Experimental Jigging for Squid off the Northeast United States

DOUGLAS LONG and W. F. RATHJEN

Introduction

Light attraction jigging is a fishing technique specifically developed for catching squid. Jigging for squid is one of the most important methods used in coastal squid fisheries in Japan. In Japan about 95 percent of the common squid, *Todarodes pacificus*, which represents a major part of the squid catch, is caught by jigging (Yajima and Mitsugi, 1976).

In North America there has been a traditional fishery for squid in Newfoundland where recent catches have approached 50,000 t annually[1]. Experimental squid fishing using jigging and light attraction has also been conducted in nearshore New England situations through the New England Fisheries Development Program (Amaral and Carr, 1980) and in the Gulf of Mexico (Rathjen et al., 1979). During 1978 and 1979 the Canadian Government sponsored commercial level demonstration fishing for squids using jigs in the waters east of Nova Scotia. Early reports of this experience suggested substantial catches could be made on a regular basis[2].

In 1973 the Japan Marine Fishery Resource Research Center sent the RV *Hoyo-Maru No. 51* followed by the RV *Hoyo-Maru No. 63* in 1974 and 1975 to conduct exploratory squid jigging from Cape Hatteras to the Grand Banks. Fishing south of Georges Bank along the edge of the continental shelf yielded 103,475 kg (227,645 pounds) of *Illex illecebrosus* in 112 days of fishing (Ichikawa and Sato, 1976). These catches were taken in July and September of 1973 and 1974, respectively.

The Polish Deep Sea Fisheries Company Odra equipped three of their vessels with Japanese squid jigging gear to conduct exploratory fishing. Their investigations began in May near the Falkland Islands in the South Atlantic. Successful catches of *Illex argentinus*, with daily catches in excess of 8,000 kg (17,600 pounds) were made. Each vessel spent about 45 days working there, after which two of the vessels proceeded to the Fishery Conservation Zone (FCZ) off the U.S. northeast coast to investigate areas along the continental slope from east of Cape Henlopen to southeast of Cape Cod. The following is a presentation of observations of their squid jigging operations made while on board these Polish vessels during August and September 1979.

Fishing Vessels and Gear

The *Wigry SWI-173* (Fig. 1), built in 1962, is a 61-m (200-foot) side trawler of 797 gross tons powered by a 1,375 horsepower engine. The *Murena SWI-193* is a 69-m (226-foot) B-23 class

Douglas Long is at 4259 West Avenue, Ocean City, NJ 08226. W. F. Rathjen is with the Fisheries Development Division, National Marine Fisheries Service, NOAA, P.O. Box 1109, Gloucester, MA 01930.

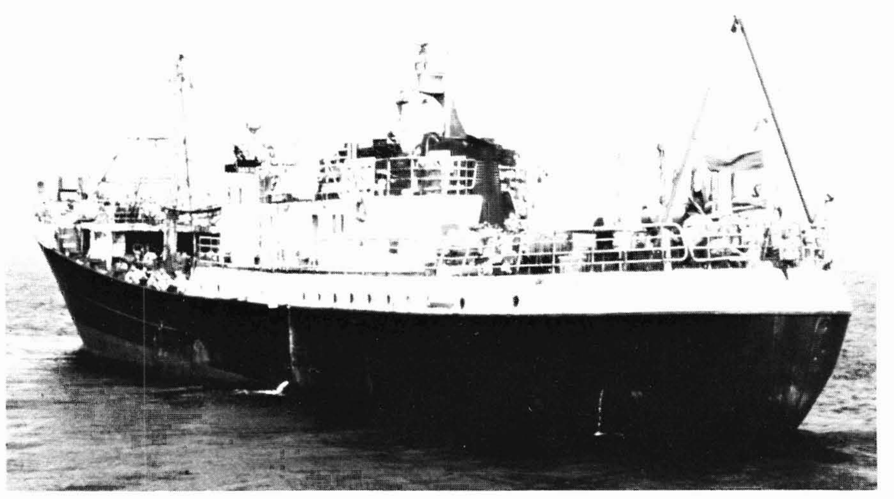

Figure 1.—Polish research vessel *Wigry*, 61 m long. Jigging gear is on the well deck.

