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Scallop Investigations in the Gulf of St. Lawrence
and off Eastern Cape Breton Island 1951.

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With Appendix by L. M. Dickie

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I INTRODUCTION

During the summer of 1951, the writer continued his investigations of scallops, Placopecten magellanicus (Gmelin), in the Gulf of St. Lawrence in the employ of the Fisheries Research Board of Canada. The work was of three sorts. Likely places were explored for new beds, beds discovered in 1949 and 1950 were re-examined and, lastly, the efficiency of small gear hauled by lobster boats was compared with that of Digby-type gear hauled by regular Digby-type draggers. In studying the known beds a good deal of effort was spent in discovering the biological characteristics of their scallop stocks because an understanding of these is required to explain past records and predict future trends.

Lobster boats were hired for testing the efficiency of small gear and the commercial scallop dragger "My Boys" owned by Bertram Polley of Caribou, N.S., was chartered for the period from June 6 to August 6 to aid in all phases of the work. An unfortunate accident marred the progress of the summer's work when the "My Boys" was wrecked by a gasoline explosion at North Sydney on July 27. Extensive damage was wrought to her hull so that she sank almost immediately at the wharf where she was tied up. Two of the crew were seriously injured, and all members of the crew lost practically all their personal possessions. Nearly all the fishing gear and scientific equipment was salvaged although some of it suffered damage from a three-day submersion in salt water. Most of the field records of the investigation up to the time of the explosion were recovered in a usable condition but many water temperature records, water salinity samples and meat yield records, and some scallop samples and data pertaining to population studies were lost.

The hauls made are grouped in series that are labelled "I" to "O", sequential to the labelling of last year's series, "G" to "K".

II EXPLORATION OF NEW AREAS

Compared with 1949 and 1950 a relatively small amount of time was spent in exploring new areas in 1951. A Digby-type scallop dragger, "My Boys", and lobster boats were hired for this work. "My Boys" was used with her Digby-type gear on three areas. The first was discovered by the industry in 1950 and fished in the autumn of that year and the spring and summer of 1951. It lies east of Pictou Island halfway between Cape Bear, P.E.I., and Arisaig, N.S., and is referred to as the "Pictou Island East Bed". The other two new areas were off St. Anne Bay and Big Bras d'Or Harbour. Lobster boats and light gear were used to explore four

new areas, three of them off Cape Breton Island, N.S. (Port Morien Bay, New Waterford and Lingan), and the other off Caraquet, N.B.

1. Pictou Island East Bed

Some of the dragging in this general region (Figs. 1 & 2) covered areas explored in 1949 and 1950 (See earlier reports). Scallops were found over quite an expanse of bottom but at the time of the exploration they were not sufficiently concentrated anywhere to encourage commercial dragging although this had been going on until then. There was evidence of a 1951 mass mortality which affected about 50% of the scallops. If this had not taken place, profitable fishing would likely have continued beyond July (Table 4).

2. Off Big Bras d'Or and St. Anne Bay

Dragging was done here (Fig. 4) because we received reports from fishermen that numerous scallops had been taken on hooks and lines of cod trawl set there and from Mr. Harold Westhaver of North Sydney that he had made good hauls with a scallop dragger there in the fall of 1950. Except for one small spot the yield was less than two bushels (10 lbs. of meats) per 15-minute haul. This spot was to the south of Ciboux Island and identified as N 19 in Figure 3. The landmarks here are numerous and excellent, and since the visibility was always good, it was thus definitely established that this spot was shorter than the distance normally covered in a 15-minute drag, and much narrower. The extreme scarcity of scallops in the hauls made in the immediate vicinity of station N 19 confirmed the belief that the bed was extremely small and of little value commercially. In general, then, the areas off Big Bras d'Or and St. Anne Bay seem to have nothing to offer.

3. Other Areas

Areas off Port Morien Bay, Lingan and New Waterford, all in Cape Breton Island (Fig. 4), and off Caraquet in New Brunswick (Fig. 5) were explored because we had seemingly reliable reports from cod and lobster fishermen that scallops were present there in greater than ordinary numbers. Since only a few scallops were found even in the best 15-minute hauls (Figs. 4 & 5), no comment is required except that there is no evidence of commercial concentrations of scallops in these areas.

In correspondence with the writer Mr. Lloyd Dickie stated that on August 21 & 24 the M. B. "Mallotus" took scallops "in large numbers" off Cape John and Amet Shoals in Northumberland Strait (Positions marked A & B in Figure 1) in hauls with a flounder drag equipped with rollers. An unsuccessful search for beds in this area was made in June 1951 by the scallop dragger "Bonnie K." skippered by Mr. Seldon Heighton of River John and following Dickie's report similar fruitless attempts were made by other commercial fishermen. From these efforts we conclude that

commercial quantities are probably not present in the area although minor concentrations may be present.

III STUDIES OF KNOWN BEDS

During the summer, scallops from various samples were measured individually to obtain statistical information regarding the size composition of the scallops on the various beds under study. The measurements, generally made "on the spot", involved the heights of the upper shells. Height in this sense designates the greatest distance between the hinge and the opposite curved edge of the shell measured at right angles to the hinge. The measurements were recorded in the field by punching celluloid strips held on a measuring board (See Dickie 1951, p. 4 and Fig. 7). The measurements in 5 mm. groups were later translated and used to plot the histograms in Figures 6 to 29. In these plottings frequencies for intervals 67.5 to 72.5 were plotted as 70, 72.5 to 77.5 were plotted as 75 and so on (See Figure 6). Samples were taken with standard-mesh Digby drags to see what the present commercial possibilities were and with a small-mesh drag. The latter was designed to take small scallops the abundance of which might indicate future possibilities.

1. With Standard Gear

(1) Pictou Island East Bed. The scallops on the part of this bed that was fished commercially in 1951 (Figs. 6 to 8 and 19 to 21) had a modal height of 95 mm. (3.8 in.) with 96% of the catch falling between 90 and 105 mm. (3.6 to 4.2 in.) When the test dragging was done only the northwestern portion of the bed (Figs. 1 and 2) had concentrations that were dense enough to warrant commercial exploitation (2 bushels or more per haul).

The size composition on other parts of the bed varied considerably. Before fishing in the area was abandoned fishermen had detected differences in size composition of the scallops in different parts of this bed even without measurements and these showed up clearly in our samplings. For example, the scallops in haul L21 (Fig. 7) showed two modes, one at 80 mm. (3.2 in.) and another at the usual 95 mm.. In L 29 (Fig. 8) there was only one size class with a mode at 90 mm. (3.6 in.) and 97% of the stock ranged from 85 to 100 mm. (3.4 to 4.0 in.). These examples are quoted to show how hard it is to describe the average size of scallops on a particular bed precisely even when the scallops are all of the same year class as we believe these to be. Evidently there are great place-to-place differences in growth rate.

(11) Pictou Island West Bed (Referred to previously as "Pictou Island Bed"). The modal size for scallops taken on this bed (Figs. 9 to 14) was 95 to 100 mm. (ca. 4.0 in.). The corresponding values in 1949 and in 1950 were 77.5 (3.1 in.) and 85 mm. (3.4 in.) respectively (Chiasson 1949 and 1950). The numbers

taken were not great even where the scallops were most concentrated.

(iii) Richibucto Bed. Figures 22 to 26 describe the stock on and about this bed. Figure 22 representing stocks from near the main bed shows a small size class of young scallops and a much larger class of old scallops. The catches made on this particular spot contained so few scallops that it is hard to pick out a modal size from the frequency polygon.

Figures 23 and 24 show that on the bed itself there was little place-to-place variation in size composition. The modal height at that time (July) was 85 mm. in one and 80 mm. in the other suggesting less variety in growing conditions than is met with in the two previously-mentioned areas.

2. With Small-Mesh Gear

On some beds efforts were made to obtain samples of scallops too small to be retained in standard, Digby-type drags and for this purpose a special small-mesh drag was used. Its frame was of the standard Digby type, but the bag was made of chain and wire links instead of the usual rings and washers. This drag was heavy and awkward to handle, and, as will be shown below, had a lower efficiency than the standard in sampling the larger stock. It did, however, take many more of the smaller sizes when they were present but there is no means of telling what proportion of these it captured. Its catches may be considered as providing a minimum estimate of the number of small relative to the number of large scallops.

(i) Richibucto Bed. Several tows were made with the fine-mesh drag here and the catches were measured. Unfortunately the records of these were lost in the explosion but the writer has a clear recollection that so far as size composition was concerned they were identical with those for standard gear (Figs. 22 to 26).

It was quite clear that there were no scallops on the bed that were small enough to escape the standard gear.

(ii) Pictou Island East Bed. In size-composition the catches with the small-mesh drag on this bed were identical with those taken in the toothed or toothless Digby-type or the Charlotte County-type drags (Figs. 19 to 21). This is taken as evidence that there are no small scallops on this bed.

(iii) Pictou Island West Bed. In contrast with the above, the size composition in hauls with the small-mesh drag on the Pictou Island West bed were very different in some respects from that in catches with the standard gear (Figs. 9 to 14).

The live scallops taken by Digby drags in haul L 35 (Fig. 11) showed a range of 75 to 110 mm. and a mode at 95 mm. The small-mesh drag passed over the same amount of ground and took large numbers of small scallops (Fig. 12). They constituted 74% of the total catch by count. The modes were at 40 and 95 mm. respectively.

3. Comparison of Catches by Standard and Small-Mesh Drags

As pointed out above the small-mesh drag will take small scallops that are not retained by standard drags.

There is a second characteristic which shows up very well in Table 1 because there are no small scallops on the Richibucto bed to complicate the picture. The catch of large scallops by small-mesh drags is far below that by the standard mesh.

Table 1. Catches by the single small-mesh drag compared with catches of several standard drags on the Richibucto bed.

Haul No.	Standard Drags			Catch per drag (bu.)	Single small-mesh drag catch (bu.)
	No.	Type	Pooled catch (bu.)		
M 34	5	toothed	3½	2/3	1/8
M 35	5	"	5	1	1/8
M 36	5	"	4	4/5	1/8
M 37	5	"	1½	1/3	1/8
M 38	5	"	2¾	½	several by count
M 46	(3	"	2½	5/16	Nil
	(2	Digby-type	3/8	3/16	
M 47	(3	toothed	2	2/3	½
	(2	Digby-type	1	½	

It is interesting to speculate on the cause for this. The lower efficiency of the small-mesh drag could result from a sagging of the upper surface of the heavy bag which could reduce the effective size of the mouth. The drag therefore might bulldoze a high proportion of the scallops out of its way instead of capturing them.

Conceivably a small-mesh, light, twine net placed inside a regular bag such as Stevenson (1936) arranged might be a better device than the one used here. Such a gear might sample the small stock just as effectively and at the same time yield catches of larger scallops that approximate those of standard drags much more closely.

An alternative explanation for the smaller catch of large scallops by the small-mesh drag might be that the bag allows no trash to escape and quickly fills and thereafter can do nothing but bulldozing. In the end it will have a lower catch than standard drags whose larger mesh strain out only the larger items that enter them.

The small-mesh drag has a third interesting characteristic. In spite of its failure to take many large live scallops compared with the standard, it seemed to take "cluckers" (paired empty shells still attached by the hinge) almost as well.

4. Comparison of Toothed and Toothless Drags

Table 1 suggests that toothed drags take heavier catches than toothless on the Richibucto bed. The data are few but are worth mention since last year's records for the Pictou Island West bed (Chiasson 1951, p. 17) indicated that the reverse was true. These observations and others made this year suggest that the relative efficiency of the two types changes with bottom characteristics.

5. Growth Studies

Knowledge of growth rates is important along with information on size composition of stocks in predicting the commercial prospects for any bed. For this reason much time was spent in studying growth. Many of the data assembled were lost in the explosion but several were saved.

Growth curves for Richibucto, Pictou Island East and Pictou Island West bed scallops were obtained by measuring distances between successive shell annuli (growth rings or winter rings) of samples from each bed, and plotting the averages of these against a time scale (Figs. 31 to 33). Since the scallops on the two first-named beds belong to a single year class or virtually so, a single year class had to serve as a basis for these growth rate determinations. The writer still has doubts about the accuracy of the position of the first annulus in some instances, but this does not seriously affect the usefulness of the curves for prediction because for this purpose the upper parts of the growth curves only are referred to. If our main interest were in the life history of scallops in these areas, this uncertainty of the true age might be more upsetting.

The size characteristics of the hauls made on the Richibucto bed in 1951 and reported under "Studies of Known Beds with Standard Gear" are of interest by themselves but they assume greater importance when they are compared with similar data obtained in 1950 on this same bed. Such a comparison has been made in Figure 29 for the stocks on a rocky ledge to the northwest of the main concentration of scallops. A similar comparison of the stocks on the bed proper is made in Figure 28. The shift in the

position of the mode during the year (73 mm. to 85 mm.) suggest that a growth of 12 mm. took place. This accords with the photographs (Fig. 30) that show a margin of shell beyond the last annual ring of approximately this width and with the results of growth studies based on annual rings.

Another interesting comparison is afforded by Figure 27 in which there is a superposition of histograms for samples taken from the same spot close to a fixed marker buoy on July 9 and 10 and August 31. The mean heights were 83.5 mm. and 85.4 mm. respectively, indicating an increase in height of 2.4 mm. in slightly over 7 weeks. This sort of growth might be reasonably expected from the results of the study of shell annuli.

A comparison of the growth rates of scallops of different year classes on the Pictou Island West bed (Fig. 33) suggests that there is a considerable difference in the size scallops attain in their first year and that this difference is maintained in subsequent years but not exaggerated. Because of this variation, the smallest scallops of one year class are apparently sometimes smaller than the largest of the next succeeding year class (Fig. 32). Dickie (1951) has discussed these year-to-year variations in mean size of the one-year-olds and the within-year-class variation of individuals and has suggested reasons for them.

