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Report on a Canadian Commercial Fishery for Flying Squid Using Drifting Gill Nets off the Coast of British Columbia

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REPORT ON A CANADIAN COMMERCIAL FISHERY FOR FLYING SQUID USING DRIFTING GILL NETS OFF THE COAST OF BRITISH COLUMBIA

by

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ABSTRACT

Robinson, S. M. C. and G. S. Jamieson. 1984. Report on a Canadian commercial fishery for flying squid using drifting gillnets off the coast of British Columbia. Can. Ind. Rep. Fish. Aquat. Sci. 150: 25 p.

During July and August 1983 a Canadian commercial fishing vessel used monofilament drifting gill nets to catch flying squid (Ommastrephes bartramii), fishing approximately 322 km offshore between 45°58'N to and 52°47'N with a mean net length per set of 3.89 km. The total catch of O. bartramii was 33.0 t which was 56.8% of the entire catch from 25 sets. Salmonids and tuna represented 0.24 and 0.82% respectively, pomfret (Brama japonica) 24%, sharks 17.7% and other miscellaneous catch 0.44%. Squid weight was fairly consistent with a mean weight of 2.33 kg, and average CPUE was 339.2 kg squid/km net.

An automatic, electric squid jigging machine was tested but the catch was low partly because the weight of the squid caused the animal to tear off the hook. Mean catch was 0.6 squid/hour.

RÉSUMÉ

Robinson, S. M. C. and G. S. Jamieson. 1984. Report on a Canadian commercial fishery for flying squid using drifting gillnets off the coast of British Columbia. Can. Ind. Rep. Fish. Aquat. Sci. 150: 25 p.

Un bateau de pêche commerciale a été utilisé en juillet et août 1983 pour faire une pêche au calmar (Ommastrephes bartramii). On s'est servi de filets maillants dérivants en monofilament de 3,89 km de longueur de moyenne. La pêche a été effectuée à environ 322 km des côtes entre les latitude 45°58'N et 52°47'N. Les prises de O. bartramii se sont élevées à 33,0 tonnes, soit 56,8% du total des prises effectuées avec 25 mouillages. De ce total, les salmonidés et les thons représentaient respectivement 0,24 et 0,82%, le castagnole (Brama japonica) 24%, les requins 17,7% et les autres espèces 0,44%. Le poids des calmars était relativement constant, la moyenne étant 2,33 kg. La prise moyenne par effort de pêche unitaire a été de 339,2 kg de calmar par km de filet.

On a fait l'essai d'une turlutte électrique automatique, mais les prises ont été peu importantes, entre autres parce que le poids des calmars les faisait s'arracher de l'hameçon. La prise moyenne a été de 0,6 calmar à l'heure.

INTRODUCTION

Industry and government have recently shown interest in the fishery potential of the flying squid, Ommastrephes bartramii (Lesueur) off the coast of British Columbia. In September and October 1979, two Japanese squid fishery vessels undertook test fishing for squid in B.C. waters in cooperation with Canadian fisheries and again in July and August 1980 (Bernard, 1980; 1981). Because of the encouraging results from these studies, it was decided to evaluate the fishing ability of a Canadian fishing vessel in catching flying squid using gillnets and jigs. This was also particularly opportune as a commercial Japanese vessel was experimentally fishing at the same time in Canadian waters (N. Sloan, unpublished) which allowed a more rapid identification of the better fishing areas and the opportunity to evaluate relative fishing performance.

O. bartramii is a large oceanic squid often weighing up to 4.5 kg (Bernard 1980). It is distributed in tropical and temperate waters although its normal northern boundary has not yet been determined for eastern Pacific waters. Based on Japanese studies, the squid spawn in tropical latitudes during January to May. They appear to have a lifespan of approximately one year and males mature before females (Murata and Ishii 1977).

The Japanese fishery on this species uses two methods to harvest the squid: automatic jigging machines and long, drifting, monofilament gill nets. Jigging accounts for the largest catch of O. bartramii in the coastal Japanese waters (Murata and Shimagu 1982) while the high seas gill net fishery catches large quantities in the north Pacific around the longitude of 180°.

The objectives of this study were several fold. First, more information on the population of O. bartramii was needed with respect to distribution and abundance. This is of particular interest as the warm ocean water (WOW) influx this year from the southern areas may greatly extend the northern range of the squid. Second, the amount of squid that could be caught during late summer was of interest as Bernard (1980) suggests that this time of year may produce the largest catches. Third, the feasibility of a commercial Canadian fishery vessel for catching squid was to be evaluated. Bernard (1981) suggests that while a fishing fleet strictly for squid is probably uneconomical, it is possible that a multispecies fleet could viably exploit both squid and tuna. Therefore, if a commercial tuna boat could catch a sufficient quantity of squid, a fishery on squid may be feasible if shore based facilities also develop.

MATERIALS AND METHODS

The fishing operation was conducted approximately 322 km off the coast of British Columbia and Washington between the latitudes 45°58'N to 52°47'N. A total of 25 sets were made (Fig. 1). Fishing was done outside the

1000 fathom (1829 m) edge to minimize the potential salmon catch. The water temperature ranged from 13.3 to 15.7°C with a mean of 15.2°C.

The SIMSTAR is a 230 ton Canadian tuna vessel (length: 29 m; beam: 9.1 m). The nets were handled by means of rollers and a hydraulic operated drum on the stern of the ship. The catch was stored in four holds and frozen with a blast freezer system. Each hold has a capacity of 45 tons.

The nets used for fishing were monofilament, drifting gill nets in sections with a depth of approximately 7.2 m from the corkline to the leadline per section when hanging in the water. These were lashed together but were easily removable in order to repair any damage.