[1]G. V. Hurley, Department of Fisheries and Oceans, St. John's, Nfld., Canada. Personal commun., Nov. 1979. See also Hurley (1980).
[2]David Lemon, Fisheries Development Branch, Department of Fisheries and Oceans, P.O. Box 550, Halifax, Nova Scotia, Canada. Personal commun.

stern trawler of 1,005 gross tons powered by a 1,620 horsepower engine.

Each vessel is equipped with 10 automatic jigging machines (model MD-3SE[3]) manufactured by the Towa Denki Seisakusho Co., Ltd. (Fig. 2). The machines were mounted on the bow of the *Murena* and on the well deck of the *Wigry*. A windlass drum is mounted on each end of a levelwind shaft which passes through the motor assembly. Each drum can fish one line to a depth of 180 m (590 feet). A depth control knob enables each machine to be adjusted to fish at the depth of the squid. The set and hauling speed can be varied from 20 to 80 rpm according to weather and fishing conditions. Experience proved that 60 rpm (59.8 m or 197 feet per minute) was the best running speed. In case of a sudden entanglement of jigs or lines the machine stops automatically. The "jigging" motion is produced by the six-sided oval shaped drums. Each unit is equipped with a push button control box on a cord which allows one man to control several units.

The jigs consist of a plastic body with two sets of barbless hooks (Fig. 3). The body varies in length from 48 to 72 mm (from 1.9 to 2.9 inches) and is either soft or hard plastic of various colors, including clear. They are both luminescent and nonluminescent. Jigs are classified according to the length of the barbs. The "shelf jig" used to catch *Illex illecebrosus* has two rings of 16 hooks each 11 mm (0.4 inch) in length. Figure 4 shows a comparison of a 22-cm (8.6-inch) mantle length *Illex* to two shelf jigs. "Ocean jigs," used for larger species of squid such as *Illex argentinus*, have two rings of 14 hooks 16 mm (0.6 inch) in length.

The jigs are attached in a series spaced 80-100 cm (31-39 inches) apart with 20-50 jigs per line. The line is made of clear monofilament which varies in diameter according to depth. The jigs at the bottom end of the line are tied with about 0.9 mm (0.035 inch) diameter line while those near the surface

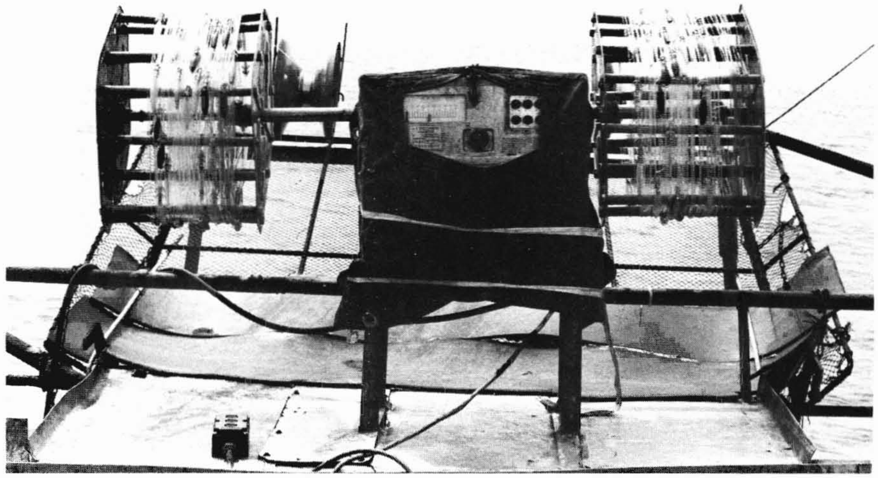

Figure 2.—Automatic jigging machine mounted on the bow of the vessel. Electric motor unit is protected by a canvas cover. Note the three-button control box.