6. Mass Mortalities

As in 1950, the extent of mortalities on various beds was estimated from the percentage of "cluckers" in the total catch of cluckers and live scallops combined. From observations made last year at St. Andrews (Medcof and MacPhail 1950) on the lifetime of cluckers, it appears that such mortality estimates must inevitably be less than the total annual natural mortality. The relative abundance of cluckers on various beds is shown in Table 2 but not by the Figures (graphs) referred to. The graphs are intended to show only differences in the size-composition of samples of live scallops and cluckers - not their relative abundance.

(1) Pictou Island East Bed. The percentage of cluckers on this bed was 21% (Table 2). According to reports of fishermen who worked this bed in 1950 and 1951 a mass mortality occurred there in the autumn of 1950. If the cluckers taken in our 1951 catches resulted from that mortality then the results of the tank studies on the lifetime of cluckers certainly cannot be applied directly to field observations in estimating natural mortalities for two reasons: (a) The lifetime of cluckers in tanks and on natural beds seems to be different; (b) Commercial fishing is selective in that it removes live scallops but returns cluckers and thereby changes the value of the ratio we wish to measure. Fishermen almost invariably separate the two shells in the process of shucking scallops and these are returned to the beds. Their operations do not therefore add directly to the actual numbers of

Table 2. Percentage of cluckers on several beds in the Gulf of St. Lawrence judged from catches in 15-minute tows with standard drags.

Fishing Area	Haul No.	Fig. No.	No. Live Scallops	No. Cluckers	% Cluckers*
Pictou Island East	L17A	-	238	53	
	L18	-	216	73	
	L21	7	175	54	
	L22	-	27	7	
	L42	-	384	67	
	L42A	-	514	73	
	L50	-	346	84	
	L106	20	585	165	
	L107	-	411	130	
	L109	-	560	150	
	L115	21	255	114	
	L116	-	230	77	
	L117	-	350	75	
	L118	-	429	68	
	L119	-	182	57	
L120	-	202	83		
			<u>5104</u>	<u>1351</u>	20.9
Cape Bear	L63	16	120	97	
	L64	17	27	33	
	L65	-	240	302	
	L67	18	179	287	
	L68	-	82	142	
			<u>648</u>	<u>861</u>	57.1
Pictou Island West	L31	9	140	620	
	L33	10	131	367	
	L36	-	286	821	
	L37	13	183	890	
	L38	14	79	473	
	L40	14	90	875	
			<u>909</u>	<u>4046</u>	82.3
Richibucto	M13		476	11	
	M20		991	57	
	M23		550	9	
	Charlotte Co. drags		1125	67	
			<u>990</u>	<u>70</u>	
			<u>4132</u>	<u>214</u>	5.2

* % Cluckers = $\frac{\text{No. Cluckers}}{\text{No. Live} + \text{No. Cluckers}}$

cluckers present.

(11) Pictou Island West Bed. One day's work on this bed showed that recent mortalities have been severe. The percentage of cluckers (82%) was the highest observed anywhere. The fact that there was no fishing here for the past year suggests that the mortality must have been more than four times as heavy as on the Pictou Island East Bed (21%) where there was a fishery this year.

The data gathered show the great value the results of Medcof and MacPhail's 1950 tank experiment might have if they were applicable in nature. They found that the valves of freshly-killed 85 mm. scallop shells kept in tanks of circulating water, separate in about 25 days. If this were true in nature, the dates of natural mass mortalities could be estimated and other observed phenomena could be causally related to them.

A comparison of the recently dead shells on the Pictou Island West bed in 1951 (Figs 9, 11 to 12) and in 1950 (Chiasson 1951, Figs. 27 to 29) shows very little difference in size composition. In contrast the modal sizes of samples of live scallops are different. It appears that the live scallops have enjoyed a season's growth since the mortality. If the valves of the 1950 dead shells had separated at the rate indicated by Medcof and MacPhail's empirical test, it would be hard to explain these results. It is even doubtful that enough live scallops could have been left to provide for 1951 mortalities of an order indicated by Table 2 if we accept what their results imply - that the mortality occurred in 1951. It would appear that the lifetime of cluckers on natural beds is much greater than in tanks. Concentrated work on this bed could add information of much value on this point.

(111) Richibucto Bed. On the Richibucto bed, there was less evidence of recent mortalities than on any other bed explored. They were much lower than those observed there in 1950. The respective percentage mortalities in the two successive years were 22% and 5%. Two possible explanations of this difference suggest themselves, (1) the toothed Digby-type drags used in 1951 may not pick up cluckers as readily as the toothless Digby-type used in 1950; (2) many of the cluckers present in 1950 may have separated and there may have been no production in 1951 of new ones to replace them.

The first possibility can be eliminated by the fact that 1951 catches with Charlotte County drags (toothless) showed 6% cluckers. They may be reasonably assumed to fish in the same way as the toothless Digby-type drags which were used in 1950 and yielded catches with 22% cluckers. Unfortunately the punched celluloid sheets recording the measurements of the cluckers collected from this bed in 1951 were lost in the explosion before the size-frequency distributions were transcribed. The data that were lost should have indicated certainly whether the 1951 cluckers were of the same size as those taken in 1950 and provided another

check of Medcof and MacPhail's conclusions. As well as the writer can recall the live and dead shells from this bed were of approximately the same size. This would indicate that these shells were from scallops that died in 1951.

(iv) Possible Causes of Mortality. Occasional observations were made during the past summer which are suggestive of the causes of mortalities and these are presented here, inconclusive though they may be, to add to previously reported circumstantial evidence.

(a) Starfish. In 1950, there was a great abundance of starfish all over the Richibucto bed. As many as 1500 were counted in the catch of a single 15-minute six-drag haul. Their numbers frequently approached or surpassed those of the live scallops taken. The counts of starfish were much lower. Typical hauls contained only 200 to 300 starfish. These figures are given from memory because records of actual counts on several hauls were lost in the explosion.

While exploring to find the edge of the bed on the first day's dragging at Richibucto, a heavy concentration of starfish was located about one half mile to the southwest of the main bed. These were not associated with worthwhile quantities of scallops. With the four hand drags that were used on this bed the following counts of starfish were made -- 50 in one 15-minute haul; 128 and 104 in two 25-minute hauls. To make these counts comparable with those made in 1950, they should be multiplied by 1.5 because the total width of the four drags is 10 feet while that of the Digby gear was 15 feet.

High mortalities were associated with heavy concentrations of starfish in 1950 and low with low in 1951. The significance of this correlation is uncertain without further observations on the relationship between starfish and scallops here and on other beds and on other factors contributing to mortality.

(b) Hydrography. In his correspondence, Dickie reports that there were no dead shells present in the catches of scallops made with the flounder drag at depths of 120 to 140 feet at stations A and B (Fig. 1). The beds where we have observed mortalities are at depths of 50 to 100 feet. Dickie suggests that the more uniform temperatures at greater depth may explain the absence of mortality. The plausibility of this suggestion is supported by one surviving series of temperature data listed in Table 3. This seems to establish the thermocline at a depth of about 80 feet. If warm-water flooding of scallop beds is responsible for mass mortalities then deep beds might be expected to show fewer cluckers than shallow beds.

Table 3. Water Temperatures in Northumberland Strait off Amet Shoals August 27, 1951.

<u>Depth</u>	<u>Temperature (°C.)</u>
Surface	17.4
36 ft.	16.0
53 "	14.3
73 "	14.0
75 "	13.75
82 "	12.5
106 "	8.0

Dickie's observations support belief in the hydrographic explanation of mass mortalities only on the assumption that his flounder drag, which was equipped with rollers, had roughly the same relative efficiency in taking live scallops and cluckers as our scallop drags. This point has yet to be established and is open to serious question (See Appendix to this report).

7. Scallop Migrations

Since scallops are fairly motile, one might suppose a priori that they are capable of extensive migrations and occasionally reports come in that seem to support this supposition. For instance -- one fisherman reports having seen schools of scallops swimming at the surface in deep water on the Grand Banks. While no such personal observations have been made in the course of this work, we have obtained evidence that scallops in considerable numbers have moved at least one eighth mile southward on the Richibucto bed between August 1950 and July 1951.

In 1950 the sharply-defined southern boundary of this bed was established much more precisely than any boat compass bearing would permit. This was possible from a landmark (Chiasson 1950). The southern end of the bed was exactly opposite a narrow road on Prince Edward Island. This road has tall trees flanking it in such a way that the road is seen as a narrow slit on the horizon, but only when an observer is on a boat directly opposite it. In 1951, good catches were made an eighth of a mile to the south of this range as well as on it. Apparently the scallops migrated this distance during the year.

8. Commercial Fishing Records

Through the kindness of J. Hewitt of Lower Montague and W. A. Broidy of Pictou, records of daily catches of several boats fishing the Pictou Island East and the Boughton Island beds in 1950 and 1951 were obtained (Tables 4 to 6). These may be compared with those listed by Dickie (1951) for the same areas in earlier years to show trends in the fishery.

Table 4. Daily catches of scallop meat (pounds) on the Pictou Island East bed in 1950 and 1951.

Day of Month	1950				1951									
	Sept.		Oct.		May		June		July					
	#1	#6	#1	#6	#1	#2	#3	#1	#2	#4	#2	#5	#6	#4
1								388	230					
2								349	345		296		146	
3			325	190									192	427
4			128	287					268		171		108	441
5			299	273						94	55			359
6			314	291										
7				280			34		252	114	200			
8							27		198	244			156	
9			268	372					258		213	140		
10				296							212	130	162	
11												81	143	
12				229								105	167	
13			439						347		145		161	
14					257				408			10		100
15					298		18		203		197			
16												135	175	
17				193	221						39	10	29	307
18			345	259	328		29				22	91	150	320
19				279	123	76			239	186	134	74	142	292
20			179	247					335	218				95
21				286					235		23		17	
22	200			246					247					
23				168					245		181	83	90	
24						62						85		
25									319					
26				318	148									
27				329										
28	284	276		377	247				305					
29	359	264							323					
30	382	237							259					
31														

- #1 M. V. "My Boys" - Skipper Bert Polley, 1950; Fred Polley, 1951
- #2 Unnamed boat - Skipper Henry MacMaster
- #3 Unnamed boat - Skipper Jos. Savidant*
- #6 M. V. "Bonnie K." - Skipper Seldon Heighton (Part-time at least)
- #4 M. V. "Robert H." - Skipper Horace Hewitt
- #5 M. V. "Terraplane" - Skipper K. MacDonald

* Jos Savidant's boat fished only two drags. The other five used six most of the time.

Table 5. Daily catches of scallop meat (pounds) on the Boughton Island bed by two boats in 1950.

Day of Month	June		July		August		Sept.		Oct.		Nov.
	#1	#1	#1	#2	#1	#2	#1	#2	#1	#2	#1
1					257						
2					545		310	197			
3						285					367
4							152	190	252	167	
5					647	217	250		45		
6								220			
7							300	160	264	170	
8							217	170	210		
9	100				310						
10	280				80	227					94
11	160	680			310	187					97
12					60	172					
13	240	215			200			105			
14		217								120	
15	75				225	115					
16						205	100	125			
17	470				22	45					
18	49	62			202		132	115			
19					202	135					
20		205			207				234		
21	445								95	60	
22	84	577					165	130			
23	60				80		67				
24					320	115	132	20			
25	332	515			312	145					
26		400			360	175					
27		655				182					
28								165			
29		800						145			
30					115	70		160			
31		420			205	137					

#1 M. V. "Robert H." - Skipper Horace Hewitt
 #2 M. V. "Adventure II" - Skipper Richard Sencabaugh

Table 6. Daily Catches of Scallop meat (pounds) by M. B. "Robert H." on Boughton Island Bed in 1951.

June 27	-	393
" 29	-	409
" 30	-	40
" 31	-	225

It is strange that the crew of the "Robert H." reported that there were "no scallops available" after the four days' catches shown in Table 6. In comparison with 1950 the above catches look very attractive (cf. Table 5 - June 8, 9, 10, 12 under # 1). It may be that some important information about these catches is not available. In any event, the "Robert H." ceased fishing on the Boughton Island bed and from then on dragged the Pictou Island East bed.

9. Prospects for Commercial Fishery

The prospects for a commercial fishery on the known beds may ordinarily be judged from the volume of catches and their size composition as shown by the samplings with the standard and small-mesh gear and from the results of growth and migration studies. Results of migration studies suggest that any mass movements that take place are likely to be of small extent and that we need not concern ourselves with them in making predictions. But we have yet to discover the cause of mass mortalities and have no means of predicting them. Any predictions for the commercial fishery may therefore be vitiated by mass mortality.

(i) Pictou Island West Bed. The Pictou Island West bed was discovered in 1949 and its position described by the author in his report for that year (Chiasson 1949). Its stock has been seriously depleted by recent mass mortalities and it will not be a producer until the new year class of scallops that has appeared grows to fishable size. From the size composition of samples taken this summer (Figs. 9, 10, 13 and 14) and our knowledge of their growth rates (Fig. 32), this will be in 1954 at the earliest. Mass mortalities between now and then could destroy the stock.

(ii) Pictou Island East Bed. The industry discovered the Pictou Island East bed in the fall of 1950. It was intensely fished in September and October 1950 and in June and part of July 1951, and yielded catches of about 300 lbs. per fishing day (Table 4). Towards the end of July catches became so poor that all boats involved abandoned fishing. The fact that there are few small scallops on the bed (Figs. 7, 20 and 21) suggests that this bed is "done" until a new set of seed scallops settles there and grows to maturity. There can be no fishing there for several years to come.

(iii) Richibucto Bed. The Richibucto bed which we discovered in 1950 yielded very good catches in this summer's exploratory hauls but there has been no commercial fishing there yet. It seems likely that a scallop dragger with six Digby-type toothed or toothless drags could average 4 or 5 bushels (18 to 25 pounds of meats) of scallops per 15-minute haul. While the scallops found are still too small to shuck profitably (Figs. 22 to 26), it is expected from what we know of growth rates (Fig. 31) that by 1952 they will be as large as those that were profitably fished on the Pictou Island East bed in 1951 - roughly, 95 mm. (3.8 inches) and that they will be equally or more abundant unless an unusual mortality takes place.

