10941

# Canadian-Japanese Experimental Fishery for Oceanic Squid off British Columbia, Summer 1983

N. A. Sloan

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

August 1984

**Canadian Industry Report of Fisheries and Aquatic Sciences No. 152**

Government of Canada Fisheries and Oceans
Gouvernement du Canada Pêches et Océans

## Canadian Industry Report of Fisheries and Aquatic Sciences

These reports contain the results of research and development that are useful to industry for either immediate or future application. Industry Reports are directed primarily towards individuals in the primary and secondary sectors of the fishing and marine industries. No restriction is placed on subject matter and the series reflects the board interests and policies of the Department of Fisheries and Oceans, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevent to Canada.

Industry Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted in *Aquatic Sciences and Fisheries Abstracts* and will be indexed annually in the Department's index to scientific and technical publications.

Numbers 1-91 in this series were issued as Project Reports of the Industrial Development Branch, Technical Reports of the Industrial Development Branch, and Technical Reports of the Fisherman's Service Branch. Numbers 92-110 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Industry Reports. The current series name was changed with report number 111.

Details on the availability of Industry Reports in hard copy may be obtained from the issuing establishment on the front cover.

## Rapport canadien à l'industrie sur les sciences halieutiques et aquatiques

Ces rapports contiennent les résultats des recherches et des progrès qui peuvent être utiles à l'industrie pour des applications soit immédiates, soit futures. Ils sont préparés à l'intention principalement des membres des secteurs primaire et secondaire de l'industrie des pêches et de la mer. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du Ministère des Pêches et des Océans, notamment gestion des pêches, techniques et développement, sciences océaniques et environnements aquatiques, au Canada.

Les Rapports destinés à l'industrie peuvent être considérés comme des publications complètes. Le titre exact paraît au haut du résumé de chaque rapport, qui sera publié dans la revue *Aquatic Sciences and Fisheries Abstracts* et qui figurera dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros de 1 à 91 de cette série ont été publiés à titre de rapports sur les travaux de la Direction du développement industriel, de rapports techniques de la Direction du développement industriel, et de rapports techniques de la Direction des services aux pêcheurs. Les numéros 92 à 110 ont été publiés à titre de Rapports à l'industrie du Service des pêches et de la mer, Ministère des Pêches et de l'Environnement. Le nom de la série a été changé à partir du rapport numéro 111.

La page couverture porte le nom de l'établissement auteur où l'on peut se procurer les rapports sous couverture cartonnée.

Canadian Industry Report of
Fisheries and Aquatic Sciences No. 152

August 1984

# CANADIAN-JAPANESE EXPERIMENTAL FISHERY FOR OCEANIC SQUID OFF BRITISH COLUMBIA, SUMMER 1983

by

N. A. Sloan

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

Cat. No. Fs 97-14/152E ISSN 0704-3694

Correct citation for this publication:

Sloan, N. A. 1984. Canadian-Japanese Experimental Fishery for Oceanic Squid off British Columbia, Summer 1983. Can. Ind. Rep. Fish. Aquat. Sci. No. 152: 42 p.

TABLE OF CONTENTS

## ABSTRACT

Sloan, N. A. 1984. Canadian-Japanese Experimental Fishery for Oceanic Squid off British Columbia, Summer 1983. Can. Ind. Rep. Fish. Aquat. Sci. No. 152: 42 p.

A joint Canadian-Japanese test fishery for oceanic squid occurred in summer, 1983 mostly within 200 nautical miles off the British Columbia coast. The vessel was a 50 m, 500 tonne Japanese longliner with 27 crew. In forty drift gillnet sets (averaging 34.4 km in length) 329.5 tonnes of the flying squid Ommastrephes bartramii was caught. Major by-catch species were the pomfret Brama japonica (188.8 tonnes), salmon shark Lamna ditropis (32.8 tonnes) and blue shark Prionace glauca (29.1 tonnes). Fishing stations were mainly determined by sea surface temperature between 14.0° to 16.0°C. On 42 nights jigging with automatic jigging machines under strong lighting yielded poor catches. A Canadian drift gillnet fishery for oceanic squid is considered possible although with smaller vessels and less crew than Japanese deep-sea vessels.

Key words: squid, fishery, gillnet, British Columbia

## RESUME

Sloan, N. A. 1984. Canadian-Japanese Experimental Fishery for Oceanic Squid off British Columbia, Summer 1983. Can. Ind. Rep. Fish. Aquat. Sci. No. 152: 42 p.

A l'été 1983, des chercheurs canadiens et japonais ont mené une pêche expérimentale du calmar commun du Pacifique, principalement en deça de 200 milles de la côte de la Colombie-Britannique. Le bateau, un palangrier japonais de 50 m de longueur et de 500 t de jauge, comptait 27 membres d'équipage. En 40 mouillages de filets maillants dérivants (d'une longueur moyenne de 34,4 km), 329,5 t de calmar volant (Ommastrephes bartramii) ont été prises. La catasgnole, Brama japonica (188,8 t), la taupe du Pacifique, Lamna ditropis (32,8 t), et le requin bleu, Prionace glauca (29,1 t) constituaient les principales prises accessoires. En général, une température marine variant entre 14,0 et 16,0°C était le facteur déterminant le choix des stations de pêche. Une pêche à la turlutte automatique, menée pendant 42 nuits sous des lumières intenses, n'a généré que de piètres résultats. On croit qu'une pêche canadienne du calmar commun du Pacifique à l'aide de filets maillants dérivants est réalisable quoiqu'il faudra utiliser de plus petits bateax et moins de membres d'équipage que dans le cas des bateaux japonais de pêche hauturière.

Mots-clés: calmar, pêche, filet maillant, Colombie-Britannique.

# INTRODUCTION

Squid are one of the great underutilized food resources of the world's oceans. In his detailed review of squid biology and fisheries Arnold (1979) estimated annual harvest to be about one million tonnes. Arnold suggested 8-10 million tonnes as a conservative estimate of the potential annual catch from continental shelf and upper continental slope waters. Furthermore, he considered that oceanic resources could be 8-10 times greater than shelf resources. Indeed, sperm whales alone eat at least 100 million tonnes of squid a year (Arnold 1979).

World production is dominated by the Japanese fishery in the NW Pacific (Table 1; Court 1980). Two squid families, the oceanic Ommastrephidae (genera such as Ommastrephes, Todarodes and Illex) and the generally inshore, shelf-dwelling Loliginidae (such as Loligo), comprise most of the catch (Table 1). The two main species, now both considered as exploited to their sustainable limit, are Todarodes pacificus Steenstrup in the NW Pacific and Illex illecebrosus (Lesueur) in the NW Atlantic (Anon. 1978; Arnold 1979; Court 1980; Table 1). With the exception of 10-20,000 tonnes per year fishery for the 'market' or 'opal' squid Loligo opalescens Berry off California (Recksiek and Fry 1978; Dewees and Price 1983), the E-Central and NE Pacific have contributed relatively little to the world squid fishery (Table 1).

Previous Canadian-Japanese oceanic squid fishing expeditions off British Columbia in 1979 and 1980 (Bernard 1980, 1981) have stimulated interest in NE Pacific squid resources and gave rise to the 1983 exploratory fishery. The target species were the large oceanic 'flying' squid Ommastrephes bartramii (Lesueur) and the smaller continental shelf-dwelling 'nail' squid Onychoteuthis borealijaponica Okada. As with the previous surveys a Japanese vessel fished with a Canadian scientist aboard, mostly within Canada's 200 nautical mile zone of extended fisheries jurisdiction. Between July 15 and August 31, 1983 gillnetting occurred at 40 stations and jigging at 42 stations (Fig. 1). Gillnetting only occurred offshore whereas jigging took place both in- and offshore.

The 29 m (7 crew) Canadian fishing vessel SIMSTAR fished 25 sets yielding 33 tonnes of squid in the same areas as the TOMI MARU at the same time. SIMSTAR sets averaged less than 4.0 km in length and one automatic jigging machine was used. That cruise is being reported in detail by Robinson and Jamieson (in press).

I report here on the fishing gear, method, product processing and catch, and discuss the results in relation to previous surveys. Scientific reports on N Pacific squid biology, with special reference to NE Pacific squid resources, are reviewed. I discuss squid distribution in relation to this unusual oceanographic year (Cone 1983) in which relatively warm ocean waters extended further north and closer to shore than in previous years. Finally, I discuss the potential prospects for Canadian oceanic squid fisheries development and recommendations for further biological work.

## FISHING OPERATIONS

The 500 gross tonne, 50 m long TOMI MARU NO. 88 was equipped with 48 km of drift gillnet and 15 automatic squid jigging machines. The ship was operated by Kanai Gyogyo Co., Ltd. from its home port of Kushiro City, Hokkaido which is a centre for offshore Japanese squid fishing. The crew of 27 was commanded by a Fishing Master with the Captain functioning as his first officer either on deck or aiding in wheelhouse duties.

## DRIFT GILLNETTING

### METHODS

Gillnets are highly effective for flying squid (Kubodera and Yoshida 1981) and the Japanese fleet concentrates on this method in offshore waters (Osaka and Murata 1983; Sato and Hatanaka 1983).

Gillnets were strung in groups of panels (or 'tan' in Japanese) each 48 to 50 m long by 8.5 m (80 meshes) deep as illustrated in Bernard (1981, p. 23). The nets were constructed of green No. 8 nylon monofilament with diagonal stretched mesh sizes of either 118 or 121 mm. To enhance the catchability of the net, about 1.5 m of net (when meshes stretched to the maximum) was attached to each meter of lead and float line. The float line was in fact 2 lines of 5 mm, 3-strand laid polypropolene rope with lays going in opposite directions to counteract twist. Similarly, the lead line was 2 lines of 10 mm, 3-strand laid polypropolene rope with opposing lays. On the float line 220 g floats were attached approximately every meter.

After continuous monitoring of sea surface temperature, fishing areas were located between 14.0° and 16.0°C with preference for closely situated isotherms and a secondary preference of proximity to seamounts. An average of 34.4 km (±7.5 km S.D.) of gillnet was deployed on a straight course on each of 40 fishing days. Deployment, which occurred over a large roller at the stern, averaged 12.4 km/hr and was completed between 1730 to 2130 h. In rough weather nets were deployed in 110 to 125 tan groups with a radio buoy at each end. In calm weather longer groups of 220 to 250 tans were used with radio end buoys and a central light buoy. Care was taken not to deploy the net under too much tension. Distance between net groups was usually less than one km. Four crew aided in net deployment: two were in the huge net box keeping lead and float lines separate and one each in baskets astern of the big roller using bamboo poles to keep the lead and float lines separate. Nets were not deployed in winds greater than 65 km/hr which could twist a net as it passed over the stern or twist them in rough seas. After setting of the last net group the vessel would stand off and jig for squid. In previous surveys, the vessel patrolled the net to prevent damage from merchant shipping (Bernard 1980, 1981). When deploying the net sea surface temperature and position were noted on a chart recorder at least three times for each net group.

Hauling gillnets began between 0400 and 0500 h over the foreward starboard side after retrieving by grapple the last radio buoy deployed. While hauling the vessel was orientated with the wind coming across the bow from starboard to port. During hauling, the fishing master controlled the vessel from the starboard wing of the wheelhouse overlooking the haul site. Average haul rate was 3.8 km/hr (±0.6 km/hr S.D.). A 2-spooled friction line hauler, taking most the strain, brought in the lead line and a hydraulically operated rubber-sphered line hauler about 7 m astern pulled in the float line (Fig. 2). The TOMI MARU did not use this float line hauler in 1979 and 1980 at which time relatively less net was fished, as will be mentioned later. The floatline hauler was essential to handling the large amount of net used. Its two inflatable rubber spheres (about 30 cm in diameter) rotated in contact and it was extremely easy to engage or disengage the float line. Standing between the two haulers were 9 to 12 crew who brought in the meshes by hand and removed all sharks, almost all squid and as many pomfret as time would allow (Fig. 3). The haul rate remained constant until the whole net group was retrieved. After sufficient net had accumulated between the net crew and the gunwale they would pick it up and drag it across to the port side where 2 to 3 crew would remove more squid and feed the net into the 35 cm diameter tube running along the port side. The net was hauled astern through the tube using a pair of rubber-sphere haulers mounted over the net box. The net feeders controlled net hauling astern by pulling on a bell string poised over the stern net box. In the stern net box 3 or 4 crew would control the tow net haulers upon bell command, remove any remaining squid and carefully fold the net for the next set. To sustain the rapid inhaul and servicing rate of so much netting all phases of this process had to be run smoothly by an exceptionally hard working crew. Factors slowing haul rate were shark entanglement in the net, necessity of occasionally removing net panels severely damaged by shark or cut by merchant shipping, high catch loads and heavy sea. Catch was passed down a hole in the foreward deck to the factory below where 6 to 8 crew processed it. Every effort was made to haul the nets in quickly as shark predation of netted squid increases dramatically in daylight hours (Bernard 1981).

The selection of optimal fishing sites was a continuous process. Ship position and sea surface temperature monitoring during net group deployment has been mentioned above. As each net group was hauled the Fishing Master tallied all squid with a hand counter. At the end of fishing the sea surface temperature, position and catch of each net group could be compared and the optimal site could thus be identified, approximately relocated and fished again. The importance of temperature discontinuity to squid abundance is shown in the yield of set 014.

Yield of set 014 during which 11107 kg of squid were caught in seven 125 tan groups.

| Order in which net group was deployed | % of squid catch in each net group | Average sea surface temperature of each net group (°C) |
|---|---|---|
| 1 | 7.7 | 16.0 |
| 2 | 6.7 | 16.0 |
| 3 | 6.1 | 16.0 |
| 4 | 8.4 | 15.7 |
| 5 | 17.3 | 15.6 |
| 6 | 23.2 | 15.4 |
| 7 | 30.6 | 15.3 |

From 34 of the sets, 30 individuals were selected at random and their dorsal mantle length (DML) measured (Fig. 4). DML is a reliable convention used in squid studies (Arnold 1979) and, in flying squid, has a close relationship with body weight, regardless of sex, over a wide size range (Ishii 1977; Murata and Ishii 1977). Some individuals were weighed but ship movement resulted in only approximations.