Two types of sections were used for fishing. 1) Translucent white monofilament were of 10 gauge and had a stretched mesh diameter of 121 mm. There were two of these sections, each 200 m long and they were used in all sets. 2) Green monofilament were of 8 gauge and had a stretched mesh diameter of 121 mm. These sections were 100 m long. The mean length of net used ($\pm$1S.D.) over the 25 sets was 3.89 ± 0.91 km with a range of 1.6 to 4.8 km.

The nets were set from the stern while sailing at approximately 3 (1.5 m/sec) knots with the wind. Two men tended the net as it came off the drum to avoid backlashes and a third man controlled the drum speed. An intercom system allowed communication with the wheelhouse in case problems developed or the end of the net was reached. Setting the net took approximately 1 hour.

Once the net was in the water it was tracked and located with various markers. On each end of the net there was a 50 cm diameter red float (scotchman), a 3 m pole with a radar reflector and a radio directional beeper and a 2 m pole with a light which flashed at night. The radio directional beeper was monitored with a VHF radio directional scanner from the wheelhouse.

Hauling the net started at first light (0545 hrs in the southern areas and 0615 hrs in the northern region above Vancouver Island) as studies have shown that the catch of blue sharks increases substantially with daylight (Bernard 1981). After removing the locating devices on the downwind end of the net, the end was attached to a rope brought over the side roller, around the dead-drum and onto the hydraulic drum on the stern (Fig. 2). The net was brought onboard until the catch reached the dead-drum at which time the hydraulic drum was stopped and the net cleared of fish. The squid were put in enclosures on deck with flowing seawater to wash away the ink which will stain the flesh. The by-catch was put in tubs.

The squid were either frozen whole in lots of 5 per bag or cleaned and packaged. Cleaning the squid involved removing the head and viscera by hand, washing the mantle in running seawater, removing any viscera remaining and individually packaging each mantle in a plastic bag. The remaining viscera and head sections were put in large plastic bags with 23 kg of squid remains per bag. All the squid catch was frozen in the holds by blast freezers and kept at -40°C. With the remaining by-catch, the albacore tuna were frozen whole, a small amount of pomfret was frozen in lots of 10 per bag and a few large sharks were gutted and frozen whole. The rest of the by-catch was discarded.

From each day's gill net catch, a sample of usually 30 or more specimens were taken of each species and weighed on a platform scale to the nearest 0.5 kg. After the eighth set dorsal mantle lengths (DML) were taken to the nearest 1.0 cm on the weighed sample of squid. Specific observations on the catch were made at this time. All of the catch was counted after it was processed. The unwanted by-catch was counted as it was thrown overboard.

Surface isotherms were determined with a temperature sensor in the water intake of the ship's engine. The readout values in the wheelhouse were to the nearest 0.1°C. Daily communication was maintained with the Japanese fishing vessel when water temperature and daily catch information would be exchanged.

An automatic, electric 2-line jigging machine was used for jigging squid. Each line had 15 standard squid jigs, one with alternating colors of red and green and the other with groups of colors of red, green and orange. The hook size of the jigs was 17 mm. Jigging was conducted on the windward side of the ship to avoid tangling the lines on the bottom of the hull to a depth of 50 m. Jigging started at approximately 2300 h nightly and continued until 0300 h. Four powerful deck lights (unknown wattage) were turned on while the jigging occurred.

In data analysis, the CPUE of the net was defined in two ways:

$$\mathrm{CPUE}^1 = \frac{\text{weight of squid caught in net (kg)}}{\text{length of net (km)}}$$

This definition allows comparison with the observations of Bernard (1981).

Another definition of CPUE considers the duration the net is in the water at night. The time is calculated from when the entire net is in the water until the time it is hauled at first light (i.e. 0545 in the southern areas and 0615 in the northern area). This definition of CPUE is defined as:

$$\mathrm{CPUE}^2 = \frac{\mathrm{CPUE}^1}{\text{hours of fishing}}$$

In order to calculate the difference between the fishing efficiencies of the two types of net sections, the catch of two 100 m green sections on each side of the 200 m white sections which were attached together were counted and compared with the catch of the white sections. This allowed for the same length of sections to be compared and was done on two separate occassions.

Stomach contents of *O. bartramii* and *B. japonica* were examined subjectively during the cleaning and processing of the catch and the major food groups identified.

RESULTS

A. Gill nets

A total of 16 species were captured in the gill nets (Table 1). Of these, 3 species, *Ommastrephes bartramii*, *Brama japonica* and *Prionace glauca*, composed 95.9% of the total catch by weight. *O. bartramii* was the most abundant composing 56.8% of the catch. The salmonids made up 0.24% of the catch and tuna 0.82% (Table 2). The details of each set may be seen in Table 3. The mean $CPUE^1$ ($\pm$1SD) of the net was 339.2±168.7 kg squid/km, and the mean $CPUE^2$ was 39.68$\pm$19.98 kg squid/km/hr.

The squid caught in the 25 sets were relatively uniform in size based on mean weights and dorsal mantle lengths (Table 4). The mean weights ranged from 1.87 to 2.69 kg with an overall mean of 2.33 kg while the mean dorsal mantle lengths ranged from 38.4 to 4.1 cm with an overall mean of 42.1 cm (not including the first 8, mean set values estimated from the length/weight regression (Murata and Ishii 1977). The mean weights for the rest of the by-catch may be seen in Table 5.

There was a significant negative correlation between the number of *Lamna ditropis* caught in the nets and the water temperature (r^2=-0.38, $p<0.01$). No significant trends with temperature were found for any other species. Squid $CPUE^1$ was found to be significantly positively correlated with the latitude of the gill net set (r^2=0.20, $p<0.05$) but was not correlated with the water temperature (r^2=-0.03, n.s.). There was a significant difference ($P<0.05$, Student t-test) between the fishing efficiencies of the two types of nets used. The green monofilament net, based on catch per km, had a higher catch than the white monofilament net by a factor of 2.7 (Table 6).