(iv) Boughton Island Bed. Our information on conditions on this bed in 1951 is scanty. We have only the data listed in Table 6 as a guide. Unless there was an unusual mass mortality there in 1951 there should be good fishing again in 1952 although this opinion is not shared by the skipper of the "Robert H."

(v) Summary. Judging from the conditions just described, the outlook for the southern Gulf's scallop industry is not bright. This is the same conclusion we drew from our own earlier experience and from the statistics of the fishery (Chiasson 1951, pp. 14 and 15). The producing areas are small, growth is slow and sets of seed scallops are irregular but, what appeals to the industry as being worst of all, there are periodic mass mortalities of scallops as they approach fishable size.

In spite of these discouraging conditions abundant stocks of commercially-valuable scallops do appear on the beds at intervals. Right now the Richibucto bed is the one bright spot in the whole area.

IV GEAR TRIALS

In good times scallop fishing with conventional Digby-type draggers in the Gulf of St. Lawrence pays. But because of the fluctuating productivity of the Gulf scallop beds, the cost of buildings and outfitting a regular Digby-type scallop dragger is unwarranted if it is to be used for scallop dragging alone. An effort has therefore been made to discover an efficient and inexpensive gear that could be used profitably from the two-man lobster boats which are already common in the area. At present these boats are in operation only during the lobster season and idle the rest of the season.

Because of their small size and power, lobster boats are able to use only light gear that can be boarded with pot-haulers. Two such types of drags, illustrated in Figures 35 to 38, were tested during the summer of 1951. One has long been

in use in Lunenburg County, N.S., and is referred to in last year's report (Chiasson 1951, p. 16). The other was not tried last year but is a type that was used in pairs from lobster boats in Charlotte County, N.B., for several years before Digby gear replaced it there.

Besides testing these small drags for ease in handling from small boats, their performance was compared in a rough way with that of the Digby-type gear, to provide some information as to whether the light gear could be operated profitably in a place where a Digby dragger was successful.

1. Lunenburg Drags

The Lunenburg drags (Fig. 38) are by far the lighter of the two types, a single drag weighing only 40 pounds. The frame is of the same general plan as in the Digby-type and the same width across the mouth. It is made of lighter iron and is toothed on one side. The bag is quite different from the Digby type. It is 28" deep and the upper side is knit of seal twine, belly of hand-wound, 3"-diameter wire rings (13 gauge) and twisted wire joiners (13 gauge). There is no "tail-board" or "tail-chain". At one time several hundred men equipped with such drags successfully prosecuted a winter scallop fishery in Lunenburg County, N.S. Reportedly owing to a scarcity of scallops, this number has dwindled down to a few fishermen, but these still use the same type of gear profitably. A boat may haul 1 to 4 drags but each is fastened to a separate rope as shown in Figure 35 for the Charlotte type.

Frank Vaughan, a fisherman of Western Shore, Lunenburg County, was engaged for a month following June 18, as a practical expert in the use of this gear. Lobster boats were hired wherever tests were performed, and the boat owner in each case worked as the second "hand" on the boat. While these drags can be boarded by hand, a trap hauler is almost essential to bring them from the bottom to the boat rail. This saves much time and back-breaking labour. In the tests conducted in 1951, four drags were generally used on individual ropes so that each one had to be hauled and boarded separately. On the average it took about 15 minutes to haul, board, empty and arrange the four in position to let them go again for another haul. In our work the drags were towed for only 15 minutes before dumping. From this it seems obvious that too much time was spent in the manipulation of the drags to make for efficient commercial practice. Some of this loss of precious dragging time could be obviated in one or both of two ways: (1) by dragging for longer periods, (2) by teaming or ganging two or more drags on a small drag-bar on the Digby principle. This requires that the boat be provided with a hoisting tackle for boarding. The use of a drag bar would make hand-boarding out of the question.

Table 7 shows pooled catches per haul made with four Lunenburg drags on the Richibucto and Pictou Island East beds.

In considering these catches, especially the days' catches, as indicators of the commercial possibilities of the areas and gear, account should be taken of the fact that hired boats never work as many hours per day as commercial boats. The catch per hour of dragging is therefore a better index because it is independent of the starting and finishing times of fishing operations. When weather and other circumstances permitted, the boats we engaged left the wharf at 6:30 a.m., and returned about 5:00 or 5:30 p.m. Even on fine days the long distances to be travelled to and from the scallop beds and the hour lunch period reduced the actual dragging time to 5 or 6 hours. Under commercial conditions one might expect the dragging time per day to be almost double this because fishermen leave earlier, return later and continue dragging while eating their meals. With this in mind it is clear that two men could easily have landed 200 pounds or about seventy dollars' worth of scallops a day (the Richibucto wharf price was 35¢ per pound in 1951) on the Richibucto bed. Daily expenses for fuel, oil, etc., would be in the vicinity of only \$5.00, so such a fishery should be a paying proposition even if it demands very long hours of work. One man's time is completely occupied with controlling the boat so it would be necessary to add another "hand" to the crew for shucking if catches were much heavier than those made last summer. Even then or especially then, it seems certain that each of the three men could earn a good day's pay.

2. Charlotte Drags

Charlotte County drags are built on the same general plan as the Digby type except that they are 48" instead of 31" across the mouth and are made of lighter iron. Each weighs 87 pounds. In the early days in Charlotte County they were used in a gang - two drags on a drag-bar approximately 4' long. The results of trials with these on the Richibucto bed are listed in Table 8. On the first day they were used on a bar but they were so heavy that the pot-hauler could not always raise them and manual boarding was most difficult. Thereafter they were hauled on separate ropes as were the Lunenburg type. The pot-hauler managed them then but the manual boarding was still a most strenuous job.

Table 7. Combined scallop catches from 15-minute hauls with four singly-towed Lunenburg drags used from a lobster boat.

Fishing Area	Date	Haul Catches ($\frac{1}{2}$ bu.)	Day's Operations			Meat Catch	
			Whole Scallops caught ($\frac{1}{2}$ bu.)	Meat Catch (lbs.)	Fishing time (hrs.)	Per Hour (lbs.)	Per Haul (lbs.)
Pictou Island East Bed	June 20*	8	8	20	3 $\frac{1}{2}$	11	16
	" 21	3, 2, 1 $\frac{1}{2}$, $\frac{3}{4}$, 2 $\frac{1}{2}$, 2 $\frac{1}{2}$, 5 $\frac{1}{2}$, 4 $\frac{1}{2}$, 4 $\frac{1}{2}$.	27	67	5	12	6.7
	" 22	1, 1 $\frac{1}{2}$, 1 $\frac{1}{2}$, 2, 2, 2, 1 $\frac{1}{2}$, 4, 1, 1 $\frac{1}{2}$, 2	20	50	5	9	4.6
	" 25#	1, 2, 5	8	20	-	-	-
	" 28#	1 $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, 2 $\frac{1}{2}$, 1, 1 $\frac{1}{2}$ 2, $\frac{3}{4}$, 2, 1	13	32	-	-	3.2
	" 29	4, 7, 5 $\frac{1}{2}$, 6, 5 $\frac{1}{2}$, 4, 3, 1 $\frac{1}{2}$, 2 $\frac{1}{2}$, 1 $\frac{1}{2}$, 3 $\frac{1}{2}$	44	110	6	18	10.0
	" 30	3, 1, 2 $\frac{1}{2}$, 5 $\frac{1}{2}$, 5 $\frac{1}{2}$, 6, 6, 5, 7	42	105	6	17	11.7
	July 2	4 $\frac{1}{2}$, 6, 5, 5 $\frac{1}{2}$, 6, 4, 5 $\frac{1}{2}$	36	90	6	15	12.8
	Average		25	62	5.2	14	7.9
	Richibucto Bed	July 9#	1, 1 $\frac{1}{2}$, $\frac{3}{4}$, 1 $\frac{1}{2}$, $\frac{1}{2}$, 5, 4	14	35	-	-
" 10		2 $\frac{1}{2}$, 4, 6 $\frac{1}{2}$, 6 $\frac{1}{2}$, 5 $\frac{1}{2}$, 4 $\frac{1}{2}$, 8 $\frac{1}{2}$, 10 $\frac{1}{2}$	58	145	6	24	18.2
" 11		8, 7.	15	35	1	35	17.5
Average		29	72	3.5	30	13.6	

* Two drags only used this day: four drags on all others. The meat catches per hour and per haul are therefore doubled.

These were exploratory hauls and not on the bed proper.

+ These two were 25-minute hauls: all others 15-minute.

Table 8. Catches per 15-minute haul with a pair of Charlotte drags towed by a lobster boat on the Richibucto Bed.

Date	No. Drags	How Fished	Haul Catches ($\frac{1}{2}$ bus.)	Day's Operations			Av. Meat Catch by Two Drags	
				Whole Scallops Caught ($\frac{1}{2}$ bus.)	Meat Caught (lbs.)	Fishing Time (hrs.)	Fishing Hour (lbs.)	Per Haul (lbs.)
July 11	2	on bar	4,4	26	65	5	15	9.3
	1	on rope	2,1 $\frac{1}{2}$					
	2	on separate ropes	5,6,3 $\frac{1}{2}$					
July 13	2	"	6 $\frac{1}{2}$, 3 $\frac{3}{4}$, 4 $\frac{1}{4}$, 5 $\frac{1}{2}$, 5	25	62	3	21	12.4
July 14	2	"	5 $\frac{1}{2}$, 1, 2, 7 $\frac{1}{2}$, 4 $\frac{1}{2}$, 7 $\frac{1}{2}$, 3	31	67	4	17	9.6
Average				27	65	4	18	10.4

In referring to the data in Table 8, it should be pointed out that on July 11 much time was spent in changing from one type of gear to another so that the day's effort is hardly a normal one even for the experimental boat. The first haul was so heavy that the trap hauler in the lobster boat could not hoist it up. It took the combined crews of the lobster boat and "My Boys" to bring the drags to the side of the boat. They were boarded only with the aid of the "My Boys" hoisting cable and winch.

The catches with the pair of Charlotte drags was a little lower than from the 4 Lunenburg drags but it seems certain that they could be profitably fished from a lobster boat.

There are some features against them when used paired on the drag-bar. They require more power for hauling than the average auxiliary gasoline engine used with lobster trap haulers provides. They can be used, however, on lobster boats with haulers that are powered by a "take-off" from the main engine, which is usually a car engine or a powerful marine engine. Even if the hauler is equal to the job and the drags can be brought to the rail they are too heavy when filled with scallops to be boarded manually. A boom and tackle is required. Such equipment is not common on lobster boats so in our work from these craft the drags were separated from the drag-bar and hauled by separate ropes in the way Lunenburg drags are used. Even then it usually took the full strength of two men to board the drags manually after they were raised by the trap hauler.

All things taken into account, Charlotte drags seem less adaptable to use from Gulf and Strait lobster boats than Lunenburg drags.

3. Digby Gear

As a basis for judging the efficiency of the Lunenburg and Charlotte gear (Tables 7 and 8) hauls were made on July 9 to 11 on the Richibucto bed by "My Boys" using a six-drag gang of Digby-type toothed drags attached to a six-drag drag-bar. These hauls (Table 9) were made on the same parts of the bed and on the same days as hauls reported in Tables 7 and 8.

Table 9. Catches during 15-minute hauls on the Richibucto bed by scallop dragger "My Boys" using toothed Digby-type gear.

Date	No. of Drags Used	Haul Catches ($\frac{1}{2}$ bu.)	Day's Operations		Mean Meat Catch per Haul of 6 Drags (lbs.)
			Whole Scallops Caught ($\frac{1}{2}$ bu.)	Meat Catch (lbs.)	
July 9	6	4,2,3,4,3,4,4 $\frac{1}{2}$,6 $\frac{1}{2}$	31	75	9.4
" 10	5	5 $\frac{1}{2}$,14,9,3,3,5,15, 9,6,1,2,10	84	210	21
" 11	5	6 $\frac{1}{2}$,10,8,3,5 $\frac{1}{2}$, $\frac{1}{4}$,1	34	85	14.6
Average			50	123	11.7

In connection with Table 9 it should be noted that on both the days the 5-toothed drags were used, a small-mesh drag was placed at one of the end positions on the 6-drag drag-bar. It was observed that generally the first and occasionally the second drag, next to the small-mesh drag, took very few scallops compared with the other three or four. It is reasonable to assume that the catches would have been heavier if the six drags had been uniform.

As a basis for comparing the efficiency of Lunenburg drags on the Pictou Island East bed (Table 7) records were obtained from a commercial dragger (boat # 2, Table 4) which operated there on the same days as, and close to the ground covered by the lobster boat we chartered (See Table 4 entries for June 20,21,22,25,28,29,30 and July 2). The average catch per day by the dragger on these days was 290 pounds. If it had fished the same number of hours as our lobster boat (approximately 5 hours) the catch would probably have averaged about 150 to 175 pounds.

Reviewing Tables 4, 7, 8 and 9, it would seem that on the average both light drags are highly efficient. It should be remembered here that the combined widths of the mouths of 4 Lunenburg drags is 10' and of 2 Charlotte drags is 8' as compared with 15 $\frac{1}{2}$ ' for the combined widths of the mouths of 6 Digby-type drags which were regularly fished by the Digby-type draggers which operated in the Gulf. A rough comparison of efficiencies is possible if the Lunenburg catches are multiplied by 1.5 and the Charlotte catches doubled (Table 10).

Table 10. Actual and adjusted mean catch per 15-minute haul by three types of gear on Richibucto bed for comparison of efficiencies.