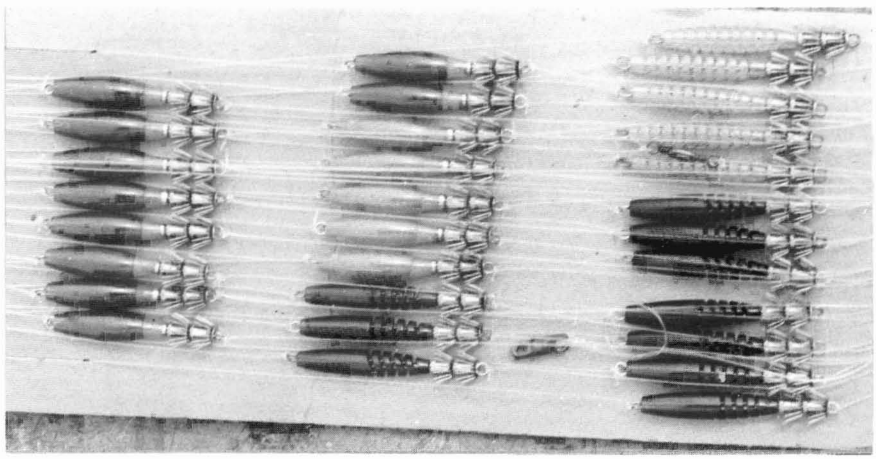

Figure 3.—One set of pre-tied shelf jigs with swivel ready to attach to the main line.

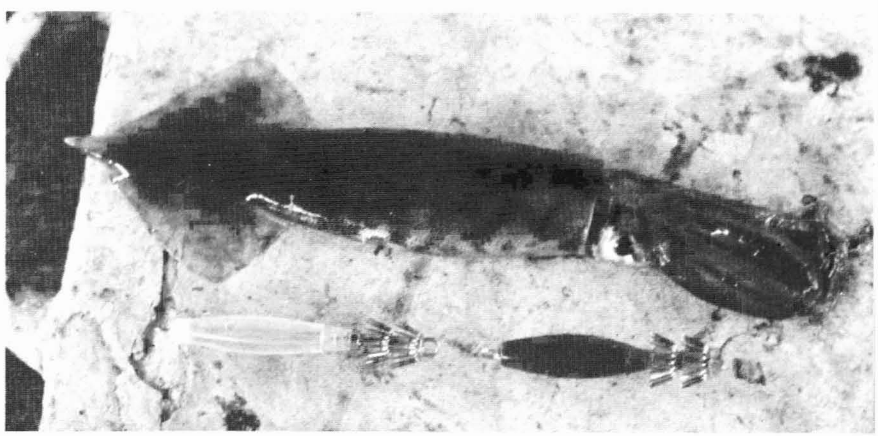

Figure 4.—A 22-cm (mantle length) *Illex* and two shelf jigs.

[3]Mention of trade names, products, or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA

have 1.15 mm (0.045 inch) diameter line since the latter receive more strain. This series of jigs is attached by means of a swivel to a 100-m (328-foot) main line 2 mm (0.08 inch) in diameter. After a few nights fishing, this line scheme was modified by retying all the jigs using 1.9 mm (0.075 inch) diameter line in an effort to reduce breaking lines. A 1-kg (2.2-pound) lead sinker is tied at the bottom of each line to keep the gear vertical as it enters the water. When strong currents are encountered, another 0.5-kg (1.1-pound) of lead is added to each line. The jig line runs from the drum to a plastic roller mounted on the outboard end of a metal frame that is covered with netting (Fig. 5).

