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Investigation of the deep-sea shrimp, *Pandalus borealis* K., off Nova Scotia

by

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Further to the data obtained on the shrimp beds of the Northwest Atlantic, research cruises were made in order to show the importance of deep-sea shrimp populations in certain canyons on the continental shelf off Nova Scotia. This report gives preliminary results obtained during a cruise by R/V *Cryos* in May 1971.

The survey area consisted of the deeps located off Nova Scotia; 46 trawl hauls of 30-min duration were made. Shrimp and the main commercial fishes were collected for further study in the laboratory.

A. Survey areas

The continental shelf extends for over 100 miles from the shores of Nova Scotia. It consists of a series of ridges separated by canyons of glacial origin. The coastal plain for 12 miles offshore has already been explored by the Canadian Fisheries Service for exploitable shrimp beds and has since been exploited occasionally south of Nova Scotia. On the other hand, the offshore canyons have not yet been surveyed.

Depths inside the 100-fm isobath were chosen for trawling. These deeps are found grouped into three large zones connected to the adjacent fishing banks and are, north to south:

1. Deep adjacent to the Laurentian Channel (Fig. 1)

Perpendicular to the southwest slope of the Channel is a series of depressions, some blocked, some open. North of Artimon Bank, the first deep is connected to the Laurentian Channel by a gully which consists of two basins with a maximum depth of 145 fms. The first basin has a rather irregular bottom profile, while the second one has a smooth bottom suitable for trawling. Southeast of Scatari Bank, there is a large basin 35 miles long and 15 miles wide; it is known locally as Grey Sole Basin and it has a very soft bottom and a maximum depth of 135 fms.

A series of rough bottomed gullies among the above basins allows very little trawling and then hauls of only limited duration.

2. Canso Bank deeps (Fig. 2)

These are located among Canso, Banquereau and Middle Banks; they form a complex of basins which are connected by deep submarine gullies. One finds a highly hazardous bottom, crossed or followed by abandoned submarine cables which limit fishing in some areas. The maximum depths range from 140 to 160 fms.

3. Halifax deeps

This term refers to two basins, Emerald and LaHave Basins, which are separated by Sambro Bank. These basins located south of Halifax have a smoother bottom than those mentioned above. LaHave Basin is 60 miles long and 35 miles wide. The Basins have a soft bottom not more than 145 fms deep and are easy to trawl.

B. Material and gear

The shrimp trawls used during the R/V *Cryos* cruise, designed by the Boulogne Marine Laboratory, are of three types: 33.50/39.50 wide-mouth trawl, 29.10/37.10 balloon trawl, and the 33.10/37.80 flat trawl, constructed with 600 and 400 m/kg nylon line. The horizontal opening of the gear is assured by oval otter boards of 3.10 m on 1.80 m. The ratios varied from 2.5 to 3 because of the particularly irregular bottom.

1. 33.30/39.50 wide-mouth trawl (Fig. 3)

This trawl with a 33.30-m headrope and 39.50-m footrope is characterized by the taper of its wings which gives an important vertical opening. The V-shaped wing end ropes have a 1-m loose end strap.

The trawl has 30-mm mesh net (measured on the side) in the wings and body and 20-mm in the extension and codend. The bosom has a 60-mm piece which partially eliminates trash (pebbles, invertebrates, etc.). To prevent tears in the net, belly lines have been installed.

The vertical opening and the set on the bottom are assured by 30 4-litre aluminum floats on the headrope and rubber footrope of 110-mm diameter; in addition, a further 30 kg of ballast chain is added to the bosom of the net. In front of the trawl, there are two 12-m legs connected to 50-m ground cables by danlenos made up of steel rollers and butterfly (Fig. 4-A).

Four hauls with this trawl took 150 kg of shrimp.

2. 29.10/37.10 balloon trawl

Though the same gear was used as above, this four-seam trawl was completely different. The angle of the taper, extension of the back and wide sides give it an important fullness from which the name "balloon" is derived. The net is made of 30 and 25-mm meshes and also has belly lines.

On the 29.10-m headrope there are 30 4-litre aluminum floats, while the 37.10-m footrope has rubber discs 220-m in diameter. A 30-kg ballast is attached to the bosom of the net. The right wing end ropes have 1-m loose end straps. With this gear, ground cables and legs, 7 trawl hauls were made resulting in a 130-kg shrimp catch. The loss of the hooking gear prevented evaluation of its efficiency.