Type of Drag	Actual Catch (lbs.)	Adjustment Factor	Adjusted Catch (lbs.)
Charlotte	10.4	2.0	20.8
Lunenburg	13.6	1.5	20.4
Digby (toothed)	11.7	1.0	11.7

This comparison, rough though it be, supports the conclusion from the trials that small gear can be used profitably on beds in the southern Gulf where stocks are abundant enough to make dragging with toothed Digby gear worth while. It also indicates that toothed Digby drags hauled from the large boat was less efficient than either of the types of light gear (which were equally efficient) hauled from lobster boats but this may have been caused by the small-mesh drag interfering with the standard drags that were fished with it (See above).

V CONCLUSIONS

The following conclusions may be noted as practical results of the past summer's work, which may have immediate importance.

1. No new scallop beds were found around Pictou Island, St. Anne Bay, Big Bras d'Or, Port Morien, Lingan, New Waterford, or Caraquet.
2. From studies of abundance, growth rates and size-frequency distribution, it is concluded that the Richibucto bed is the one and only ground that can support a commercial fishery in 1952, but, it is of fair size and barring mass mortalities, fishing there should be good.
3. The Pictou Island West bed has many young scallops on it which should reach fishable size in 1954 or 1955 if there are no mass mortalities.
4. Lunenburg County and Charlotte County drags are quite efficient in catching scallops in paying quantities. The former is the more suited to use from lobster boats such as are common in the parts of the Gulf of St. Lawrence where they are likely to engage in scallop fishing.

VI SUGGESTIONS FOR FUTURE WORK

The Fisheries Research Board's scallop work in the Gulf of St. Lawrence should be continued along three main lines to encourage full commercial exploitation of the limited scallop resources that are there.

1. For the next few years at least, the stocks on known beds should be sampled yearly with small gear to follow their progress. The results would be useful in different ways but would enable us to advise fishermen who are just beginning and not yet familiar with the grounds or fishing methods, as to what beds are worth working and at the same time demonstrate to others who may exhibit interest, the practicability of scallop fishing from lobster boats. The annual cost of such a small-boat operation would be approximately one-quarter of what it has been during the past three years using Digby-type gear from Digby-type draggers.
2. Data on mass mortalities and subjects related to them should be collected from every possible source. We should like eventually to be able to predict the violent changes in abundance which we have found to be so important in regulating the stocks and the industry, or at least, explain them.
3. Since the use of fish draggers in the Gulf is on the increase it is probable that more and more new and valuable information regarding the position of new scallop beds will become available. Such information should be systematically collected and cross-checked, where possible.

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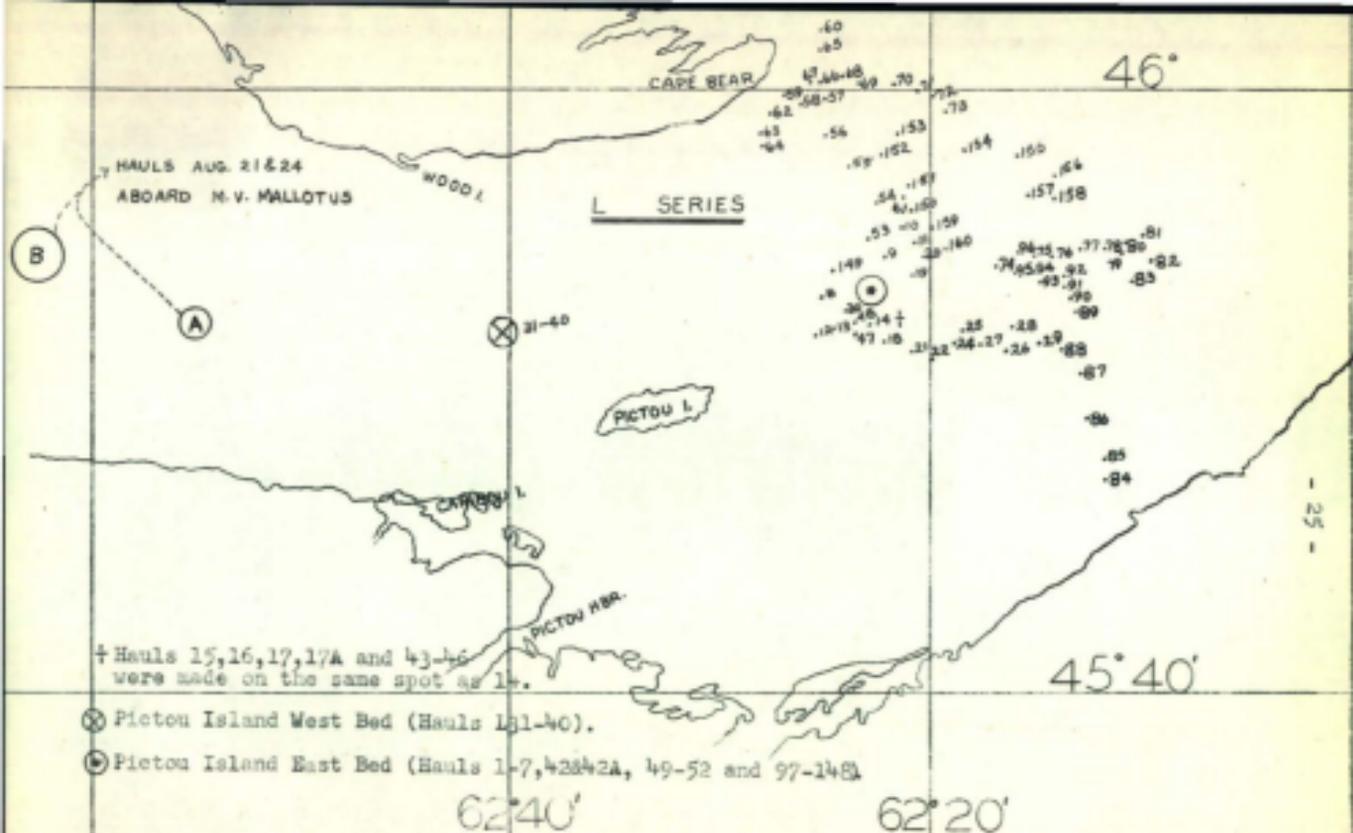


Fig. 1. Positions of Hauls in "L" Series.

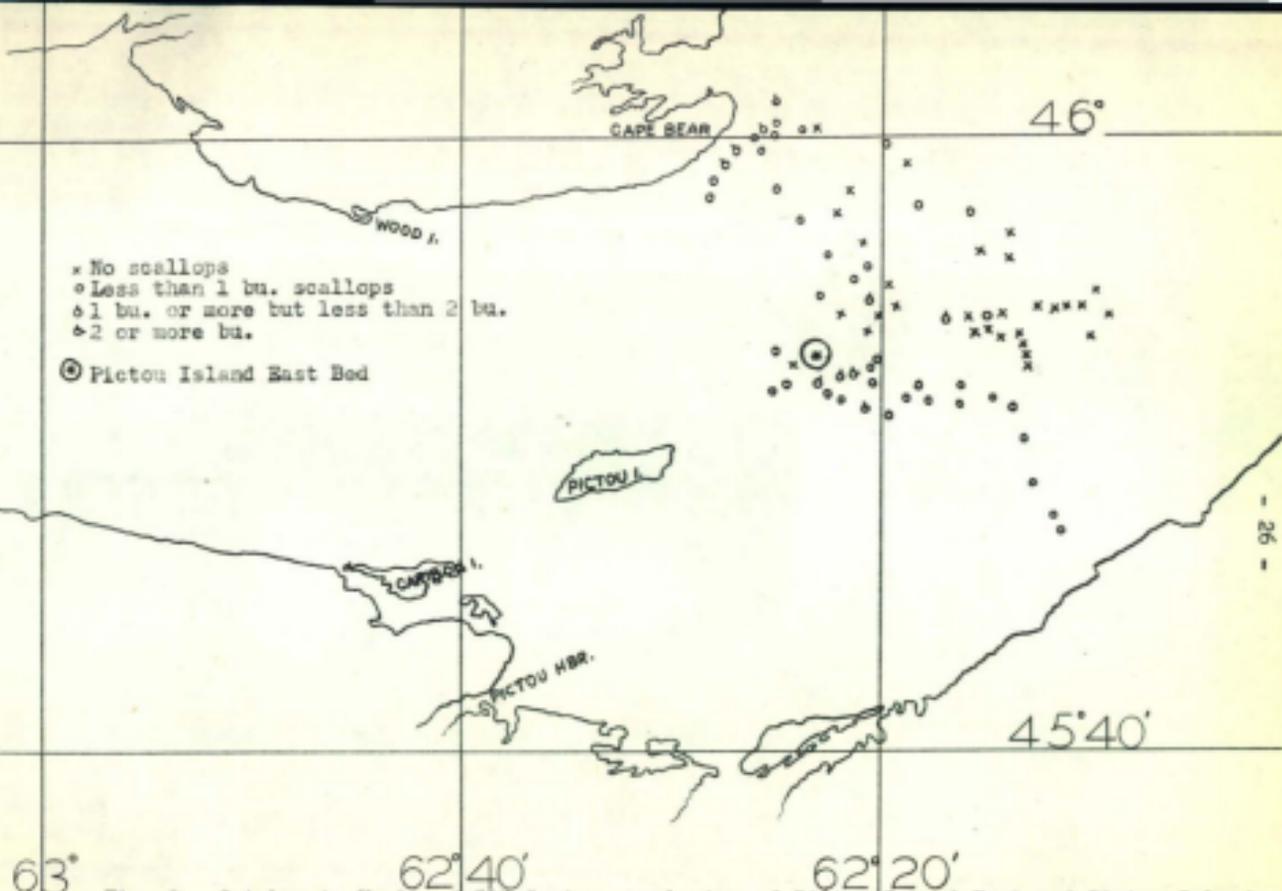


Fig. 2. Catches in Hauls of "L" Series, exclusive of Pictou Island East and Pictou Island West Beds.

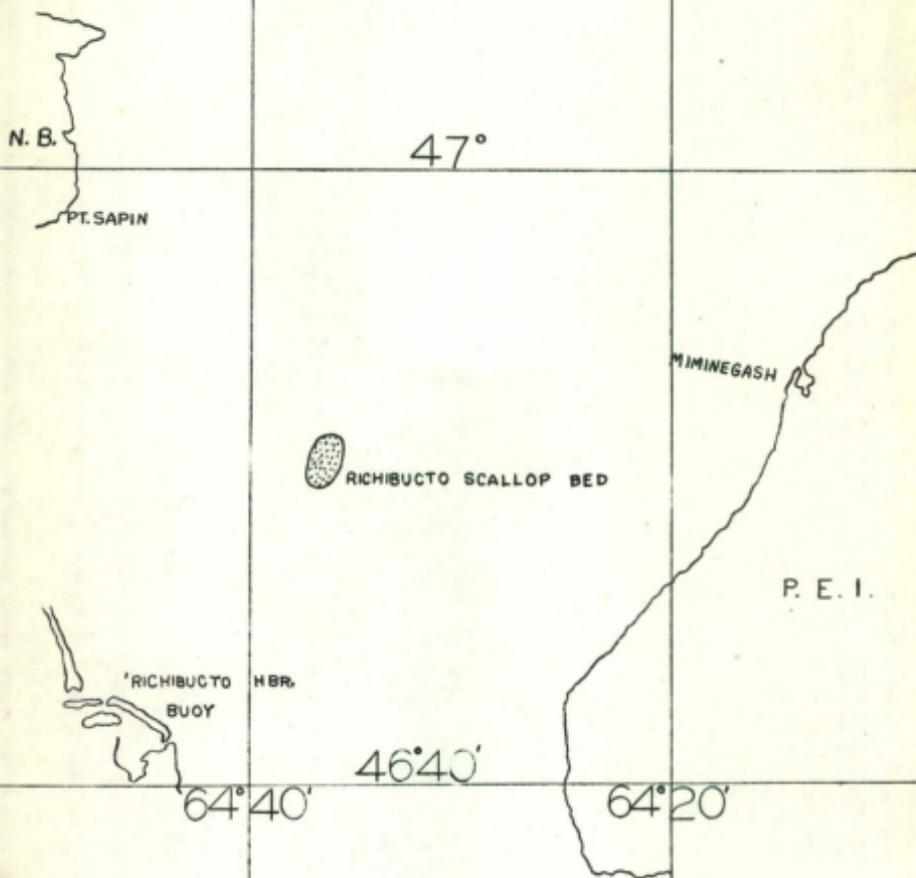


Fig. 3. Position of Richibucto Scallop Bed (Hauls taken off this bed in 1951 are in the "N" series).

