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Bay of Fundy Scallop Stock Assessment - 1980

by

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Abstract

The status of the Bay of Fundy scallop stock in 1980 is assessed on the basis of relative age frequency, log reports, and recent fishery landings. In 1980, scallop abundance was well above average in Bay of Fundy waters, and relatively little effort was directed towards offshore grounds on the Scotian Shelf or Georges Bank. Revised scallop meat yield-age regressions and yield per recruit analyses are presented, and gear and vessel characteristics of the fishing fleet are described. Present average age of exploitation is close to that giving maximum yield per recruit; however, this situation is not supported by regulation and could deteriorate rapidly if future recruitment declines.

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La fréquence relative des âges, les journaux de bord et les récents débarquements ont servi à évaluer la condition du stock de pétoncles de la baie de Fundy en 1980. Cette année-là, les pétoncles étaient nettement plus abondants que la moyenne dans cette région, et c'est ce qui explique que relativement peu d'effort fut dirigé vers les bancs du large, le plateau néo-écossais et le banc Georges. Nous présentons des régressions révisées de rendement en chairs sur les âges des pétoncles et des analyses de rendement par recrue, en plus d'une description des engins et des caractéristiques de la flottille de pêche. L'âge auquel on exploite présentement ce stock se rapproche de celui du rendement maximal par recrue; cependant, aucune réglementation n'est en cause, et la situation pourrait se détériorer rapidement s'il y avait diminution du recrutement dans les années à venir.

INTRODUCTION

The scallop ground off Digby, N.S., has in recent years supported a fishery well above the long-term average yield of 325 t (Jamieson and Lundy 1979; Jamieson et al. 1980). These high landings, combined with high scallop prices and recent above-average landings from both Georges Bank and the Scotian Shelf, have resulted in considerable prosperity for the Bay of Fundy scallop fleet. However, some of these "inshore" vessels are large enough (Table 1) to fish offshore (Scotian Shelf, Georges Bank) in fair weather.

This report presents the 1980 scallop stock assessment for the grounds off Digby, N.S., and includes new scallop meat yield-age regressions. Modified yield per recruit analyses are presented, and management options to ensure a continued optimal fishery yield in the future are discussed.

MATERIALS AND METHODS

A. Resource surveys

Survey design and procedures were similar to those utilized by Jamieson and Lundy (1979) and Jamieson et al. (1980). The number of stations in each stratum and substratum (Table 2) were determined from the combined distributions of commercial effort in all of 1979 and January to May, 1980, inclusive. To standardize substrata boundaries, the fishing ground off Digby, N.S., was gridded (Fig. 1) into unit areas one minute of longitude by one minute of latitude (OMS = one minute square = 2.6 km^2). Each unit area was assigned to the stratum and substratum (Fig. 1) in which 50% or more of its area was included.

Substrata commenced 3.2 km from shore and, being one mile (1.6 km) deep, are referred to by the number of miles they are from the shoreline [e.g. 3 miles (4.9 km) off Gulliver's Head]. This is the common method by which fishermen report fishing locations. Because of their continuity, the Broad Cove and Digby Gut strata used by Jamieson and Lundy (1979) and Jamieson et al. (1980) were combined in data analysis, giving a total of five strata for this study. Inshore and offshore designations are the same as those used in both earlier studies, with locations greater than 6 miles (9.7 km) from shore termed "offshore". Station distribution and assignment by strata and substrata are given in Figure 2 and Table 2. All stations were at a depth less than 110 m (60 fathoms).

The survey was conducted over a two-week period in mid June, 1980, from the chartered 19.2 m scallop dragger "M/V LEONA S II," skippered by Captain Greg Morrell. The gear (Fig. 3) was a 7-gang Digby drag with 76 cm rings. Buckets 3, 4, and 5 contained 38 mm stretch mesh liners, with a similar mesh hood on Bucket 4 extending to a height of 1 m above the bottom.

Individual shell heights were measured to 5 min intervals on all live scallops and dead scallops caught by the hood, lined buckets (Fig. 3: Buckets 3, 4, and 5) and from at least two (randomized) of the unlined buckets (Fig. 3: Buckets 2, 6, or 7). Scallop age was inferred from height by the von Bertalanffy growth parameters given in this report. Depth was recorded, and for most tows an attempt was made to standardize towing distance at 800 m using an on-board coordinate converter (Internav CC2) directly wired to a Loran C receiver. When this system was not operative, tow duration was standardized at ten minutes, and tow distance was estimated as the straight-line distance between the start and end locations. In areas where bottom type caused the drags to quickly fill with trash, shorter tows were made to prevent the drag from overfilling and stop effective fishing. In all tows, Loran C readings were taken at the beginning and end of the tow; and subsequent data analysis weighted catches to a tow length of 800 m.

At each station, the volume of total catch (trash plus scallops) in each bucket was measured by recording the number of empty rings from the top while the drag was hanging vertically; and the total scallop catch was weighed (round weight).

Over the years 1978 to 1980 inclusive, live scallop samples were routinely obtained to determine both growth and meat yield at age relationships. These combined data were used in new calculations or regression parameters, with distance from shore being incorporated as a new variable.

COMMERCIAL FISHERY CHARACTERISTICS

1) Fleet characteristics

Scallop licenses along the Bay of Fundy coasts of Nova Scotia and New Brunswick are of two types: restricted licenses, which confine scalloping to within seven miles of shore, and unrestricted licenses, which allow fishing in nearshore and offshore waters. Restricted licenses are typically associated with small vessels used in multispecies, inshore fishing, and as such contribute relatively little to overall scallop landings. In contrast, many vessels carrying unrestricted scallop licenses have only this one fishing license; and this feature, combined with an average larger size (Table 1), results in these latter vessels landing most of the scallops fished. Unrestricted licensed vessels comprise what is termed the "inshore, or Bay of Fundy, scallop fleet" and are concentrated in Digby, N.S. (45 vessels) , and on Grand Manan Island, N.B. (9 vessels).

Inshore scallop fleet size has continued to increase in recent years although ostensibly frozen at 59 vessels in 1973. Fleet size was 86 vessels in 1978, and in 1980 consisted of 92 (70 in Nova Scotia, 22 in New Brunswick).

2) Gear characteristics

Gear size data are only available for those vessels fishing out of Digby, N.S. In 1979, regulation was introduced restricting maximum overall gear width towed per vessel to 5.5 m (18 ft). Recommendations have been made to ban sweep-chain drags from Bay of Fundy waters (boundaries can be obtained from "Territorial Seas and Fishing Zones of Canada", Ottawa, 1978, p. 38: 16), and it is anticipated that this will be in regulation shortly. Use of sweep-chain drags will then be confined to the Scotian Shelf or Georges Bank.

Gear characteristics of inshore vessels are quite uniform, consisting of seven individual rock buckets, each 0.79 m (30 in) wide, attached to a single tow bar. All vessels are side draggers to accommodate the large total width of the gear (about 6.5 m). Sweep-chain drags used by this fleet average about 3 m wide, and only one is fished at a time.