3. 33.10/37.80 flat trawl

The four-seam trawl has a 33.10-m headrope and a 37.80-m footrope, (montés respectivement sur 31.10 m et 35.80 m = mounted on 31.10 m and 35.80 m respectively?). At the mounting, the wings spread extensively thus reducing the vertical opening. Similar to the balloon type, the net is 30-mm mesh size in the wings and body, and 25-mm double-mesh in the extension and codend. There are 20 4-litre aluminum floats on the headrope, and the footrope has 110-mm diameter rubber discs, while a ballast of 10 kg is attached to the bosom, thus assuring proper setting on the bottom. The gear does not have ground cables (Fig. 4-B) but only 10-m legs extending with 3-m backstrops. This type of gear allows an important horizontal opening with the vertical opening consequently diminished. It was used for 18 trawl hauls of 30-min duration for a total shrimp catch of 590 kg. In spite of the small vertical opening, 10 trawl hauls yielded a catch of 425 kg of silver hake (*Merluccius bilinearis*) which were encountered in the deep waters of Emerald and LaHave Basins.

The deep-sea shrimp is a species which swims off the bottom and therefore less ballast is necessary when trawling. One must also note the mesh size which allowed a high rate of escape; it would certainly be interesting to study the selectivity of various meshes. The use of this gear on different kinds of bottom does not allow us to compare their efficiency.

C. Results

During the cruise, 865 kg of shrimp were taken. In addition to this catch, one must also note the incidental catch of commercial fish, giving a plus-value which cannot be overlooked.

1. Shrimp

a. Yield

After a 13-day survey, 29 out of 46 trawl hauls yielded a 865-kg catch of shrimp, that is, an average yield of 30 kg/half hour.

In the deeps adjacent to the Laurentian Channel (Fig. 1), 12 hauls yielded

a catch of 276 kg. The yields from the small basins and submarine canyons are very irregular, ranging from 10 to 81 kg. On the other hand, the yield was more constant, but also smaller over the whole of Grey Sole Basin. In the latter case, the balloon trawl was used after serious damage to the wide-mouth trawl on an abandoned cable.

It is, therefore, possible that the difference in yield is due to using different gear. It should be noted that the bottom temperature was between 3.31°C and 4.02°C.

At the end of the cruise, one of the first stations was reoccupied, this time using a flat trawl. This station, located in the first basin, north of Artimon Bank, yielded 46.5 kg compared to 81 kg the first time. One could attribute this difference to the gear used, but it will be seen later that the yield of deep-sea shrimp can, within a few days, double in the same area.

Seventeen trawl hauls were made in the second section which consists of Canso deeps (Fig.2). The entire balloon trawl was lost on a hang-up during the first haul north of Banquereau Bank and all hauls were then made using a flat trawl. This gear gave an average yield of 35 kg, ranging from 8.5 to 88 kg. The most productive and favorable area for trawling is located southwest of Canso Bank. However, two stations reoccupied under the same conditions at 5-day intervals gave a drop in yield from 88 and 86 kg to 44 and 42 kg. At the same time, a drop in bottom temperature from 3.85°C to 2.82°C was observed. The sex determination showed a proportion of 363 to 489 males per mille and 318 to 163 females per mille. More information is required in order to establish the differences among these three observations.

On the whole of Halifax deeps, fishing operations were limited to 15 hauls as not one shrimp was taken. In fact, the bottom temperatures ranging from 7.05°C to 9.59°C are much less favorable to concentrations of this species. In the search for the best temperature conditions, it was found that, at this time of year, the cold waters from the Labrador Current are pushed back and lay just off the coast. From this observation, it is not impossible that the shrimp are concentrated in the coastal area.

The results obtained during the cruise must be analyzed carefully as they are only valuable for a specific time when our operations were carried out.

It can be considered that the yield at the end of May does not reach the level of the catches which can be made on concentrations of spawning females. In fact, this period corresponds to the end of the reproduction cycle; after the eggs have hatched, the females get ready for the spawning period in August, and the catches comprise a greater proportion of small-size males. One can also ask why the waters warm up at the end of spring considering the relatively limited thermal conditions which govern the deep-sea shrimp. During the cruise the catches were made at bottom temperature intervals from 2.75°C to 5.12°C, and the better hauls which surpassed 75 kg per half hour fishing are related to temperatures ranging from 3.25°C to 3.85°C.