N SERIES

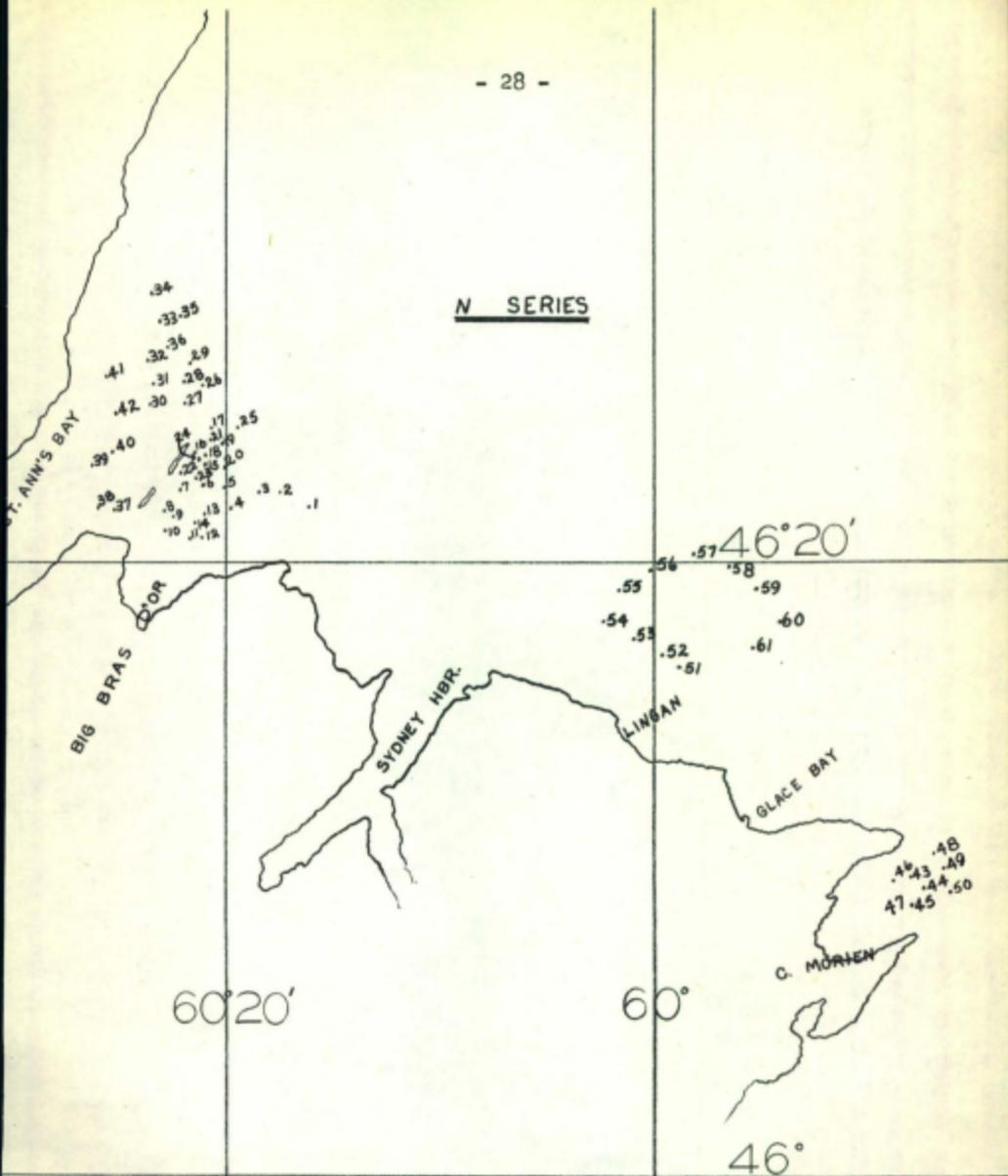


Fig. 4. Positions of Hauls in "N" Series.

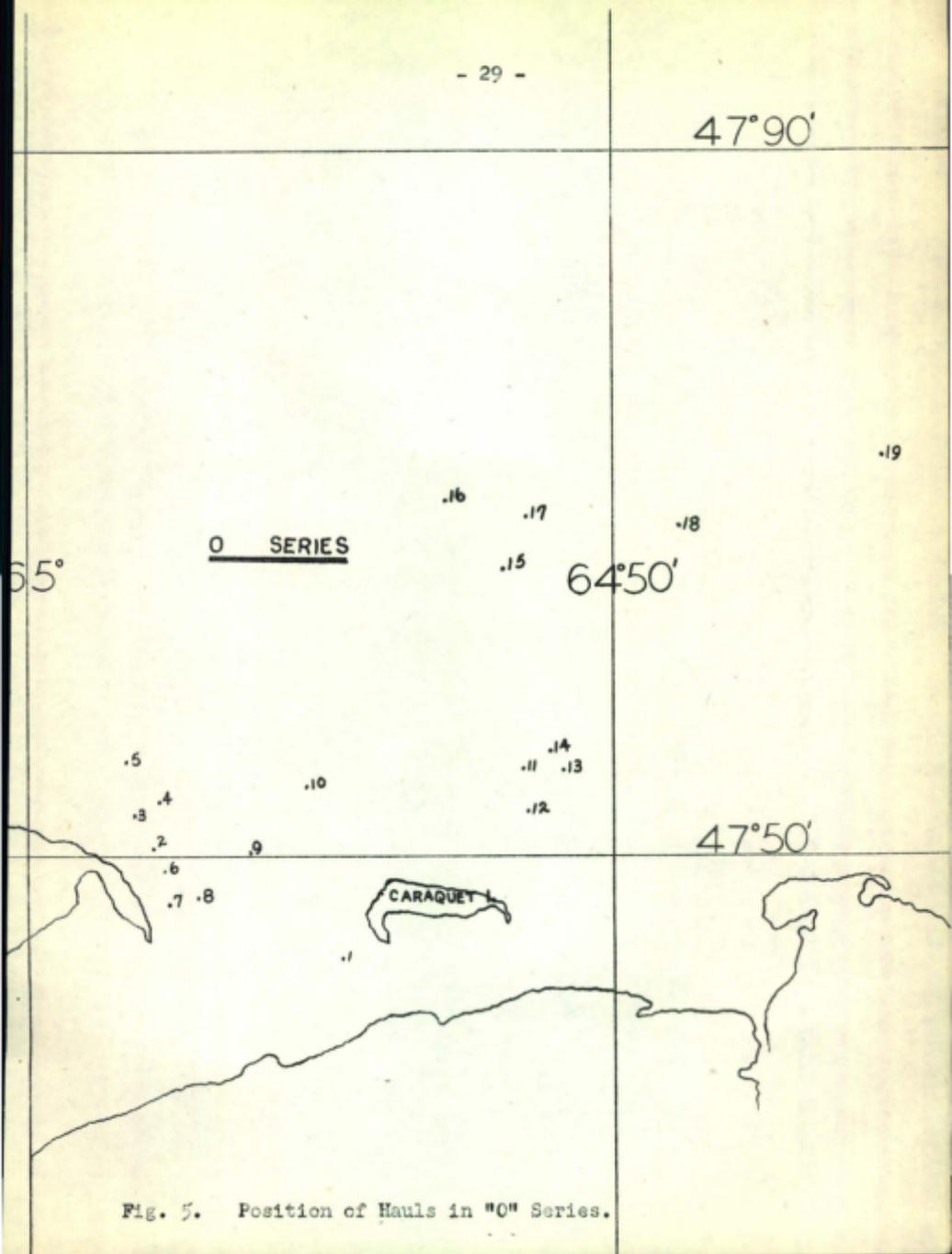


Fig. 5. Position of Hauls in "O" Series.

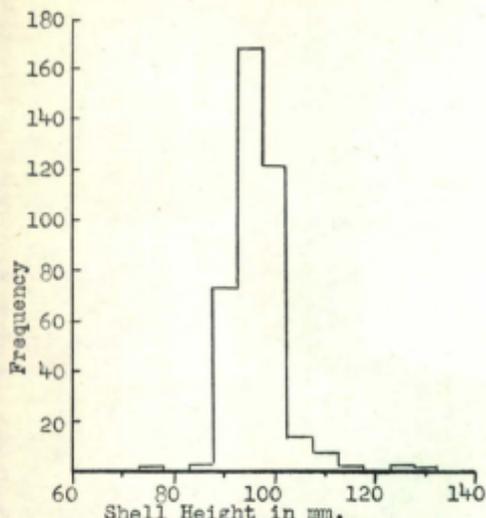


Fig. 6. Size Frequency Distribution of Scallops in Haul L1 (Pictou Island East Bed).

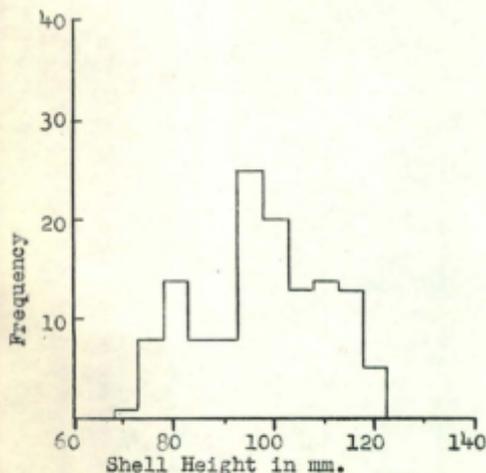


Fig. 7. Size Frequency Distribution of Live Scallops in Haul L21 (Pictou Island East Bed).

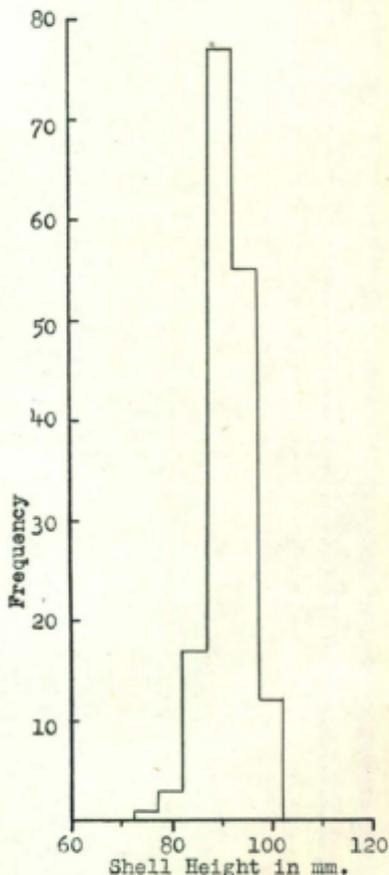


Fig. 8. Size Frequency Distribution of Live Scallops in Haul L29 (Pictou Island East Bed).

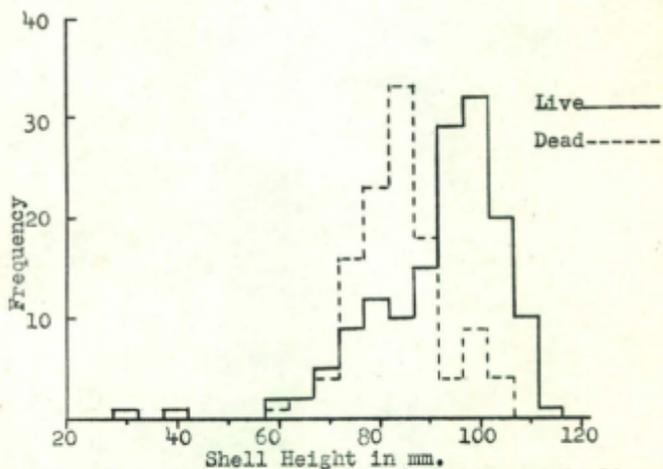


Fig. 9. Size Frequency Distribution of Scallops in Haul L31 (Pictou Island West Bed).

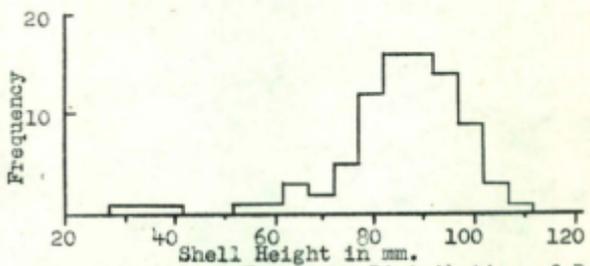


Fig. 10. Size Frequency Distribution of Dead Scallops in Haul L33 (Pictou Island West Bed).

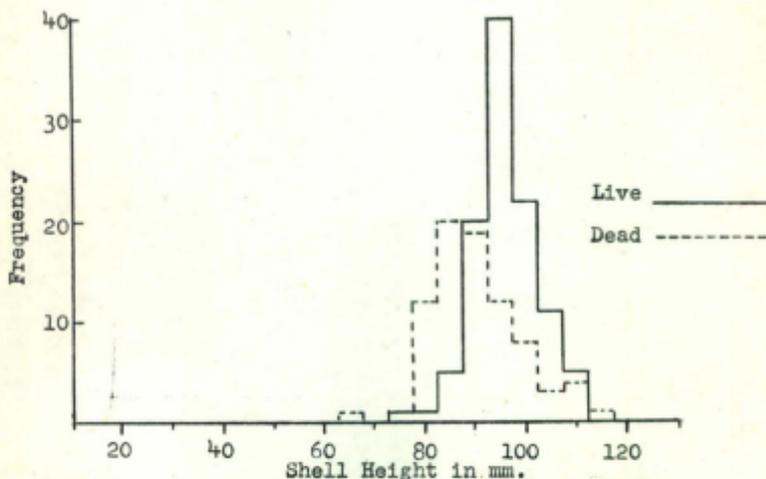


Fig. 11. Size Frequency Distribution of Scallops in Digby drags of Haul L35 (Pictou Island West).

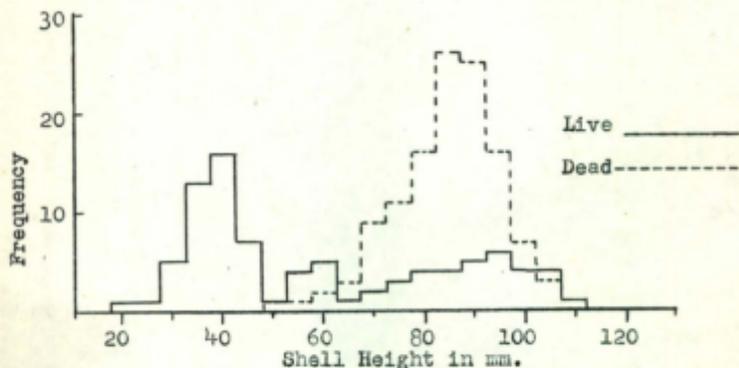


Fig. 12. Size Frequency Distribution of Scallops in the Small-mesh Drag of Haul L35. (Pictou Island West).

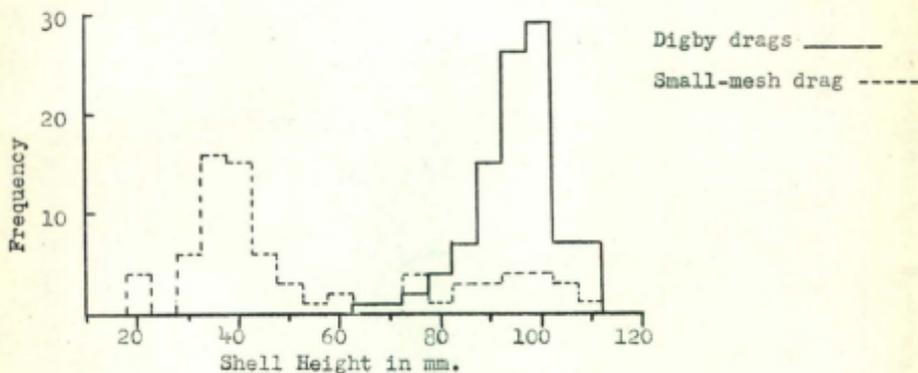


Fig. 13. Size Frequency Distribution of Live Scallops in Digby and Small-mesh Drags in Haul L37 (Pictou Island West Bed).