The vessel *Murena* had two rows of incandescent lamps suspended from steel cables at intervals of 34 cm (13.3 inches) over the area of the jigging machines. There are 48 lamps in all, 24 along each side. Of these, 14 are 4,000 watts each and the remainder, 2,000 watts each. The lights are 270 cm (8.9 feet) above the deck and 82 cm (2.7 feet) inboard from each side of the vessel. The distance from the deck to the water line is about 5 m (16.4 feet). This produces a shade zone of 1.6 m (5.2 feet) along side of the vessel. The outboard plastic rollers of the jigging machines are positioned so the jig lines pass through the boundary zone of light and shade of the vessel. The *Wigry* has a similar lighting scheme except that the 48 lamps were all 2,000 watts.

Figure 5.—Overhead view showing 2,000-watt and 4,000-watt lamps suspended over the jigging machines.

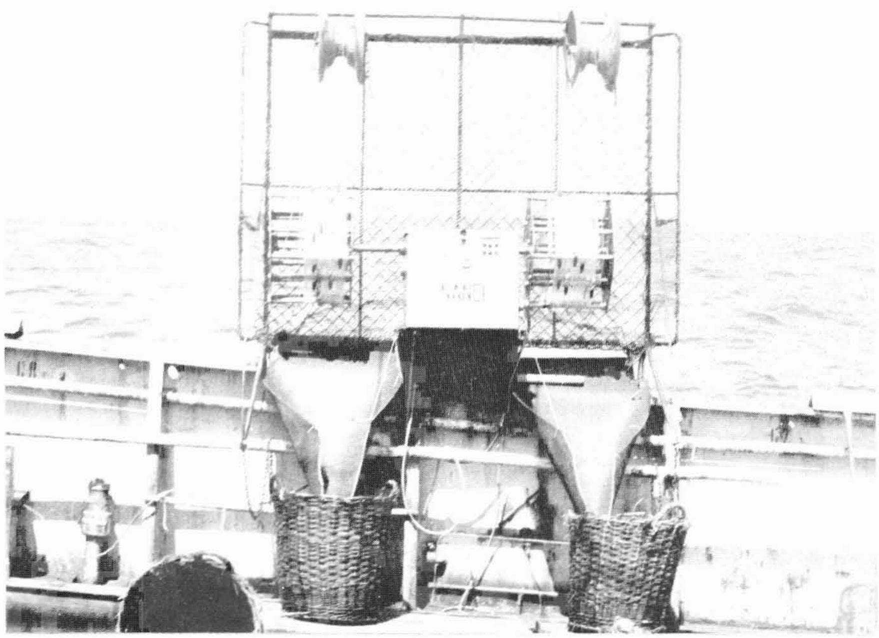

Figure 6.—Jig machine with metal mesh-covered frame turned up during the day. Note the rubber ramps that guide falling squid into wicker baskets.

Fishing Operations

When on the fishing ground the vessels begin to move into position around 1600 hours. Taking into consideration water currents and weather conditions, the vessel is positioned near the area where previous catches were made. Once in position a sea anchor (nylon parachute, 23 m (75.4 feet) in diameter) is deployed from the bow, thus allowing the vessel to drift slowly with the current. A mizzen sail is hoisted in the stern to keep the vessel heading into the wind.

The lamps are turned on between 1900 and 1930 hours (depending on the season) and automatic jiggers start between 1930 and 2030 hours. The lamps and echo sounder run continuously throughout the night. When an indication of squid is detected a few machines

Figure 7.—Crewman scraping squid from the jig machines into the waterflow trough.