Based on occurance in the stomach contents, the squid, *O. bartramii*, was found to be mostly feeding on squid, including its own species (66%), both squid and teleost species (17%) and 17% had empty stomachs (n=12). The pomfret, B. *japonica*, were eating euphausiids (58%), small squid species (27%) and other unidentifiable material (15%) (n=26).

B. Experimental jigging

Details of each squid jigging station may be seen in Table 7. A total of 26 squid were caught on the jigging machine for a mean of 0.6 squid/hour. The catch was compared with the jigging operation of another vessel, the Tomi Maru No. 88, which was fishing concurrently with this trip (N. Sloan, unpublished) (Table 8).

DISCUSSION

Catch Evaluation

The total catch of the drifting gill nets was 58.1 mt and was comprised of 16 species. This species list is similar to the catches made by Japanese vessels in this area (Bernard 1980; 1981). The species proportions by weight are also similar, with the catch of Ommastrephes bartramii more than double that of any other species. Based on Bernard's (1981) suggested by-catch allowances for presently exploited commercial fish (i.e. less than 1% for all salmonids and less than 5% for tuna), the by-catch of these species on this cruise was acceptable, (salmonids: 0.25%, tuna: 0.8%). This low by-catch of other commercial species favours the establishment of this potential fishery and supports Bernard's observation that nets set greater than 100 km offshore and in water warmer than 13°C will have an acceptably low by-catch of other important species, especially salmon.

Although the daily catch of O. bartramii caught by Japanese vessels was greater than that caught by the SIMSTAR, the difference is due primarily to the length of net used. When the actual fishing CPUE are compared, the efficiency of the SIMSTAR compared favourably with the Japanese vessels (Table 9). The larger CPUE during this study of the SIMSTAR over the TOMI MARU No. 88 is partly due to the fact that the Japanese vessel was on an exploratory research survey and therefore did not necessarily remain long in areas yielding a high CPUE. The SIMSTAR's goal was to evaluate the fishing potential and thus stayed longer in the productive areas biasing the relative CPUE performance. Another possible contributing factor to the higher CPUE of the SIMSTAR was that the net was picked clean of all catch whereas large Japanese vessels only pick out the small by-catch (i.e. Brama japonica) if time permits (N. Sloan personal communication). When the net is reset, the subsequent decaying of old by-catch would attract sharks resulting in loss of catch through consumption and possible net damage.

The variations in the CPUE indicates that there are some areas that have a greater abundance of squid than others. While catches of O. bartramii were obtained in all sets the largest catches were made in the north near the Queen Charlotte Islands. This larger catch in the cooler northern areas suggests that although O. bartramii may prefer certain isotherms (Bernard 1980; 1981) they are not exclusive to those and may be found in moderate quantities in other areas.

The sizes of O. bartramii caught in this study were quite uniform with a mean dorsal mantle length of 42.1 cm (unweighted mean not including the calculated values) and a mean weight of 2.28 kg (unweighted mean). This size consistency of the catch is probably due in part to the mesh size of the net as it may allow smaller squid to extricate themselves and prevent larger ones from becoming entangled. Whether or not this is occuring will have to be determined by further studies with more intensive quantitative sampling as there is no information to date on the range of the size frequency found within a school of O. bartramii.

The observed slight increase in size with an increase in latitude is probably explained by growth as fishing started in the southern areas and proceeded north. Japanese studies on O. bartramii have shown that the squid are capable of growing at a rate of 2-4 cm/month during July and August (Murata and Ishii 1977). It is interesting to note that the specimens of O. bartramii caught in Japanese waters at the same time of year are smaller having a mean dorsal mantle length of approximately 25-35 cm (Murata and Ishii 1977) although these values represent squid caught during jigging operations. This difference may therefore result from different fishing methods.

CPUE was a difficult parameter to quantify in this study. Because O. bartramii vertically migrate diurnally and are actively feeding at the surface at night (Bernard 1981), we have defined CPUE in two ways: 1) the catch of squid per km of net used and 2) the catch of squid per km of net divided by the number of hours the net was in the water until daybreak. While the second measurement is more detailed than the first it also has inherent error associated with it such as not knowing the exact time when the squid left the top 10 m of the water column. Another potential error of both measures of CPUE is the loss from the net due to predation, which would tend to underestimate CPUE. Further studies will have to be done before the relative accuracy and merit of these measurements can be determined.

We suggest that the significant difference in CPUE between the 8 gauge green monofilament gill nets and the 10 gauge white monofilament gill nets can be explained as follows: Squid, being nocturnal predators with well-developed vision might better detect the white net hanging in the water and hence avoid it, as it would reflect more light than the thinner green one. Green net is recommended in all future operations.

The better correlation between CPUE and latitude than with CPUE and water temperature may be somewhat misleading. O. bartramii is reported to inhabit cool boreal waters along thermal fronts when they move north (Bernard 1981). Cool water temperatures (14-15°C) were found in the southern areas of the study but were sporadic and inconsistent. Therefore, what may be happening is that many O. bartramii follow the main preferred isotherm and move north as it moves. This then results in a positive correlation with latitude and CPUE. The relatively smaller, sporadic locations of optimal water temperature further south would also attract squid but in fewer numbers due to their ephemeral nature. The effect of the warmer ocean water off the British Columbia coast this year undoubtedly extended the northern range for O. bartramii. In more usual years, this may mean that the best fishing for O. bartramii may take place in more southern B.C. waters, which would result in lower travel costs.

The results from the squid stomach content analysis indicate that O. bartramii is cannabalistic. This agrees with Clarke's (1966) observations. However, the loss of squid in the net to other squid is probably not substantial. All of the observed damage to the catch was done by sharks as determined by their characteristic bite marks.