3) Commercial meat size frequencies

Extensive port sampling of commercial Bay of Fundy scallop landings in Digby, N.S., has only been carried out in 1979 and 1980. Analysis of commercial meat weight data (Table 3) utilizing the yield at age and growth parameters for Bay of Fundy scallops from depths <110 m (Jamieson et al. 1980) suggest that average scallop age landed was 6.5 years (37.2 meats/500 g) in 1979 and 7.6 years (31.2 meats/500 g) in 1980.

Since scallop meats obtained from different fishing locations (e.g. Scotian Shelf, Georges Bank, Bay of Fundy) may be blended, the above values only reflect general fishery performance and cannot always be related to a specific stock's characteristics. Thus, in 1979, the Scotian Shelf and the Bay of Fundy contributed almost equally to overall landings (Jamieson et al. 1980), while in 1980 Bay of Fundy waters alone contributed most of the scallops landed (Table 4). With the absence of accurate data on where the sample measured was fished, aging procedures utilize Bay of Fundy growth parameters from depths <110 m (Jamieson et al. 1980). These parameters vary for scallops from other fishing areas (Haynes 1966; Jamieson et al. 1981a), and so aging bias will be proportional to the relative magnitude of landings from outside Bay of Fundy waters. Bias towards a younger average age was thus greater in 1979 than in 1980, as in 1979 a greater percentage of the landings in Digby were fished on the Scotian Shelf, and Scotian Shelf scallops yield a smaller meat at age than do Bay of Fundy scallops from <110 m (60 fathoms) (Jamieson et al. 1981a).

Monthly scallop landings (Table 5) indicate a bimodal pattern, with peaks in landings coinciding with the resumption of extensive fishing in the spring (relatively little fishing activity occurs in the winter months) and with the opening of the inshore fishing area on October 1. In 1980, discovery and exploitation of new scallop concentrations off Briar Island, N.S., combined with the exploitation of a very dense concentration of younger scallops off Digby Gut, resulted in fall landings well above the recent average.

POPULATION CHARACTERISTICS

1) Meat weight-shell height relationship

Data now allows expression of the scallop meat weight/shell height relationship off Digby, N.S., in terms of distance from shore. Previous studies (Jamieson and Lundy 1979; Jamieson et al. 1980) assumed a constant relationship for depths <110 m, the depth at which a major change in growth rate appeared to occur for the Bay of Fundy as a whole (Caddy et al. 1970).

The meat weight (w):shell height (h) regression:

$$\ln(w) = -11.58 + 3.100 \ln(h)$$

was determined from the combined data from four samples (119 scallops) collected in June, 1979 and 1980, between Centreville and Digby Gut at distances from shore of 2.3, 3.7, 3.9, and 5.5 km. Average water depth and standard deviation was 87 $\pm$ 8 m. This regression was assumed to be representative of scallops 3.9 km from shore (the mean distance from shore for the above four samples). Meat yield is inversely proportional to distance from shore, but since meat yield is also a function of scallop size, the relationship between yield and location was determined for one size of scallop (107 mm). This scallop height was selected since it approximates the modal height for scallops fished in 1979 and 1980. The regression ($r^2 = 0.55$) for meat yield (Y) versus distance (km) from shore(D),

$$Y = 18.50 - 0.34\ D$$

has been used to modify yield (W) in all subsequent data analyses, with

$$W = W * [(18.50 - 0.34\ D)/17.18]$$

where 17.18 is a constant (average scallop meat yield at 3.9 km from shore).

For yield per recruit calculations, the data from those samples collected in 1977 to 1979 inclusive within the six-mile (9.7 km) closure line was combined, permitting determination of a regression which characterized the "inshore," i.e. within the six-mile summer closure zone, meat weight-shell height relationship (Fig. 4),

$$\ln(w) = -12.367 + 3.236 \ln(h).$$

A similar procedure was utilized to generate a relationship for "offshore" (outside the six-mile closure line) scallops (Fig. 4),

$$\ln(w) = -11.299 + 2.925 \ln(h).$$

There is no reason why scallop meat yield should be inversely proportional with distance from shore *per se*. However, although the correlation coefficient is not high, distance from shore is a convenient reference variable at this time. Ocean climate can affect scallop yield (Jamieson et al. 1981a), and both substrate and current velocity are known to

change with distance from shore off Digby, N.S. (pers. obs.; Dewolfe 1981). Water current velocity is hypothesized to be an important variable in determining scallop size, abundance and distribution, since it affects food and oxygen availability, suspended sediment load, and substrate particle size. Optimal scallop fishing ground is often characterized by fishermen as areas of moderate current with a gravel substrate. In the area of the Bay of Fundy surveyed, modelled tidal currents (DeWolfe 1981) within cell sizes of 10 nm (18.5 km) do not provide sufficient detail as to the possible role of currents in influencing ambient environmental conditions. However, using the same numerical model (Greenberg 1978), M_2 tidal coefficients, i.e. the principal lunar constituent in tidal current calculations, for 7.4 km cells off Digby Gut have been calculated (Table 6) by Dr. B. Petrie (Coastal Oceanography, Bedford Institute of Oceanography, Dartmouth, N.S.). These data indicate that tidal current velocity is inversely proportional to distance from Digby shore, with a 10% change in velocity over the scallop ground (0-30 km from shore).

In the survey area, some thermal stratification may exist since modelled tidal currents are of insufficient strength to result in vertical mixing (Garrett et al., 1978). However, stratification appears to be minimal, as Dr. K. Kranck (pers. comm.) observed only a 0.37 °C difference in temperature between depths in the water column of 2 m and 71 m at a station within the summer closure zone in August, 1977. She also observed that suspended material was highest inshore and decreased with distance off the Nova Scotia shore.

2) Growth parameters

As with the scallop meat yield at size relationship, survey samples collected in 1977 to 1979, inclusive, were used to calculate von Bertalanffy growth parameters for the scallop grounds specifically off Digby, Nova Scotia. Previous studies (Jamieson and Lundy 1979; Jamieson et al. 1980) utilized growth parameters calculated for scallops from depths <110 m for the Bay of Fundy as a whole. Revised parameters for the areas surveyed are:

	Inside the closure zone	Outside the closure zone
L_∞(mm)	145.440	134.890
W_∞(g)	42.331	21.012
K	0.217	0.231
t_o	0.530	0.556

W_∞'s were determined by using the corresponding L_∞ in the above respective meat weight:shell height regressions (Fig. 5).