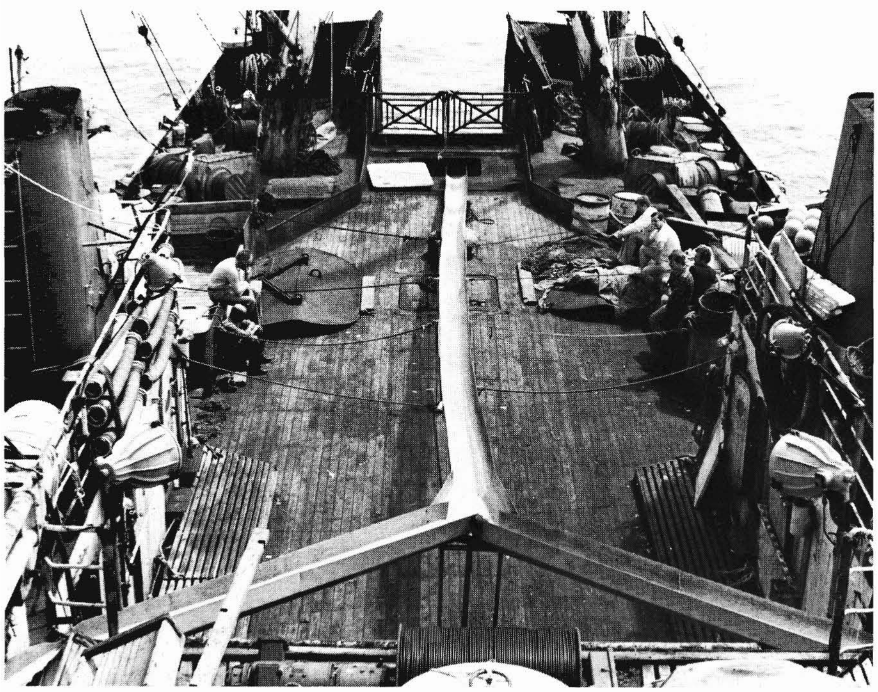

Figure 8.—Waterflow trough, leading from under the jig machines, carries squid down to the trawl deck hatch which leads to a factory holding bin.

are set so the jigs will fish at the depth indicated. The expectation is that the deeper running jig lines will lure the squid close to the surface. Once the squid are near the surface or "floating" all the machines are adjusted so that the last jig coming off the drum enters about 1 m (3.3 feet) below the water surface before the line is retrieved.

Hooked squid coming up on the jigs flip off between the outboard roller and the line drum falling onto a frame lined with netting. The *Wigry*'s crew scrapes the squid off the frame into wicker baskets that are periodically collected and dumped down a chute leading to the factory (Fig. 6). The *Murena* has a waterflow trough under the machines that carries the catch down to the trawl deck where it funnels through a hatch and into a holding bin in the factory (Fig. 7, 8).

Processing Operations

Once in the factory, the squid were washed with seawater and packed into 10-kg (22-pound) capacity metal trays. When the squid are uniform in size no grading is necessary. The trays of squid are frozen in a Freon contact plate freezer unit. The frozen block of squid has a core temperature of −24°C (−10°F). Each block of frozen squid is glazed by dipping in a hot freshwater bath. The blocks are packed into cardboard boxes (three blocks to a box) and stored in a freezer hold. When the plate freezers are full, the squid left on the packing table are covered with about a 3-cm (1.2-inch) layer of salt flake ice.

Fishing Areas

The vessels worked in an area from east of Cape Henlopen to southeast of Cape Cod. The area of investigation (Fig. 9) is divided into five parts: Lydonia Canyon to Hydrographer Canyon (A), Veach Canyon (B), Atlantis Canyon (C), Block Canyon (D), and Spencer Canyon (E) (Fig. 9). Water depth ranged from 150 m (492 feet) to over 1,000 m (3,280 feet). The majority of the fishing effort was concentrated in areas A and B which was based on the captain's success in finding squid near these canyons in previous years.