Fishing Evaluation

The size of the SIMSTAR (29 m) was adequate for the fishing operation although deck space was cramped at times. The vessel was capable of travelling long distances, staying out for periods of 60 days and could haul the gear in all but the roughest weather. With a CPUE[1] of 714.1 kg squid/km net and a net length of 4.8 km, it would take the SIMSTAR 53 days to fill its holds. Bow and stern thrusters were indispensable as they made maneuvering around the net during hauling much easier. One problem encountered was the wind drift of the ship away from the nets at night. On windy nights, the ship would drift up to 5.5 km away from the nets in 2 hours and wave clutter on the radar made location of the radar reflector buoys difficult. Consequently, the ship ran up to the net every few hours. This problem might be minimized by employing a sea-anchor after the net is set.

The technique for handling the net with the drum and roller system was satisfactory although it was slower than the Japanese system using rubber ball net haulers. Part of this may also be a function of the inexperience of the crew in handling the catch. As mentioned above, the green nets were more efficient at catching fish than the white nets but there were some problems. The 8 gauge monofilament was too small as the meshes of the net would break with strong hand tension while removing sharks. Possibly a gauge of 9 or 10 would stand up better to more stress.

Sharks caused the largest amount of damage to the nets. Large blue sharks use a tearing or whipping motion with their body when they become entangled in the net and this often results in the shark ripping the net and escaping (S. Robinson, personal observation). Salmon sharks apparently undergo a violent spinning motion when caught which results in the shark rolling itself up in in the net, often several layers thick. Occasionally, 50 m of net are rolled around one shark. Additional damage to the net incurs during the untangling of all large sharks by the crew as they free it from the net. Another source of damage occurs to the net when heavy animals are lifted out of the water and over the side roller. The use of a gaff at this point helps to relieve the stress on the net and reduce tearing.

The processing of the catch was the major area of the operation that could be improved. Hand cleaning of squid was slow and awkward and much time could be saved with the use of a gutting and splitting machine as was used on the Japanese vessel (N. Sloan, pers. communication) or similar to one developed for *Loligo opalescens* off the coast of California (Singh and Brown 1980; Brown, Singh and Coffelt 1981). Individually bagging squid in plastic bags by hand was also laborious and time consuming. The technique of glazing and freezing the squid in trays may be more efficient. Overall, the processing phase should be as rapid as possible as squid tend to deteriorate quickly after being caught (Learson and Ampola 1977).

Weather was not usually a limiting factor in fishing the gear as the net could be hauled in winds up to 35 knots (Beaufort Scale 8). After this point standing on deck became difficult and the cleaning of the net was slowed considerably.

Automatic Jigging Operation

The jigging operation was not successful. Not enough squid were caught (i.e. 1.9 squid/night) to make squid jigging feasible. While part of the problem may have been the lighting system of the ship was not designed for attracting the squid, it was the weight of the squid that resulted in the loss of most of those that got hooked. As the squid would come out of the water, their tentacles and occasionally some of their arms would rip off allowing the squid to escape. It appeared that the tentacles could be autotomized as the majority of the appendages remaining on the jigs were tentacles. This phenomena of *O. bartramii* dropping their tentacles is also found in the Japanese squid jigging fishery. Murata *et al.* (1981) report that many squid are caught with regenerating tentacles and there is a high incidence of these later on in the fishing season. They also suggest those animals with amputated appendages survive normally and regenerate the tentacle in due course.

The average CPUE of jigging was 0.6 squid/hr while the Japanese commercial jigging fishery on this species often catches 100 squid/hr/machine (Murata and Ishii 1977). Reasons for this difference are unclear but may relate to average squid size, superior gear, fishing techniques, and different enviromental conditions. The squid caught in the Japanese fishery are generally smaller and so may also be more catchable due to different schooling characteristics.

The catch from the squid jigs was too small to evaluate the performance of the colors and patterns of the jigs used. It is not known whether increasing the size of the barb rosettes on the jig would reduce the loss of squid due to autotomizing of the tentacles. More work on this aspect could be done.

Tangling of the jigging lines increased when the weather was rough and the wind caused the boat to drift quickly. This could probably be reduced if a sea anchor was used. It is possible that one jigging line was broken by a blue shark as a squid on a hand jig was bitten by a blue shark as it was hauled aboard and a blue shark was caught on a hand jig. This observation of blue sharks striking at hooked squid and breaking lines has been reported for *Illex illecebrosus* from the east coast of North America (Long and Rathjen 1980).

CONCLUSIONS

During years of warm water influx off British Columbia, there are large numbers of the flying squid, *Ommastrephes bartramii*, present as far north as the Queen Charlotte Islands which are able to be caught using drifting gill nets. Further studies should be done to determine the distribution and abundance of the squid during years with more average water temperatures.

The use of a 230 ton tuna vessel to fish flying squid with gillnets was successful, although the methodology for handling the nets and vessel size limited the length of net that could be hauled per day to approximately 5 km. The establishment of a jig fishery for flying squid based on automatic squid jigging machines does not appear to be practical.

Processing the squid on board ship should be done as soon as they are caught, in order to maintain high catch quality preferably by machine for speed and to minimize labour requirements. Freezing should also be done rapidly. The development of a market for the by-catch, especially pomfret, would enhance the profitability of a squid fishing venture.

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Table 1. List of species caught during this study.

Scientific name	Common name
Brama japonica Hilgendor	Pomfret
Erilepis zonifer Lockington	Skilfish
Lamna ditropis Hubbs and Follett	Salmon shark
Mola mola (Linne)	Sunfish
Ommastrephes bartramii (Lesueur)	Flying squid
Oncorhynchus gorbuscha (Walbaum)	Pink salmon
Oncorhynchus keta (Walbaum)	Chum salmon
Oncorhynchus nerka (Walbaum)	Sockeye salmon
Pentaceros richardsoni Smith	Pelagic armorhead
Phocoenoides dalli (True)	Dall porpoise
Prionace glauca (Linne)	Blue shark
Remora remora (Linne)	Remora
Salmo gairdneri Richardson	Steelhead trout
Sarda chiliensis (Cuvier)	Bonito tuna
Thunnus alalunga (Bonnaterre)	Albacore tuna
Trachurus symmetricas (Ayres)	Jack mackeral

Table 2. Summary of catch by numbers, weight and percentage.