It is difficult to compare the results obtained from this survey cruise with those from a commercial trawler. The duration of the trawl hauls allowed us to study more quickly and to survey more surface, but the results cannot be calculated on an hourly basis as recorded in research work.

In the Gulf of St. Lawrence, the hourly yield of two trawlers calculated in relation to total catch and numbers of hours fished (Couture, personal communication) ranges from 48 to 109 kg. In Greenland, Horsted and Smidt (1956) cite yields of 100 to 200 kg in Disko Bay by R/V *Adolph Jensen*; it must be noted that this area has the richest shrimp grounds, not only in Greenland but in the whole Northwest Atlantic.

To obtain these results, the codend mesh size, and quite often the whole body of the trawl, is generally 18 to 22 mm (measured on the side). The trawls used on board R/V *Cryos* had nets of 30 to 20-mm mesh size for the wide-mouth trawl, and from 30 to 25 mm for the balloon and flat trawls. This leads us to believe that the yields would have been higher if we had used smaller meshes.

b. Length analysis

The specimens caught off Nova Scotia are of average size; the number of individuals ranges from 60 to 68 per 500 grams, which is relative to the predominance in male and protandrous individuals (Fig. 5).

The sizes range from 16.5 to 28.5 mm in Lc (length of carapace measured from the orbit to the back edge of the cephalothorax), with an average length, in general, of 22 to 23.5 mm. It is estimated that beyond 25 mm in Lc, the proportion of individuals is lower when compared to total population. This is featured in the shrimp from Nova Scotia deeps in relation to those caught off the coast of Labrador, in the Gulf of St. Lawrence and Burgeo Basin on the south coast of Newfoundland. In fact, in these three areas, there is a high proportion of individuals ranging from 25 to 30 mm and certain large females reach a maximum length of 33 mm in Lc.

It must also be noted that in the same Basin, the average length increases with depth, from 23.5 to 25 mm in Lc for depths of 210 to 270 m respectively (Fig. 5-B and 5-C).

2. Fishes

In addition to the deep-sea shrimp, good quantities of important commercial fish are often found. Among the main species caught are skates (*Raja radiata*), herring (*Clupea harengus harengus*), cod (*Gadus morhua morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), red hake (*Urophycis* sp.), silver hake (*Merluccius bilinearis*), redfish (*Sebastes marinus mentella*), American plaice (*Hippoglossoides platessoides*), grey sole (*Glyptocephalus cynoglossus*), and anglers (*Lophius americanus*).

In general, catches are fairly regular, yielding hauls of 100 to 300 kg, ranging from 37 to 1,061 kg per half-hour haul. Skates, herring and redfish are predominant in the deeps near Laurentian Channel, whereas in the Canso deeps, American plaice, grey sole and skates predominate in much smaller concentrations, and in Halifax deeps, silver hake, redfish and cod predominate (Table 1).

Skates and herring are especially abundant in the shallower deeps north of Artimon Bank where a trawl haul yielded 485 and 450 kg respectively per half-hour fishing. For herring, 97% of the individuals are 33 to 38 cm in length. There are very few cod, haddock, pollock and red hake in the hauls; the landed weight is always small and comprises individuals of various lengths. Silver hake is encountered only in LaHave and Emerald Basins; in the latter, small individuals are more numerous, their length ranging from 11 to 20 cm with a mean of 15-16 cm, whereas in LaHave Basin, the mean is 26-27 cm.

Most redfish taken in the Halifax deeps are not commercial size; and even in the first area, it can be noted that the proportion of small individuals is often significant; total catch shows lengths ranging from 10 to 45 cm with means of 16, 23, 31 and 39 cm.

American plaice and grey sole are especially abundant in Canso deeps; small American plaice are also abundant, with a mean of 14 cm for lengths ranging from 8 to 70 cm. Landed grey sole are from 13 to 62 cm in length and have two distinct modes of 25-26 and 39-40 cm.

The abundance of fish caught in shrimp grounds off Nova Scotia depends on the time of fishing. Between March (Fontaine, 1971) and May, there is a large decrease in weight of commercial-size species found in a shrimp catch of 100 kg; accordingly, the weight ranges from 390 to 60 kg for cod, and from 867 to 205 kg for redfish.