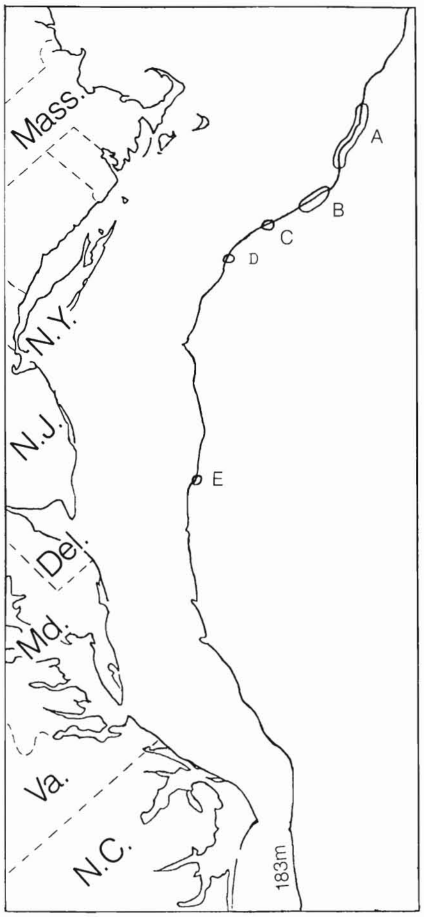

Figure 9.—Areas of investigation.

Table 1.—Squid catches of the *Wigry*.

Date	Area	Start and stop times	Number of jigs fishing	Water depth (m)	*Illex* catch (kg)	*Ommastrephid* catch (kg)	Total catch/ jig/hour (kg)
8/2-3	B	2030 h	700	284	1,620.0	0.6	0.257
		0530		207			
8/3-4	B	2035	700	246	2,465.0	0.0	0.391
		0535		151			
8/6-7	B	2030	700	246	3,185.0	—	0.515
		0520		685			
8/7-8	B	2035	700	173	2,980.0	—	0.477
		0530		264			
8/8-9	B	2050	700	261	1,355.0	—	0.219
		0540		430			
8/9-10	B	2010	700	175	550.0	0.0	0.084
		0530		157			
8/10	B	1930	700	202	1.5	0.0	0.001
		2130		176			
8/11-12	B	1915	700	233	1,615.0	0.0	0.235
		0505		235			
8/16-17	E	2015	700	264	1,460.0	0.0	0.223
		0535		214			
8/17-18	D	2000	700	196	2,370.0	1.0	0.366
		0515		348			
8/18-19	A	2025	700	474	6,205.0	0.0	0.976
		0530		245			
8/19-20	A	2035	700	303	3,995.0	—	0.652
		0520		398			
8/20-21	A	1930	700	270	1,280.0	—	0.183
		0530		296			
8/21-22	A	1930	700	500	930.0	—	0.133
		0530		347			
8/22-23	A	2000	700	341	2,000.0	—	0.298
		0535		890			
				Total	32,011.5	1.6	0.347

Table 2.—Squid catches of the *Murena*.

Date	Area	Start and stop times	Number of jigs fishing	Water depth (m)	*Illex* catch (kg)	*Ommastrephid* catch (kg)	Total catch/ jig/hour (kg)
8/4-5	C	2100 h	605	220	2	0.0	0.000
		0530		185			
8/14	A	0105	605	192	15	0.0	0.005
		0545		150			
8/14-15	A	1830	605	200	1,230	0.0	0.177
		0600		150			
8/15-16	A	1930	605	160	2,280	0.0	0.377
		0530		920			
8/16-17	A	1935	730	240	6,480	2.3	0.895
		0530		1,000			
8/17-18	A	1945	796	480	2,610	0.6	0.336
		0530		210			
8/18-19	A	1945	796	320	6,060	0.8	0.781
		0530		200			
8/19-20	A	2030	796	360	750	1.5	0.105
		0530		445			
8/20-21	A	2000	796	420	2,100	1.4	0.278
		0530		510			
8/21-22	A	1955	796	340	6,750	0.0	0.870
		0540		580			
8/22-23	A	1930	796	290	3,060	1.2	0.385
		0530		420			
				Total	31,337	7.8	0.423

Catch and Effort

Tables 1 and 2 present the catch and effort data for each vessel. The largest catches of squid were taken in area A. The best catch of 6,750 kg (14,884 pounds) was caught on the west side of Oceanographer Canyon in 340-580 m (1,115-1,902 feet) of water. The average catch of squid per night for the *Murena* was 2,848.8 kg (6,282 pounds) and 2,134.1 kg (4,706 pounds) for the *Wigry*.