Species	No.	wt.(kg)	% (by weight)
Ommastrephes bartramii	14133	32986	56.8
Brama japonica	16524	13916	24.0
Prionace glauca	2110	8796	15.1
Lamna ditropis	66	1511	2.6
Thunnus alalunga	75	446	0.8
Phocoenoides dalli	1	123	0.2
Trachurus symmetricas	63	95	0.2
Oncorhynchus gorbuscha	31	73	0.1
Mola mola	2	53	0.09
Oncorhynchus keta	11	45	0.08
Salmo gairdneri	11	35	0.06
Sarda chiliensis	3	12	0.02
Oncorhynchus nerka	1	2	0.003
Erilepis zonifer	2	1	0.002
Pentaceros richardsoni	1	0.3	0.0005
Remora remora	1	0.1	0.0002
Total	33035	58094.4	

Table 3. Catch details of each set for the SIMSTAR, July–August 1983. CPUE[2] is not available for set #24 due to problems incurred during hauling.

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
1	July 19	46°50.2', 130°58.0'	13.3	2039–1115	2.3	Ommastrephes	141	322	139.8	17.26
						Prionace	130	527		
						Lamna	11	315		
						Brama	34	26		
						Trachurus	10	10		
2	July 20	46°33.0', 131°13.5'	14.0	2115–1620	2.5	Ommastrephes	748	1616	646.3	86.17
						Brama	2860	1805		
						Prionace	117	475		
						Lamna	3	83		
3	July 22	47°51.3', 130°40.2'	14.5	2115–1110	2.5	Ommastrephes	300	636	254.2	33.89
						Brama	564	449		
						Prionace	27	188		
						Mola	1	40		
						Lamna	2	36		
						Thunnus	1	6		
4	July 23	48°11.7', 130°07.1'	15.6	2100–1415	2.5	Ommastrephes	60	130	51.9	6.65
						Brama	2601	2150		
						Prionace	63	274		
						Thunnus	2	16		
						Lamna	1	9		
5	July 30	46°32.3', 131°10.5'	15.3	2052–0800	1.6	Ommastrephes	152	323	201.9	25.56
						Prionace	25	122		
						Brama	96	86		
						Lamna	1	23		
						Trachurus	5	6		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
6	July 31	45°58.9', 131°11.0'	15.6	2058-1015	3.4	Ommastrephes	311	587	172.9	22.17
						Prionace	51	192		
						Brama	219	165		
						Thunnus	3	25		
						Lamna	1	13		
						Trachurus	6	8		
						O. gorbuscha	1	2		
7	Aug 1	46°42.1', 131°20.6'	15.6	2116-1304	3.7	Ommastrephes	769	1561	421.9	56.25
						Brama	1130	949		
						Prionace	104	325		
						Lamna	1	18		
						Trachurus	5	8		
						Thunnus	2	5		
						Salmo	1	2		
8	Aug 3	46°41.4', 131°27.2'	15.3	2059-1136	3.7	Ommastrephes	463	968	261.5	33.53
						Brama	470	395		
						Prionace	107	282		
						Lamna	4	81		
						Thunnus	2	12		
						Trachurus	7	8		
9	Aug 4	46°42.8', 131°25.0'	15.0	2034-1230	3.7	Ommastrephes	623	1166	314.9	38.40
						Prionace	107	386		
						Brama	146	143		
						Thunnus	17	93		
						Trachurus	2	4		
						Pentaceros	1	(1)		
						Remora	1	(1)		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
10	Aug 5	46°39.8', 131°19.1'	15.3	2051-1249	3.9	Ommastrephes	695	1376	352.8	44.66
						Prionace	152	550		
						Brama	326	293		
						Thunnus	8	47		
						Lamna	1	23		
						Trachurus	2	3		
						Salmo	1	3		
						O. nerka	1	2		
11	Aug 6	46°41.8', 131°23.2'	15.6	2040-1210	3.9	Ommastrephes	369	861	220.5	27.22
						Prionace	162	632		
						Brama	511	439		
						Thunnus	9	34		
						Mola	1	13		
						Thrachurus	1	2		
12	Aug 13	48°36.4', 133°04.4'	15.6	1930-1400	4.5	Ommastrephes	568	1401	311.4	33.48
						Prionace	217	724		
						Brama	749	662		
						Lamna	4	70		
						Thunnus	1	10		
						Trachurus	4	6		
13	Aug 14	48°47.3', 132°13.9'	15.6	2006-1138	4.5	Ommastrephes	488	1005	223.3	25.67
						Prionace	78	306		
						Brama	104	92		
						Thunnus	10	66		
						Trachurus	14	25		
						Lamna	1	19		
						O. keta	1	2		
						Salmo	1	2		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
14	Aug 15	49°30.6', 132°47.1'	15.7	2030-1345	4.5	Ommastrephes	561	1385	307.8	37.08
						Prionace	246	1006		
						Brama	1015	954		
						Lamna	1	23		
						Thunnus	2	12		
						O. keta	1	2		
						Salmo	1	2		
15	Aug 16	48°53.6', 133°54.5'	15.6	2055-1345	4.5	Ommastrephes	413	955	212.2	27.21
						Brama	869	860		
						Prionace	141	537		
						Thunnus	8	41		
						Trachurus	4	8		
16	Aug 17	48°54.3', 132°24.5'	15.7	2106-1127	4.5	Ommastrephes	419	976	216.8	28.16
						Prionace	59	288		
						Brama	257	260		
						Trachurus	2	5		
17	Aug 18	49°15.0', 132°16.5'	15.7	2045-1130	4.5	Ommastrephes	315	842	187.1	23.39
						Brama	1019	978		
						Prionace	58	286		
						Thunnus	1	6		
						Trachurus	1	2		
						Salmo	1	2		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
18	Aug 20	52°28.4'. 135°29.1'	15.1	2005-1558	4.5	Ommastrephes	1208	2922	649.4	70.59
						Brama	526	447		
						Prionace	27	264		
						Lamna	8	192		
						Thunnus	1	12		
						O. keta	1	6		
						O. gorbuscha	2	5		
						Salmo	1	4		
19	Aug 21	52°25.8', 135°51.4'	15.4	2048-1620	4.5	Ommastrephes	1212	3214	714.1	84.01
						Brama	1415	1025		
						Prionace	47	299		
						Lamna	5	133		
						O. gorbuscha	11	26		
20	Aug 22	52°39.5', 135°54.5'	15.0	2020-1354	4.5	Ommastrephes	712	1684	374.2	
						Brama	795	741		42.04
						Prionace	29	223		
						Lamna	8	171		
						Phocoenoides	1	123		
						Thunnus	1	6		
						O. gorbuscha	3	6		
						Salmo	1	4		
						Erilepis	2	1		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
21	Aug 24	52°28.4', 135°59.1'	15.1	2000-1310	4.5	Ommastrephes	976	2626	583.5	62.74
						Brama	215	210		
						Prionace	38	175		
						Lamna	3	63		
						Thunnus	1	14		
						O. gorbuscha	2	6		
						Sarda	1	4		
						Salmo	1	4		
22	Aug 25	52°30.5', 135°52.3'	15.4	2030-1310	4.5	Ommastrephes	750	1850	411.1	46.42
						Brama	386	381		
						Prionace	36	179		
						Lamna	3	72		
						O. gorbuscha	7	16		
						Thunnus	1	6		
23	Aug 26	53°11.5', 135°46.5'	15.0	2010-1225	4.5	Ommastrephes	767	1905	423.3	46.52
						Brama	117	201		
						Lamna	4	79		
						Prionace	9	63		
						Thunnus	5	38		
						O. gorbuscha	5	12		
						O. keta	1	3		
24	Aug 27	53°11.5', 134°37.0'	15.1	2059-2049	4.8	Ommastrephes	493	1223	254.7	*
						Brama	75	129		
						Prionace	18	126		