Conclusion

The importance of exploitable shrimp stock off Nova Scotia cannot be determined for certain, but the yields obtained compare with those obtained from deeps surveyed in the North Atlantic. The March 1970 and May 1971 cruise results must be checked at different times of the year. With this aim, we hope to conduct research in the fall of 1972 in order to compare results and to determine the importance of the shrimp stock according to the times of fishing.

In the hypothesis of a survey, the problem, as we have stated above, lies in the use of small-mesh size trawls which often take a large quantity of fish which have not yet reached commercial size.

References

- Couture, R. 1968. Pêche expérimentale aux crevettes, été 1967. *Rapp.Sta.Biol.mar. Grande-Rivière*, p. 75-82.

Fontaine, B. 1971. Commercial fishes taken on the shrimp grounds of the Northwest Atlantic. *Int. Comm. Northw. Atlant. Fish. Redbook* 1971, Part III, p. 267-273.

Horsted, Sv.Aa., and E.S. Smidt. 1956. The deep-sea prawn (*Pandalus borealis* KR.) in Greenland waters. *Medd. Komm. Danm. Fisk. Havundersøg.*, ny series, 1, No. 11, 116 p.

Table 1. Weight in kg of different species of commercial fish taken in May. Zone 1: deeps adjacent to the Laurentian Channel; Zone 2: Canso deeps; Zone 3: Halifax deeps. The last vertical column represents weight in kg of each species taken with 100 kg of deep-sea shrimp.

zones de pêche espèces	zone 1	zone 2	zone 3	Total	Poids pour 100 kg de crevettes zone 1 + zone 2
crevette (deep-sea prawn)	338	527	-	865	-
Raies (skates)	855	253	42	1 150	128
Hareng (herring)	1 024	40	28	1 092	123
Morue (cod)	233	290	38	561	60
Lieu noir (pollock)	89	-	121	210	10
Églefin (haddock)	-	2	69	71	-
Morue barbue (red hake)	43	2	170	215	5
Merlu (silver hake)	7	-	1 439	1 446	-
Sébaste (redfish)	1 615	160	906	2 681	205
Balai (american plaice)	313	529	47	889	97
Sole grise (witch)	36	346	90	472	44
Lotte (angler)	26	75	60	161	12
Total	4 579	2 224	3 010	9 813	686