3) Population age structure

In all locations but off Digby Gut (Tables 7 and 8), the modal age classes present were seven (1973 year-class) or eight (1972 year-class) year old scallops. This supports the 1979 observations (Jamieson et al. 1980) which suggested that the 1974 and 1975 year-classes were relatively abundant. In contrast, the modal age-class in 1980 off Digby Gut was six (1974 year-

class) year old scallops, a year-class poorly represented in this stratum in 1979. As the fishing location closest to port, this stratum experiences considerable fishing pressure, and so the relative depletion of the older, 1973 year-class was expected. However, the occurrence of large numbers of six-year old scallops was unanticipated on the basis of 1979 observations (Jamieson et al., 1980). Fishermen also did not observe high densities of this scallop age-class prior to the fall of 1980 (W. Halliday, pers. comm). Whether their relatively sudden occurrence in quantity (this age-class was the mainstay of the fishery in the fall of 1980) was the result of the coalescing of a previous more diffuse distribution, or the immigration of scallops into this area en masse from a previously unsurveyed location, is unknown at this time. Fishermen feel strongly that scallops are capable of micromigrations en masse, but this phenomenon has not been documented in the scientific literature.

YIELD PER RECRUIT

Bay of Fundy scallop Y/R data (Jamieson et al., 1980) has been revised so that separate Y/R calculations are now available for Bay of Fundy scallops in the area surveyed from both within and outside the six-mile (9.7 km) summer closure zone. This area has traditionally provided most of the scallops fished in Bay of Fundy waters. To preserve a supply of scallops close to port for winter exploitation, no fishing is allowed within the summer closure zone during the generally favourable weather of May to September inclusive. Bad weather often precludes long trips for these relatively small vessels during the winter months.

Within the closure zone, maximum yield per 10,000 recruits (Fig. 6), 139 kg, is achieved at F = 1.4 and age of first exploitation of 9 years. With the revised yield and growth parameters, this corresponds to a 122 mm scallop, which has an average meat yield of 24 g. This would be achieved on average by an 18 meat count/lb (21 meats/500 g).

In the survey area outside the closure zone, maximum yield per 10,000 recruits (Fig. 7), 73 kg, is achieved under the same strategy of exploitation as above ($t_o' = 9$, F = 1.4). However, since yield is reduced, this corresponds to a 120 mm scallop with an average meat yield of 15 g. This would be achieved on average with a 30 meat count/lb (33 meats/500 g).

At present, the age-classes most generally exploited are 7-8 year old scallops, and so present Y/R is relatively close to maximum Y/R. However, as was evidenced by the heavy exploitation of 6 year old scallops off Digby Gut, fishermen will preferentially exploit those concentrations of scallops giving the maximum yield per day's fishing. Since young scallops are characteristically more contagiously distributed, the likelihood always exists when a meat count regulation is not present that a year-class of above average abundance will be exploited at an age well below that giving optimal Y/R. This has occurred in the past in both the Northumberland Strait (Jamieson 1979) and Georges Bank (Caddy and Jamieson 1977) scallop fisheries.

CONCLUSIONS

Scallop landings by the inshore scallop fleet during 1980 were for the third consecutive year well above the long-term average of 325 t (Jamieson and Lundy 1979). In contrast to previous years, in which landings were high due to extensive exploitation of non-Bay of Fundy scallops (1978: Georges Bank; 1979: Scotian Shelf), scallop yield in 1980 from the Bay of Fundy itself was well above average (Table 4). This was the result of both the discovery of new scallop concentrations just inside the boundary of the Bay of Fundy (off Briar Island, N.S.) and the occurrence of a dense concentration of young scallops off Digby Gut. Both scallop concentrations have since been largely depleted, and so unless new scallop concentrations are found in areas which have not been traditionally fished in recent years, landings can be expected to decline to more traditional levels.

The likelihood of new scallop concentrations being found in the Gulf of Maine and/or Bay of Fundy is probably quite high over the next year or so, as the entire Gulf of Maine appears to have experienced recent above-average scallop recruitment (D. Schick, pers. comm.; unpublished data). Areas which have been known to support a scallop fishery in the past, yet which have not supported a fishery over the past decade or so, now contain significant numbers of scallops. In addition, areas which have never been fished before are also being found to have fishable scallop concentrations. However, the occurrence of scallops on these grounds is likely very sporadic, and so care should be taken not to allow major permanent expansion of the existing fleet if the long-term goal is to maintain acceptable annual landings per vessel. The Bay of Fundy scallop fishery is unregulated as to optimizing Y/R; and while landings are presently above average and meat count is low, historically this situation has not lasted for more than a few years at any one time (Caddy, 1979).

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Table 1. Distribution and average characteristics of unrestricted licenced scallop vessels in the Bay of Fundy.* † = weighted.

	Statistical District	Port	No. Vessels	No. Active	Avg. GVT	Avg. Length	Avg. HP
Nova Scotia	30	Lockeport	1	1	43	63	250
	32	Woods Harbour	1	1	82	64	430
	33	Lower West Pubnico	1	1	78	64	149
		Wedgeport	1	1	30	53	210
	34	Yarmouth	3	3	49	56	264
	36	Meteghan	3	3	34	37	190
		Saulnierville	2	2	59	59	610
		New Edinburgh	1	1	15	38	160
	37	Little River	1	1	86	64	425
		Westport	2	2	55	39	145
		East Ferry	2	2	53	60	377
		Freeport	1	1	36	44	300
		Centreville	1	1	45	49	227
	38	Digby	45	45	51	58	283
	39	Victoria Beach	3	3	30	53	196
	39A	Parker's Cove	1	1	28	61	150
	40A	Canada Creek	1	1	27	42	230
		Total & mean†:	70	70	49.4	55.8	278
New Brunswick	50	Grand Harbour	1	1	30	54	165
		Ingall's Head	1	1	12	42	185
		Seal Cove	2	2	23	45	167
		Woodward's Cove	1	1	20	42	165
		North Head	2	2	33	51	240
		Whitehead	2	2	35	53	265
	51	Lord's Cove	1	0	30	54	325
		Stuart Cove	1	1	15	42	60
		Leonardville	1	1	23	43	120
		Welshpool	1	1	15	43	100
		Wilson's Beach	2	1	18	40	350
		Deer Island	1	1	31	53	325
	52	St. Andrews	1	1	13	39	125
		Back Bay	3	2	19	42	160
	53	Little Lepreau	1	1	22	43	115
		Beaver Harbour	1	1	13	43	165
		Total & mean†:	22	19	22.7	45.6	199

*Source: Scotia-Fundy Licensing Unit, Field Services Branch, Halifax, N.S.

Table 2. The commercial effort distribution (%; 1979, and January to May, 1980, inclusive) and number of assigned stations (n) by stratum and substratum. * = inshore substrata.

Substrata (mi from shore)	Strata							
	Centreville (1)		Gullivers Head (2)		Digby Gut (3)		Delaps Cove (4)	
	%	n	%	n	%	n	%	n
1-2*					0.2	2		
2-3*	0.2	3	2.7	4	4.6	6	0.5	0
3-4*	0.0	1	0.7	1	10.8	8	2.9	2
4-5*	0.0	1	1.7	3	14.9	14	3.3	2
5-6	0.0	1	0.2	1	25.3	16	4.7	4
6-7			2.9	5	18.6	1	0.3	5
7-8				1	0.8	1		1
8-9					0.8	2		
9-10					2.7	1		
10-11					1.2	0		
Totals:†	0.2	6	8.2	15	79.9	51	11.7	14

†An additional nine and eight stations were located between strata 2-3 and 3-4 respectively, and one station was located in Annapolis Basin.