Table 3. (cont'd)

Set #	Date	Position Lat N, Long W	Surface Temp. °C	Time (h)	Net Length (km)	Species	Catch #	Catch kg	CPUE[1] (kg squid/km)	CPUE[2] (kg squid/km/h)
25	Aug 29	52°47.0', 132°41.5'	15.3	2013–1237	4.8	Ommastrephes	620	1457	303.5	32.99
						Prionace	62	374		
						Lamna	2	89		
						O. keta	7	32		
						Brama	25	24		
						Salmo	3	12		
						Sarda	2	8		

Table 4. Mean weights and dorsal mantle lengths (DML) of squid from each set by the SIMSTAR, July-August 1983. Set #24 not included because weather was too rough to take measurements.

Set #	Date	Position (Lat. N,	Long W)	DML (cm) x ± s.d.	Mean wt. (kg)	n
1	July 19	46°50.2'	130°58.0'	42.1*	2.28	30
2	July 20	46°33.0',	131°13.5'	41.4*	2.16	75
3	July 22	47°51.3',	130°40.2'	41.2*	2.12	80
4	July 23	48°11.7',	130°07.1'	41.4*	2.16	60
5	July 30	46°32.3',	131°10.5'	41.2*	2.13	30
6	July 31	45°58.9',	131°11.0'	39.7*	1.89	31
7	Aug 1	46°42.1',	131°20.6'	40.6*	2.03	50
8	Aug 3	46°41.4',	131°27.2'	41.0*	2.09	50
9	Aug 4	46°42.8',	131°25.0'	38.4±2.6	1.87	35
10	Aug 5	46°39.8',	131°19.1'	39.5±3.1	1.98	25
11	Aug 6	46°41.8',	131°23.3'	41.9±3.8	2.33	36
12	Aug 13	48°36.4',	133°04.4'	42.9±3.6	2.47	30
13	Aug 14	48°47.3',	132°13.9'	40.6±3.0	2.06	42
14	Aug 15	49°30.6',	132°47.1'	42.4±3.7	2.47	32
15	Aug 16	48°53.6',	133°54.5'	41.8±3.2	2.31	48
16	Aug 17	48°54.3',	132°24.5'	41.6±3.1	2.33	32
17	Aug 18	49°15.0',	132°16.5'	43.6±3.5	2.67	29
18	Aug 20	52°28.4',	135°29.1'	42.7±3.3	2.42	35
19	Aug 21	52°25.8',	135°51.4'	44.1±2.2	2.65	33
20	Aug 22	52°39.5',	135°54.5'	42.7±2.3	2.36	37
21	Aug 24	52°28.4',	135°59.1'	43.5±2.9	2.69	20
22	Aug 25	52°30.5',	135°52.3'	43.0±2.4	2.47	30
23	Aug 26	53°11.5',	135°46.5'	42.5±2.0	2.48	30
25	Aug 29	52°47.0',	132°41.5'	42.5±2.5	2.35	30

*Calculated from length/weight relationship (Murata & Ishii 1977).

$$W = 1.2799 \times 10^{-5} (L)^{3.1437}$$

where W is weight (g) and L is dorsal mantle length (mm). ($n = 922$, $r^2 = 0.978$).

Table 5. Overall mean weights of the main species caught during this trip.