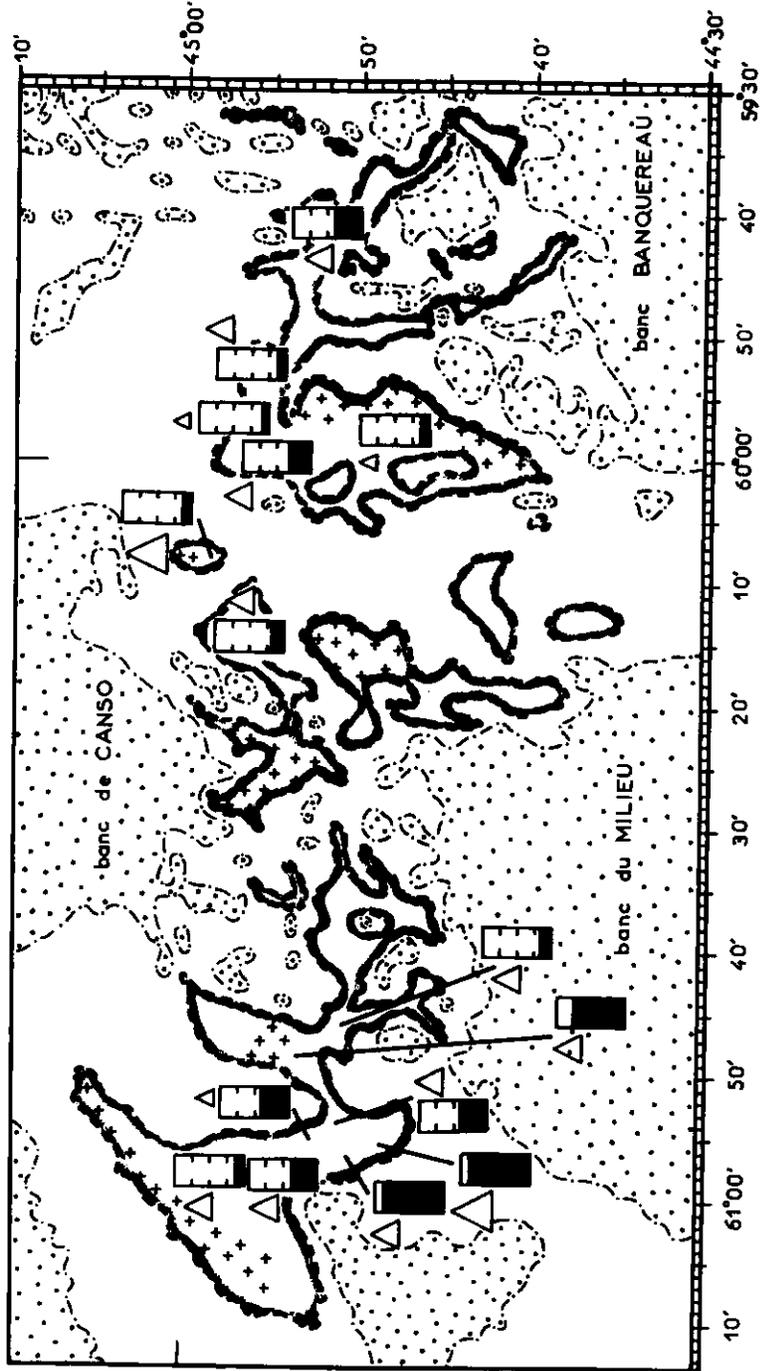


Fig. 2. Map showing Canso Bank deeps. Yield/half hour fishing time for shrimp and fish shown by same symbols as in Fig. 1.