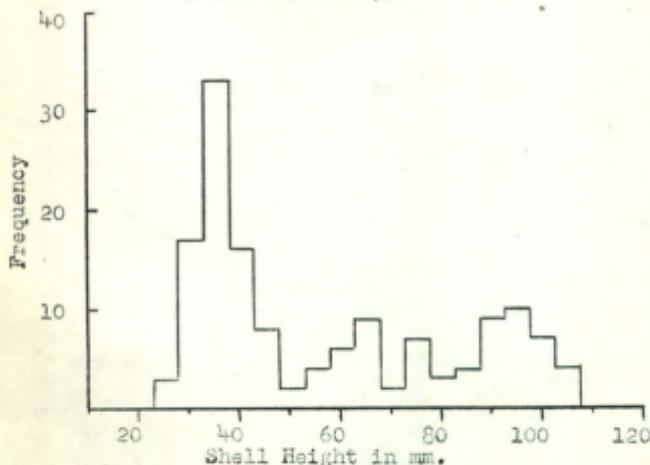


Fig. 14. Size Frequency Distribution of Live Scallops in Small-mesh Drag Catches in Hauls L38-40 (Pictou Island West Bed).

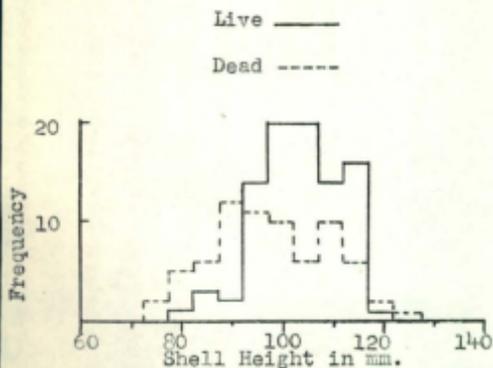


Fig. 16.* Size Frequency Distribution of Scallops in Haul L63 (Cape Bear Bed).

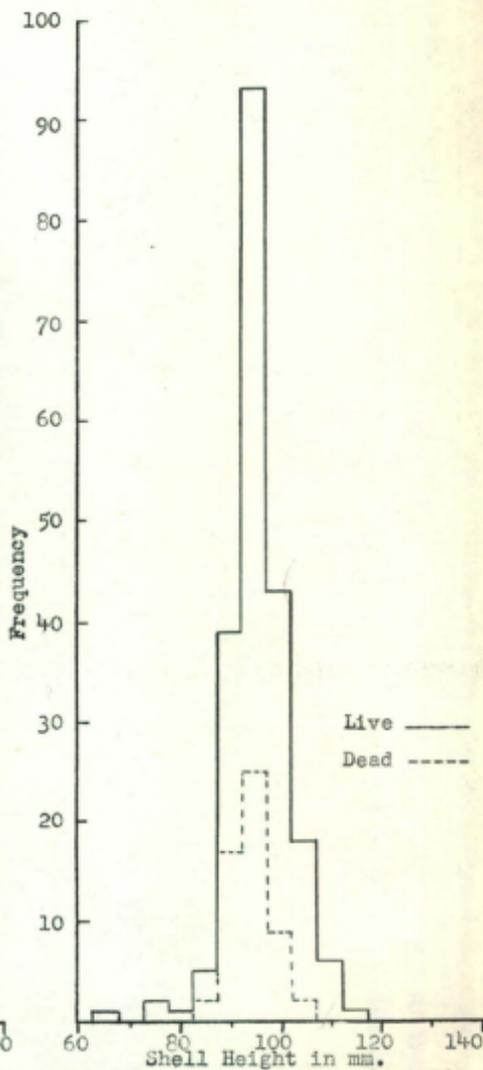


Fig. 17. Size Frequency Distribution of Scallops in Haul L64 (Cape Bear Bed).

*There is no figure 15 in this series

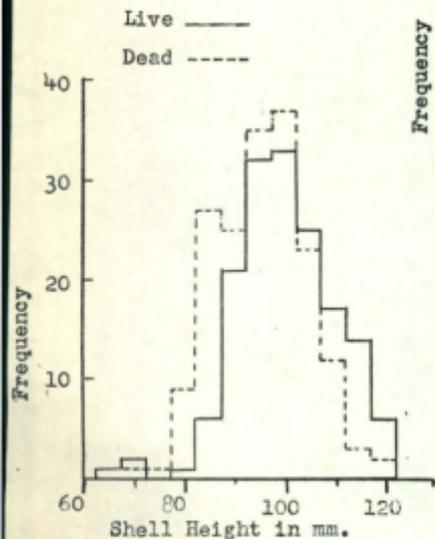


Fig. 18. Size Frequency Distribution of Scallops in Haul L67. (Cape Bear Bed).

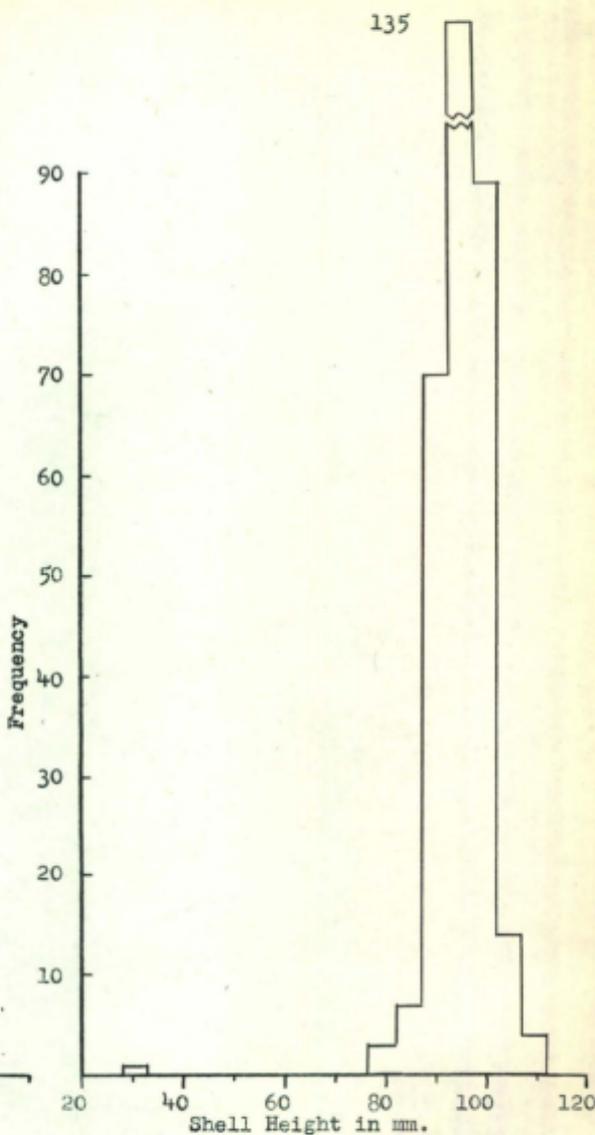


Fig. 19. Size Frequency Distribution of Live Scallops in Haul L103. (Pictou I. East).

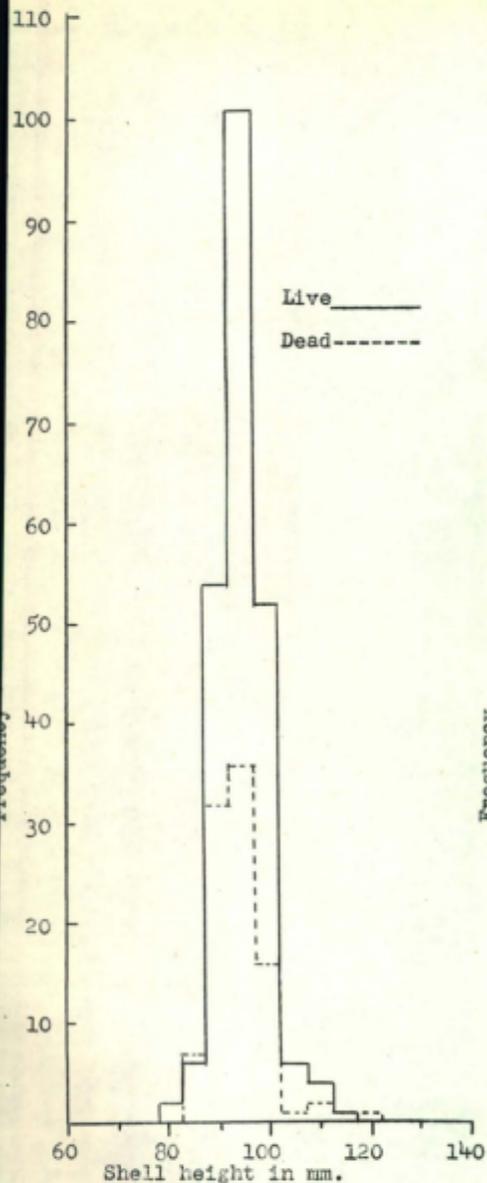


Fig. 20. Size Frequency Distribution of Scallops in Haul LL06 (Pictou I. East)

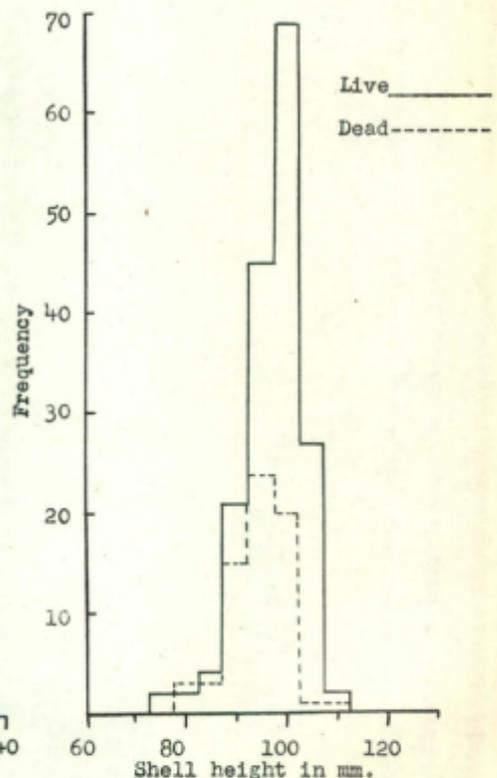


Fig. 21. Size Frequency Distribution of Scallops in Haul LL15 (Pictou I. East)

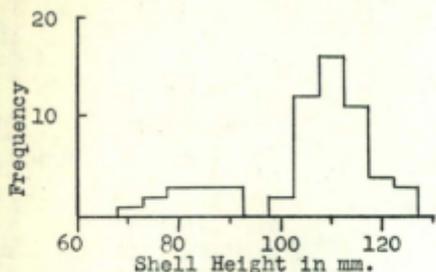


Fig. 22. Size Frequency Distribution of Live Scallops in Haul M 7 (Richibucto Area - Near Main Bed).

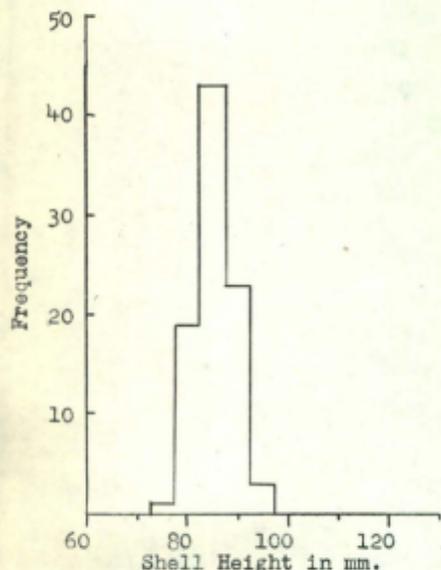


Fig. 23. Size Frequency Distribution of Live Scallops in Haul M10 (Richibucto Bed).

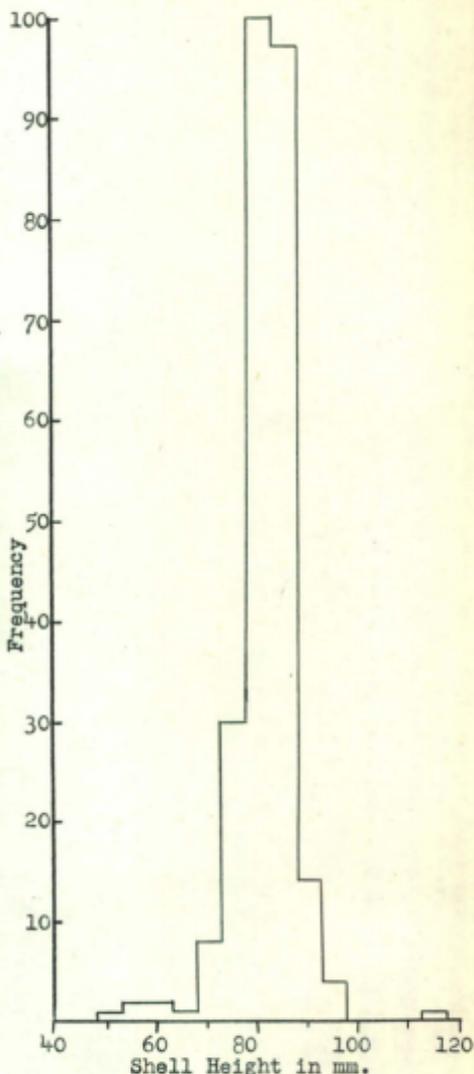


Fig. 24. Size Frequency Distribution of Live Scallops in Haul M21 (Richibucto Bed).