The *Wigry* had a substantial increase in its catch rate during the last 13 days in the FCZ. After 25 August the vessel spent 8 days on the east side of Oceanographer Canyon (area A) and had an average catch of 5,000 kg (11,025 pounds) per night. Following this, 3 days were spent at Veatch Canyon (area B) where the catch averaged 5,400 kg (11,907 pounds) per night[4]. A major factor contributing to the increase in catch may have resulted from a change in the vessel's lighting. (See the later section on vessel lighting.)

Japanese research vessels working in an area from Block Canyon to Lydonia Canyon in 1973 and 1974 had a daily

[4]Bell, G. M. Deployment on Polish squid jigging vessel *Wigry* 24 August 1979 to 8 September 1979. Unpubl. cruise rep. on file with NMFS Foreign Fisheries Inspector Program, Otis, MA 02542.

Table 3.—Relationship between environmental factors and the catch of *Illex illecebrosus*.

Date	Water temp. at 0 and 100 m (°C)	Lunar period[1]	Cloud cover[2]	Wind direction	Beaufort scale	Catch/jig/hour (kg)
8/2-3	26.0-13.2	10	8	SW	4	0.257
8/3-4	25.5-13.1	11	6	SW	4	0.391
8/4-5	26.0-13.2	12	0	SW	1	0.000
8/14	17.2-10.5	21.5	0	SW	3	0.005
8/14-15	17.6-11.0	Last quarter	8	SW	4	0.177
8/15-16	—	23	3	W NW	3	0.377
8/16-17	20.0-13.0	24	0	NW	2	0.895
8/17-18	20.5-13.0	25	1	W	1	0.336
8/18-19	20.3-13.1	26	8	SW	3	0.781
8/19-20	19.5-13.0	27	8	SE	3	0.105
8/20-21	19.4-12.9	28	8	NE	1	0.278
8/21-22	18.4-13.3	29	6	NE	1	0.870
8/22-23	21.0-13.4	New moon	8	NW	1	0.384

[1]Based on a 30-day lunar month.
[2]0 = clear skies . . 8 = total cloud cover

Table 4.—Lengths[1] and weights of randomly sampled *Illex illecebrosus*.

Date	Latitude N and Longitude W	Range of male length (cm) and weight (g)	Mean	Range of female length (cm) and weight (g)	Mean	No. of individuals sampled: Male	Female
8/3	39°55′ 69°32′	19.5-24.5 80-230	22.2 164	20.5-29.0 100-480	23.5 195	31	12
8/17	40°19′ 68°03′	20.5-23.5 110-250	21.9 196	21.0-24.0 110-400	22.7 212	30	20
8/22	40°11′ 68°29′	20.0-24.5 150-320	22.2 208	21.0-27.0 160-350	23.4 223	65	35
8/23	40°11′ 68°28′	20.5-25.5 190-340	22.4 225	22.0-26.0 190-350	23.8 242	29	31
					Total	155	98

[1]Mantle length to nearest 0.5 cm.

catch rate of 923.9 kg (2,037 pounds) using 26 jig machines on one vessel and 29 on the other (Ichikawa and Sato, 1976). In the present investigation, an average daily catch rate of 2,437 kg (5,374 pounds) was attained using only 10 jig machines per vessel. By contrast during the foreign trawl fishery for *Illex* the catch per vessel day was 9,664 kg (21,309 pounds) in August 1977 (Kolator and Long, 1979). It may be possible to substantially increase the daily catch rate for a trawler vessel with the addition of jigging machines for use at night when trawling is not at its peak.