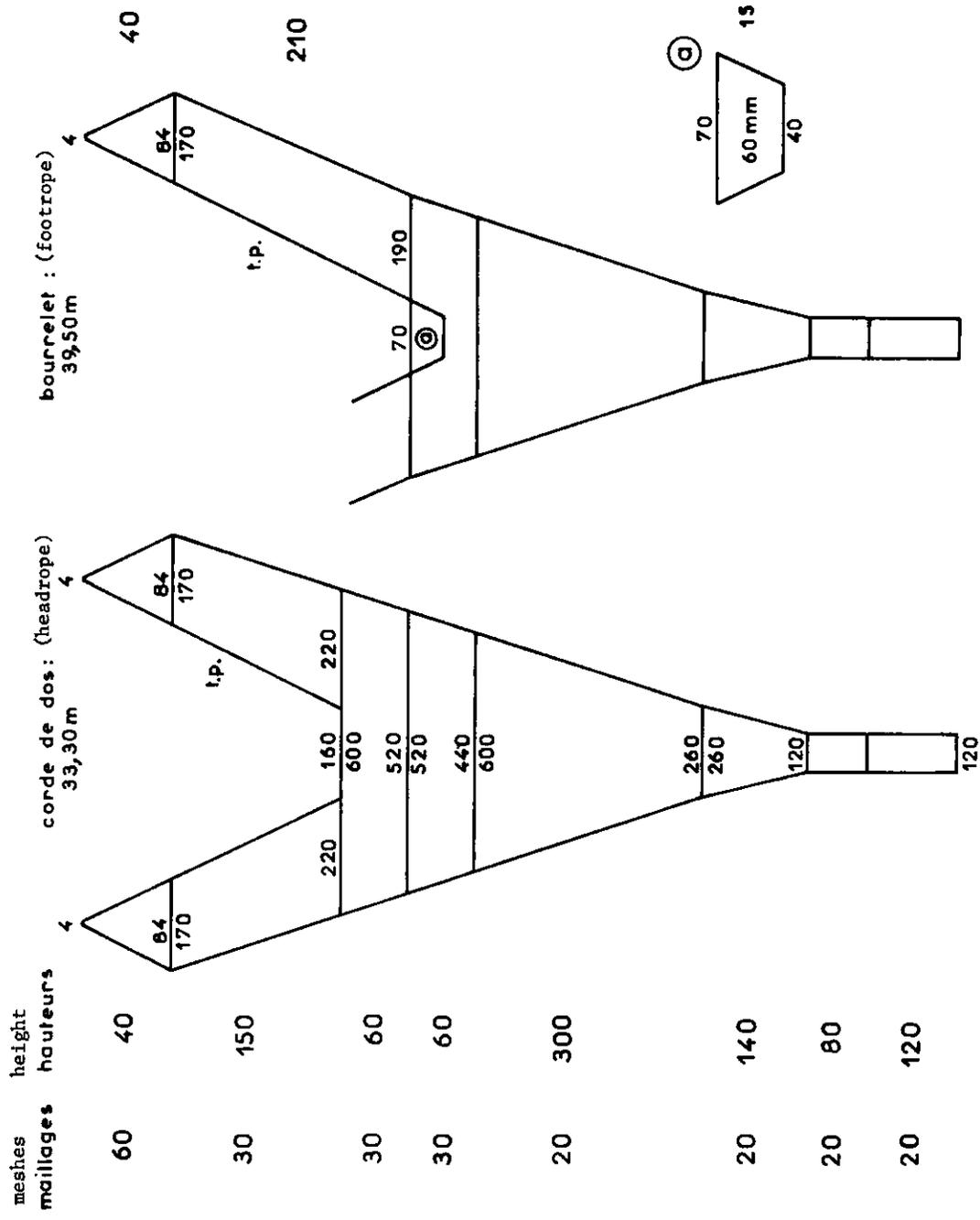


Fig. 3. Wide-mouth shrimp trawl: scale 1/200 (ISTPM drawing, Boulogne Marine Laboratory).

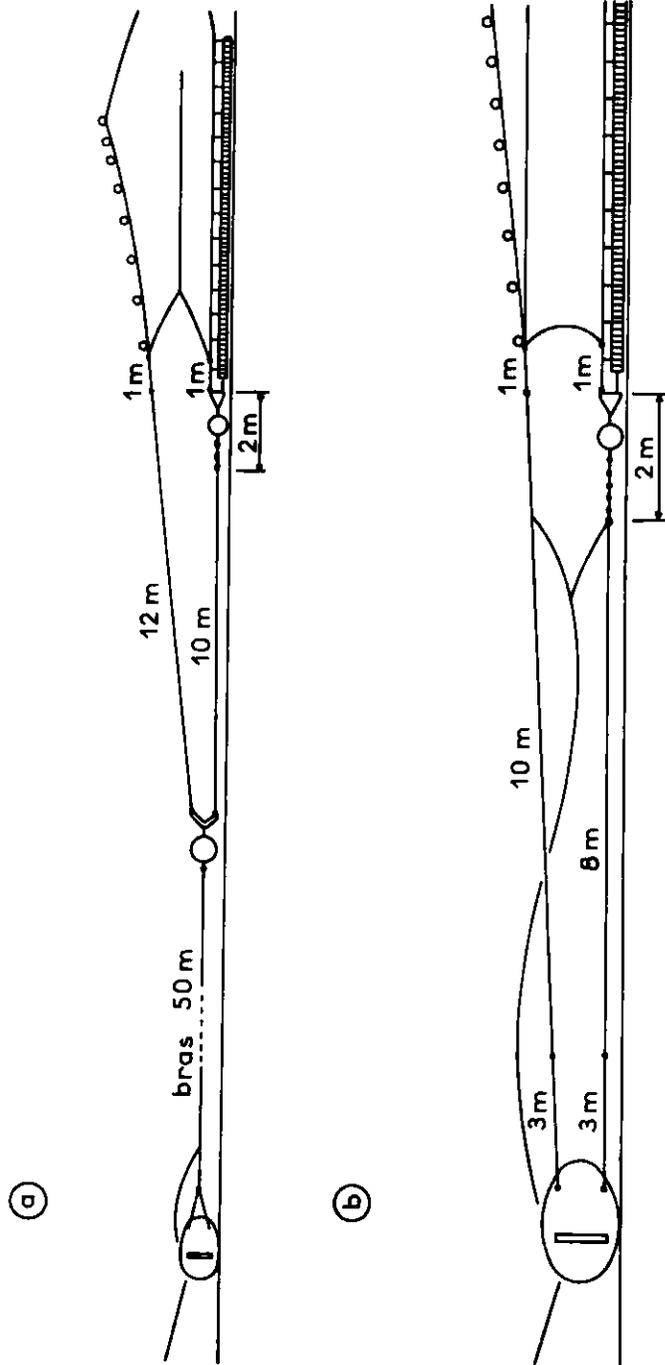


Fig. 4. Gear used with shrimp trawl on R/V *Ctyos*: a: gear used with wide-mouth and balloon trawl;
b: gear used with flat trawl.

