Experimental Squid Jigging Off the Washington Coast

ROGER W. MERCER and MICHELE BUCY

Introduction

In the spring of 1981, the Northwest and Alaska Fisheries Center (NWAFC) of the National Marine Fisheries Service was contacted by Captain Jerry Sweeney of the salmon charter vessel *Tres Cher* in regard to squid jigging as an alternative to the declining salmon charter fishery off the Washington coast. A review of existing literature on squid yielded several pieces of information which indicated some potential for a nail squid, *Onychoteuthis borealijaponicus*, or flying squid, *Ommastrephes bartramii*, fishery off the Washington coast. Marine mammal stomach content information (Kajimura et al., 1980; Fiscus, 1982) indicated that nail squid might be found along the Washington continental shelf at the head of submarine canyons. Experimental squid fishing conducted off the coast of British Columbia during 1980 (Bernard, 1981) resulted in catches of flying squid and nail squid, and reports from Japan (Okutani, 1977) indicated that both species were taken commercially by Japanese vessels for domestic markets.

In light of this information, a decision was made to conduct experimental squid fishing off Washington during the summer months of 1981. Two Japanese Sanpar[1] squid jigging machines belonging to the NWAFC were loaned to Captain Sweeney for comparison with his own Swedish Kemers Atlanter machines during the planned experimental squid jigging trips. These machines were mounted on the *Tres Cher* at its berth in Tacoma, Wash. The vessel was then moved to Westport, Wash., in early May to begin squid fishing experiments.

This paper documents this experimental squid fishing and, especially, describes in detail what was learned regarding jigging of oceanic squids.

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[1]Mention of trade names does not imply endorsement by the National Marine Fisheries Service, NOAA

ABSTRACT—In the spring of 1981, the Resource Assessment and Conservation Engineering Division of the NMFS Northwest and Alaska Fisheries Center loaned two squid jigging machines to Captain Jerry Sweeney of the fishing vessel Tres Cher. *These were used along with four of his own machines for experimental squid fishing off the Washington coast. This experimental fishing was prompted by reports of possible commercial quantities of nail squid,* Onychoteuthis borealijaponicus, *and flying squid,* Ommastrephes bartramii, *in the northeastern north Pacific Ocean. Fishing locations were selected based on northern fur seal,* Callorhinus ursinus, *stomach content data which indicated either or both species of squid might be found over depths greater than 200 m at the head of submarine canyons. Nocturnal squid jigging operations were conducted as an adjunct to daylight jigging for black rockfish,* Sebastes melanops, *or trolling for albacore,* Thunnus alalunga. *The* Tres Cher *was outfitted with tuna trolling gear, fish jigging machines, and squid jigging machines.*

A total of 1,261 squids were caught during 21 nights of jigging from 10 May to 14 September 1981. Two of the squid caught were flying squid and the rest were nail squid. About half of the squid caught were measured and examined for gender and sexual maturity. Squid were not captured in commercial quantities during these experiments, but it is felt that commercial quantities of nail squids might be available off the Washington coast during periods when coastal upwelling occurs.

Methods and Materials

The *Tres Cher* is a 17.1 m (56-foot), twin screw salmon charter vessel powered by two Volvo-Penta TMD-120 300-horsepower diesel engines. An Isuzu diesel electrical generator provides 20 kW of 60 Hz electrical power at either 230 or 115 volts. Initially, two recording depth sounders were used to search for squid schools. These were a Morrow JMF-151G system used with a 50 kHz transducer and a Si-tex HE-32E system with a 200 kHz transducer. A JRC/JFV-516 color recorder was installed in mid-August and slaved to the Morrow 50 kHz system. Navigational equipment included a Raytheon Pathfinder 2800 radar, and a Morrow Loran C system which included an LCA-3450 receiver, a CS-3450 steering computer, and an XYP 4000 plotter.

Lighting equipment consisted of three 1,000-watt incandescent lamps placed near the jigging machines on the port quarter of the vessel. In addition to the incandescent lamps, two pairs of 3,000- and 1,500-watt quartz halogen floodlights were positioned on the mast facing forward and aft, respectively.