Species	Mean weight (kg)
Ommastrephes bartramii	2.33
Brama japonica	0.84
Prionace glauca	4.17
Lamna ditropis	22.89
Thunnus alalunga	5.95
Trachurus symmetricas	1.51
Oncorhynchus gorbuscha	2.35
O. keta	4.09
O. nerka	2.00
Salmo gairdneri	3.18

Table 6. Analysis of the different gill net CPUE.

Net Type	Mesh Size (mm)	Number of Trials	Total number of nets	Length (m)	# Squid	CPUE (# squid/m)
white monofilament	121	2	4	200	43	0.054
green monofilament	121	2	8	100	117	0.146

Efficiency ratio (green:white) = 0.146/0.054 = 2.7

Table 7. Details of the squid jigging results at each station by the SIMSTAR, July-August 1982.

Station #	Date	Position Lat N, Long W	Weather	Time Fished (h)	# h.	# Squid	wt. squid (kg)	CPUE kg/hr
1	July 29	46°35.2', 131°22.5'	overcast	2252-0300	4.1	8	17.4	4.24
2	July 30	46°02.6', 131°10.8'	overcast, fog	2300-0230	3.5	1	3.0	0.86
3	July 31	46°43.2', 131°22.2'	overcast	2355-0152	2.0	1	2.2	1.10
4	Aug 3	46°43.3', 131°23.5'	overcast, squalls	2346-0247	3.0	1	2.1	0.70
5	Aug 4	46°41.8', 131°25.0'	overcast, squalls	2300-0230	3.5	3	8.6	2.46
6	Aug 12	48°32.0', 133°05.0'	overcast	2342-0254	3.2	4	10.6	3.31
7	Aug 13	48°46.0', 132°03.0'	clear	2316-0240	3.4	1	2.3	0.68
8	Aug 14	49°30.2', 132°49.0'	overcast, squalls	2318-0210	2.9	1	2.5	0.86
9	Aug 16	48°49.2', 131°57.3'	overcast	2321-0245	3.4	2	5.0	1.47
10	Aug 17	49°15.0', 132°17.5'	clear	2250-0255	4.1	1	2.4	0.59
11	Aug 20	52°28.9', 135°40.6'	overcast	2310-0230	3.3	3	7.8	2.36
12	Aug 23	52°30.5', 136°06.0'	clear	2311-0145	2.6	0	0.0	0.00
13	Aug 24	52°34.0', 135°43.0'	overcast	2354-0207	2.2	0	0.0	0.00
14	Aug 25	53°11.5', 135°46.5'	overcast	2310-0130	2.3	0	0.0	0.00
Total					43.5	26	63.9	
mean					3.1	1.9	4.6	1.33
s.d.					0.7	2.1	5.0	1.30

Table 8. Comparison between the jigging efficiency of the SIMSTAR and the Japanese vessel, the TOMI MARU No. 88.*

	SIMSTAR	TOMI MARU No. 88
# nights fished	14	42
total # machine hours fished	43.5	819.0
depth range fished (m)	0-50	0-50
total squid catch (kg)	64	1490
Mean CPUE (kg/machine/h)	1.33±1.30	2.20±2.31

*data from N. Sloan, unpublished.

Table 9. Comparison of CPUE[1] between the SIMSTAR and the other Japanese fishing vessels that have fished off the coast of British Columbia.

Vessel	Date	CPUE (kg squid/km/)	Source
SIMSTAR	July-Aug 1983	339.2	Robinson and Jamieson (1983)
TOMI MARU NO. 88	July-Aug 1983	232.3	N. Sloan unpublished
TENYU MARU NO. 37	July-Aug 1980	332.0	Bernard (1981)
TOMI MARU NO. 88	Aug 1980	165.8	Bernard (1981)

