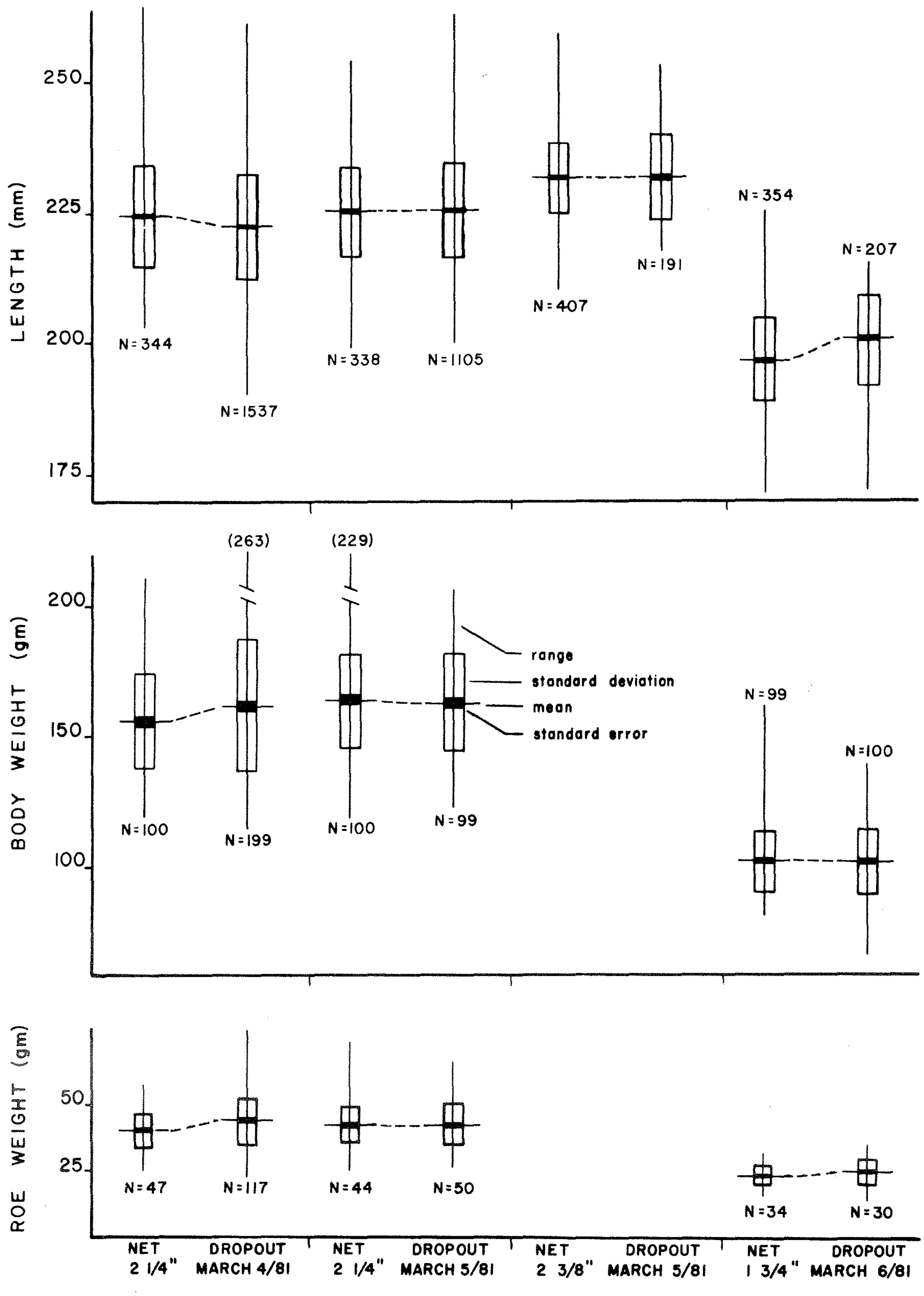

Fig. 3. Comparison of lengths, weights, and roe weights of net and dropout catches among different mesh size nets.