Table 3. Average scallop ages, meat sizes, and meat counts by month and year for commercial landings in Digby, N.S.

MONTH	AGE (yr) AVG	AGE (yr) SE	WEIGHT (g) AVG	WEIGHT (g) MIN	WEIGHT (g) MAX	WEIGHT (g) SE	MEATS/ 500 g	SAMPLE SIZE	COMMERCIAL LANDINGS (t)
A. Year = 79; Port - Digby Total MT WT landed = 708 (t) Total MT WT measured = 166.69 (kg) or .02355%									
Jan.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	4
Feb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	-
Mar.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	19
Apr.	7.9	0.2	17.9	5.6	33.7	0.5	27.9	78	66
May	6.4	0.0	13.5	2.6	35.0	0.1	36.9	2527	61
June	5.9	0.0	11.8	1.2	52.7	0.1	42.5	2111	39
July	5.9	0.0	12.1	2.9	73.7	0.1	41.2	4286	25
Aug.	6.7	0.0	14.5	1.8	38.6	0.1	34.5	2351	28
Sept.	7.7	0.2	16.7	5.3	47.1	0.3	29.9	440	30
Oct.	9.9	0.4	20.6	6.5	86.4	0.6	24.3	339	34
Nov.	11.3	0.4	21.8	5.2	44.4	0.5	22.9	374	115
Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	21
Total*	6.5	.02	13.45	1.2	86.4	0	37.2	12396	442
B. Year = 80; Port - Digby Total meat landed = 823 (t) Total meat measured = 233.24 (kg) or .02831%									
Jan.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	5
Feb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	7
Mar.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	28
Apr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	55
May	7.7	0.1	16.8	5.8	40.3	0.2	29.7	648	128
June	7.5	0.1	16.5	3.4	43.7	0.1	30.4	3646	38
July	6.8	0.0	14.5	2.4	41.0	0.1	34.4	4475	76
Aug.	7.1	0.1	15.5	2.5	79.4	0.1	32.4	3607	80
Sept.	8.6	0.1	17.9	1.7	83.7	0.2	27.9	1854	168
Oct.	17.0	0.7	26.0	5.6	60.2	0.7	19.2	329	151
Nov.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	35
Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137	32
Total*	7.6	0.0	62.0	1.7	83.7	0.1	31.2	14696	803

* Weighted mean

Table 4. Landings (t meat) and value ($\$10^{-3}$) by the Bay of Fundy scallop fleet in 1979-1980 inclusive.

Area	1978	1979	1980
Bay of Fundy	482.9	442.0	823.0
Georges Bank	262.0	3.3	-
Scotian Shelf	4.8	440.7	31.0
(Browns)	(4.8)	(172.5)	
(German)	-	(268.2)	(4.0)
(Lurcher Shoal)	-	-	(27.0)
Total	749.7	886.0	854.0
Avg price/kg	4.83	6.92	8.09
Total value ($\$10^{-3}$)	3621	6131	6909

Table 5: Monthly scallop landings (t /meat) from Bay of Fundy waters in 1978 - 1980 inclusive.

	Annual Landings (t)		
Month	1978	1979	1980
January	2	4	5
February	12	-	7
March	21	19	28
April	94	66	55
May	33	61	128
June	13	39	38
July	67	25	76
August	45	28	80
September	54	30	168
October	106	34	151
November	27	115	35
December	7	21	32
Total	490	442	803

Source: W. Halliday, Statistics Officer, Digby, N.S.

Table 6. Estimated amplitudes of the M_2 (principal lunar constituent) component in tidal current calculations [determined by B. Petrie (Coastal Oceanography, Bedford Institute of Oceanography, Dartmouth, Nova Scotia) using Greenberg's (1978) numerical tidal model].

	Distance (km) off Digby, N.S.	Depth (m)	M_2 amp. (cm/sec)	Length of major axis (km)
N.S. shore:	0-7.4	67	92	13.1
	7.4-14.8	84	92	13.1
	14.8-22.2	98	87	12.4
	22.2-29.6	95	84	12.0
	29.6-37.0	104	79	11.2
	37.0-44.4	98	73	10.4
	44.4-51.8	94	69	9.8
	51.8-59.2	67	65	9.3
N.B. shore:	59.2-66.6	21	61	8.7

Table 7. Mean inshore catch at age by strata of a 7-gang Digby drag, projected from an end, unlined bucket's catch in 1980. Estimated area per tow is 2919 m^2, and recruits are scallops older than age three.

Age (yr)	Estimated number at age				
	Centreville	Gullivers Head	Digby Gut	Delaps Cove	Between Strata
2	0	1	0	0	0
3	0	0	1	0	2
4	8	1	28	5	31
5	25	16	43	13	36
6	41	26	61	35	60
7	94	23	22	38	22
8	67	50	35	46	24
9	47	48	33	30	32
10	30	35	24	19	18
11+	14	52	42	34	37
No. stations	5	8	21	5	7
Total recruits	326	252	287	220	261
Avg. density* recruits per m^2 in 1980.	2.23	1.73	1.99	1.51	1.81

*Weighted by the gear selectivity and efficiency values in Table 6, Jamieson et al. (1980).

Table 8. Mean offshore catch at age by strata of a 7-gang Digby drag, projected from an end, unlined bucket's catch in 1980. Estimated area per tow is 2919 m^2, and recruits are scallops older than age three.

Age (yr)	Estimated number at age				
	Centreville	Gullivers Head	Digby Gut	Delaps Cove	Between Strata
2	-	0	0	0	2
3	-	0	22	0	5
4	-	1	16	5	7
5	-	3	50	24	33
6	-	23	71	19	59
7	-	67	28	42	29
8	-	104	30	62	41
9	-	71	32	35	38
10	-	16	22	12	22
11+	-	19	32	16	45
No. stations	-	4	5	5	9
Total recruits	-	304	281	215	274
Avg. density* recruits per m^2 in 1980	-	2.08	1.94	1.48	1.88

*Weighted by the gear selectivity and efficiency values in Table 6, Jamieson et al. (1980).