Surface water temperature was measured with a bucket cast thermometer. Subsurface temperatures were measured to a depth of 30.5 m using a Heathkit

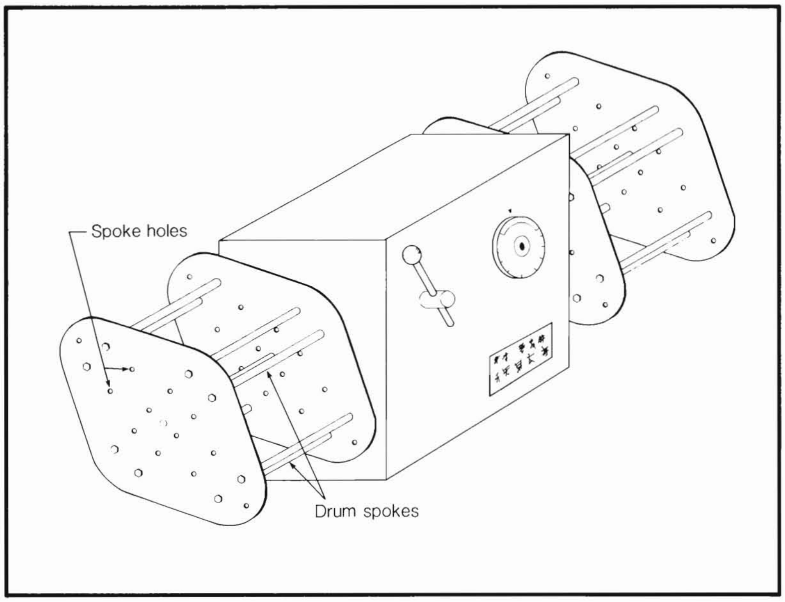

Figure 1.—The automatic jigging machine used aboard the fishing vessel *Tres Cher* in 1981 off Washington. Moveable drum spokes allow adjustment of drum eccentricity and effective diameter.

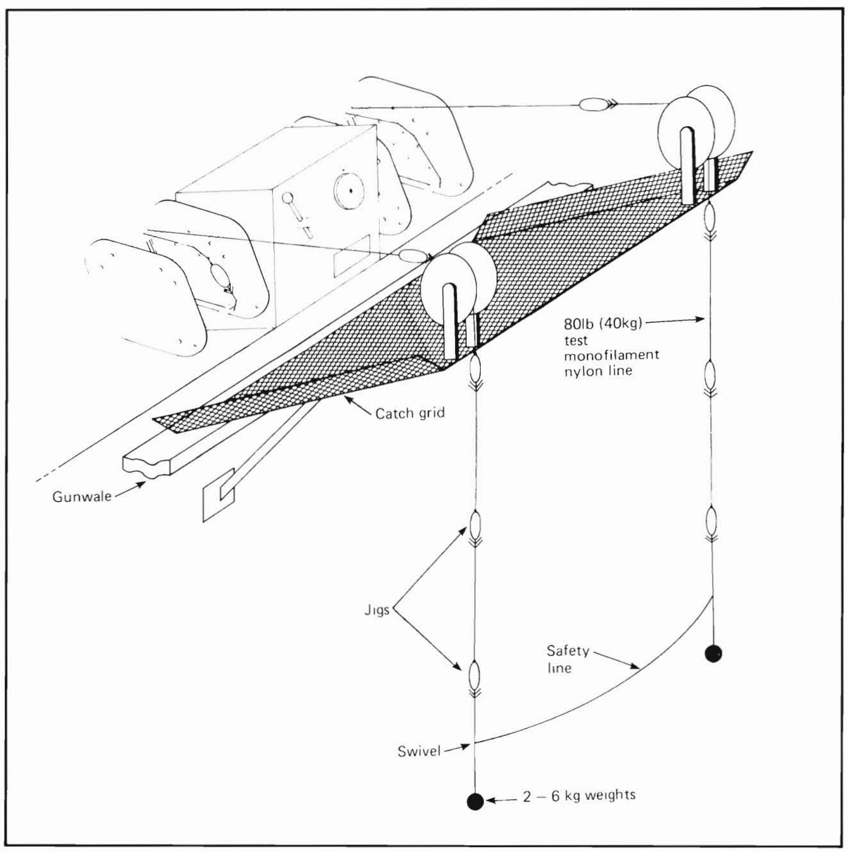

Figure 2.—Gear arrangement found most successful during experimental squid jigging aboard the *Tres Cher* in 1981 off Washington.