Sonar was not relied upon by the Fishing Master to locate flying squid. He felt that their 'weak' acoustic target strength and non-schooling tendency decreased the effectiveness of detection by echo-sounding. Ommastrephid squids do, however, produce echo-traces (Kawaguchi and Nazumi 1972) and echo-sounding for squid is considered reliable and widely used in the NW Pacific by the Japanese squid jigging fleet (Matsui et al. 1972; Hamabe et al 1982).

## RESULTS

Table 2 lists all the species caught in the gillnets. The species composition is similar to those reported by Bernard (1980, 1981). The swordfish (Xiphias gladius) is, however, the first report from British Columbia waters (A. E. Peden, personal communication).

A summary of the 1983 gillnet catch is given in Table 3 and compared to the summer, 1980 catches of the TOMI MARU NO. 88 and TENYU MARU NO. 37 using similar gear. In both surveys the order of species abundance was similar, with flying squid, pomfret and the two shark species strongly dominating (96.7% to 98.1%) the total catch. In 1983 there were relatively more pomfret and fewer squid than in 1980. Relative salmonid by-catch (Sloan 1983) was larger than in 1980 although still well below the recommended maximum acceptable level of 1.0% (Bernard 1981).

The complete catch data are supplied in Tables 4 and 5. Date, position, sea surface temperature, net lengths, squid and total catches, effort and C.P.U.E. are listed according to the 40 gillnet sets in Table 4.

Table 5 lists all the components of the non-squid catch for each set. Catches in Tables 4 and 5 are listed as either kg or pieces and some of these are estimates only as exact counting was not possible during such a large operation. In Table 4 effort is calculated in kilometers of gillnet times hours of prime fishing time. Flying squid approach the surface at dusk and remain in the upper waters at night, a common characteristic of oceanic squids (Roper and Young 1975), and retreat to the depths at dawn. Thus, prime fishing time started at completion of net deployment at dusk and ended about one hour before dawn. By dawn some net had already been hauled. Two measures of C.P.U.E. are thus given: C.P.U.E. 1 = catch 'efficiency' sensu Bernard (1981) is given as kilograms catch per kilometer of gillnet and C.P.U.E. 2 which is C.P.U.E.1 per hour of fishing.

The dorsal mantle lengths of the 1020 squid measured was examined for any appreciable size differences between arbitrarily defined North and South set groups (boundary = 51°N). The dorsal mantle lengths (DML) of 30 flying squid per set were:

| | | DML (mm) | |
|---|---|---|---|
| Sets | n | $\overline{x}$ ± S.D. | Range |
| All sets (001-039) | 1020 | 416.1 ± 30.5 | 345-505** |
| North sets (028-037*) | 270 | 430.1 ± 27.2 | |
| South sets (001-027) | 720 | 410.5 ± 30.1 | |

*039 excluded as midway between North and South set groups

**approximate weight range of 1.3 to 4.3 kg

Throughout sampling the squid were larger than those reported from the NW Pacific off Japan (Ishii 1977; Murata and Ishii 1977). Squid from North sets were significantly different (larger) than those of South sets (t-test, $p<.05$). Whether this was due to the presence of subpopulations with different ranges as off Japan, as discussed in the literature review given later, or whether it merely reflected growth over the sample period is unknown.

A comparison of C.P.U.E.1 for different vessels fishing for squid in the NE Pacific is made in Table 6. The catch efficiency of the TOMI MARU was lower than the Canadian vessel SIMSTAR which fished in the same area. This year the TOMI MARU'S C.P.U.E. was, however, higher than most previous Japanese squid fishing attempts inside Canadian waters.

# JIGGING

## METHODS

The TOMI MARU NO. 88 was equipped with 15 new Hamade MD-3 SES automatic jigging machines (Fig. 5 and Appendix 1). Each machine deployed two strings of lures from diamond-shaped drums. Line depth, deployment and inhaul rate were controlled automatically. Seven machines were on the starboard side and eight on the port side. All were mounted immediately inboard of the gunwale from which the 2 m wide and 1.6 m long squid recovery trays with outboard line guides, could be suspended outboard (Arnold 1979, p. 12). Each machine occupied about 3 m of gunwale with 60 cm between spools of adjacent machines. A string of 25 2-kilowatt incandescent lights was set about 1 m above and 1 m inboard of each of the machine arrays. Thus, when lights were turned on at dusk, the jig lines passed through a shadow cast by the gunwale which enhanced contrast of the lures in the water (Arnold 1979, p. 13; Hamabe et al. 1982, p. 17). Squid do not have color vision, but they are sensitive to visual contrast (Flores et al. 1978). Each of the 90 kg test nylon lines had a 1 kg weight at the end which was connected loosely with the other line from the same machine. Each line had 25 lures set about 80 cm apart. Lures were 10-12 mm long and consisted of a plastic body with two rosettes of sharp, barbless hooks. About 50% of lures were dark green, 40% were clear and 10% were red (Appendix 2). Fishermen operated single hand jigging lines which usually had two heavy chrome-plated metal jigs between 20 to 30 cm long set about 3 m apart (Appendix 2). A few were weighted bamboo shafts with bait tightly wound on the shaft above the spike rosettes. Bait (squid or fish) or colored tape, would also be bound to the shafts of the metal jigs to enhance their effectiveness.

During all-night jigging operations not to be followed by gillnetting, a 37 m diameter parachute-like sea anchor was deployed about 200-300 m from the boat. The Japanese sea anchor method is well illustrated in Hamabe et al. (1982, p. 51). It was not used on nights when gillnets were used because its retrieval time interfered with the net hauling schedule.

Jig line depths were set mostly between 45 and 60 m. In this depth range the jig line spent approximately 38% of the fishing time descending, 60% of the time ascending and 2% of the time wrapped on the drum. When the vessel was jigging only, machines were working just before dusk until dawn. Rough seas prevented jigging because of line tangling. Furthermore, after the first night's jigging when all 15 machines were used, it was clear that the machines were too close together, causing chronic line tangling problems. Thereafter alternate machines were used. Lines longer than 60 m from machines on opposite sides of the vessel deployed in times of rapid drifting also tended to tangle. The same equipment was used throughout and the only changes to the jigging regime were made by altering the machine controls for line depth.

## RESULTS

The complete jigging results are listed in Table 7 which includes date, position, sea surface temperature, catch and effort according to machine jigging or jigging by hand. Intensive jigging effort occurred on the first six days of the cruise; this was the only time nail squid (Onychoteuthis borealijaponica) were taken. Catches of squid were very low throughout the 42 jigging sites. Nail squid are mainly shelf-dwelling (Bernard 1980) so after the eighth site (Fig. 1) catches of this species could be expected to be low at the deep-sea locations (Sites 009 to 042). Catches of flying squid (Fig. 6) were uniformly low and worsened by a 30 to 40% catch loss due to these large squid falling off the lures when hauled out of the water. In Japanese waters this species readily breaks off (autotomizes) its two prey-grasping tentacles during jigging operations and falls back into the sea (Murata et al. 1981).

Although very labour intensive, jigging by hand was relatively more effective than machine jigging when considering that each man-hour represented 2 lure-hours whereas each machine-hour was 50 lure-hours.

## CATCH PROCESSING

All squid were processed into six products which were quick frozen in galvanized trays. Frozen 14 to 15 kg blocks approximately 58 cm long x 36 cm wide x 8 cm thick were knocked out of the trays 8-10 hours later and stored in the main freezer hold. Squid products were:

1) unskinned, gutted mantles with fins ) two size classes of 10 to 15 or 15 to 20 per tray
2) unskinned, gutted mantles without fins )
3) slit, gutted and skinned mantles with fins and mantle tips removed
4) slit, gutted but unskinned mantles with fins removed but mantle tips intact
5) fins only
6) heads with attached arms and tentacles but eyes and beak removed

Figure 2 illustrates the main features of a squid mentioned above. The majority of mantles were frozen slit rather than intact. A 'squid splitting' machine (Appendix I) slit and gutted the mantles, some of which were skinned on a separate skinning machine (Appendix I). Heads were always removed by hand and eyes and beaks discarded. According to Arnold (1979) squid have the highest meat yield (approximately 80% of body weight) compared to most finfish

(50-60%) or other shellfish (40%). Mantles comprise approximately 54% of squid round weight and heads/arms/tentacles 26%. Squid will be reprocessed into many different products upon return to Japan (Anon. 1978; Bernard 1980).

Albacore tuna were frozen in the round, jack mackerel were headed and gutted before being frozen in trays. Only the largest salmon sharks were frozen (headed and gutted) and all blue shark were discarded. Only a small percentage of pomfret were processed (headed and gutted).

## WARM OCEAN WATERS PHENOMENON OF SUMMER, 1983

The oceanography of the entire E Pacific was greatly influenced by unusually warm waters whose causes and effects have been reviewed by Cone (1983). In the NE Pacific the effect on flying squid distribution could be anticipated as range extension due to warm water fronts penetrating further north than usual. Fig. 7 illustrates the long term average position of the 15° and 16°C sea surface isotherms off the British Columbia coast. The northerly limit of 15°C water occurs at approximately 51°30'N and the 16°C isotherm just north of 50°N. Figures 8 and 9 show the unusual northward extension of sea surface isotherms in time series from the end of June to the beginning of September, 1983. In Figure 8 the warm front was pushing steadily north until the 15°C isotherm was at approximately 49°30'N by July 18. In Figure 9, however, the 15°C isotherm has pushed substantially further north before mid August. The 16°C isotherm limit moved more steadily north to about 51°30' by August 21 where it remained until the beginning of September by which time the 15°C isotherm receded somewhat south from its marked northward thrust in early August. The increased extent of these seasonal warm waters may have increased the extent of flying squid distribution.

## PREVIOUS NE PACIFIC SQUID INVESTIGATIONS

Until recently local interest in NE Pacific squid fisheries concentrated only on the opal squid Loligo opalescens which supports a viable fishery off California (Recksiek and Frey 1978; Dewees and Price 1983; Rathjen 1983). The first report on potential British Columbia squid fishery development, based on a literature survey and interviews, dealt almost entirely with the inshore opal squid (MacFarlane and Yamamoto 1974). Factors influencing this were the success of the California fishery and the lack of Canadian off-shore fisheries resource data. Scientists were, however, aware that squid were common offshore from by-catch in surveys of high seas salmonids (Manzer and Neave 1958) and offshore salmonid stomach contents (Manzer 1968). Recently, marine mammal stomach contents have revealed squids as well (Fiscus 1982). It was not until the reports of Bernard (1980, 1981) that the oceanic squid resources off British Columbia were first described. Recent additional data is available from by-catch reports from N Pacific salmonid surveys (Fiscus and Mercer 1982), Alaskan squid resource surveys (Wilson and Gorham 1982) and Japanese surveys which are moving eastward across the Pacific (Kubodera et al. 1983).

## FLYING SQUID IN THE NE PACIFIC

Although flying squid can be the most common species encountered offshore of the British Columbia coast in summer (Table 4), they were not reported as a member of our local fauna until Bernard (1980). Bernard (1980) related this to taxonomic confusion in earlier salmonid survey by-catch reports, and perhaps for the same reason Pearcy (1965) did not list O. bartramii among 17 species trawled in all seasons off the Oregon coast. Flying squid occur as far north as the Gulf of Alaska (Wilson and Gorham 1982) but become much more common south of Alaskan waters (Fiscus and Mercer 1982). Their distribution extends southward, nearly to the equator and all across the Pacific (Bernard 1981; Murakami et al. 1981; Kubodera et al. 1983). Bernard (1981) suggests that the NE Pacific population may migrate north in the summer after breeding in tropical latitudes. As with Albacore tuna (Ketchen 1980) this species enters Canadian waters in warm ocean waters ( 13°C) in summer when it feeds and grows very rapidly (Bernard 1980). Bernard proposed that flying squid may live about a year before returning south to spawn and die. There is, as yet, little data on the biology of NE Pacific flying squid populations but circumstantial evidence comes from NW Pacific flying squid research.

## FLYING SQUID IN THE NW AND N CENTRAL PACIFIC

O. bartramii is the most common species after Todorades pacificus Steenstrup in the large Japanese fishery from the NW Pacific (Court 1980; Osako and Murata 1983). Court provides a comprehensive overview of the entire Japanese squid industry. In recent years a decline in T. pacificus catches has accompanied increased flying squid catches by the Japanese fleet (Murata et al. 1976; Murata and Ishii 1977; Osako and Murata 1983). After conflict (Court 1980; Anon. 1982) between the Japanese jigging and drift gillnetting fleets over flying squid resources off the NE coast of Japan in 1978, the gillnetting fleet has moved rapidly eastward across the Pacific (Fig. 10). This new fishery has not yet, however, featured prominantly in the Japanese distant-water squid fisheries literature (Sato and Hatanaka 1983). Only the jigging fleet remains close to Japan, although its vessels have the option to venture further afield. In 1981 the high seas Japanese gillnet fleet consisted of over 530 liscensed vessels all with the capacity of working approximately 30 km of gillnet per day (Anon. 1982). There may also be

Taiwanese and/or Korean vessels fishing flying squid as well. The Japanese government operates a vessel authorization and time-areas closure system between 170°E to 145°W and 20°N to 46°N. The flying squid fishery closes from January to May to prevent salmonid by-catch.

The Fisheries Agency of Japan (1983) has reported on a 1982-1983 flying squid and pomfret survey in the N Central Pacific 40°N to 45°N and east of 160°E. The report confirmed a "large flying squid resource" east of 160°E. The Agency included flying squid catches for the Japanese fleet of 84,000 and 96,000 tonnes for jigging and gillnetting respectively for grounds between 35°N to 45°N and 165°E to 170°. Despite the increasing importance of N Central Pacific resources, there are few reports on the biology of the stocks (Murakami et al. 1981; Kubodera et al. 1983).