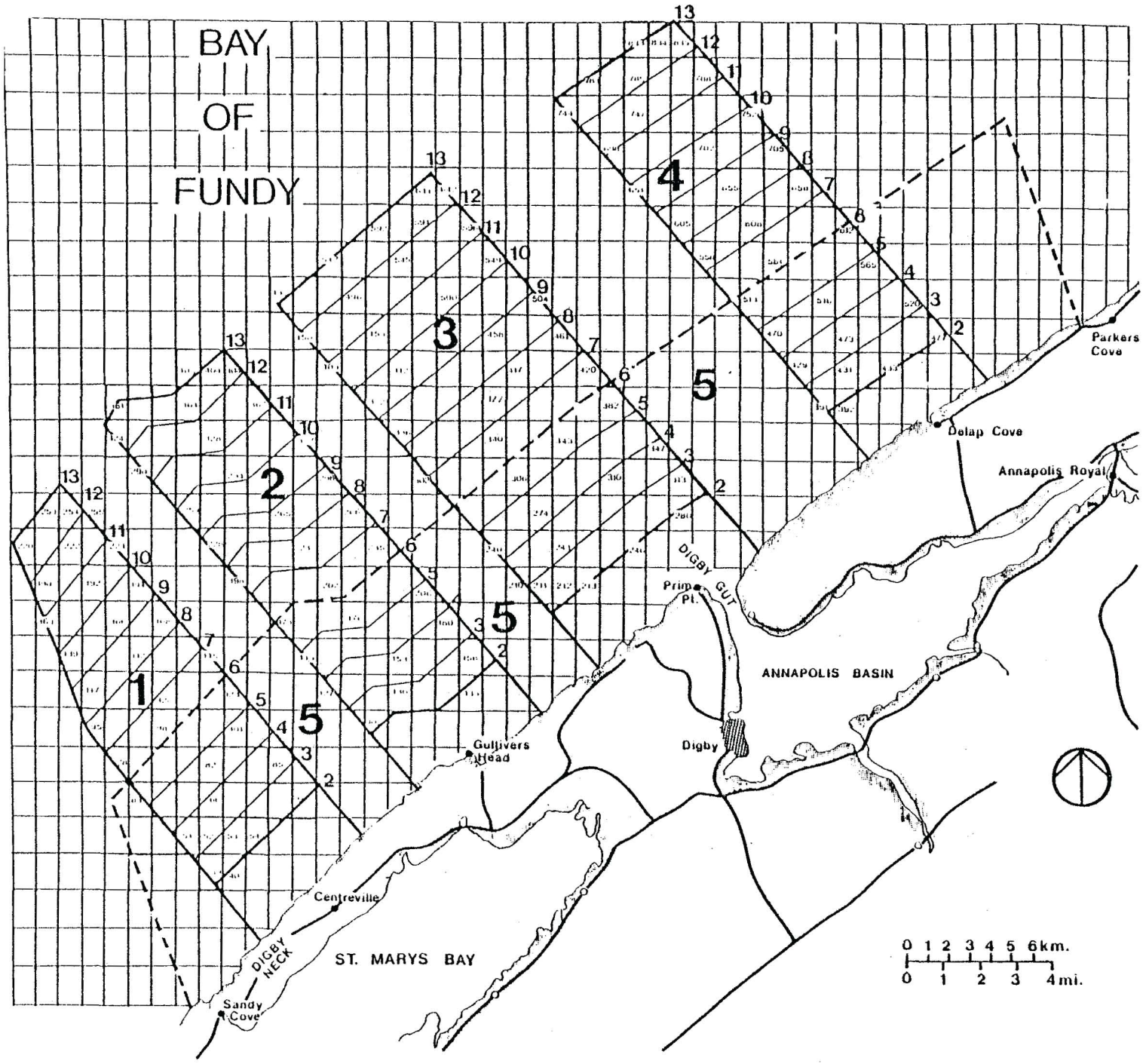

Figure 1. Scallop unit survey areas (small type numbers) in the Bay of Fundy off Digby, N.S., and their location relative to strata (large type numbers) and substrata (medium type numbers). Unit areas were assigned to the stratum and substratum in which was located 50% or more of their area.

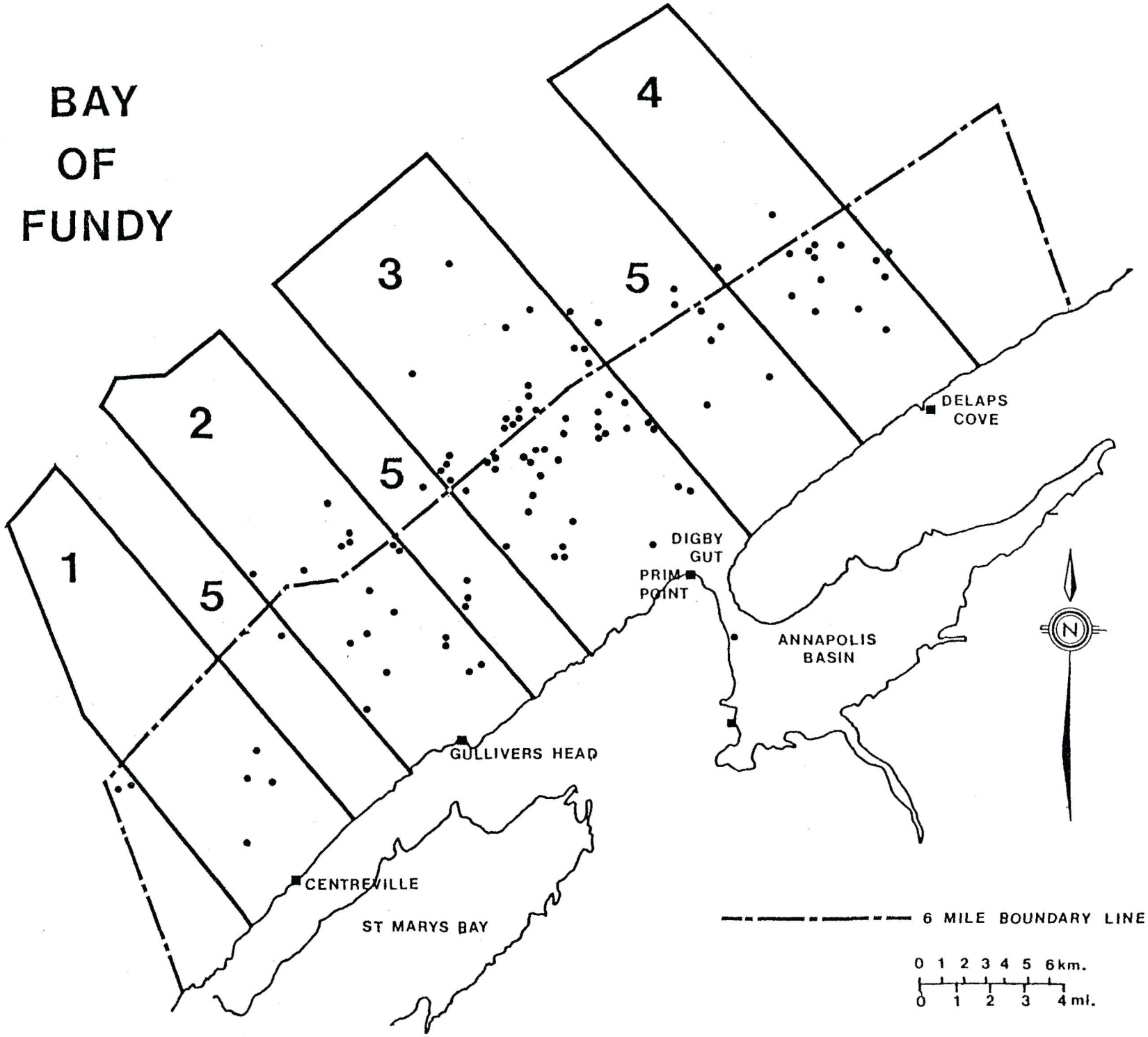

Figure 2. Survey station location (•), weighted by commercial effort distribution, in the 1980 scallop resource survey in the Bay of Fundy off Digby, N.S.