Thermospot thermometer. Thermospot temperatures were indicated in Fahrenheit and converted to Celsius. Corrections were applied to the Thermospot values per calibration checks against the bucket cast thermometer. National Weather Service sea surface thermal analyses were obtained on a weekly basis and used to help locate areas of coastal upwelling.

Fishing gear used for squid included sport rods (hand jigging), two Japanese Sanpar Models 76-2 and 7-2 squid jigging machines (Fig. 1, 2), and one Swedish Kemers Atlanter cod jigging machine rigged with an adapter drum for squid jigging. Usually only one jigging machine was operated at a time. Dip nets with 45.7 cm diameter and 4.6 m aluminum handles were also used to capture squids near the surface. A 50 fathom long by 4 fathom deep gill net of 50.5 mm (2¼-inch) stretched mesh was deployed off the bow during several early trips as a combination drogue and sampling tool.

The selection of fishing locations was based on a study (Fiscus, 1982) of stomach contents of northern fur seals, *Callorhinus ursinus*, which indicated that either or both species of squid might be found over depths greater than 200 m at the head of submarine canyons. Site selection each evening depended upon sea surface temperature, presence and concentration of seabirds such as petrels and shearwaters, presence of floating jellyfish, *Velella velella*, and density of any scattering layer detected by either of the sounders. Thermal boundaries were sought as indicators of boundary and strong thermoclinal conditions often associated with oceanic squid species (Okutani, 1977; Naito et al., 1977b). Generally, albacore, *Thunnus alalunga*, fishing was conducted during daylight hours along the blue-water edge (thermal boundary) so the vessel was usually close to good "squid water" at sunset. If a scattering layer was detectable by the sounders, an area of peak target strength for the Si-tex 200 kHz sounder was generally chosen for a starting place.

After an initial jigging site was selected, the vessel would lay to and await sunset. If winds were above 10 knots, a drogue was deployed from the bow of the vessel to prevent excessive rolling motion. A 50-fathom (50.5 mm mesh) gill net was initially used for a drogue but was replaced later in the summer by a 6 m diameter parachute drogue. Rate and direction of drift were monitored using the Loran C and XY plotter. After sundown, quartz-halogen floodlights and incandescent lights were turned on to attract squid and jigging machines were started. Placement of the lamps in relation to jigging machines (Fig. 3) was in accordance with that found successful in other squid jig fisheries (Bernard, 1980; Ogura and Nasumi, 1976). Behavior of the scattering layer was monitored on echo sounders, and the presence of squid or bait fish at the surface was noted. Hand jigging was often conducted in conjunction with automatic jigging to help attract squid to the boat and to determine what type of jigging motion might be most effective. Rate of drop and retrieval and pause interval on the jigging machines were adjusted to coincide as closely as possible to that found successful by hand jigging. Quartz-halogen floodlights were turned off periodically to help concentrate squid under the incandescent lamps. If no squid were observed in the first hour or two, the gear was brought in and the vessel would search for a more productive site using the sounders to detect a heavier scattering layer. Shark lines were frequently deployed in an attempt to catch any sharks which might be attracted to the boat before they could foul the jigging gear. Squid jigging operations were secured at dawn.

Captured squid were measured, sexed, and examined for sexual maturity when they were to be sold dressed. When whole squid were to be delivered, only measurements of dorsal mantle length were obtained. Whole and cleaned squid were held on ice for up to 3 days in stackable, self-draining, plastic tubs (102 × 61 × 30 cm) before delivery.

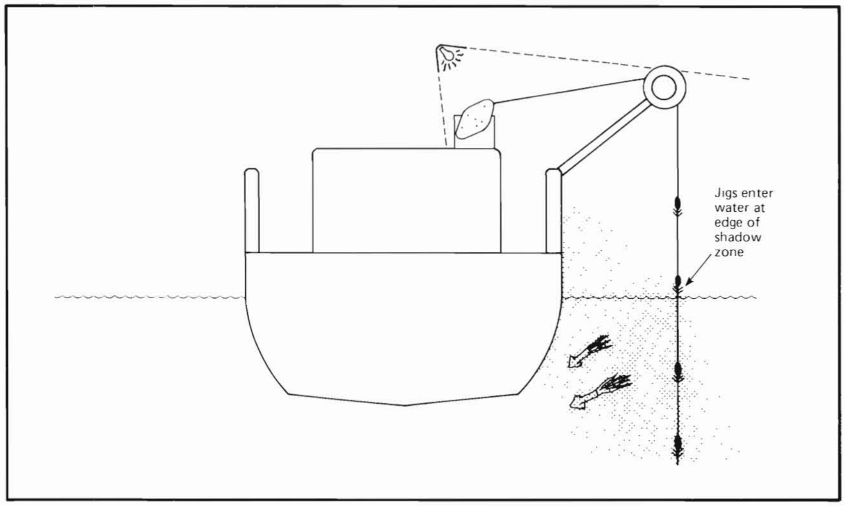

Figure 3.—Lighting arrangement found to be most effective for nail squid during the *Tres Cher* jigging experiments in 1981 off Washington.