Japanese scientists are compiling literature on flying squid in the NW Pacific. O. bartramii occurs mostly in areas where surface water temperature ranges between 15 to 20°C and usually remain north of latitude 40°N during summer when they follow northward warm branches of the Kuroshio Current (Murata et al. 1976; Naito et al. 1977a). They further suggest that during the winter and spring flying squid are widely distributed and spawn south of latitude 36°N off Japan, having migrated south in the autumn. The onset of sexual maturity corresponds with the development of the southward Oyashio Current. O. bartramii live for approximately one year during which time growth is rapid on their northward migration until they reach sexual maturity (Ishii 1977; Naito et al. 1977b). Body size, conventionally measured using dorsal mantle length, increases steadily between June and February with females growing larger and maturing later than males (Murata and Ishii 1977; Naito et al. 1977b; Murakami et al. 1981). There are different sub-populations (based on body size) of flying squid which originate at different hatching times (Naito et al. 1977b; Murakami et al. 1981). Murakami et al. (1981) identified four discrete subpopulations, the largest of which migrated furthest north in the summer. On the northward migration young flying squid eat small fish, squid (including each other) and crustaceans whereas adults take only fish and squid (Naito et al. 1977b). Lantern fishes (myctophids) followed in order by small anchovy, sardine and mackerel comprise most of the fish diet. As Bernard (1981) suggests, feeding must be very active to permit rapid growth within the year to approximately 2 kg body weight. Flying squid congregate and feed most actively along thermal discontinuities, presumably because prey concentrate at these water mass interfaces. Oceanographic and biological monitoring of the Japanese flying squid fishery is continuing (Murata and Shimazu 1982) as an important component of their squid fishery.

In keeping with squids generally (Arnold 1979) catch levels of flying squid can fluctuate greatly from year to year (Murata et al. 1976). One of the main reasons for these changes is fluctuating oceanographic conditions. The Japanese have for some time studied the effects of interfaces or 'boundary zones' between water masses of different temperature on the behavior, migration and distribution of oceanic squid (Soeda 1950; Suzuki 1963; Kubodera et al. 1983). On a large scale, major changes in oceanographic conditions such as unusually low sea surface temperatures, apparently on a 9-year cycle in the NW Pacific, at squid spawning or feeding grounds can precede marked decreases in squid catches of the following year (Kitano

1979). At the seasonal level movements of at least four oceanic squid species are now reasonably predictable by monitoring boundary zone locations (Araya 1976; Murata et al. 1976; Naito et al. 1977a). It is at these boundary zones where oceanic squid fishing is best (Araya 1976; Kubodera et al. 1983).

## DISCUSSION

### THE RESOURCE AND ITS FISHERY

This report extends the range of flying squid in offshore waters to the northern boundary of the Canadian zone or extended jurisdiction (north of 53°N) from Bernard's (1980, 1981) surveys which extended to 50°N. The northern range extension is probably closely related to the unusual northern penetration of warm ocean waters. The presence of warm surface waters (>14°C) remains a dependable prediction factor (Bernard 1981) in forecasting the presence of flying squid in Canadian waters. The preferred temperature range is between 14°C and 16°C. In the seasonally occurring warm ocean waters, which also bring Albacore tuna (Ketchen 1980), flying squid have consistently been the most common species which is surface gillnetted in meshes ≥118 mm (Bernard 1980, 1981, this report, Robinson and Jamieson in press). We predict that the resource may occur regularly in Canadian waters although a data set spanning a number of consecutive years is required for verification. The Japanese have shown the widespread distribution of flying squid by the rapid eastward penetration of their fleet across the N Pacific (Fig. 10; Osaka and Murata 1983).

Bernard (1981) reported a 'break-even' squid catch of 5 tonnes per day for a 500 tonne vessel with about 30 crew. This year the Japanese proposed a break-even catch level of 10 tonnes per day for the TOMI MARU. Working 34 km of net per day "a catch" of 294 kg per km net was therefore required. Our efficiency averaged 232 but would certainly have been higher if we had relocated less often and intensively fished local stocks as the SIMSTAR tended to do; their average CPUE' was 339 kg/km. Jigging for flying squid was extremely unproductive and is considered less efficient than gillnetting for this large species in B.C. waters. Jigging is preferred by the Japanese in inshore waters from small vessels (Osako and Murata 1983) and by some workers for stock assessments (Murata 1983).

The possible occurrence of a significant nail squid resource remains unsolved. This is a smaller, shelf-dwelling species (Bernard 1980) rarely taken on the high seas, as the gillnet catches of all surveys to date show. Furthermore, jigging in all surveys has also yielded poor nail squid catches. Bernard (1980) reported that both Japanese vessels had low nail squid catches in September-October, 1979 and therefore suggested that earlier in the season could be better. We jigged intensively in the third week of July in or close to shelf waters and had poor catches. A more concentrated effort aimed at just the nail squid should occur just in or over shelf waters.

Salmonid by-catch can be a problem during early summer gillnetting for squid despite the suggestion that drift gillnets are more efficient for flying squid than salmonids (Kubudera and Yoshida 1981). Bernard (1981) proposed four guidelines for reducing this by-catch:

(1) Nets set more than 100 km offshore.

(2) Nets set in surface waters >13°C.
(3) Nets set at surface or submerged (maximum 10 m).

(4) Maximum of 30 km net per set.

All sets satisfied guidelines 1-3, but we averaged over 34 km of net per set. Furthermore the total salmonid by-catch weight was considerably less than Bernard's recommended 1.0% of total catch and albacore by-catch was well below the recommended 5.0% level. The first few sets, however, demonstrated a potential concern. Set 001 (July 16) in 14.6° to 14.8°C waters about 160 km offshore caught 428 salmonids in 12.5 km of net and set 002 (July 22-23) in 13.9° to 14.1°C waters about 350 km offshore yielded 432 salmonids in 43.2 km of net. It is interesting to note that the final set 040 (August 31) which occurred roughly halfway between set 001 and 002 sites, in 15.6° to 16.3°C waters yielded only 3 salmonids in 27.6 km of net. I suggest that as the summer wears on salmonid by-catch can be expected to decrease offshore generally. In the late spring-early summer, however, salmonid by-catch in certain locations may be a problem, especially if in the path of migrating salmon such as off the mouths of Johnstone or Juan de Fuca Straits.

The feasibility of larger Canadian boats with the 27 or so crew required to service such long net sets and subsequently process the catch remains undetermined. Domestic squid markets are not highly developed and export values of squid to Japan could be anticipated as much less than salmon or roe herring. The report by Robinson and Jamieson (in press) on the Canadian vessel SIMSTAR and its crew of 7 will provide information what could be on a more appropriately sized Canadian operation for flying squid.

If the Canadian fishing industry is interested and a regular flying squid fishery is to be considered, more detailed biological information on flying squid stocks and oceanographic information on seasonally-occurring warm ocean waters in needed. Managers will want to know when and where to allow high seas gillnetting to best exploit squid stocks yet minimize salmonid by-catch. Year-to-year variations in distribution of surface temperatures and presumably concomitant variations of squid and salmonid distributions complicate this task.

## RECOMMENDATIONS

(1) Better define, and eventually predict, flying squid occurrence in Canadian waters from June to October in relation to sea surface temperature, water mass interfaces and sea mounts.

(2) The biology of NE Pacific flying squid stocks remains poorly understood in respect to stock size, recruitment, growth, migration, reproduction and mortality. Data on these parameters are a prerequisite to a sustained fishery and should be gathered.

(3) Guidelines will have to be proposed firstly as to the minimum temperature at which nets would be set to avoid most salmonids (somewhere between 15 to 17°C) and secondly, what level of bycatch is deemed unacceptable.

(4) The potential for a nail squid fishery would probably best be determined by carrying out a jigging survey in our shelf waters. A jigging fishery is particularly appropriate in areas where netting could yield salmonids.

## ACKNOWLEDGMENTS

I would like to acknowledge the excellent hospitality and cooperation of Fishing Master Kudou, Captain Onodera and the crew of TOMI MARU NO. 88 during the seven week cruise. The vessel operators, Kanai Fisheries Co., Ltd. of Kushiro City, Hokkaido, were most accommodating and ensured that the survey occurred over a wide area even though the constant relocation, sometimes from good sites, decreased catches. Ms. L. Mackey drafted the illustrations. Special thanks to Dr. G. S. Jamieson for support and thorough text reviewing. Drs. F. R. Bernard, K. S. Ketchen, and Mr. G. A. McFarlane kindly commented on the manuscript. This study was jointly funded by Fisheries Research Branch and Fisheries Development Division, Department of Fisheries and Oceans.

## REFERENCES

Anonymous. 1978. Japan's squid fishery. Yamaha Fish. J. 3: 8 p.

Anonymous. 1982. Proceedings of the 29th Annual Meeting of the International North Pacific Fisheries Commission, Tokyo, Japan.: 164-173.

Araya, H. 1976. Migration and fishing ground of winter subpopulation of the squid, Todarodes pacificus Steenstrup, in the northern waters of Japan. Bull. Hokkaido Reg. Fish. Res. Lab. 41: 119-129.

Arnold, G. P. 1979. Squid: A review of their biology and fisheries. Lab. Leafl. MAFF Direct. Fish. Res., Lowestoft. 48: 37 p.

Bernard, F. R. 1980. Preliminary report on the potential commercial squid of British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 942: 51 p.

Bernard, F. R. 1981. Canadian west coast flying squid experimental fishery. Can. Ind. Rep. Fish. Aquat. Sci. 122: 23 p.

Cone, J. 1983. EL NINO: What are its causes and effects? Sea Grant Today. 13: 9-11.

Court, W. G. 1980. Japan's squid fishing industry. Mar. Fish. Rev. 42: 1-9.

Dewees, C. M. and R. J. Price. 1983. The California squid fishery. Cooperative Extension, University of California Sea Grant College Program Leaflet 21330: 14 p.

Fiscus, C. H. 1982. Predation by marine mammals on squids of the eastern north Pacific Ocean and the Bering Sea. Mar. Fish. Rev. 44: 1-10.

Fiscus, C. H. and R. W. Mercer. 1982. Squid taken in surface gillnets in the North Pacific Ocean by Pacific Salmon Investigations Program, 1955-72. Report of Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Seattle, Washington State, February, 1982. 32 p.

Fisheries Agency of Japan. 1983. Survey on the feasibility of using surface gillnets for pomfret and drift gillnets for flying squid resources in the North Pacific Ocean in 1982. (Document submitted to the International North Pacific Fisheries Commission.) 7 p. Fisheries Agency of Japan, Tokyo, Japan 100.

Flores, E. E. C., S. Igarashi and T. Mikami. 1978. Studies on squid behaviour in relation to fishing. III. On the optomotor response of squid, Todarodes pacificus Steenstrup, to various colors. Bull. Fac. Fish. Hokkaido Univ. 29: 131-140.

Hamabe, M., C. Hamuro, and M. Ogura. 1982. Squid jigging from small boats. FAO Fisheries Manual, Fishing News Books, England. 74 p.

Ishii, M. 1977. Studies on the growth and age of the squid, Ommastrephes bartrami (Lesueur) in the Pacific of Japan. Bull. Hokkaido Reg. Fish. Res. Lab. 42: 25-36.

Kawaguchi, T. and T. Nazumi. 1972. Echo-traces of squid Ommastrephes sloani pacificus, in the central waters of Japan Sea. FAO Fish. Circ. 142: 15-25.

Ketchen, K. S. 1980. Report on the Canadian fishery for Albacore in 1979. Can. Ind. Rep. Fish. Aquat. Sci. 116: 21 p.

Kitano, K. 1979. Note on the fluctuation tendency of the total catch of the common squid Todarodes pacificus Steenstrup in the light of the unusual oceanic conditions. Bull. Hokkaido Reg. Fish. Res. Lab. 44: 73-76.

Kubodera, T., W. G. Pearcy, K. Murakami, T. Kobayashi, J. Kakata and S. Mishima. 1983. Distribution and abundance of squids caught in surface gillnets in the Subarctic Pacific, 1977-1981. Mem. Fac. Fish., Hokkaido Univ. 30: 1-49.

Kubodera, T. and H. Yoshida. 1981. The gill-net mesh selectivity for flying squid, Ommastrephes bartrami (Lesueur). Res. Inst. N. Pac. Fish., Hokkaido Univ. Special Vol.: 181-190.

Macfarlane, S. A. and M. Yamamoto. 1974. The squid of British Columbia as a potential fishery resource - A preliminary Report. Tech. Rep. Fish. Mar. Serv. 477: 35 p.

Manzer, J. I. 1968. Food of Pacific salmon and steelhead trout in the northeast Pacific Ocean. J. Fish. Res. Bd. Can. 25: 1085-1089.

Manzer, J. I. and I. Neave. 1958. Data record of Canadian exploratory fishing for salmon in the northeast Pacific Ocean in 1957. Fish. Res. Bd. Can. MS Rep. 657: 303 p.

Matsui, T. Y. Teramoto, and Y. Kaneko. 1972. Target strength of squid. FAO Fish. Circ. 142: 27-29.

Murakami, K., Y. Watanabe, and J. Nakata. 1981. Growth, distribution, and migration of flying squid (Ommastrephes bartrami) in the North Pacific. Res. Inst. N. Pac. Fish., Hokkaido Univ. Special Vol.: 161-179.

Murata, M. 1983. Quantitative assessment of oceanic squid by means of jigging surveys. Biol. Oceanogr. 2: 433-456.

Murata, M., M. Ishii, and M. Osako. 1981. On the regeneration of tentacle of the oceanic squid, Ommastrephes bartrami (Lesueur). Bull. Hokkaido Reg. Fish. Res. Lab. 46: 1-14.