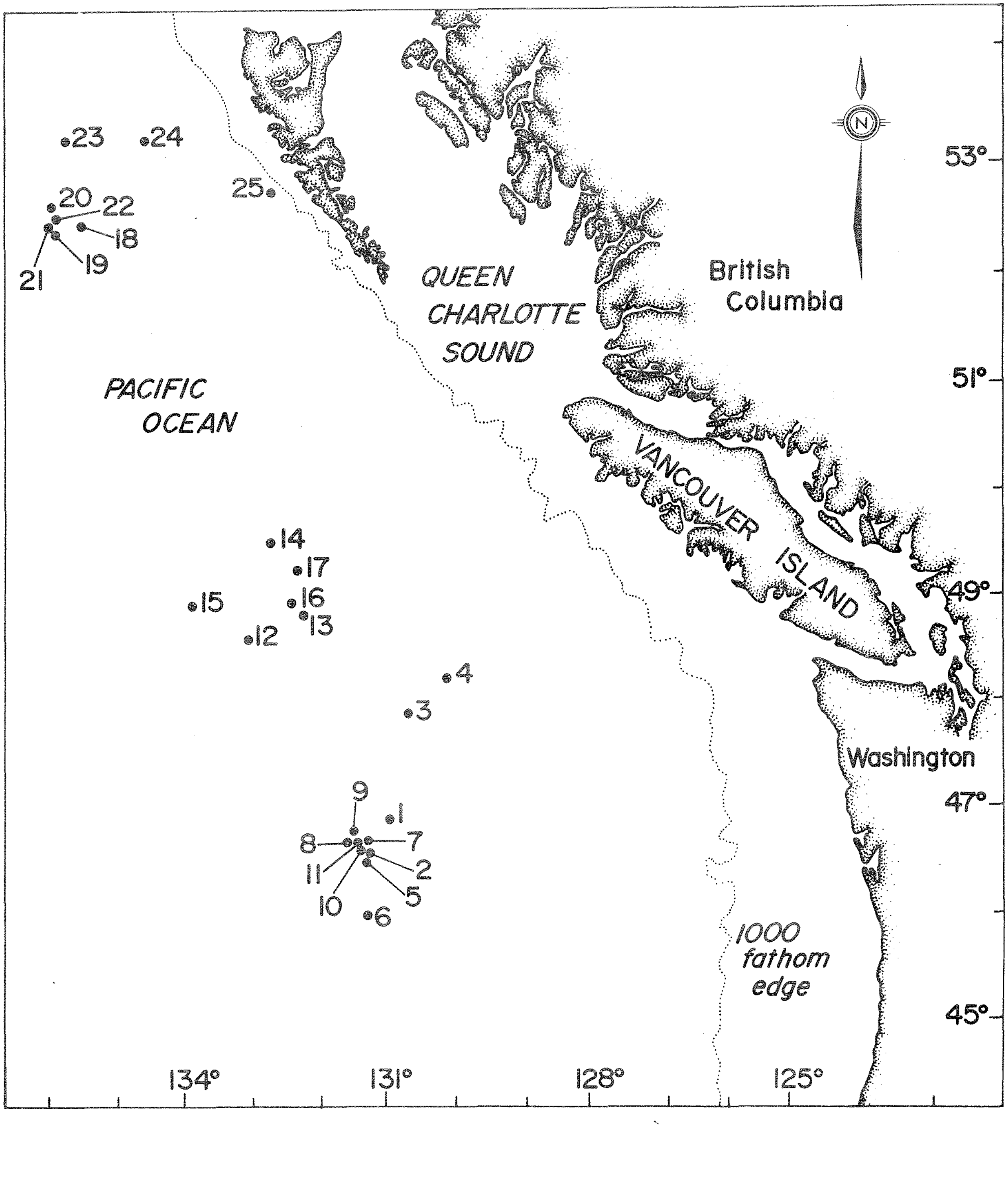

Fig. 1. Location of the drifting gillnet sets for Ommastrephes bartramii by the SIMSTAR, July-August 1983.

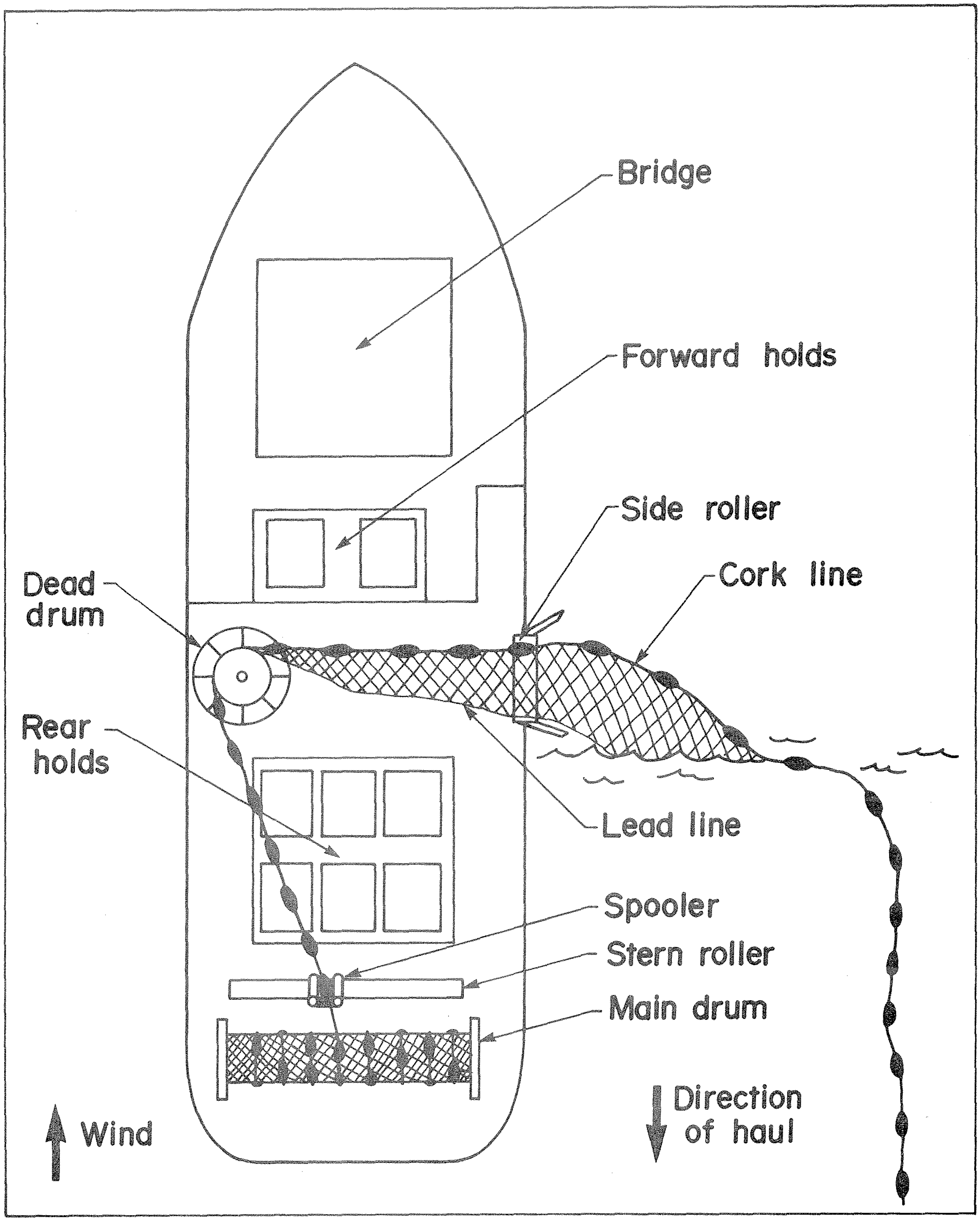

Fig. 2. Diagramatic top view of the gillnet fishing operation by the SIMSTAR, July-August 1983.