Table 1.—Station and catch data including water temperature and lunar phase for experimental fishing stations of the fishing vessel *Tres Cher* in 1981 off Washington.

Station No.	Date	Location Lat. N	Long. W	Time	Temperature (°C) Surface	100 ft	Catch (no.) Total	Taken on jigs	Minimum fishing time (min.)	Lunar phase
1	5-10	48°02.4	125°16.6	2155	10.0	6.7				
	5-11	47°54.7	125°10.8	0400		6.7	0	0	365	1/4
2	5-11	47°26.0	125°09.7	2000	9.4	8.3				
	5-12	47°21.4	125°09.9	0430	8.9	8.3	6	1	510	1/4
3	6-13	46°52 7	124°56.3	2350	13.6					
	6-14	46°47.9	124°53.6	0540	14.5		8	4	350	1/4
4	6-25	47°02.5	124°37.5	0040	15.3		0	0	30	3/4
5	6-29	46°59.0	125°11.1	2100	15.3					
	6-30	46°55 1	125°09.8	0530	15.5		97	2	510	New
6	7-2	47°00.9	125°11.6	1800	14.8					
	7-3	46°52.8	125°10.9	0430	14.8		105[1]	2	630	New
7	7-11	46°36.0	125°00.9	2200	16.1					
	7-12	46°33 1	125°03.9	0500	15.9		111	6	420	1/4
8	7-16	47°00.0	125°00.0	2030	15.8		17	0	180	Full
9	7-17	47°00.5	125°08.7	0023	15.6		4	0	45	Full
10	7-17	46°54.5	124°59.9	0200	15.0		0	0	75	Full
11	7-17	46°53.3	124°47.9	0400	14.2		0	0	40	Full
12	7-28	46°35.2	125°07.5	2245	16.8					
	7-29	46°33.6	125°15.9	0300	12.5		2	0	255	New
13	7-29	46°13.8	126°01.5	2214	16.8		2	0	60	New
14	7-30	46°34 8	124°46.2	2300	16.5					
	7-31	46°31.7	124°43.1	0300	16.4		13	0	240	New
15	8-1	46°20 7	125°12.9	2200	15.8					
	8-2	46°19.8	125°13.5	0430	15.5	10.0	305	105	390	New
16	8-2	46°18.5	125°08.9	2145	15.8	9.4				
	8-2	46°18.5	125°08.9	2230	15.8		41	10	45	New
17	8-3	47°21.2	124°54.5	2130	15.6	7.2				
	8-4	47°16.9	124°55.3	0600	14.8		239	154	510	New
18	8-6	47°18.3	125°00.4	2345	15.0					
	8-7	47°07.6	124°48.9	0530	13.5		0	0	345	1/4
19	8-27	47°22.3	124°56.5	2045	15.7	6.6				
	8-28	47°12.1	124°55.5	0610	14.5		194	194	565	New
20	8-28	47°20 3	124°58.2	1900	15.4	7.7				
	8-29	47°18 4	124°59.5	0200	15.4		106	106	420	New
21	9-13	47°19 4	125°00.0	1925	14.3	8.2				
	9-14	47°15.5	124°57.7	0315	14.3		11	11	470	Full