Murata, M. and Y. Shimazu. 1982. On some population parameters of flying squid, Ommastrephes bartrami (Lesueur) in the northwest Pacific. Bull. Hokkaido Reg. Fish. Res. Lab. 47: 1-10.

Murata, M. and M. Ishii. 1977. Some information on the ecology of the oceanic squid, Ommastrephes bartrami (Lesueur) and Onychoteuthis borealijaponica Okada, in the Pacific Ocean off northeastern Japan. Bull. Hokkaido Reg. Fish. Res. Lab. 42: 1-24.

Murata, M., M. Ishii, and H. Araya. 1976. The distribution of oceanic squids, Ommastrephes bartrami (Lesueur), Onychoteuthis borealijaponica Okada, Gonatopsis borealis Sasaki and Todarodes pacificus Steenstrup in the Pacific Ocean off northeastern Japan. Bull. Hokkaido Reg. Fish. Res. Lab. 41: 1-29.

Naito, M., K. Murakami, T. Kobayashi, N. Nakayama, and J. Ogasawara. 1977a. Distribution and migration of oceanic squids (Ommastrephes bartrami, Onychoteuthis borealijaponica, Berryteuthis magister and Gonatopsis borealis) in the western subarctic Pacific region. In, Fisheries Biological Production in the subarctic Pacific Region. Res. Inst. North Pac. Fish, Hokkaido Univ. Special Vol.: 321-337.

Naito, M., K. Murakami and T. Kobayashi. 1977b. Growth and food habit of oceanic squids (Ommastrephes bartrami, Onychoteuthis borealijaponica, Berryteuthis magister and Gonatopsis borealis) in the western subarctic Pacific region. In, Fisheries Biological Production in the subarctic Pacific Region. Res. Inst. North Pac. Fish., Hokkaido Univ. Special Vol.: 334-351.

Osako, M. and M. Murata. 1983. Stock assessment of cephalopod resources in the northwestern Pacific. In, J. F. Caddy (ed.). Advances in assessment of world cephalopod resources. FAO Fish. Tech. Rep. 231: 55-144.

Pearcy, W. G. 1965. Species composition and distribution of pelagic cephalopods from the Pacific Ocean off Oregon. Pacific Sci. 19: 261-266.

Rathjin, W. F. 1983. Present status of North American squid fisheries. Mem. Natl. Mus. Victoria 44: 255-260.

Recksiek, C. W. and H. W. Frey. (editors). 1978. Biological, oceanographic and acoustic aspects of the market squid, Loligo opalescens Berry. Calif. Dept. Fish Game Fish Bull. 169: 185 p.

Roper, C. F. E. and R. E. Young. 1975. Vertical distribution of pelagic cephalopods. Smithson. Contrib. Zool. 209: 51 p.

Robinson, S. M. C. and G. S. Jamieson. Report on a Canadian commercial fishery for flying squid (Ommastrephes bartramii) using drift gillnets off the coast of British Columbia. Can. Ind. Rep. Fish. Aquat. Sci. in press.

Sato, T. and H. Hatamaka. 1983. A review of assessment of Japanese distant-water fisheries for cephalopods. In, J. F. Caddy (ed.). Advances in assessment of world cephalopod resources. FAO Fish. Tech. Rep. 231: 145-180.

Sloan, N. A. 1983. Salmonid by-catch during exploratory squid fishing off British Columbia, Summer 1983. Document submitted to I.N.P.F.C., Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, B.C. V9R 5K6, 6 p.

Soeda, J. 1950. The migration of the squid, Surume-ika; Ommastrephes sloani pacificus (Steenstrup) in the coastal waters of Japan. Sci. Pap. Hokkaido Fish. Sci. Inst. 4: 1-30.

Suzuki, T. 1963. Studies on the the relationship between current boundary zones in waters to the southeast of Hokkaido and migration of the squid, Ommastrephes sloani pacificus (Steenstrup). Me. Fac. Fish. Hokkaido University. 11: 75-153.

Wilson, J. R. and A. H. Gorham. 1982. Alaska underutilized species Volume 1; Squid. Alaska Sea Grant Report 82-1: 77 p.

Table 1. Squid catches according to certain areas, species and countries in tonnes ($10^3$) from FAO statistics.

| Area/species/country | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| NW Pacific | 552.5 | 509.5 | 549.2 | 569.3 | 722.8 |
| NE Pacific | 0.5 | 3.4 | 3.5 | 2.4 | 3.4 |
| W-Central Pacific | 66.7 | 79.6 | 82.1 | 72.3 | 75.0 |
| E-Central Pacific | 10.1 | 9.5 | 19.7 | 27.2 | 30.5 |
| NW Atlantic | 98.8 | 123.1 | 100.3 | 176.8 | 113.0 |
| NE Atlantic | 10.7 | 10.3 | 10.6 | 5.0 | 11.3 |
| W-Central Atlantic | 1.4 | 2.2 | 0.8 | 0.9 | 1.4 |
| E-Central Atlantic | 39.8 | 23.7 | 37.5 | 35.0 | 32.8 |
| World Total | 826.8 | 846.4 | 942.9 | 1095.5 | 1119.4 |
| Todarodes pacificus (Japanese squid) | 325.7 | 225.9 | 234.3 | 239.5 | 360.3 |
| Illex illecebrosus (Short-finned squid) | 68.2 | 98.6 | 149.2 | 236.7 | 107.5 |
| Loligo spp. | 123.0 | 132.5 | 148.7 | 141.7 | 139.5 |
| All others | 309.9 | 389.4 | 410.7 | 477.6 | 512.1 |
| Japan | 466.1 | 459.6 | 494.3 | 515.0 | 669.7 |
| Korea Republic | 73.0 | 38.1 | 41.7 | 48.0 | 69.8 |
| U.S.S.R. | 41.9 | 75.3 | 21.4 | 55.8 | 50.9 |
| China | 35.7 | 40.4 | 61.9 | 42.4 | 43.2 |
| Spain | 29.4 | 23.6 | 43.3 | 30.9 | 40.4 |
| Argentina | 7.6 | 2.2 | 59.2 | 87.2 | 9.3 |
| Canada | 10.9 | 30.5 | 35.9 | 80.5 | 30.4 |
| U.S.A. | 13.1 | 11.3 | 18.6 | 22.0 | 16.0 |
| All others | 149.1 | 165.4 | 166.6 | 213.7 | 189.7 |

Table 2. List of species caught in gillnets of the TOMI MARU NO. 88, July-August, 1983.

| Species | Common name |
|---|---|
| Ommastrephes bartramii (Lesueur) | Flying squid |
| Lamna ditropis Hubbs & Follett | Salmon shark |
| Prionace glauca (Linnaeus) | Blue shark |
| Brama japonica Hilgendor | Pomfret |
| Thunnus alalunga (Bonnaterre) | Albacore tuna |
| Trachurus symmetricus (Ayres) | Jack mackerel |
| Scomber japonicus Houttuyn | Chub mackerel |
| Oncorhynchus gorbuscha (Walbaum) | Pink salmon |
| Oncorhynchus keta (Walbaum) | Chum salmon |
| Oncorhynchus kisutch (Walbaum) | Coho salmon |
| Oncorhynchus nerka (Walbaum) | Sockeye salmon |
| Salmo gairdneri Richardson | Steelhead trout |
| Salvelinus malma (Walbaum) | Dolly varden |
| Seriola dorsalis (Gill) | Yellowtail |
| Mola mola (Linnaeus) | Ocean sunfish |
| Erilepis zonifer (Lockington)* | Skilfish |
| Xiphias gladius Linnaeus | Swordfish |
| Pentaceros richardsoni Smith | Pelagic armorhead |
| Alepisaurus ferox Lowe | Longnose lancetfish |
| Sarda chiliensis lineolata (Girard) | Pacific bonito |
| | |
| Globicephala scammoni Gray | Pilot whale |
| Phocaena vomerina Linnaeus | Harbour porpoise |
| Phocoenoides dalli (True) | Dall porpoise |

*Juveniles only.

Table 3. Summary of the gillnet catch of the TOMI MARU NO. 88, July-August, 1983 and a comparison with the 1980 survey reported by Bernard (1981).

| | July-August, 1983 | | July-August*,1980 | |
|---|---|---|---|---|
| Species | % | (pieces) | % | (pieces) |
| Flying squid | 55.72 | | 81.14 | |
| Pomfret | 31.93 | | 5.46 | |
| Blue shark | 4.94 | | 6.84 | |
| Salmon shark | 5.56 | | 3.26 | |
| Pink salmon | 0.26 | (708) | 0.02 | (9) |
| Sockeye salmon | 0.17 | (319) | 0.02 | (7) |
| Steelhead trout | 0.12 | (198) | 0.02 | (17) |
| Chum salmon | 0.02 | (55) | 0.07 | (40) |
| Coho salmon | 0.02 | (47) | 0.02 | (10) |
| Dolly Varden | <0.01 | (2) | 0.0 | |
| All salmonids | 0.59 | (1329) | 0.15 | (83) |
| Albacore tuna | 0.95 | (793) | 2.21 | (502) |
| Pacific bonito | 0.02 | (28) | 0.0 | |
| Jack mackerel | 0.18 | | <0.01 | |
| Chub mackerel | <0.01 | | 0.78 | |
| Others | 0.10 | | <0.01 | |
| Total catch | 590,175 kg | | | 160,072 kg |

*Combined gillnet catches of TOMI MARU NO. 88 and TENYU MARU NO. 37, July-August, 1980 which worked 28 fishing days; using 504.7 km gillnet (Bernard 1981) compared to 40 fishing days; 1376.4 km gillnet used by TOMI MARU NO. 88 in July-August 1983.

Table 4. TOMI MARU NO. 88: Squid gillnetting results, July - August, 1983.

| | | Position | | | | T (°C) | | Length | Catch | | C.P.U.E.[1] | | | C.P.U.E.[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Set start | | Haul start | | | | of | Flying | Total | (kg/km net) | | | (kg/km-h) | |
| Set no. | Day* | Lat. N. | Long. W. | Lat. N. | Long. W. | Set start | Haul start | gillnet (km) | squid (kg) | catch (kg)** | Squid | Total** | Fishing effort*** | Squid | Total |
| 001 | 19 | 50°31.0' | 130°39.0' | 50°24.1' | 130°53.2' | 14.8 | 14.6 | 12.5 | 3560 | 5353 | 284.8 | 428.2 | 93.7 | 38.0 | 57.1 |
| 002 | 22-23 | 50°32.6' | 134°30.7' | 50°12.5' | 134°03.1' | 14.1 | 13.9 | 43.2 | 4505 | 21946 | 104.3 | 1433.9 | 328.3 | 13.7 | 188.7 |
| 003 | 23 | 49°35.1' | 133°35.3' | 49°40.6' | 134°04.4' | 14.3 | 14.3 | 30.0 | 19776 | 35902 | 659.2 | 1363.4 | 228.0 | 86.7 | 179.4 |
| 004 | 24 | 49°24.8' | 133°57.8' | 49°19.2' | 133°26.7' | 14.4 | 14.3 | 36.0 | 13088 | 17468 | 363.5 | 485.2 | 284.4 | 46.0 | 61.4 |
| 005 | 25-26 | 49°32.0' | 132°49.5' | 49°30.0' | 133°15.3' | 14.8 | 14.5 | 42.0 | 17107 | 33432 | 407.3 | 1153.1 | 264.6 | 64.6 | 183.0 |
| 006 | 26 | 49°09.9' | 133°16.3' | 49°11.3' | 132°50.0' | 14.4 | 14.4 | 29.0 | 7490 | 10296 | 258.2 | 355.0 | 232.0 | 32.3 | 44.4 |
| 007 | 27 | 49°17.2' | 132°49.3' | 49°04.1' | 132°23.8' | 14.7 | 14.6 | 35.0 | 7290 | 14168 | 208.3 | 294.1 | 287.0 | 25.4 | 49.4 |
| 008 | 28 | 48°36.8' | 132°49.1' | 48°34.0' | 133°18.6' | 14.8 | 14.4 | 41.7 | 7203 | 16336 | 172.7 | 391.7 | 276.8 | 26.0 | 59.0 |
| 009 | 29 | 49°22.9' | 133°53.2' | 49°28.5' | 133°22.2' | 15.2 | 14.4 | 36.0 | 6170 | 15702 | 171.4 | 436.2 | 268.5 | 23.0 | 58.5 |
| 010 | 30 | 49°22.3' | 132°38.2' | 49°22.6' | 131°58.3' | 14.7 | 14.6 | 41.0 | 9070 | 24400 | 221.2 | 595.1 | 342.7 | 26.4 | 71.2 |
| 011 | 31 | 49°28.8' | 132°05.1' | 49°29.0' | 131°32.0' | 14.8 | 14.8 | 32.6 | 4792 | 18334 | 147.0 | 562.4 | 280.3 | 17.1 | 65.4 |
| 012 | 1 | 48°36.4' | 131°30.7' | 48°38.5' | 130°56.8' | 15.2 | 14.8 | 40.5 | 7146 | 16965 | 176.4 | 418.9 | 285.5 | 25.0 | 59.4 |
| 013 | 2 | 48°06.8' | 130°57.3' | 48°07.0' | 130°35.0' | 15.3 | 15.4 | 24.0 | 3387 | 5071 | 141.1 | 211.2 | 206.4 | 16.4 | 24.6 |
| 014 | 3 | 47°33.4' | 131°12.5' | 47°33.2' | 130°37.0' | 15.3 | 16.0 | 42.0 | 11107 | 18662 | 264.4 | 444.3 | 319.2 | 34.8 | 58.5 |
| 015 | 4 | 47°47.0' | 131°28.0' | 47°57.0' | 130°54.0' | 15.2 | 14.9 | 42.0 | 12342 | 22570 | 293.8 | 537.4 | 321.7 | 38.4 | 70.1 |
| 016 | 5 | 47°18.0' | 131°43.8' | 47°20.5' | 131°09.4' | 15.1 | 15.4 | 41.5 | 12255 | 21717 | 295.3 | 523.3 | 327.8 | 37.4 | 66.2 |
| 017 | 6 | 47°07.0' | 131°51.0' | 47°13.6' | 131°38.7' | 15.4 | 15.9 | 35.5 | 22905 | 30782 | 645.2 | 867.1 | 298.2 | 76.8 | 103.2 |
| 018 | 7 | 47°13.0' | 131°30.0' | 47°20.2' | 131°05.5' | 16.2 | 16.0 | 35.5 | 16015 | 20560 | 451.1 | 579.1 | 255.6 | 62.6 | 80.4 |
| 019 | 8 | 47°36.6' | 131°03.1' | 47°48.0' | 131°29.0' | 16.1 | 15.6 | 35.5 | 6572 | 10227 | 185.1 | 288.1 | 301.7 | 21.8 | 33.9 |
| 020 | 9 | 47°53.0' | 131°47.9' | 48°01.5' | 132°23.4' | 15.5 | 15.3 | 41.5 | 15700 | 21424 | 378.3 | 516.2 | 327.8 | 47.9 | 65.3 |
| 021 | 10 | 48°10.1' | 132°55.9' | 47°57.6' | 132°25.3' | 15.5 | 15.3 | 41.5 | 11566 | 16859 | 278.6 | 406.2 | 344.4 | 33.6 | 50.0 |
| 022 | 11 | 48°01.0' | 132°25.5' | 47°42.0' | 132°01.0' | 15.5 | 15.6 | 41.5 | 6112 | 13586 | 147.2 | 327.3 | 346.9 | 17.6 | 39.1 |
| 023 | 12 | 48°03.4' | 132°24.4' | 48°04.0' | 132°59.0' | 15.8 | 15.5 | 41.5 | 4850 | 14095 | 116.8 | 339.6 | 352.7 | 13.7 | 40.0 |
| 024 | 13 | 48°19.9' | 133°04.8' | 48°13.6' | 133°26.0' | 15.4 | 15.4 | 28.8 | 1607 | 7316 | 55.8 | 254.0 | 250.5 | 6.4 | 29.2 |
| 025 | 14 | 48°55.5' | 134°32.5' | 48°55.0' | 134°50.0' | 15.5 | 15.6 | 23.0 | 2438 | 5538 | 106.0 | 246.7 | 156.4 | 15.6 | 35.4 |
| 026 | 15 | 48°44.1' | 135°15.3' | 48°40.0' | 134°41.0' | 15.2 | 15.2 | 38.6 | 4477 | 7579 | 116.0 | 196.3 | 324.2 | 13.8 | 23.3 |
| 027 | 16 | 49°01.5' | 133°15.6' | 48°56.0' | 132°56.0' | 15.6 | 15.5 | 21.1 | 1406 | 3423 | 66.6 | 162.2 | 128.7 | 10.9 | 26.6 |
| 028 | 18 | 53°07.0' | 136°58.7' | 52°57.0' | 136°31.0' | 15.0 | 15.3 | 33.1 | 10677 | 13740 | 322.5 | 415.1 | 294.6 | 36.2 | 46.6 |
| 029 | 19 | 53°14.8' | 136°24.8' | 53°10.0' | 136°06.0' | 14.8 | 15.2 | 22.1 | 659 | 2863 | 29.8 | 129.6 | 181.2 | 3.6 | 15.8 |