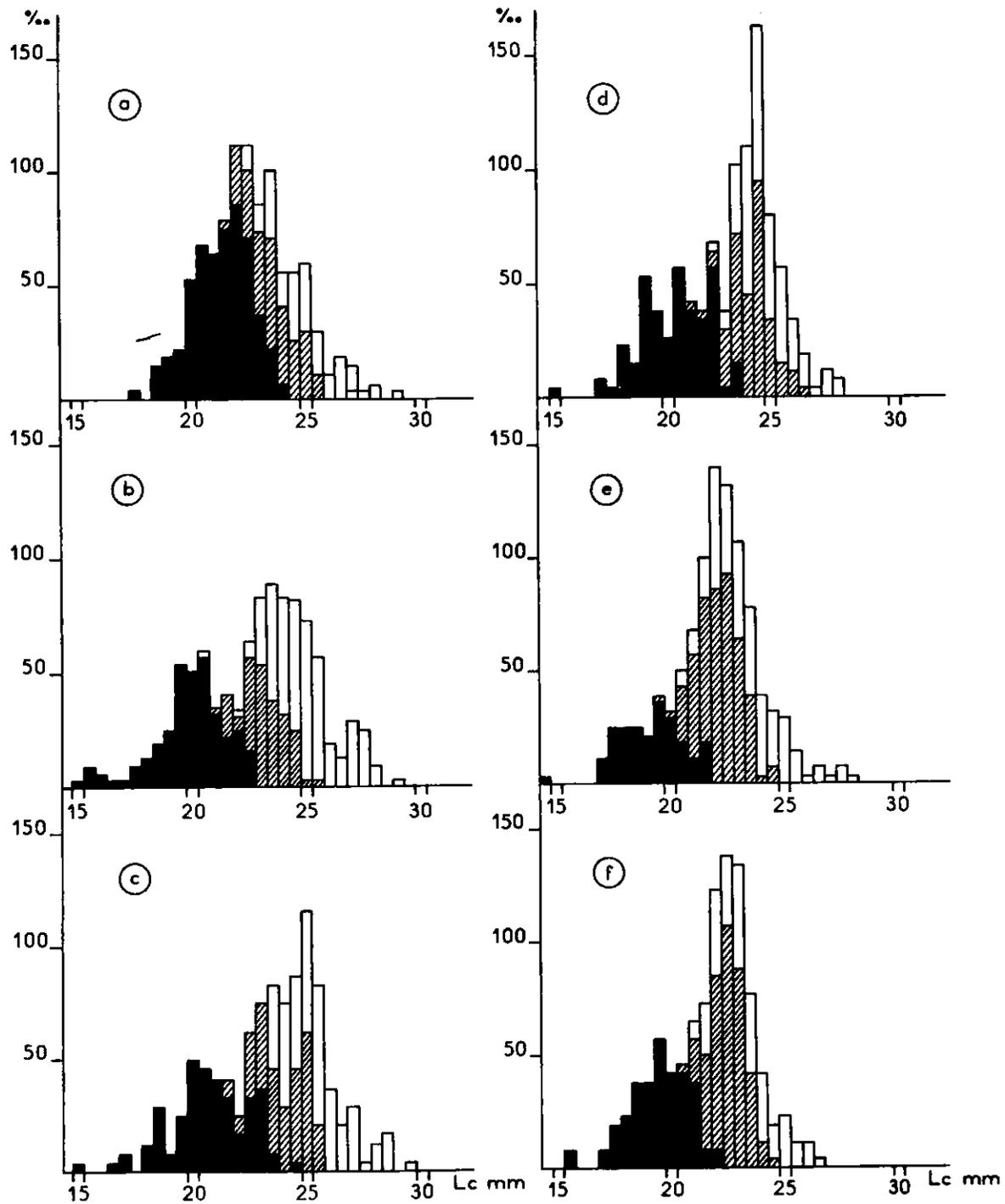


Fig. 5. Length distribution of shrimp taken: a: basin located north of Artimon Bank; b: Grey Sole Basin at a depth of 200 m; c: Grey Sole Basin at a depth of 270 m; d: basin south of Canso Bank; e: basin northeast of Middle Bank; f: basin north of Banquereau Bank.



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Page 1.