[1]Two *Ommastrephes bartramii* included

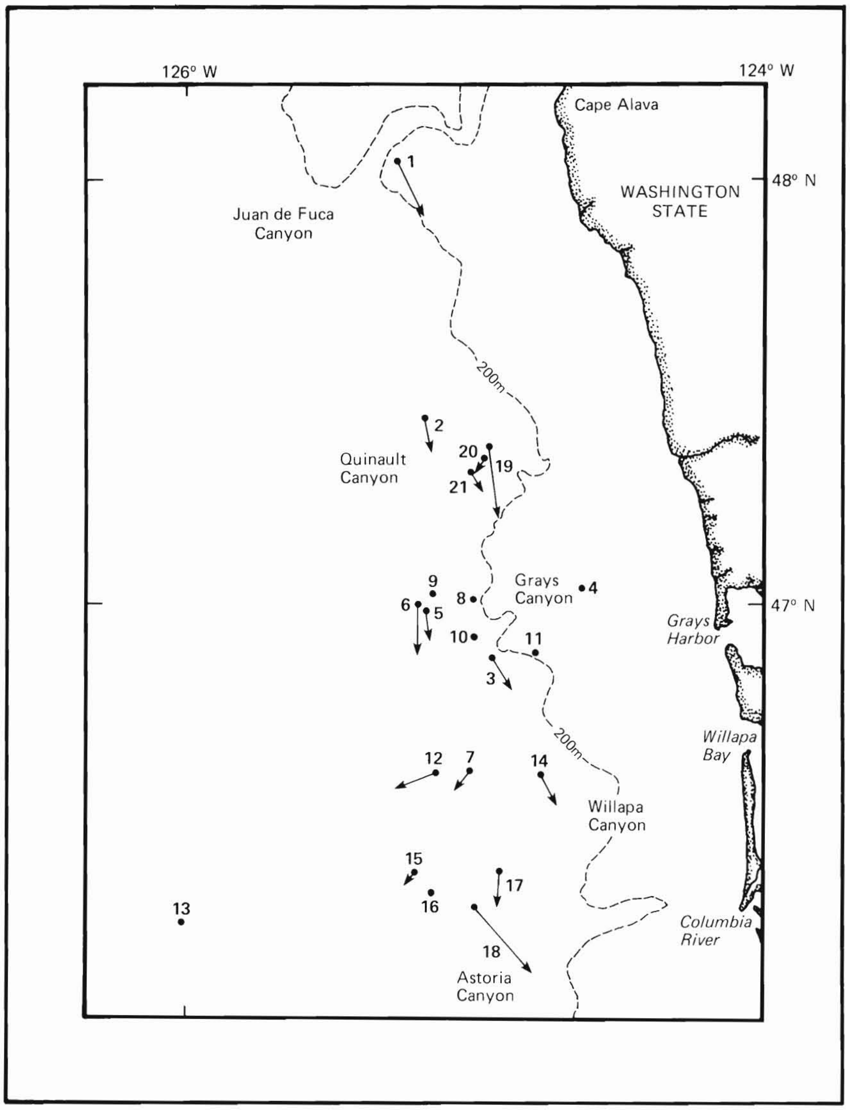

Figure 4.—Location and station number of sampling sites of the *Tres Cher* during 1981 squid jigging experiments off Washington.

Results

Experimental squid jigging was conducted during 21 nights between 10 May and 14 September 1981. Fishing locations (Fig. 4) were primarily at the head of submarine canyons in depths that exceeded 200 fathoms (366 m). A total of 1,261 squid were captured during the experimental fishing period (Table 1). With the exception of two flying squid taken on 2 July, the catch consisted entirely of nail squid. Catch rates were initially poor but improved as jigging expertise was acquired and water temperatures increased. Of the 1,259 nail squid captured, 595 were taken on automatic jigging machines and 664 were dip netted. No squid were captured in the gill net. Maximum catch rates of 30 pounds per machine per night were experienced later in the summer.

In addition to collecting information on the best conditions for jigging squid, biological data, such as dorsal mantle length (DML), gender, and sexual maturity, were obtained from some of the captured specimens.

A total of 687 nail squid and the 2 flying squid were examined. All were measured and 455 nail squid and 1 flying squid were sexed. The flying squid measured 404 mm DML and appeared to be an immature female. Data for the nail squid are presented in Table 2. None of the squid examined were sexually mature, but early signs of maturation (Murata and Ishii, 1977) were evident in male nail squids taken in early August and in one female nail squid taken on 13 September.

Table 2.—Dorsal mantle length (DML) of male and female nail squid, *Onychoteuthis borealijaponicus*, captured during experimental jigging off the Washington coast in 1981.