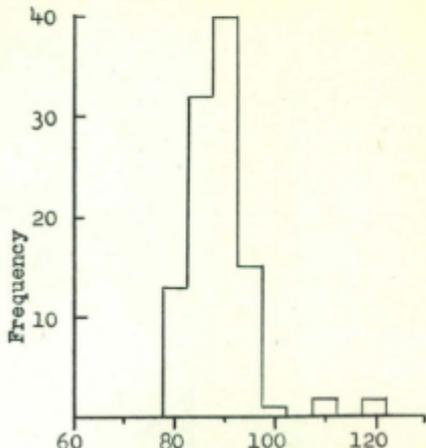


Fig. 26. Size Frequency Distribution of Live Scallops in Haul M57 (Richibucto Bed).

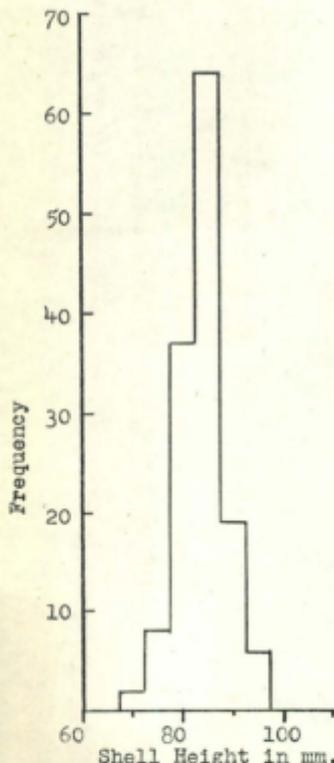


Fig. 25. Size Frequency Distribution of Live Scallops in Haul M56. (Richibucto Bed).

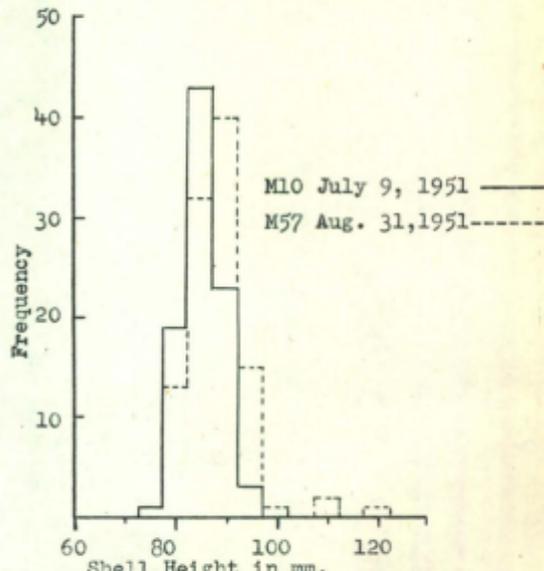


Fig. 27. Size Frequency Distributions to Compare Hauls made on Richibucto Bed Seven Weeks Apart.

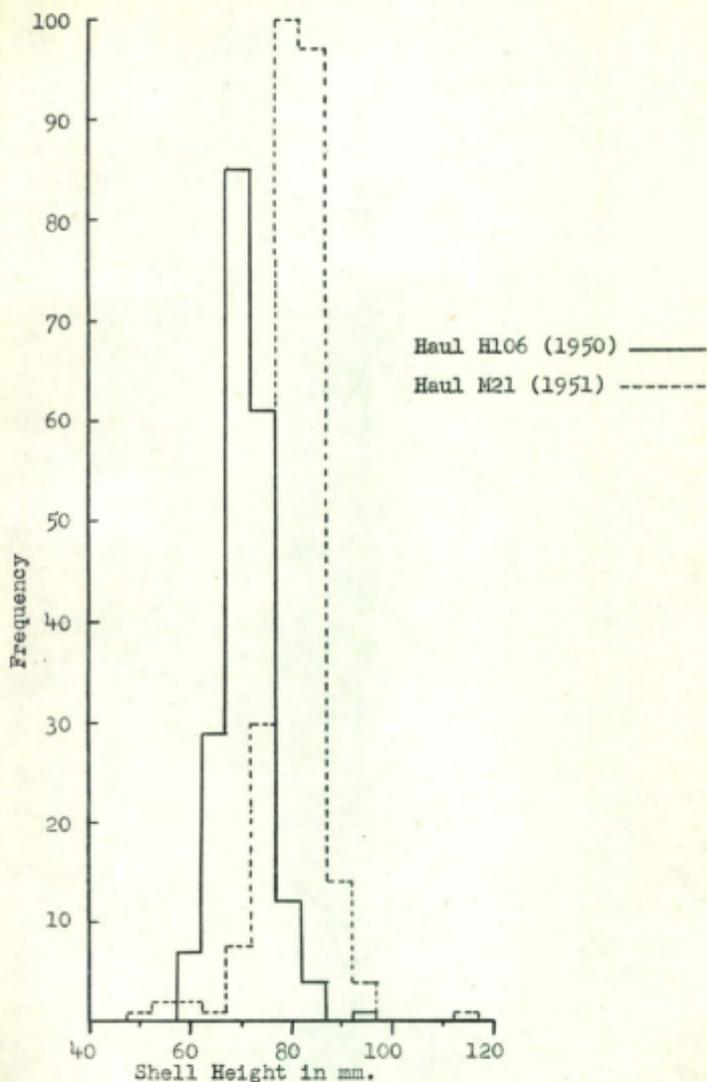


Fig. 28. Size Frequency Distribution of Scallops on Main Richibucto Bed in 1950 and in 1951.

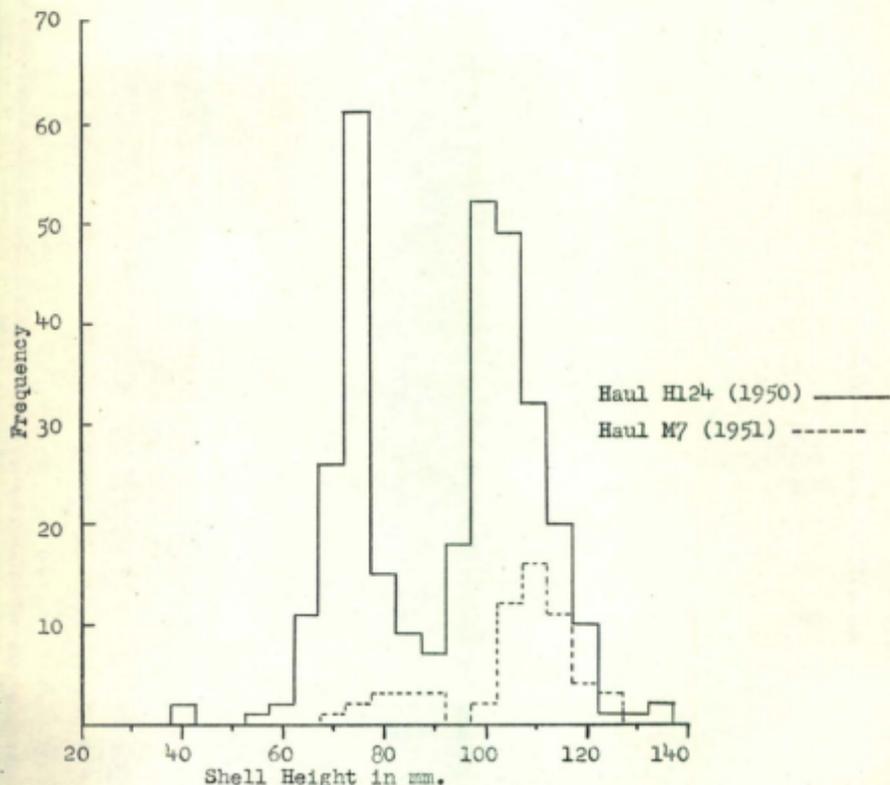


Fig. 29. Size Frequency Distribution of Live Scallops Caught on the Same Ground (a rocky ledge NW of Main Richibucto Bed) in 1950 and in 1951.

Fig. 30. Photographs of Upper Valves of Scallops from the Richibucto Bed showing Growth Lines and the Margin of New Shell added between August 1950 (a & b) and July 1951 (c & d).

(Photograph by L. P. Chiasson)

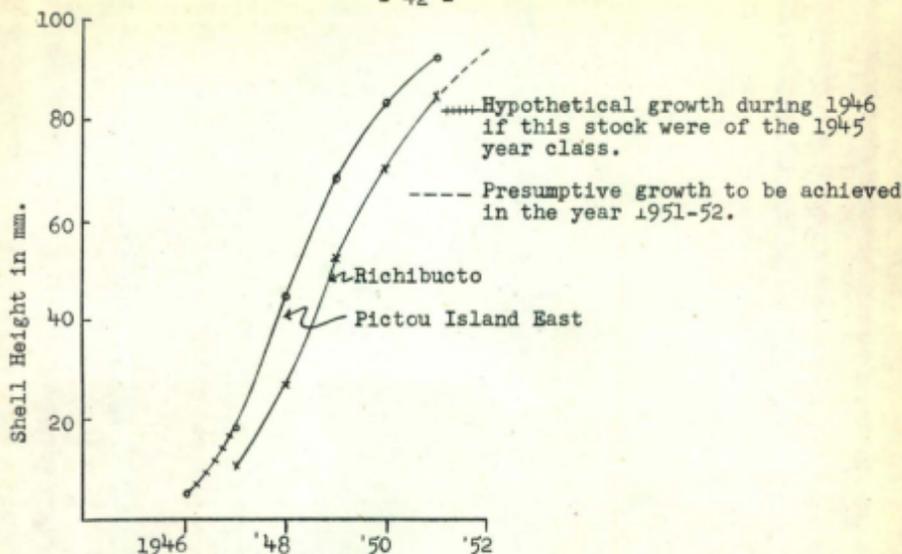


Fig. 31. Growth Curves for scallops taken haul in L142, Pictou Island East bed, and haul M10, Richibucto bed. The heights indicated are for the early spring of the year. Presumably both stocks are of the 1946 year class but there is some doubt of this for Pictou Island East Bed.

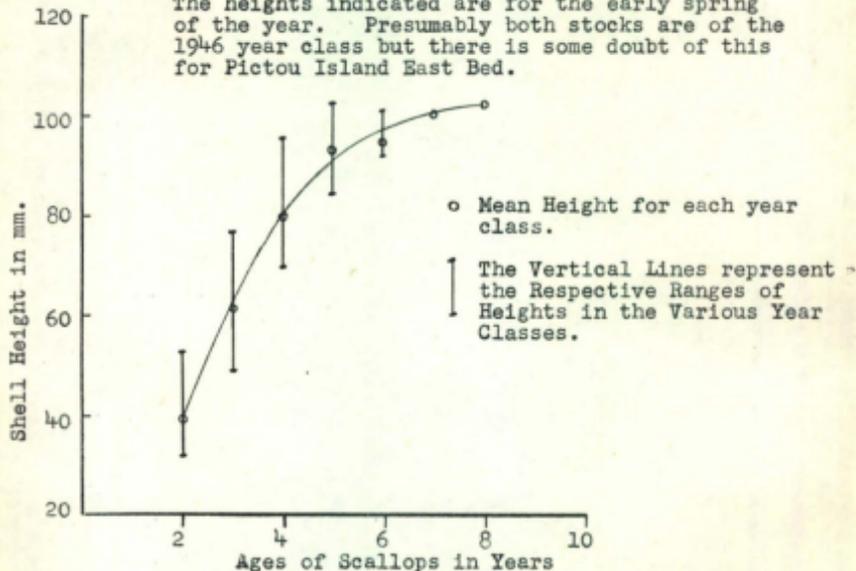


Fig. 32. Growth Curve of Scallops from Several Hauls on Pictou Island West Bed.

- ° Mean shell heights of scallops of year classes 1944 to 1950 in the springs of different years.

——— Solid lines join mean heights of each year class.

----- Broken lines join mean heights attained by different year classes at the same ages.

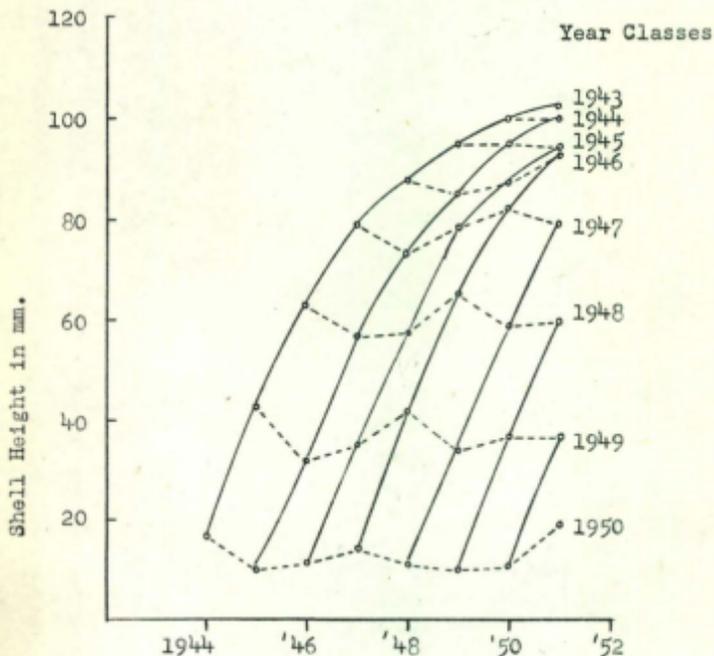


Fig. 33. Growth Curves of Different Year Classes from Stocks of the Pictou Island West Bed.

Fig. 34. Two- to Six-year-old Scallops of Successive Year Classes (as judged from shell annuli) from the Pictou Island West Bed. This photograph brings out the variation of shell height at corresponding ages as evidenced by the position of the annuli with respect to the hinges.