Table 4 (cont'd)

| Set no. | Day* | Position: Set start Lat. N. | Position: Set start Long. W. | Position: Haul start Lat. N. | Position: Haul start Long. W. | T (°C) Set start | T (°C) Haul start | Length of gillnet (km) | Catch: Flying squid (kg) | Catch: Total catch (kg)** | C.P.U.E.[1] (kg/km net) Squid | C.P.U.E.[1] (kg/km net) Total** | Fishing effort *** | C.P.U.E.[2] (kg/km-h) Squid | C.P.U.E.[2] (kg/km-h) Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 030 | 20 | 52°47.9' | 136°38.9' | 52°43.1' | 136°07.7' | 14.8 | 15.1 | 31.7 | 18140 | 25404 | 572.2 | 801.4 | 298.0 | 60.9 | 85.2 |
| 031 | 21/22 | 52°48.0' | 136°33.0' | 52°46.6' | 135°59.6' | 14.9 | 14.9 | 38.6 | 18512 | 26820 | 479.6 | 694.8 | 320.4 | 57.7 | 83.7 |
| 032 | 22 | 52°30.6' | 137°04.1' | 52°28.0' | 136°40.0' | 14.9 | 14.8 | 27.6 | 2840 | 9177 | 102.9 | 332.5 | 198.7 | 14.3 | 46.2 |
| 033 | 23 | 51°55.0' | 136°43.0' | 51°53.0' | 136°25.0' | 14.9 | 14.7 | 22.1 | 516 | 4785 | 23.3 | 216.5 | 196.7 | 2.6 | 24.3 |
| 034 | 24 | 51°59.5' | 135°49.6' | 51°58.5' | 135°14.4' | 15.0 | 15.1 | 38.6 | 3242 | 8844 | 84.0 | 229.1 | 328.1 | 9.9 | 26.9 |
| 035 | 25 | 52°56.2' | 135°16.5' | 52°50.0' | 134°42.5' | 14.9 | 15.3 | 38.6 | 9185 | 10137 | 237.9 | 262.6 | 324.2 | 28.3 | 31.3 |
| 036 | 26 | 53°05.8' | 134°54.5 | 53°02.7' | 134°20.3' | 15.0 | 15.3 | 38.6 | 12195 | 14050 | 316.0 | 364.0 | 312.6 | 39.0 | 44.9 |
| 037 | 27 | 53°22.5' | 134°34.4' | 53°20.0' | 134°03.7' | 15.2 | 15.2 | 38.6 | 5309 | 7198 | 137.5 | 186.5 | 289.5 | 18.3 | 24.8 |
| 038 | 29 | 52°50.8' | 134°00.5' | 52°54.5' | 134°38.6' | 14.9 | 15.0 | 38.6 | 3214 | 4511 | 83.3 | 118.7 | 343.5 | 9.3 | 13.1 |
| 039 | 30 | 51°32.1' | 133°30.7' | 51°25.7' | 133°56.6' | 15.0 | 15.2 | 27.6 | 3157 | 8182 | 114.4 | 296.4 | 173.8 | 18.1 | 47.0 |
| 040 | 31 | 50°40.0' | 131°50.5' | 50°35.1' | 132°04.4' | 16.3 | 15.8 | 27.6 | 1979 | 4754 | 71.7 | 172.2 | 207.0 | 9.5 | 23.0 |

*According to G.M.T.

**Estimates only.

***Units of km net X hr soak time.

Table 5. TOMI MARU No. 88: Gillnetting catch other than squid.

| | Catch (kg or pieces) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Salmonids (pieces) | | | | | | |
| Set no. | Pomfret (kg)* | Shark (kg)* | Albacore (pieces) | Jack mackerel (pieces) | Others (pieces) | Pink | Sock. | Chum | Coho | Steel head | Dolly V. | Total |
| 001 | 600 | 38 | 0 | 0 | 0 | 148 | 254 | 9 | 5 | 10 | 2 | 428 |
| 002 | 15125 | 1155 | 0 | 0 | 2 | 323 | 49 | 38 | 21 | 1 | 0 | 432 |
| 003 | 15002 | 824 | 0 | 0 | 4 | 55 | 6 | 0 | 8 | 40 | 0 | 109 |
| 004 | 3108 | 1220 | 0 | 7 | 6 | 6 | 1 | 0 | 9 | 1 | 0 | 17 |
| 005 | 15000 | 1290 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 11 | 0 | 13 |
| 006 | 1633 | 1115 | 0 | 1 | 1 | 9 | 0 | 1 | 0 | 11 | 0 | 21 |
| 007 | 5258 | 1530 | 0 | 0 | 0 | 13 | 0 | 1 | 0 | 20 | 0 | 34 |
| 008 | 7830 | 1280 | 0 | 12 | 1 | 2 | 0 | 0 | 0 | 8 | 0 | 10 |
| 009 | 8100 | 1400 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 10 | 0 | 12 |
| 010 | 14269 | 934 | 8 | 0 | 1 | 6 | 0 | 0 | 0 | 11 | 0 | 17 |
| 011 | 12248 | 1128 | 13 | 0 | 1 | 10 | 6 | 0 | 0 | 9 | 0 | 25 |
| 012 | 8365 | 1350 | 8 | 0 | 0 | 2 | 0 | 0 | 0 | 14 | 0 | 16 |
| 013 | 992 | 578 | 13 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 |
| 014 | 4867 | 2100 | 78 | 13 | 1 | 0 | 0 | 1 | 0 | 6 | 0 | 7 |
| 015 | 8104 | 1584 | 70 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 016 | 6228 | 1762 | 204 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 017 | 5449 | 1818 | 84 | 2 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |
| 018 | 2767 | 1246 | 70 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 019 | 2664 | 600 | 42 | 20 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 020 | 3892 | 1686 | 22 | 6 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 2 |
| 021 | 3892 | 1236 | 23 | 14 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 022 | 6228 | 1188 | 5 | 11 | 1 | 2 | 1 | 0 | 0 | 3 | 0 | 6 |
| 023 | 7006 | 2168 | 5 | 25 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 024 | 3780 | 1842 | 7 | 24 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| 025 | 1296 | 1688 | 6 | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 026 | 1449 | 1548 | 1 | 64 | 7 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 027 | 909 | 1048 | 5 | 10 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 |
| 028 | 630 | 2319 | 1 | 0 | 0 | 40 | 0 | 0 | 0 | 5 | 0 | 45 |
| 029 | 453 | 1740 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 5 |
| 030 | 630 | 6600 | 1 | 6 | 0 | 10 | 0 | 0 | 0 | 2 | 0 | 12 |
| 031 | 5796 | 2460 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 |
| 032 | 3105 | 3081 | 22 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 3 |
| 033 | 1584 | 2279 | 57 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 3 |
| 034 | 2898 | 2512 | 26 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 4 |
| 035 | 27 | 875 | 1 | 0 | 0 | 14 | 0 | 0 | 0 | 4 | 0 | 18 |
| 036 | 720 | 1069 | 3 | 0 | 1 | 12 | 1 | 0 | 2 | 0 | 0 | 15 |
| 037 | 1260 | 561 | 0 | 0 | 13 | 11 | 0 | 0 | 0 | 1 | 0 | 12 |
| 038 | 90 | 1166 | 0 | 0 | 10 | 2 | 0 | 0 | 0 | 2 | 0 | 4 |
| 039 | 4050 | 930 | 1 | 2 | 4 | 1 | 0 | 4 | 0 | 4 | 0 | 9 |
| 040 | 1530 | 1119 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |

*Estimates only

Table 6. Comparison of squid catching efficiencies (kg squid per km gillnet) from exploratory fishing cruises in the NE Pacific.

| | | | Length of net (km) | | T (°C) | | C.U.P.E.[1] | |
|---|---|---|---|---|---|---|---|---|
| Fishing vessel | Fishing dates | Fishing days | $\bar{x}$ | Range | $\bar{x}$ | Range | $\bar{x}$ ± SD | Source |
| TENYU MARU #37 | Sept., 1979 | 10* | 8.3 | 7.5-9.0 | 15.3 | 14.7-15.9 | 71.3±29.5 | Bernard (1980) |
| KOHOKU MARU #18 | Sept.-Oct., 1979 | 3 | 13.9 | 13.8-14.0 | 15.9 | 15.3-16.4 | 112.3±7.6 | Bernard (1980) |
| TENYU MARU #37 | July-Aug., 1980 | 16 | 17.4 | 10.0-20.0 | 14.3 | 14.0-14.6 | 326.4±125.0 | Bernard (1981) |
| TOMI MARU #88 | July-Aug., 1980 | 17** | 18.3 | 4.6-42.2 | - | - | 328.0±48.8 | Bernard (1981) |
| TOMI MARU #88 | Aug., 1980 | 12 | 18.8 | 18.2-19.1 | 15.1 | 14.5-16.0 | 166.3±73.1 | Bernard (1981) |
| TOMI MARU #88 | July-Aug., 1983 | 40 | 34.4 | 12.5-43.2 | 15.1 | 14.1-16.3 | 232.3±162.1 | This report |
| SIMSTAR | July-Aug., 1983 | 25 | 3.9 | 1.6-4.8 | 15.2 | 13.3-15.7 | 339.4±168.7 | Robinson and Jamieson (in press) |

*Two fishing days, with temperatures of 14.1 and 14.2°C and efficiencies of 0.4 and 4.0 respectively, excluded from analysis.

**North Pacific (43-47°N Latitude and 176°-133°W Longitude) catches of TOMI MARU NO. 88 enroute to eastern Pacific fishing grounds prior to the 12 fishing days in Canadian waters in August, 1980.

Table 7. TOMI MARU NO. 88: Squid jigging results, July-August, 1983.