	Sexes combined				Males			Females		
Date	Station no.	No. examined	Mean DML (mm)	S.D.	No. examined	Mean DML (mm)	S.D.	No. examined	Mean DML (mm)	S.D.
5/10-5/11	1	0								
5/11-5/12	2	2	235	22.6						
		3	92	3.0						
6/13-6/14	3	8	180	33.0						
6/29-6/30	5	97								
7/12-7/13	6	102	139	39.0						
7/11-7/12	7	70	145	28.6	31	139	21.4	39	151	34.4
7/16-7/17[1]	8									
	9	17	134		8	132		9	137	
	10									
	11									
7/30-7/31	14	13	191		6	193		7	188	
8/1-8/12	15	78	131	26.1	46	132	26.2	32	130	26.0
8/3-8/4	17	84	164	23.4	53	162	23.0	31	166	24.2
8/27-8/28	19	193	176	21.6	128	174	20.7	65	182	23.3
9/13-9/14	21	21	176	45.3						

[1]Four different stations fished during one night. Catch from all stations combined.

Several methods of processing squid for market were tested. Some squid were gutted and iced, others were iced in the round (whole). In both cases, a ratio of one part squid to one part ice was used. In-the-round nail squid were held iced in tubs for up to 3 days with no detectable loss of quality.

Discussion

Although large numbers of nail squid were attracted to the lights of the vessel on several occasions, it was difficult to tempt them into attacking the jigs. Several factors including sea state, light intensity and placement, jig shade, jigging motion, sea temperature, and lunar phase were found to affect the catch rate significantly.

One of the most important conditions for catching squid was placement and intensity of artificial lights. High light output all around the boat attracted the most squid, but too much direct light on jig lines reduced the catch significantly. Three 1,000 watt incandescent lights were rigged with directable shades as suggested in Ogura and Nasumi (1976) and focused over the gunwale to strike the water at an approximate 45° angle (Fig. 3). This arrangement of the incandescent lights permitted the jig lines to enter the water at the edge of the shaded zone resulting in an improved catch rate. Further improvements in catch were obtained by turning off the quartz-halogen floodlight that illuminated the port quarter of the vessel where the jigging machines were located and by intermittently turning all quartz-halogen floodlights on and off. By this method, the squid could be attracted to the vessel and then concentrated under the incandescent lamps in the area of the jigging machines. The squid seemed to prefer remaining in the shadow area under the vessel until they sighted a jig or prey in the lighted area, at which time they rushed out to attack.

Because of the importance of light intensity to squid jigging, lunar phase has a pronounced effect upon the success of fishing operations (Arnold, 1979; Bernard, 1981). When the moon was full and the sky clear, very few squid were attracted by our lights and, conversely, the best catch rates were experienced on the darkest nights.

Sea temperature was measured carefully both at the surface and at a depth of approximately 30 m in an effort to locate temperature conditions similar to those where nail squid were found in the northwestern Pacific (Naito et al., 1977b). Squid were encountered and taken by jigs in greatest abundance in areas where the surface temperature exceeded 15°C. The best jigging success occurred on 28 August in an area where the surface temperature was 15.7°C and the temperature measured at 30 m depth was 6.6°C. Although this seems to indicate that nail squid may not be caught on jigs in surface waters below 15°C, these increased catch rates may relate more to improvement in jigging and lighting technique than water temperature. Nail squid are taken by jigs successfully in the western north Pacific in surface water temperatures of 11°-13°C (Murata et al., 1976).

Several colors and sizes of jigs and jigging motions were tested to determine the best combination. Catch rates did not seem dependent on the color of the jigs but, when few squid were around the boat, the lighter shaded jigs such as white, yellow, and clear were taken preferentially. When squid were plentiful around the boat and the catch rate was up, all colors and shades worked equally well. Size of the jigs also seemed to have little effect on the catch rate. Small squid were willing to attack jigs that were almost as large as themselves.

Jigging motion turned out to be very important in catching squid. The best motion varied in different locations and at different times. Hand jigging for squid was the quickest way to determine what the best motion and depth settings might be on any particular occasion. Retrieval rate of the automatic jigging machines could be adjusted by rheostat or reducing the drum diameter; jigging motion was achieved by moving the drum spokes to various positions to change the eccentricity of the drum (Fig. 1). A motion that worked well during August was achieved by adjusting the drums to maximum eccentricity and slowing the average retrieval rate to 51 m per minute with a 1-second pause for about every 4 m of line retrieved. This retrieval rate was considerably slower than the 70-75 m per minute found successful in other jig fisheries (Suzuki, 1963; Igarashi et al., 1968). It was found best to lower the jigs only as deep as necessary to attract the squid because tangles in the lines increased as more line was let out. It was not generally necessary to lower the bottom of the jig string deeper than 40 m. Although many squid followed the jigs up from the depths, almost all squid caught were observed to attack the jig just before it cleared the water during retrieval.