(Photograph by L. P. Chiasson)

Fig. 35. Drags ready to be let go for a tow from a lobster boat. The towing rope for the drag on the right is coiled on the floor boards ready to "pay out".

Fig. 36. Hauling full drags to the gunwale ready for manual boarding. The trap hauler is in use.

Fig. 37. Drags have been boarded manually. One has been emptied.

Fig. 38. Lunenburg County Drag Showing the Toothed Frame and the Bag with its Seal-twine Back and Belly of Wire Rings.

(Photograph by J. S. MacPhail)

APPENDIX
VIII HYDROGRAPHY AND THE CAUSE OF MASS MORTALITIES IN GULF OF
ST. LAWRENCE SCALLOPS

by

L. M. Dickie

Sudden and heavy mortalities of scallops in the south-eastern part of Northumberland Strait have been reported from time to time since 1927-28 (Chiasson 1949). During 1950 and 1951 sampling starfish were found in concentrations in the northern straits about the Richibucto area and were considered to have caused the mortalities there (Chiasson 1952), but similar concentrations of starfish have never been found in the southern areas where the heaviest mortalities have been observed. The heaviest and most studied concentration of "cluckers" was found in 1951 on the Pictou Island West bed, described by Chiasson in this report (Table 2). It is a clear case of a mortality not associated with any concentration of starfish. From an examination of the 1946 Boughton Island mortality Dickie (1951) concluded that predators were too scarce and that the mortality was too sudden to have resulted from depredation. Chiasson (1951) likewise discounts depredation as the factor responsible for the severe mortality on the neighbouring Pictou Island West bed in September and October 1949. From depths of beds relative to the thermocline and from evidence of less susceptibility of the young to mortality, Dickie (1951) concluded that mass mortalities resulted from sudden changes in the marine climate and data gathered since then on mortalities in the southern straits support this theory.

Depth Distribution of Cluckers

Table A1 summarizes data on depth and numbers of living scallops and cluckers in hauls by the M. B. "My Boys" using scallop gear and the M. B. "Mallotus" using a flounder net. The scanty "Mallotus" catches were incidental to flounder exploration, and by themselves mean little, but they assume significance when considered with those of "My Boys". The two sets of records overlap to form a series which shows that as depth of beds increases the relative frequency of cluckers in the catches decreases.

The evidence from flounder drag catches, that cluckers are rarer in deep water is complete in itself but the propriety of combining it with that from scallop drag catches depends upon the assumption that there is no difference in the selectivity of flounder and scallop drags for dead and living scallops. This assumption is supported by what data are available.

Table A1 The relationship between depth and the relative frequency of cluckers in catches with a flounder drag (hauls reported separately) and a scallop drag (catches of several hauls pooled) in different parts of Northumberland Strait.

Catch No.	Place	Av. Depth (meters)	Flounder Drag			Scallop Drag			
			Nos.	Living Cluckers	No. of Clucker Hauls Frequency	Nos.	Living Cluckers	Hauls Pooled Clucker Frequency	
1	Cape Bear	17(?)				240 302	1	5%	
2	"	22				261 429	2	62%	
3	Pictou Island West	22-27	0	0	1	100%	1046 4864	7	82%
4	" " East	31-33	0	0	2	0	5104 1351	16	21%
5	George Bay	31	16 158		1	48%			
6	"	33	36 4		1	38%			
7	Cape Bear	33				147 130	2	47%	
8	Off Souris - Near Boughton I. Bed	33-38	3 0	6 0	4 1				
9	Cape Bear	37	0 2		1	0%			
10	Deep Channel between Aset Shoals and Indian Rocks	37	189 12		1	4%			
11	"	42	300+ 0		1	0%			

For example the two deep-water catches made with a 50-ft. flounder net with rollers (Nos. 10 and 11, Table A1) contained relatively few cluckers. Of the somewhat shallower George Bay catches, number 6 (September 3 to 6) made with rollers and number 5 made on the same ground without rollers (August 10 to 11) captured approximately the same ratios of living and cluckers. This suggests that there is little difference in the selectivity of flounder drags with and without rollers and that both rigs can and do catch cluckers.

The "Mallotus" and "My Boys" fished approximately the same areas on the two Pictou Island beds (Catches 3 and 4, Table A1). The "Mallotus" catches are small and show that flounder drags are inefficient compared with scallop gear in taking scallops but the relative frequencies of cluckers are of the same order in catches with both flounder and scallop drags. This indicates that we are justified in combining the "Mallotus" and "My Boys" series of records in this study.

We may therefore conclude from the data of Table A1 that in 1951 the numbers of cluckers and so the incidence of mass scallop mortalities decreased with depth. This observation, together with information on hydrographic conditions, offers strong support to the theory that mortalities are the result of changes in marine climate.

Changes in the Marine Climate of Southern Strait Scallop Beds.

The general features of the waters of the southern Gulf of St. Lawrence are described by Lauzier (1952) and show that hydrographic conditions at the depths where the greatest scallops mortalities occur are subject to large and rapid changes. In summer a thermocline with a temperature gradient of up to 1° C. and salinity gradient of 0.2‰ per meter is present somewhere below 10 meters, it has a tendency to sink gradually towards the end of August and September and is deeper along the Prince Edward Island and Cape Breton coasts than it is offshore. In common with all waters of the Gulf area higher temperatures are associated here with lower salinities. Stratification is very stable in summer and autumn and reactions to external forces are largely by internal adjustment of layers (changes in thickness) not intermixing of the layers.

Lauzier describes two extreme cases of internal adjustment. The most pronounced is illustrated by a section of hydrographic stations from North Rustico, P.E.I., to Cheticamp, N.S., from August 27 to September 3, 1948. During this period, the temperature off North Rustico at 30 meters increased from 5° C. to 14.5° C. and salinity decreased from 29.9‰ to 28.2‰. While this was going on the temperature at 20 meters off Cheticamp decreased from 16.0° C. to 8.4° C. with a corresponding salinity increase from 29.4‰ to 30.6‰. This case of adjustment of the

water layers and others like it are shown to have resulted from changes in the force and direction of winds accompanying storms in the area. North to northwest winds produce an inshore movement of surface water at North Rustico and an offshore movement at Cheticamp. The compensating movement of bottom water is in the opposite direction, resulting in a subsidence of the thermocline and a general increase of temperature and decrease of salinity in the water column at North Rustico and a rise of the thermocline at Cheticamp accompanied by general cooling and increase of salinity. The reverse situation is produced by southerly winds.

It is not known whether these phenomena are felt in the straits to the same extent as in the open Gulf. Lauzier (personal communications) suggests that the relatively narrow and shallower straits tend to damp oscillations which occur there. However, scattered temperature observations of the waters of the straits by both the "Mallotus" and "My Boys" (Table A2) show that the thermocline in this area was rather sharply defined in 1951. In late August the gradient near Pictou Island was steepest between 23 and 30 meters showing a change of about 5° C. in 7 meters. On September 6, there was a difference of about 7.5° C. between 28 and 32 meters. Since the main scallop beds are found to be at about these depths it appears that even slight oscillations of the thermocline would subject the scallops to rather large variations in temperature and minor changes in salinity.

In depths well below the thermocline, these hydrographic phenomena are less likely to occur and scallops are less likely to be subjected to temperature changes. Therefore, the relative scarcity of cluckers at the greater depths offers support to the hydrographic explanation of mortalities provided it can be shown that temperature and salinity changes of the kind which occur at the level of the thermocline are fatal to scallops.

Reactions of Scallops to Changes in Marine Climate.

There are no published data to show how sensitive scallops may be to sudden changes in hydrographic conditions. In the Bay of Fundy, where there is an active fishery for them, bottom temperatures are quite stable and seldom exceed 11° C. or 12° C. No mass mortalities have ever been reported there. Posgay (1950) reports that in his preliminary scallop-growth experiments in tanks at the Woods Hole Oceanographic Institution, growth was best at 6° C., ceased at 19° C., and death occurred at 23° C. He did not indicate how fast he was able to change scallops from one temperature to another, or describe the condition of his animals, but if 23° C. is the ultimate upper incipient lethal limit of thermal tolerance for this species (Fry 1947) a rapid and extensive rise from a low temperature to some level below 23° C. might produce a shock severe enough to cause death. From what little is known about reactions of animals to

combined temperature and salinity changes, changes in salinity may be expected to decrease their tolerance to temperature changes. In the Gulf, as pointed out before, salinity changes accompany temperature change and may exaggerate its adverse effects as it approaches the incipient lethal limit for scallops and cause their death at temperatures lower than would be otherwise required.

The scanty data on reactions of scallops to temperature changes and the demonstrated occurrence of great and sudden changes in the marine climate of scallop beds in the southern Gulf strongly suggests that hydrographic conditions could produce scallop mortalities there. This conclusion is further supported by a comparison of conditions in the southern straits where mortalities are quite common with those in the northern straits where they appear to be less common.

Comparison of Northern and Southern Strait

Biological characteristics, bottom topography and hydrographic conditions in scallop areas in the southern strait in the vicinity of Pictou Island or Boughton Island, appear to be very different from those in the northern entrance of the strait between Richibucto and Miminegash.

A. Biological Differences

(1) Chiasson (1952) suggests that the scallops he found on the Richibucto and the Pictou Island East beds both belonged to the 1946 year class. If this is true, it appears that the stocks on the Richibucto bed grow more slowly.

(2) Sampling in 1951 (Chiasson 1952) showed that place-to-place variation in the size of scallops on the Richibucto bed was less than in the Pictou Island area. This might be interpreted (Dickie 1951, p. 10) as having resulted from smaller variations in environmental conditions during the growth of animals in the Richibucto area.

(3) It was shown (Table 2) that mortality on the Richibucto beds to the end of the summer of 1951 was far less than on the others.

(4) Large numbers of starfish were reported off Richibucto but few were found in the southern straits.

All these biological characteristics suggest a difference in the environment on the beds in the northern and southern straits.

B. Differences in Bottom Topography

The depth of the Richibucto scallop bed is between 13 and 17 fathoms (24 to 31 meters), i.e., it is at about the same depth as the main beds in the southern straits and both are at about the

level of the thermocline. In spite of this, there is a difference in bottom topography which could produce great differences in the hydrographic features of the two areas and explain the observed differences in their biological characteristics. Leading into the southern straits is a long, deep channel. It is deeper than the thermocline and the scallop beds are close to the shelving banks of this channel. In the Richibucto area there is a wide shelf between the scallop beds and the nearest deep areas. It is interesting to speculate on the kinds of hydrographic changes which might follow summer shifts in the level in the thermocline in the two areas.

C. Possible Hydrographic Differences

In the southern region strong southerly winds would cause movement of warm surface waters out of the straits and away from the scallop beds, raising the thermocline and allowing the cold water of the deep channel to overflow its banks and flood the scallop beds. A change in wind to a northerly direction or even the subsidence of conditions after southerly winds "blow themselves out" would exactly reverse this situation, and warm water would return to the shelf. In this way the scallop beds would be subjected to a double change from warm low-salinity water to cold, high-salinity water and back again. Conceivable changes of this sort could produce the mass mortalities in scallop populations there.

The first change, from warm to cold water, should be well within the limits of thermal tolerance for the species and would not be expected to produce any untoward effects. The importance of the change from the standpoint of this theory is that if it lasts for a day or two it may allow the scallops to acclimate themselves to a low temperature - from 3 to 6° C. If then, the readjustment of the water layers over-compensates this first shift and the thermocline sinks as much as 3 to 5 meters below its normal level, scallops then acclimated to low temperatures would be subjected to water temperatures up to 18 or 19° C. Although from Posgay's results this would be within the tolerance limits of scallops acclimated to high temperatures, it is possible that sudden changes in temperature from 3 to 6° C. to 18 to 19° C. may be a sufficient shock to weaken seriously or kill them at this time of year when they are ripe to spawn.

When the thermocline rises there would be a similar tendency at the northern entrance to the straits for a flooding of the shelf by cold water from the outer deeps. However the body of cold water is so far away from the scallop beds (ca. 45 miles) that it is questionable whether the flooding could extend that far unless the disturbances were particularly violent and prolonged. If this damping effect does exist then hydrographic changes on the Richibucto bed will be less frequent, smaller and slower than in the Pictou Island district and would be correlated with the observation that mortalities there are less frequent and

less disastrous. They are, in fact, so small at times as to be overshadowed by the effects of starfish depredation.

If these hydrographic differences, which seem so likely, actually do exist they would explain the biological differences which have been observed.

Summary

In the southern Northumberland Strait mass mortalities of scallops occur frequently on shallow beds where great and rapid changes in hydrographic conditions appear likely, and less frequently or not at all at greater depths where hydrographic conditions are more uniform. Our scanty knowledge of temperature and salinity tolerance of scallops suggests that scallops on shallow beds may not be able to withstand changes in the marine climate that seem likely to occur there. These deductions support previous evidence reviewed by Dickie (1951) which indicates that hydrographic changes are responsible for mortalities there.

In the northern strait the coincidence of hydrographic changes and mortalities is not nearly so clear as in the south and the areas are remarkably different biologically. It appears that these differences are attributable to smaller, slower and less frequent temperature and salinity changes in the north than in the south and that these in turn are dependent on differences in bottom topography.

Importance of the Problem

Samplings of scallop populations in the Gulf have shown that sporadic mass mortalities may very quickly kill up to 80% of the stocks of adult scallops on beds in the southern strait. Their cause is unknown so we have no means for predicting them. This ignorance prevents any reliable prediction of commercial fishing possibilities of the beds and clouds all thinking on fisheries management programs the Department of Fisheries may wish to establish.

The evidence so far accumulated indicates that changes in hydrographic conditions are chiefly responsible for mass mortalities in the southern strait, but less important in the northern regions. However, this theory remains to be established by more detailed field observations and appropriate laboratory experiments. The solution of the problem would simplify many difficulties that are now perplexing.

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(See also references quoted by Chiasson in Part VII of this report)