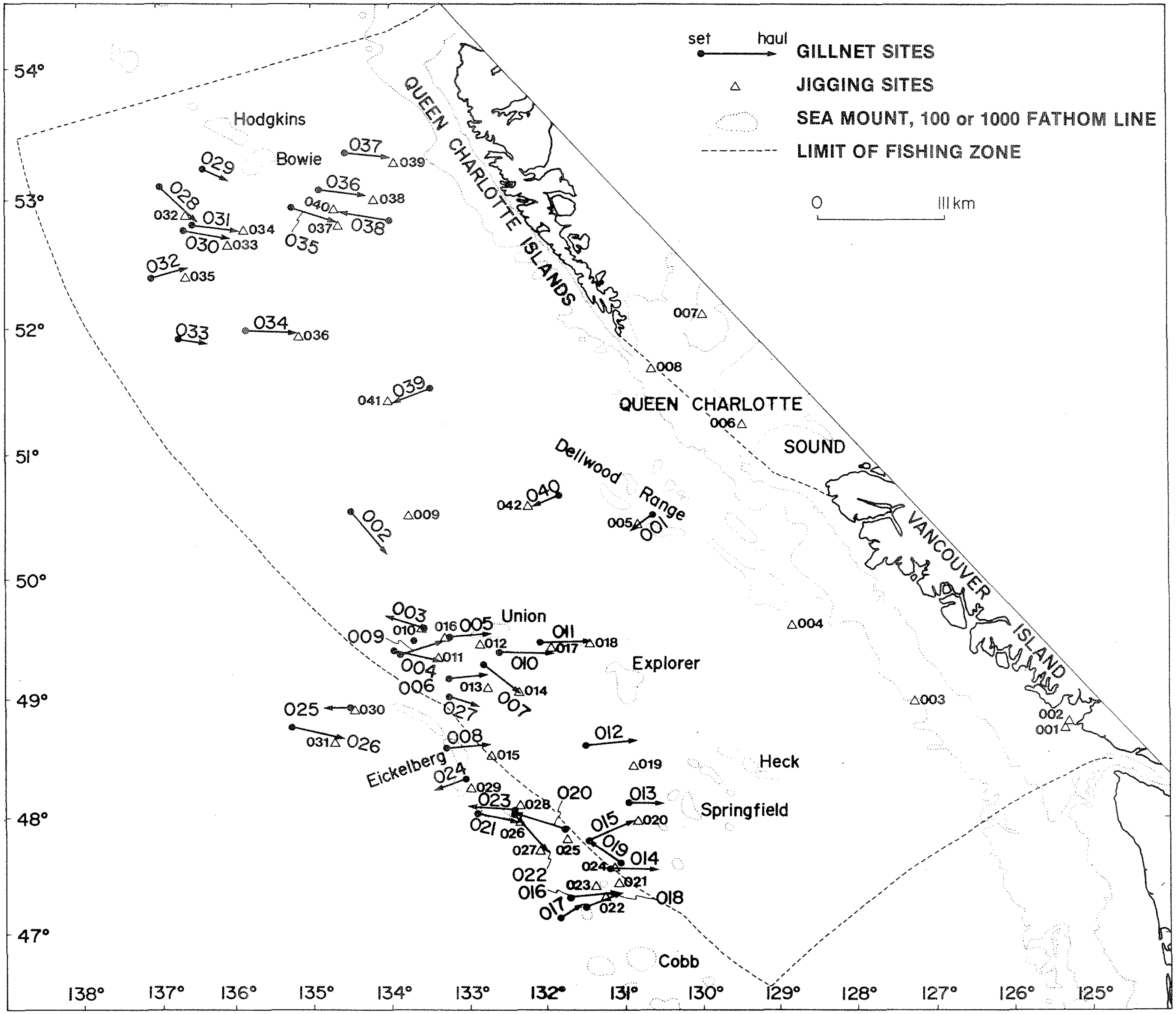
| Set no. | Day* | Position: Lat. N. | Position: Long. W. | T (°C) | Jig depth (m) | Catch (kg): Flying squid | Catch (kg): Nail squid | Catch (kg): Total | % Caught by machine | Effort (hr): Machine | Effort (hr): Man | C.P.U.E. (kg squid per hr): Machine | C.P.U.E. (kg squid per hr): Man |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | 16 | 48°45.8' | 125°28.8' | 13.5 | 60-80 | 0 | 0 | 0 | 0 | 34.9 | 0 | 0 | 0 |
| 002 | 16 | 48°48.9' | 125°17.1' | 14.0 | 60-80 | 0 | 0 | 0 | 0 | 19.6 | 22.5 | 0 | 0 |
| 003 | 17 | 48°58.5' | 127°17.5' | 15.0 | 50 | 15.3 | 6.2 | 21.5 | 11.5 | 66.0 | 144.0 | 0.03 | 0.13 |
| 004 | 18 | 49°36.7' | 128°50.2' | 14.5 | 45 | 95.0 | 6.2 | 101.2 | 54.7 | 44.0 | 160.0 | 1.23 | 2.86 |
| 005 | 19 | 50°25.0' | 130°51.0' | 14.8 | 45 | 33.7 | 1.5 | 35.2 | 31.6 | 51.0 | 48.0 | 0.22 | 0.50 |
| 006 | 20 | 51°24.3' | 129°30.2' | 14.6 | 50-60 | 0 | 0 | 0 | 0 | 44.0 | 99.0 | 0 | 0 |
| 007 | 21 | 52°06.0' | 130°01.0' | 14.6 | 45 | 0 | 0 | 0 | 0 | 8.0 | 36.0 | 0 | 0 |
| 008 | 21 | 51°41.0' | 130°38.0' | 14.6 | 45 | 0 | 0 | 0 | 0 | 4.5 | 0 | 0 | 0 |
| 009 | 22 | 50°32.0' | 133°48.0' | 14.2 | 45 | 0 | 4.3 | 4.3 | 100 | 16.5 | 0 | 0.24 | 0 |
| 010 | 23 | 49°34.0' | 133°36.0' | 14.2 | 50 | 61.6 | 0 | 61.6 | 100 | 18.0 | 0 | 3.38 | 0 |
| 011 | 24 | 49°16.3' | 133°23.5' | 14.4 | 50 | 42.0 | 0 | 42.0 | 100 | 15.9 | 0 | 2.64 | 0 |
| 012 | 25 | 49°26.0' | 132°51.0' | 14.6 | 50 | 0 | 0 | 0 | 0 | 11.2 | 0 | 0 | 0 |
| 013 | 26 | 49°05.8' | 132°46.1' | 14.6 | 50 | 53.0 | 0 | 53.0 | 100 | 16.3 | 0 | 3.25 | 0 |
| 014 | 27 | 49°03.2' | 132°22.0' | 14.5 | 50 | 9.0 | 0 | 9.0 | 100 | 28.3 | 0 | 0.32 | 0 |
| 015 | 28 | 48°31.0' | 132°44.0' | 14.6 | 50 | 2.2 | 0 | 2.2 | 100 | 14.0 | 0 | 0.15 | 0 |
| 016 | 29 | 49°29.0' | 133°19.0' | 14.9 | 50 | 35.2 | 0 | 35.2 | 100 | 24.0 | 0 | 1.46 | 0 |
| 017 | 30 | 49°25.0' | 131°57.0' | 14.7 | 50 | 42.0 | 0 | 42.0 | 100 | 15.0 | 0 | 2.80 | 0 |
| 018 | 31 | 49°27.2' | 131°27.0' | 14.8 | 50 | 28.6 | 0 | 28.6 | 100 | 14.4 | 0 | 1.90 | 0 |
| 019 | 1 | 48°25.0' | 130°54.0' | 15.4 | 50 | 39.6 | 0 | 39.6 | 100 | 9.7 | 0 | 4.08 | 0 |
| 020 | 4 | 47°57.0' | 130°50.0' | 15.3 | 50 | 70.4 | 0 | 70.4 | 100 | 15.7 | 0 | 4.48 | 0 |
| 021 | 5 | 47°25.0' | 131°05.0' | 15.2 | 50 | 88.0 | 0 | 88.0 | 100 | 18.4 | 0 | 4.78 | 0 |
| 022 | 6 | 49°18.0' | 131°15.0' | 15.4 | 50 | 50.7 | 0 | 50.7 | 100 | 20.0 | 0 | 2.53 | 0 |
| 023 | 7 | 47°23.0' | 131°23.0' | 15.5 | 50 | 15.5 | 0 | 15.5 | 100 | 11.25 | 0 | 1.36 | 0 |
| 024 | 8 | 47°33.0' | 131°11.0' | 15.5 | 50 | 75.1 | 0 | 75.1 | 100 | 7.0 | 0 | 10.75 | 0 |
| 025 | 9 | 47°48.0' | 131°45.0' | 15.6 | 50 | 20.0 | 0 | 20.0 | 100 | 11.2 | 0 | 1.78 | 0 |
| 026 | 10 | 47°57.0' | 132°20.0' | 15.3 | 50 | 83.6 | 0 | 83.6 | 100 | 19.0 | 0 | 4.40 | 0 |
| 027 | 11 | 47°42.0' | 132°05.0' | 15.6 | 50 | 35.2 | 0 | 35.2 | 100 | 15.0 | 0 | 2.34 | 0 |
| 028 | 12 | 48°04.0' | 132°21.0' | 15.6 | 55 | 86.0 | 0 | 86.0 | 100 | 9.9 | 0 | 8.68 | 0 |
| 029 | 13 | 48°14.0' | 132°59.0' | 15.3 | 55 | 4.0 | 0 | 4.0 | 100 | 16.0 | 0 | 0.25 | 0 |

Table 7 (cont'd)

| Set no. | Day* | Position Lat. N. | Long. W. | T (°C) | Jig depth (m) | Catch (kg) Flying squid | Nail squid | Total | % Caught by machine | Effort (hr) Machine | Man | C.P.U.E. (kg squid per hr) Machine | Man |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 030 | 14 | 48°53.0' | 134°28.0' | 15.4 | 55 | 46.0 | 0 | 46.0 | 100 | 16.0 | 0 | 2.87 | 0 |
| 031 | 15 | 48°36.0' | 134°43.0' | 15.3 | 55 | 24.0 | 0 | 24.0 | 100 | 15.7 | 0 | 1.52 | 0 |
| 032 | 18 | 52°53.8' | 136°37.0' | 15.3 | 55 | 53.0 | 0 | 53.0 | 100 | 16.0 | 0 | 3.31 | 0 |
| 033 | 20 | 52°39.0' | 136°06.2' | 14.7 | 55 | 53.0 | 0 | 53.0 | 100 | 10.0 | 0 | 5.30 | 0 |
| 034 | 21 | 52°46.0' | 135°53.0' | 14.8 | 50 | 6.0 | 0 | 6.0 | 100 | 20.0 | 0 | 0.30 | 0 |
| 035 | 22 | 52°25.0' | 136°38.0' | 14.8 | 50 | 17.0 | 0 | 17.0 | 100 | 14.2 | 0 | 1.21 | 0 |
| 036 | 24 | 51°56.7' | 135°11.4' | 15.0 | 50 | 53.0 | 0 | 53.0 | 100 | 19.0 | 0 | 2.82 | 0 |
| 037 | 25 | 52°48.1' | 134°39.4' | 15.3 | 50 | 79.0 | 0 | 79.0 | 100 | 19.0 | 0 | 4.15 | 0 |
| 038 | 26 | 53°00.3' | 134°15.6' | 15.1 | 50 | 11.0 | 0 | 11.0 | 100 | 15.0 | 0 | 0.73 | 0 |
| 039 | 27 | 53°17.1' | 133°58.5' | 15.2 | 55 | 22.0 | 0 | 22.0 | 100 | 17.0 | 0 | 1.29 | 0 |
| 040 | 29 | 52°55.7' | 134°42.9' | 14.9 | 55 | 66.0 | 0 | 66.0 | 100 | 20.1 | 0 | 3.31 | 0 |
| 041 | 30 | 51°25.3' | 134°27.7' | 15.1 | 55 | 42.0 | 0 | 42.0 | 100 | 21.2 | 0 | 2.00 | 0 |
| 042 | 31 | 50°34.0' | 132°14.6' | 15.7 | 55 | 17.0 | 0 | 17.0 | 100 | 18.4 | 0 | 0.90 | 0 |

*Date according to G.M.T.

Fig. 1. Map of all the gillnetting and jigging positions with distances between sets and hauls to scale.


set
haul
GILLNET SITES
JIGGING SITES
SEA MOUNT, 100 or 1000 FATHOM LINE
LIMIT OF FISHING ZONE
0
111 km
Hodgkins
Bowie
QUEEN CHARLOTTE ISLANDS
QUEEN CHARLOTTE
SOUND
VANCOUVER ISLAND
Dellwood
Range
Union
Explorer
Eickelberg
Heck
Springfield
Cobb
54°
53°
52°
51°
50°
49°
48°
47°
138°
137°
136°
135°
134°
133°
132°
131°
130°
129°
128°
127°
126°
125°

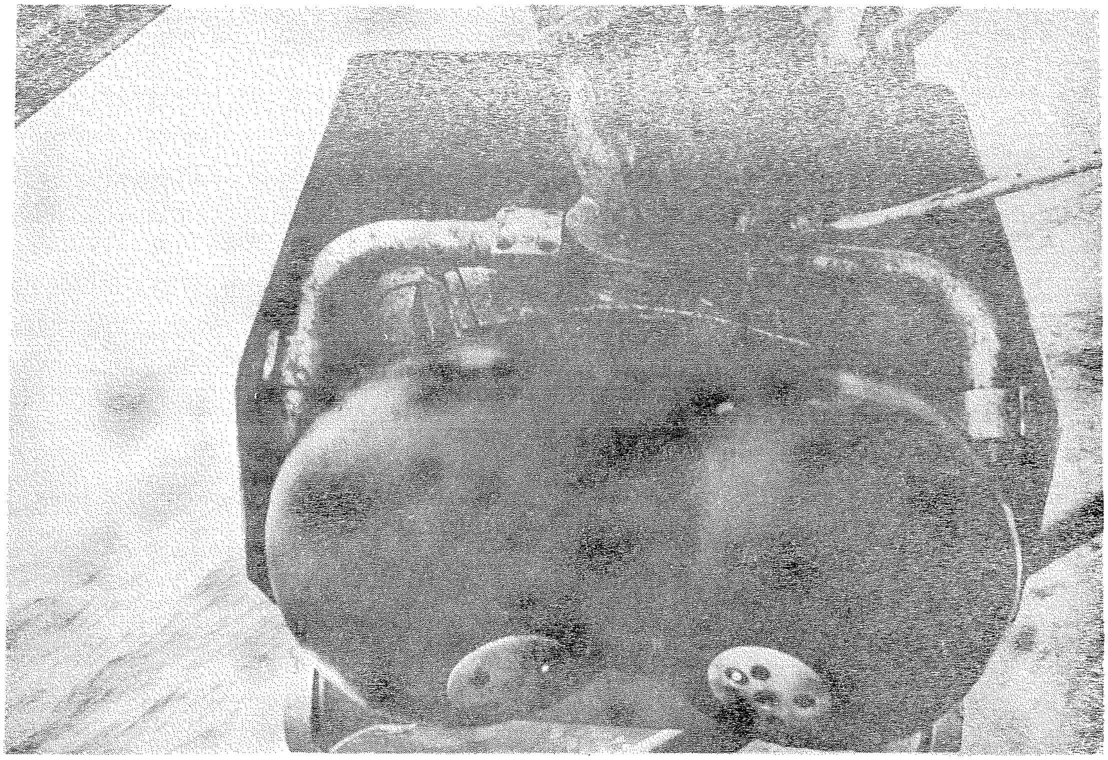


Fig. 2. Photograph of inflatable rubber-sphered line hauler.