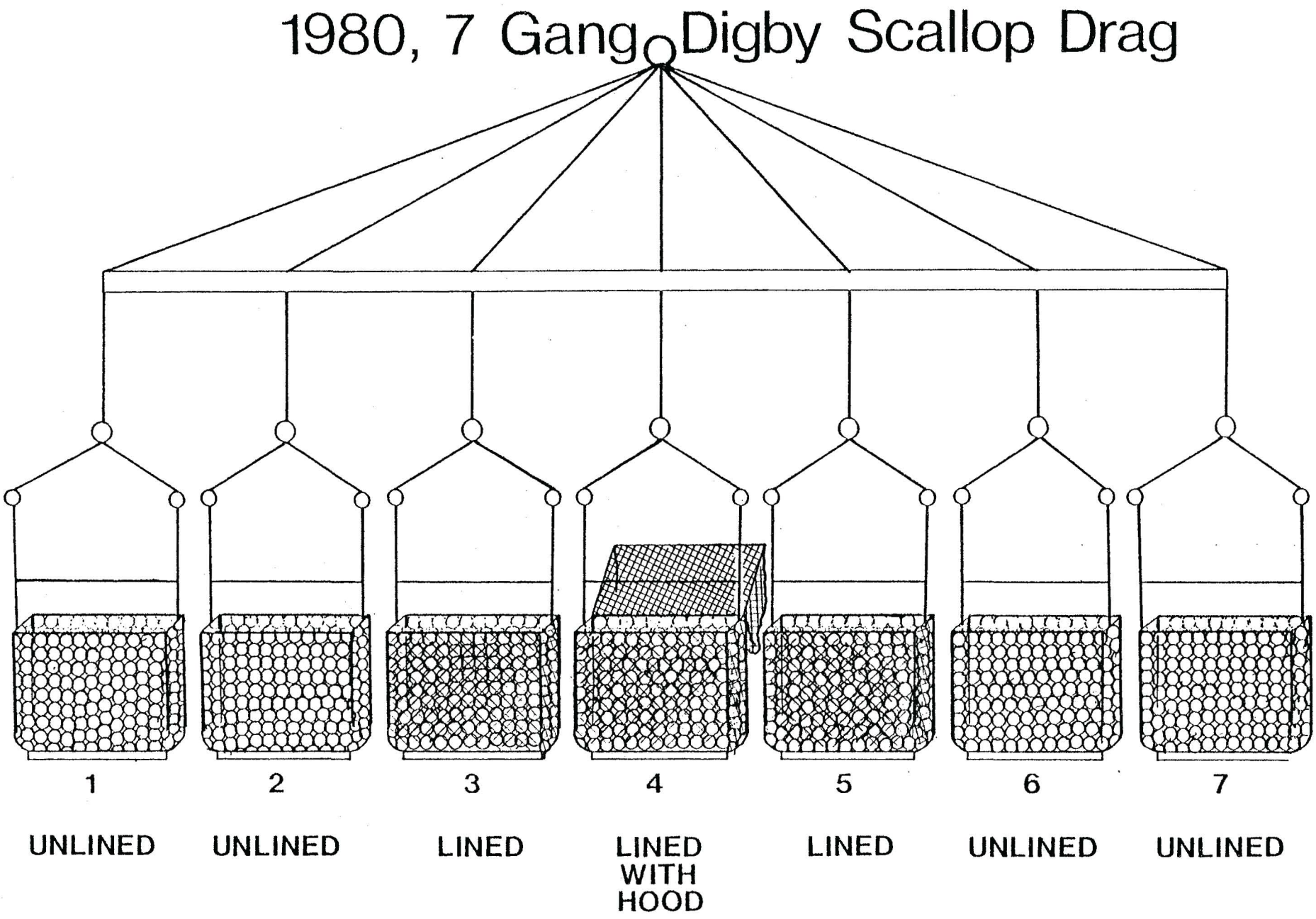

Figure 3. Scallop gear design used in the 1980 Bay of Fundy scallop survey.