Sea state and wind conditions directly affected jigging success. Ideal conditions were calm seas and little wind. When wind velocity exceeded 10 knots a parachute drogue was deployed from the bow to minimize rolling motion and prevent an excessive drift rate. Rolling motion disturbed the motion of the jig lines causing occasional tangles and significantly reducing the catch rate. Although tangling could be minimized by changing to heavier weights (3-6 kg) on the jig lines, a sustained wind velocity exceeding 25 knots prevented successful jigging operations from the *Tres Cher.*

Another unexpected problem significantly affecting jigging success was interference from blue sharks, *Prionace glauca*, which were also attracted by the lights of the vessel. By striking at or becoming entangled in the jig strings, a shark could break off part or all of a 30-jig string which could prove costly in terms of time and gear lost. Shark lines were deployed fore and aft on the vessel in an attempt to intercept blue sharks before they could damage the jigging gear. Later communication with a Japanese squid jigging expert[2] revealed that sharks are a common problem in squid jigging and that no better method than rigging shark lines has been discovered.

In addition to learning how to locate and catch squids, some biological data were collected: DML, gender, and an

[2]Yutaka Ikeda, squid jigging consultant, Taito Seiko Co. Ltd., Imaasa Building, No. 1-21, 1-chome, Higashi-shimbashi, Minato-ku, Tokyo 105, Japan. Pers. commun., September 1981.