Fig. 3. Photograph of crew bringing in the gillnet meshes between the lead and float lines.

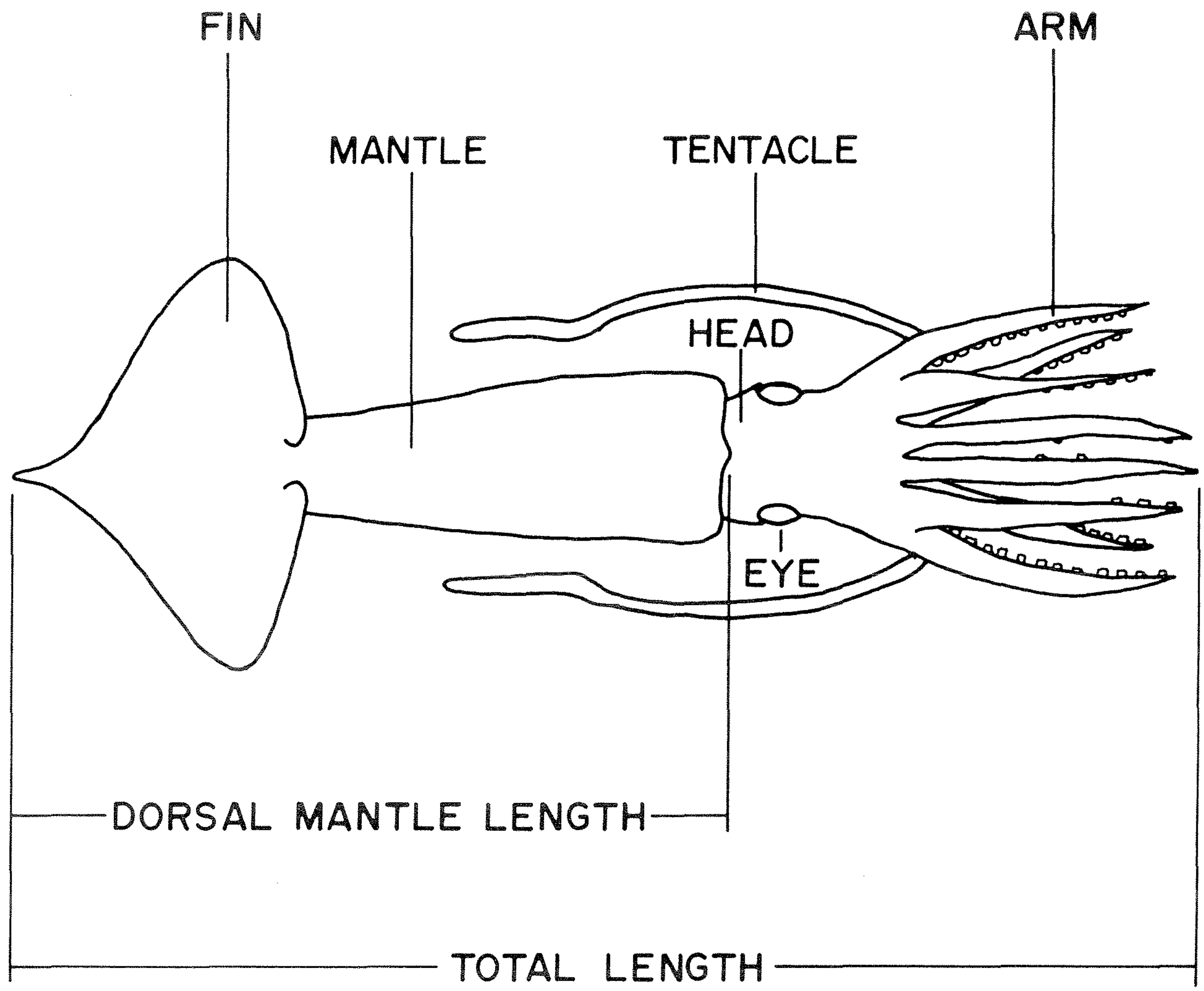



Fig. 4. Diagram of a squid (after Bernard 1980).

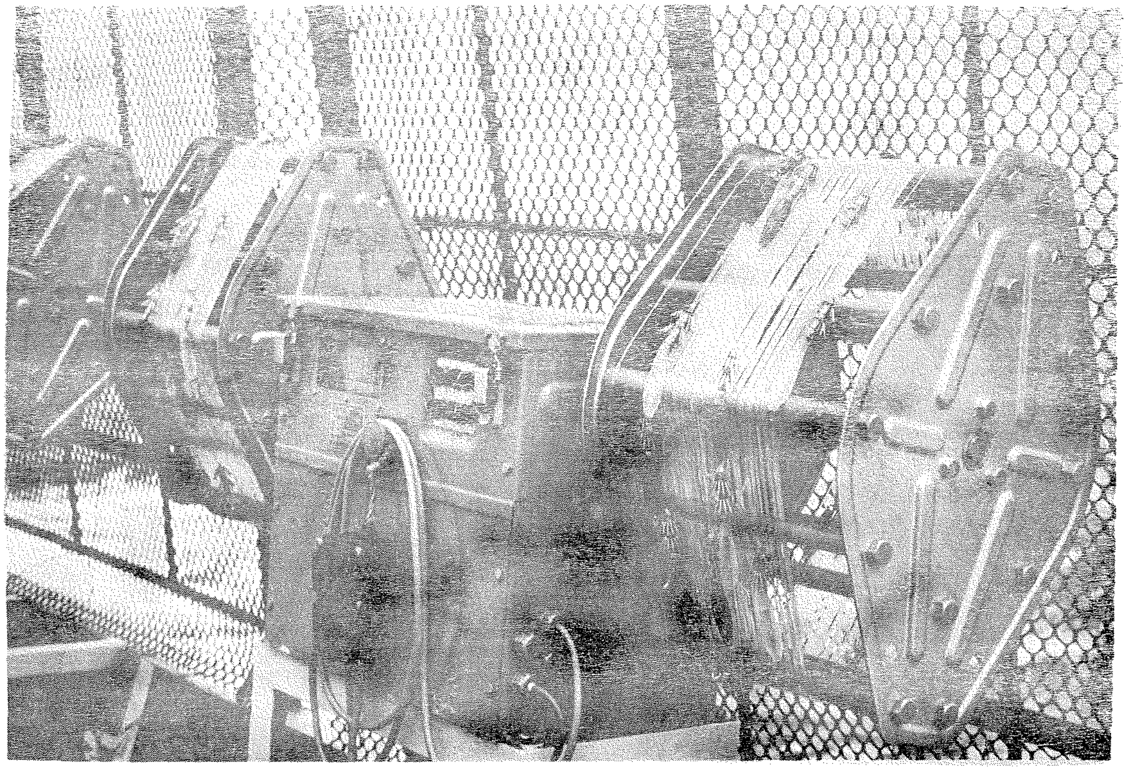


Fig. 5. Photograph of a Hamade MD-3 SES automatic jigging machine.

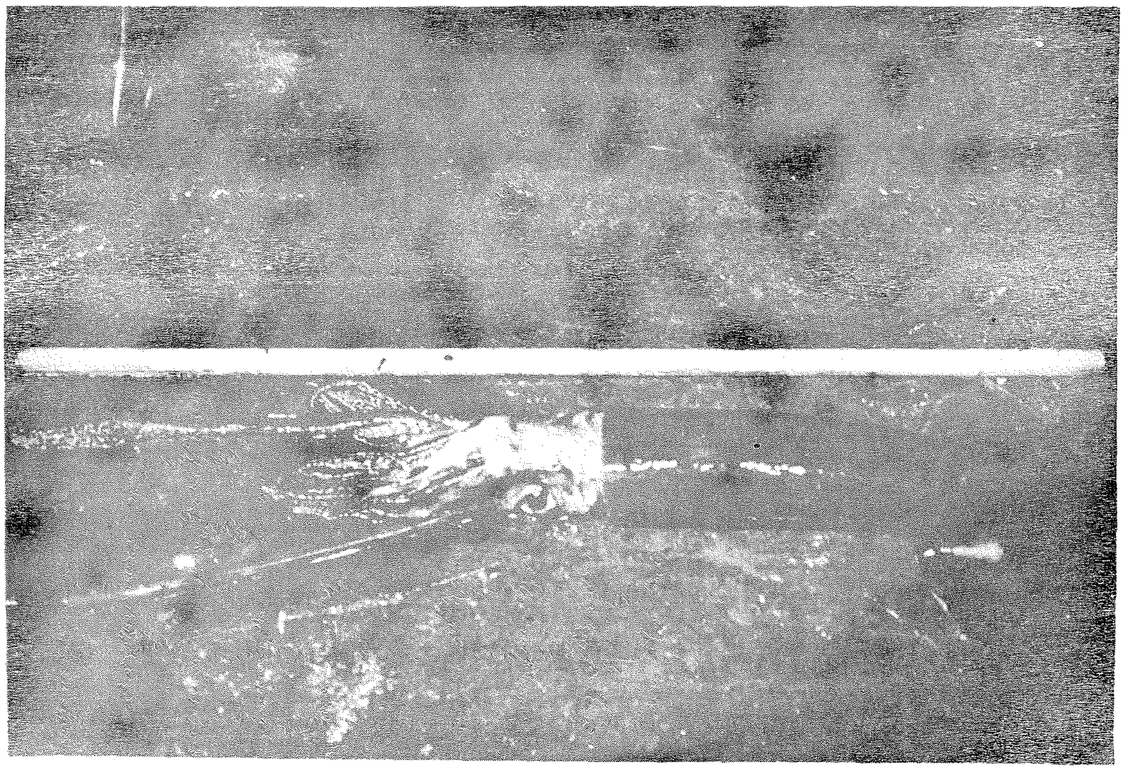


Fig. 6. Photograph of a large flying squid caught by jig.

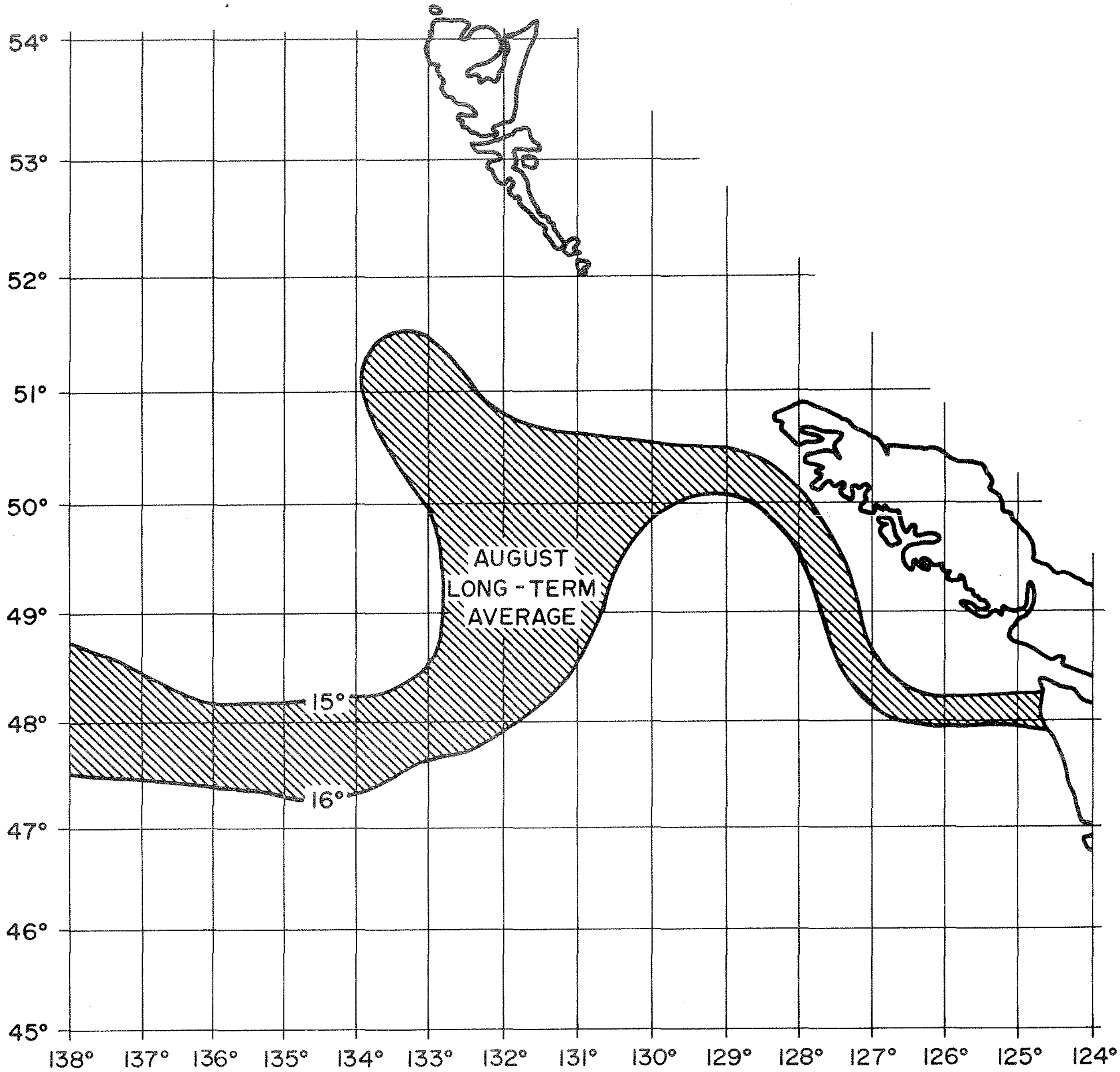
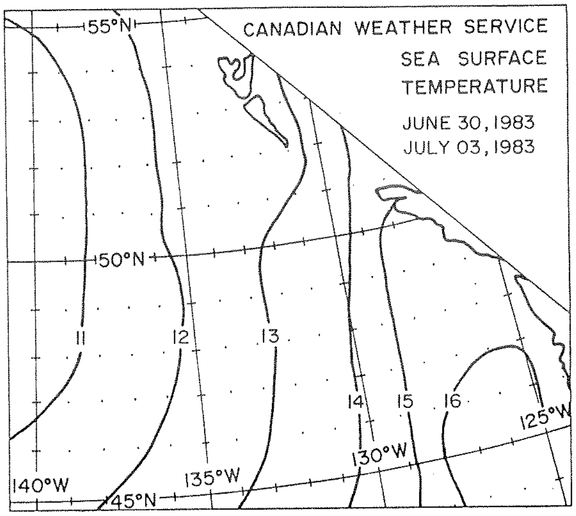
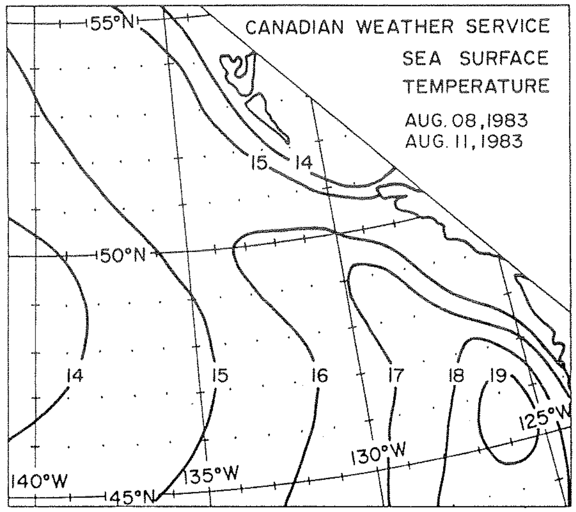