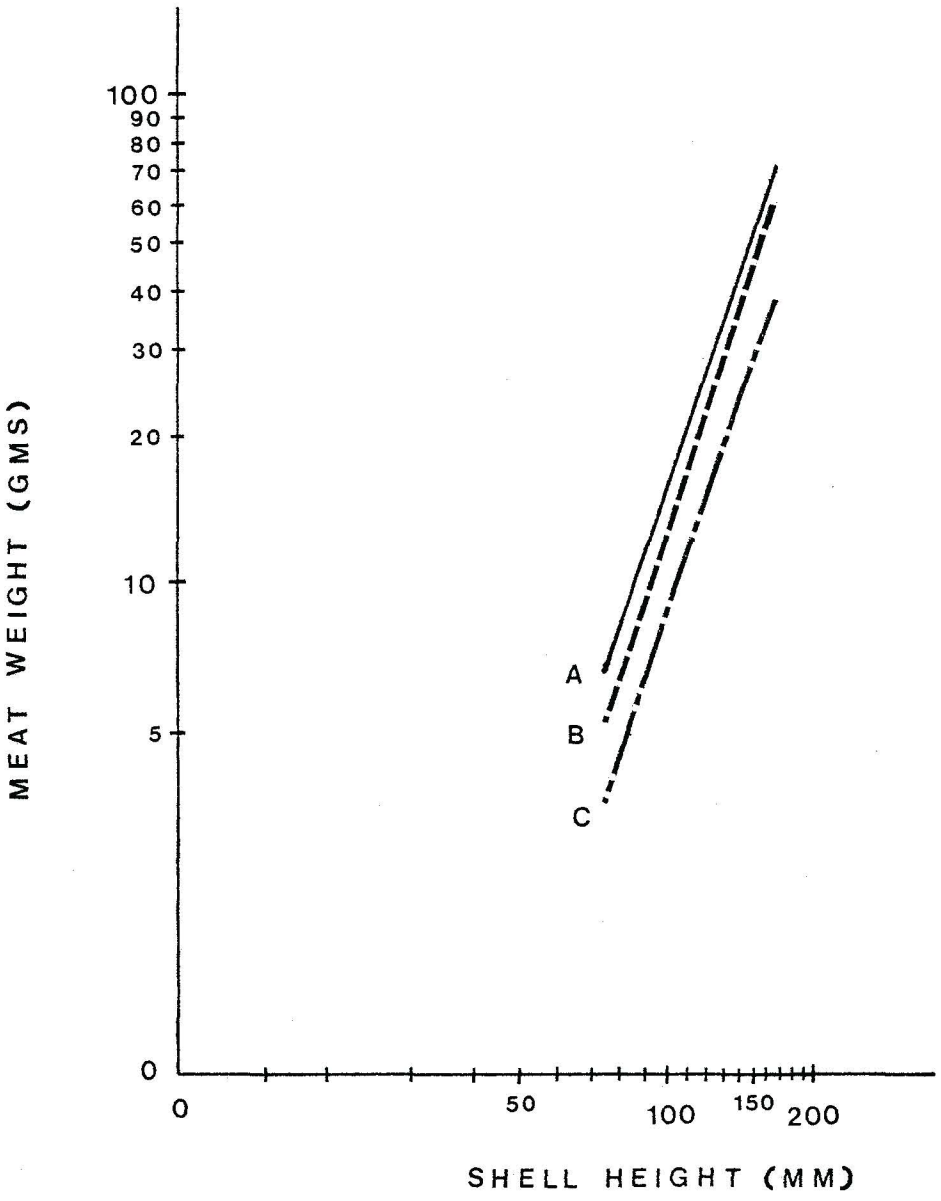

Figure 4. Meat weight-shell height relationships for A) Georges Bank scallops; B) scallops inside the six-mile closure line off Digby, N.S.; and C) scallops outside the six-mile closure line off Digby, N.S. Bay of Fundy scallop samples are from scallop resource surveys between 1978-1980 inclusive. Regressions are:

A: $\ln(w) = -10.8421 + 2.949 \ln(h)$
B: $\ln(w) = -12.367 + 3.237 \ln(h)$
C: $\ln(w) = -11.299 + 2.925 \ln(h)$

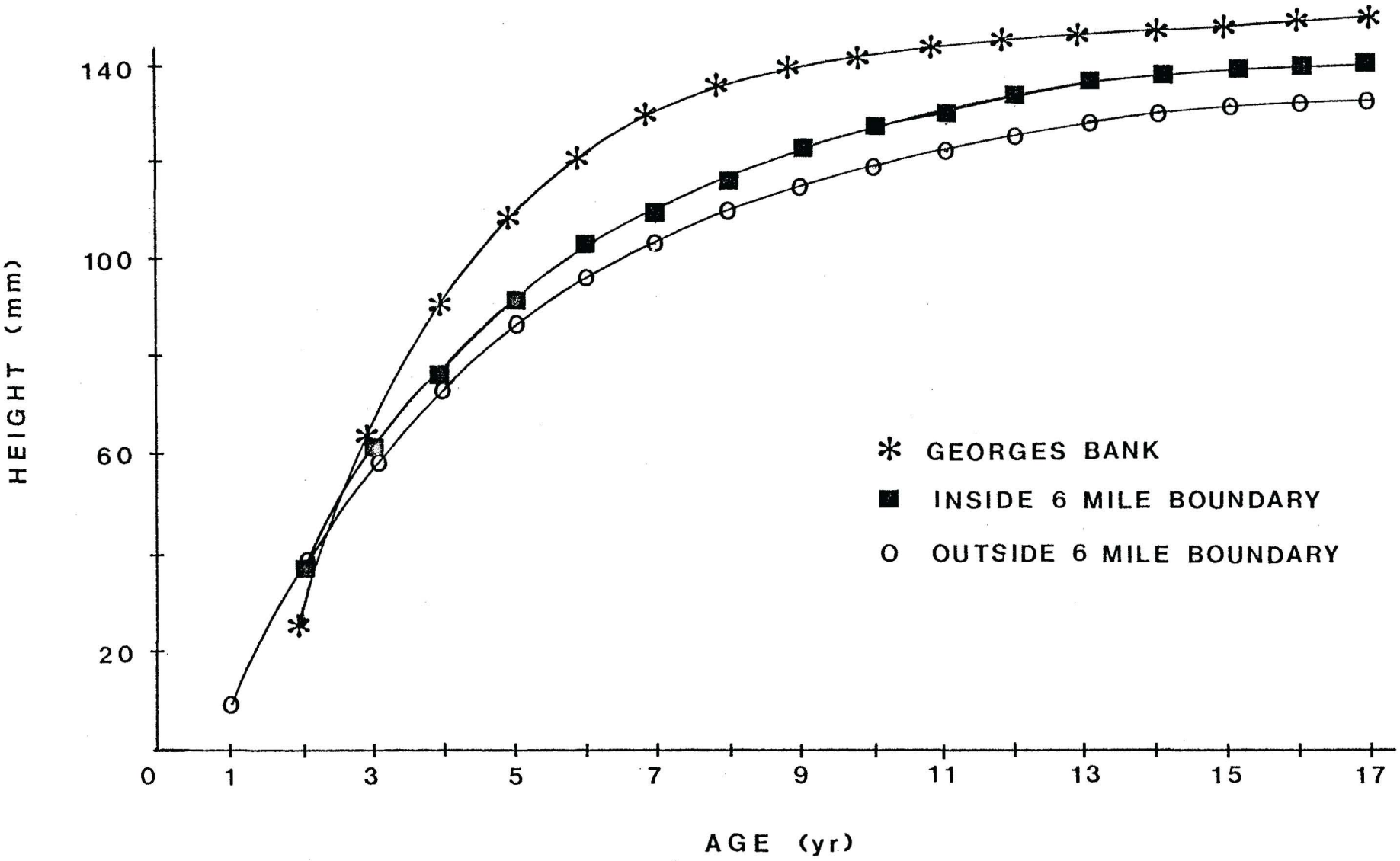

Figure 5. Von Bertalanffy growth curves for scallops from Georges Bank, and from inside and outside the 6-mile closure line off Digby, N.S: *: $k = .38$, $t_0 = 1.5$, $L_\infty = 145.4$; ■: $k = .2.7$, $t_0 = 0.53$, $L_\infty = 145.4$; O: $k = .23$, $t_0 = 0.56$, $L_\infty = 134.9$