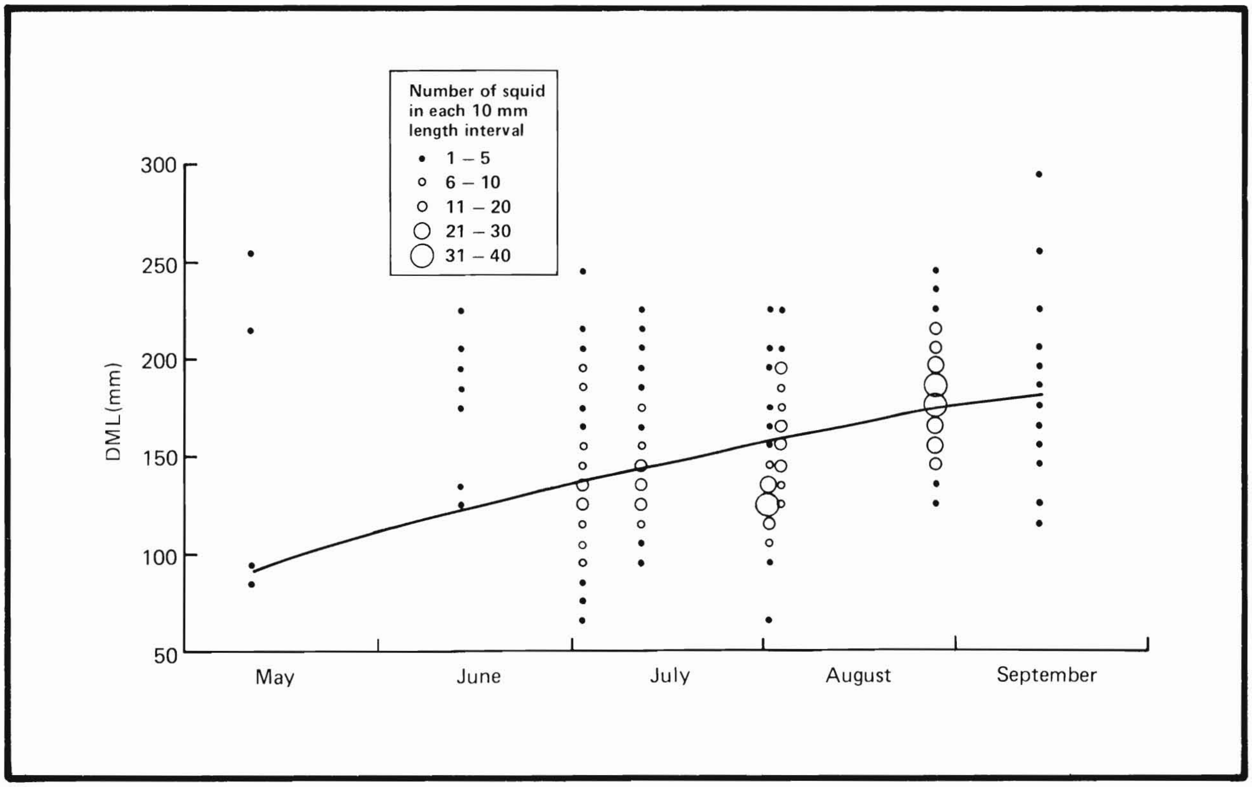

Figure 5.—Dorsal mantle length frequency of nail squid taken in 1981 off Washington during experimental jigging aboard the *Tres Cher.*

indication of sexual maturity. The two flying squid taken on 3 July had DML's of 410 mm and 220 mm. Mean dorsal mantle lengths for nail squid are presented in Figure 5 and in Table 2. There appeared to be an increase for one size group of nail squid in mean DML from 92 mm on 11 May to 176 mm on 28 August (Fig. 5). This reflects a growth rate of approximately 2 cm DML per month which compares well with that reported from the northwestern Pacific (Naito et al., 1977a; Murata and Ishii, 1977).

The wide range of observed nail squid DML (Fig. 5) made modal length analysis for age and growth information very difficult. Widely separated DML's are also reported in nail squid from the western north Pacific and, apparently, reflect different age groups and highly variable growth rates (Naito et al., 1977a; Murata and Ishii, 1977). Actual values of mean DML were 80-100 mm smaller than those reported from the western and central north Pacific during the same season (Naito et al., 1977a; Murata et al., 1976).

Although more length and maturity information, especially at different seasons of the year, is required to fully define age groups, growth, and spawning seasons, it was possible to draw some preliminary conclusions from our data. A hypothetical growth curve for the sampling period was drawn using modal DML for both sexes from stations where nail squid were measured. Squid from two jigging stations were excluded from the growth curve computation. The larger squid (235 mm average DML) that were caught on 11 May were representative of many more large squid which were observed around the boat but not captured; such numbers of large squid were not observed again until 13 September. Consequently, we feel that they probably represented a different age group which either spawned and died or departed the area before the 13 June trip. The eight nail squid that were measured from the 13 June trip were excluded because of the small sample size and poor curve fit. The shape of the growth curve suggests that nail squid caught during these experiments were probably hatched during mid- to late winter 1981.

Some of the squid taken during these experiments were examined for sexual maturity. Male nail squid (272) were examined for sperm packets while aboard the vessel and 9 additional nail squids (4 male, 5 female) were saved for laboratory examination by Clifford Fiscus (scientific consultant, Brier, WA 98036, August 1981). Sperm packets were observed developing in males during late July, and one female (294 mm DML) which was taken on 13 September had nidamental glands which measured 103 mm in length and were orange in color. This coloration is reported to signify the onset of maturation (Murata et al., 1976). Divergence in size of males and females reported to occur during sexual maturation of nail squids (Naito et al., 1977a; Murata and Ishii, 1977) was not observed in these squid.

Although some signs of maturation were detectable in the nail squid taken during late August and early September, other signs such as size difference in males and females and the attainment of spawning size (300-370 mm DML), as reported by Naito et al. (1977a) and Murata and Ishii (1977) were not. For these reasons, we believe that the growth and maturation of our squid were probably 1-2 months behind the squid described by Murata and Ishii (1977); and, according to the hypothetical growth curve (Fig. 5), the nail squid taken off Washington probably would only reach a maximum size of 250-280 mm DML at spawning. Spawning for these squid would probably occur from early to mid-winter and subsequent hatching from mid- to late winter. Also, there may have been several age groups present off Washington during our investigations: One age group of nail squid represented by the large size group (235 mm mean DML) taken in early May, a second group represented by most of our catch from May to September, and a third group represented by many small (approximately 50 mm DML) squid observed on 13 September.

The effect of ocean currents and related migratory behavior of nail squid off the Washington coast should be studied. It is possible that nail squid migrate in a northerly direction past Washington to spawn in the north Pacific; this migration, if it occurs, would be similar to those reported for squid of the western north Pacific (Naito et al., 1977b).

Acknowledgments

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