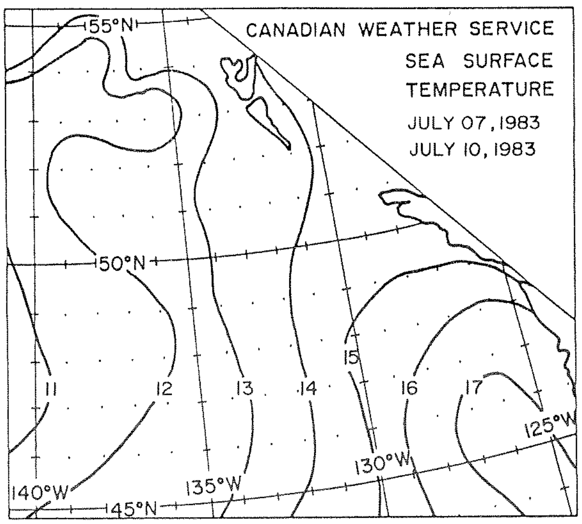

Fig. 7. Position of long term average 15° and 16°C isotherms for August off British Columbia (after Ketchen 1980).

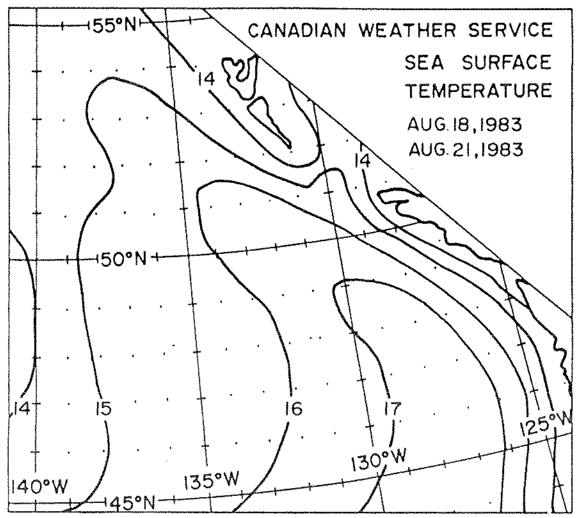
Fig. 8. Maps of sea surface isotherms off British Columbia, June-July, 1983.

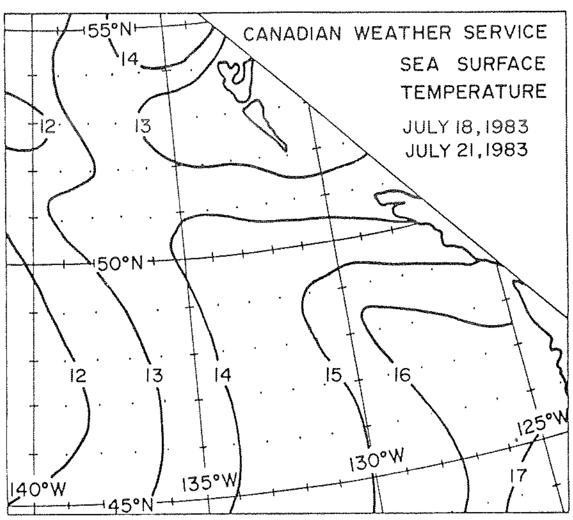
Fig. 9. Maps of sea surface isotherms off British Columbia, August-September, 1983.

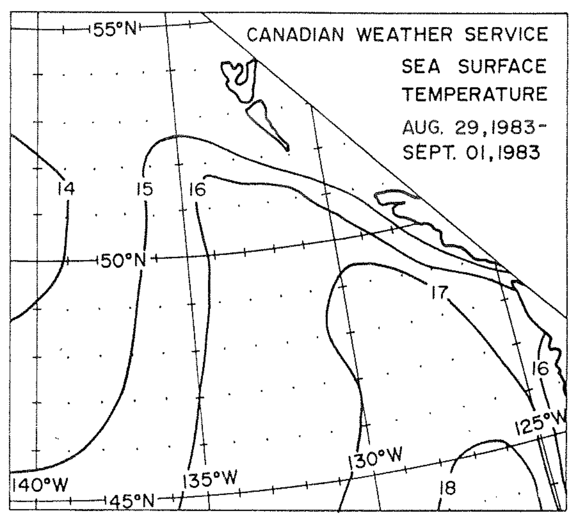

CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
JUNE 30, 1983
JULY 03, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
11
12
13
14
15
16


CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
AUG. 08, 1983
AUG. 11, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
14
15
16
17
18
19


CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
JULY 07, 1983
JULY 10, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
11
12
13
14
15
16
17


CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
AUG. 18, 1983
AUG. 21, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
14
15
16
17


CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
JULY 18, 1983
JULY 21, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
12
13
14
15
16
17


CANADIAN WEATHER SERVICE
SEA SURFACE
TEMPERATURE
AUG. 29, 1983-
SEPT. 01, 1983
55°N
50°N
45°N
140°W
135°W
130°W
125°W
14
15
16
17
18

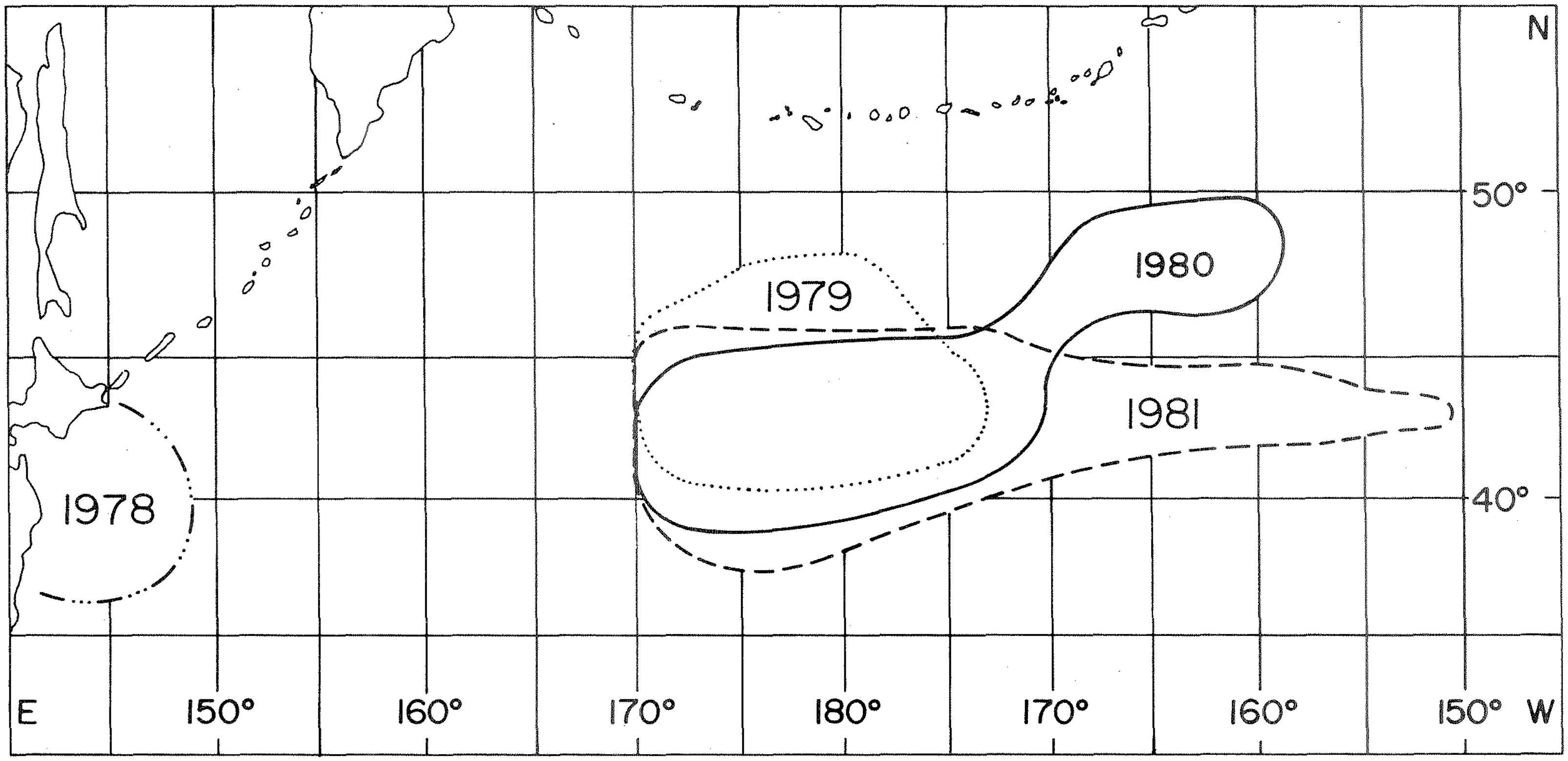



Fig. 10. Spread of Japanese flying squid gillnetting fleet across the North Pacific (after Anon. 1982).

# APPENDIX I. SQUID GEAR SUPPLIERS

## CANADIAN SUPPLIERS AND CONTACTS

A local supplier of some jigging equipment is:

Puretic Fishing
3900 - 3920 Moncton St.
Steveston, Richmond, B.C.
V7E 3A6 (604) 277-9661

A local contact for Japanese manufacturers is:

Hokkaido Fisheries Co. Ltd.
215-470 Granville St.
Vancouver, B.C.
V6C 1V5 (604) 685-8749

## JAPANESE SUPPLIERS AND CONTACTS

Squid Skinning Machine (TOACO Type TM-38)
Toakoeki Co. Ltd.
Telex: 232-4645

Iwasi's High Performance Squid Splitting Machine
Taiyo Seisakusho Mfg. Co. Ltd.
25-Showa, 3-Chome
Hakodate, Hokkaido

Rubber Ball Line Hauler
Koyo Co. Ltd.
7-3 Tateshita
Kamigamishiro
Iwaki Onahama
Fukushima

Lead Line Hauler
Izui Iron Works Co. Ltd.
Suisan-kikai Bldg.
4-5 Muromachi, Chuoku
Tokyo

Automatic Jigging Machines
Towa Denki Seisakusho Co. Ltd.
6-29, Yoshikawa-cho, Hakodate
Hokkaido 040

Jigging Lures and Sundry Accessories
Taito Seiko Co. Ltd.
Imaaso Bldg., No. 1-21, 1-chome
Higashi-shimbashi, Minato-ku
Tokyo 105

# APPENDIX II. JAPANESE SQUID LURES USED

All lures were manufactured by Taito Seiko Co. Ltd., and had 2 rosettes of 1.5-2.0 cm spikes at one end. This firm will supply a catalogue in English.

| | | |
|---|---|---|
| Machine lures: | 100 mm | 'CM' type (red or dark green) |
| | 120 mm | 'SM' type (clear) |
| Hand lures: | 120 mm | Weighted bamboo shaft |
| | 200 mm | 'HEM 3' type with luminous panel |
| | 270 mm | 'H4' type squared and flattened |
| | 300 mm | 'HM-2' type hexogonal |

Last three lures either stainless steel or chrome plated.