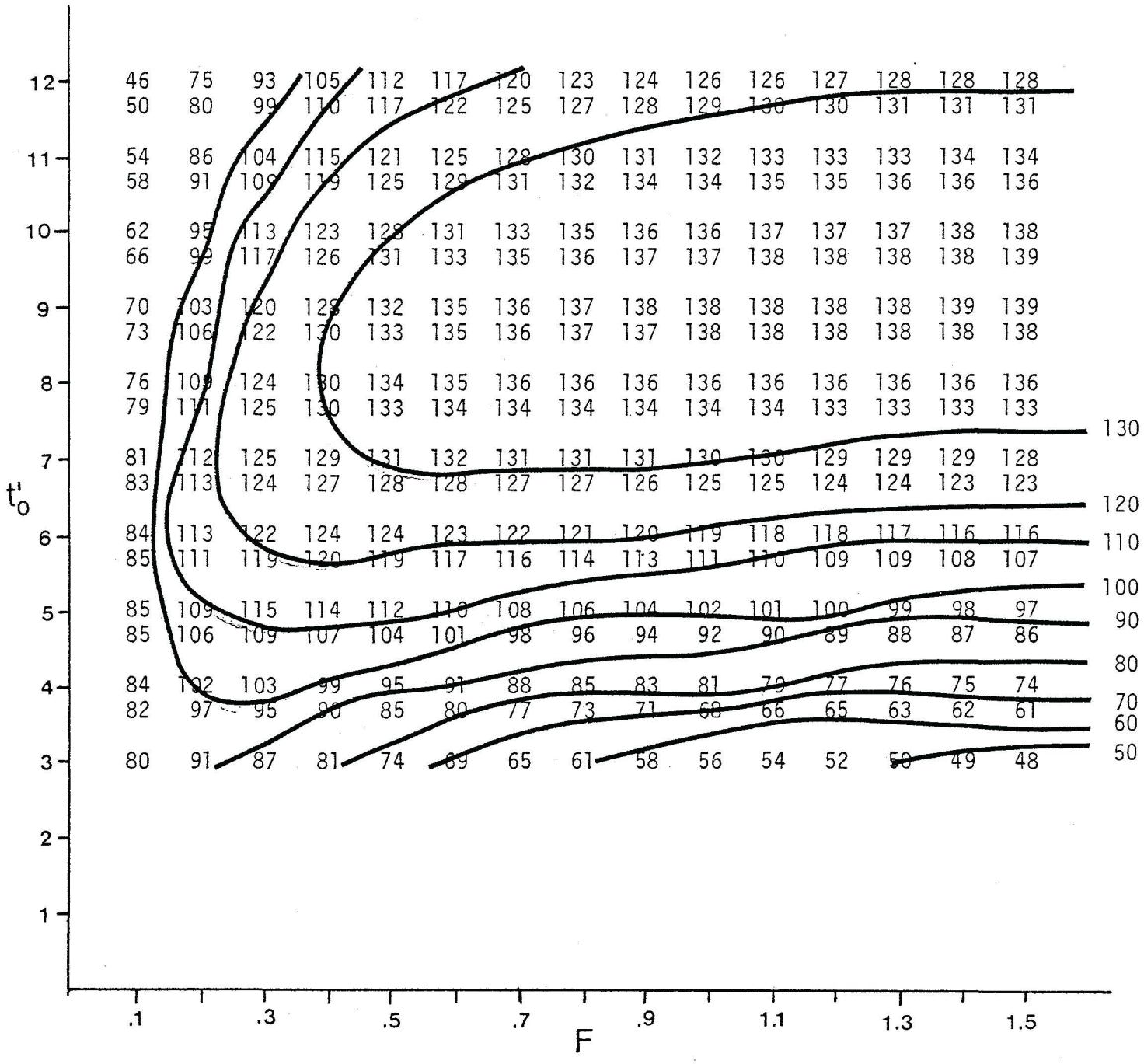

Fig. 6. Yields and yield isopleths (kg) per 10,000 recruits calculated for inshore, Bay of Fundy scallops, from a distance < 6 mi (9.7 km) off Digby, N.S., based on M = 0.1 and the von Bertalanffy growth parameters presented in the Figure. t'_0 = age (years) of first capture; F = fishing mortality.

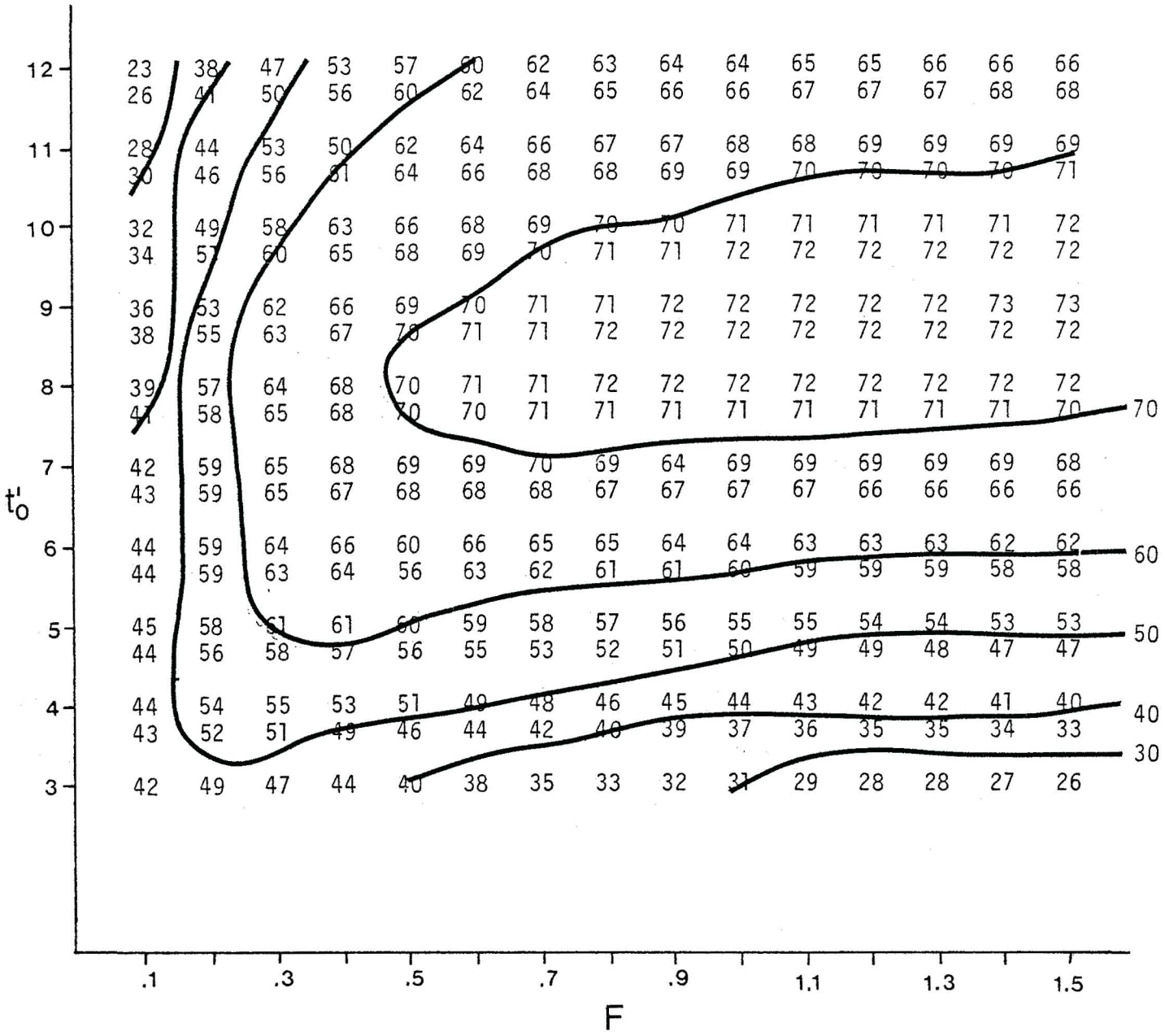

Fig. 7. Yields and yield isopleths (kg) per 10,000 recruits calculated for offshore, Bay of Fundy scallops from a distance of > 6 mi (9.7 km) off Digby, N.S., based on M = 0.1 and the von Bertalanffy growth parameters presented in the text. t_0' = age (years) of first capture; F = fishing mortality.