A. Survey areas

- line 1: please replace the words "over 100 miles" by "about 100 miles"
- line 6: please replace the words "Depths inside the 100-fm" by "Grounds deeper than the 100-fm"

1. Depths adjacent to the Laurentian Channel

- line 9: please replace the words "trawling and then hauls of only limited duration" by "trawling, except for hauls of limited duration"

2. Canso Bank deeps

- line 3: please replace the words "One finds a highly hazardous bottom" by "One finds several irregular bottoms"

3. Halifax deeps

- line 2: please replace the words "smoother bottom" by "greater area"
- lines 3 and 4: please replace the words "The Basins have a soft bottom.....trawl" by "Their soft bottoms not deeper than 145 fm are easy to trawl"

B. Material and gear

- line 2: please replace the words "wide-mouth trawl" by "high opening trawl"
- line 3: please replace the words "nylon line" by "nylon twine"
- line 5: please replace the words "The ratios varied from" by "The warp length/depth ratios varied from"

Page 2.

1. 33.30/39.50 wide-mouth trawl should read "33.30/39.50 high opening trawl"
- line 4: please replace the words "The trawl has 30-mm mesh net" by "The trawl has 30-mm meshes"
- line 9: please add the word "a" to "and rubber footrope" to read "and a rubber footrope"
: please delete the words "in addition"
- line 12: please replace the words "rollers and butterfly" to "rollers and butterflies"
- line 13: please replace the words "trawl took 150 kg" by "trawl caught 150 kg"

(over)

Page 2. (cont'd)

2. 29.10/37.10 balloon trawl

- line 2: please replace the sentence "The angle of the taper, derived." by "The angles of tapers, the wide square and the sides give it an important fullness from which its name of "balloon" trawl is derived."
- lines 7-9: please replace the sentences "With this gear, ground.... catch. The loss.... efficiency." by "With the ground cables and legs gear, this trawl was used for 7 hauls resulting in a 130-kg shrimp catch. The loss of the gear on a hang-up did not allow any evaluation of its efficiency."

3. 33.10/37.80 flat trawl

- lines 1-2: please replace the sentence "The four-seam trawl.....respectively??" by "This four-seam trawl has a 33.10-m headrope and a 37.80-m footrope, mounted on 31.10 m and 35.80 m."
- line 4: please replace the words "the net is 30-mm mesh" by "the net has 30-mm mesh"
- line 5: please replace the words "25-mm double mesh in the codend." by "25-mm in the extension and double-mesh codend."
- line 12: please replace the figure "425 kg" by "1,425 kg"
- line 14: please replace the words "The deep-sea shrimp is a species" by "The deep-sea shrimp being a species"
- lines 14-15: please replace the sentence "and therefore less ballst is necessary when trawling." by "it was not necessary to make the footropes "scratch" and therefore few ballasts were used with the gears."

Page 3.

C. Results

1. Shrimp

a. Yield

- line 4: please replace the words "wide-mouth trawl" by "high opening trawl"
- line 15: please replace the words "using a flat trawl" to "using the flat trawl"
- line 16: please replace the words "an average yield of 35 kg" to "an average catch of 35 kg"
- line 36: please replace the sentence "One can also ask why shrimp." by "We can also study the consequences of the warming up of the waters at the end of spring in relation with the relatively limited thermal conditions which govern the deep-sea shrimp."
- line 42: please replace the words "to study more quickly" by "to study the catches more quickly"
- line 43: please replace the words "results cannot be calculatedas recorded" by "the results cannot be multiplied by two to obtain hourly yields as recorded"
- line 52: please replace the words "wide-mouth trawl" to "high opening trawl"

Page 4.

2. Fishes

- line 24: please replace the words "the shallower deeps" to "the small deeps"

Conclusion

- line 45: please replace the sentence "The importance of exploitable.....Atlantic." by

Page 4. (cont'd)

- line 45: "The importance of exploitable shrimp stock in the deeps off Nova Scotia is not (cont'd) exactly determined, but the yields obtained can be compared with those of the other North Atlantic fishing grounds."
- line 51: please replace the words "In the hypothesis of a survey,....stated above" by "In the hypothesis of an exploitation, the problem as we have already stated"

Page 8.

- Fig. 3. Please change caption to read: "High-opening shrimp trawl: original plan was 1/200 (ISTPM design, Boulogne Marine Laboratory)."

Page 9.

- Fig. 4. Please change the words in caption "wide-mouth and balloon trawl" to "high opening trawl and balloon trawl"