Small quantities of *Ommastrephes* spp. were caught along with the *Illex*. The *Ommastrephes* were usually caught when the vessel was drifting in depths over 400 m (1,312 feet). One night the *Murena* moved offshore to a depth of 4,753 m (15,590 feet) where 19 kg (42 pounds) of *Ommastrephes* were caught.

On most nights catches of squid would be rather low and sporadic until about midnight at which time they would increase. About midnight, large concentrations of squid often started to form near the surface. The catch rate would peak between 0400 and 0515 hours when extremely large masses of squid were "floating" on the surface sometimes encompassing the entire lighted area around the vessel. On one particular night about 1,200 kg (2,646 pounds) of squid was caught from 2000 to 0330 hours while in the remaining time period (from 0330 to 0530 hours) over 5,500 kg (12,128 pounds) of squid was caught. This phenomena of the jig fishery is referred to as "Asa-mazume" or morning harvest (Flores, 1972).

Environmental Factors

The relationship between certain environmental factors and the catches of *Illex* is presented in Table 3. It has long been recognized that there is a correlation in the jig fishery between squid catches and lunar age. According to Ichikawa and Sato (1976), catches of *I. illecebrosus* during the 15 days around the new moon were 10 times greater than catches taken during the full moon. During the present investigation three poor catches (15 kg (33 pounds) or less) were taken during the full moon period. On lunar day 11 (5 days before the full moon) under heavy cloud cover, a relatively good catch of 2,465 kg (5,435 pounds) was made. It is possible that the negative effect of a full moon is masked by heavy cloud cover which produces a darker night.

The water temperature was taken from each vessel with a bathythermograph. In general the catches were larger in areas where the surface water was 18.4°-26.0°C (65°-79°F).

Strong currents, winds, and seas adversely affected the jigging operation. Frequent tangles would occur sometimes causing the jig lines to break. Tangled and broken jig lines could keep one or more jig machines out of operation for up to 0.5 hour. In an effort to reduce the frequency of tangled lines during foul weather only every other jig machine was operated.

Biological Data

Random samples of *Illex* were taken at various locations. The range and means of lengths and weights is presented in Table 4. In the four samples taken, females consistently showed a higher mean length and weight than males. Males represented 61.3 percent of the 253 squid sampled. Of the females sampled, 89 percent were reproductively immature while 34 percent of the males were maturing and another 23 percent were mature (large testes and the spermatophore sac contained spermatophores).

When the squid were present on the surface they could be seen feeding heavily on euphausids and small fish. Good fishing may be related to the abundance of plankton and small fish attracted by the lamps. The presence of blue sharks, *Prionace glauca*, did not seem to affect the schooling squid. The only problem they presented was occasionally grabbing a hooked squid causing the jig line to break.

Vessel Lighting

The *Wigry*'s increased catch rate during its last 13 days of fishing could be directly related to the change in the lighting system. A wider shade zone was created along the sides of the vessel by moving the two lines of lamps farther inboard. This adjustment may have provided a wider area with the proper illumination for the squid to see the jigs and react to their motion. Apparently the bright light serves to attract the squid, while the zone of shaded light seems to encourage them to react to the motion of the jigs.

At present, incandescent lamps such as those used on the Polish vessels are the most commonly used in the jig fishery. However, comparative tests with incandescent lamps and mercury vapor lamps indicate mercury lamps are about 2.5 times more efficient in attracting squid (Ogura and Nasumi, 1976). Mercury lamps are also more efficient in converting electric energy into light, are brighter and have a longer life, but the price is higher than for incandescent lamps.

Summary

Illex illecebrosus is very aggressive and exhibits an attractive taxis toward light which lends very well to night light jigging. Squid jigging is a fishing technique that is relatively simple in operation when compared with a trawl fishery. Since the jigging machine is fully automatic only a few men are required to run a dozen machines. Considering the rising cost of fuel, a jigging operation has favorable aspects. Indeed, the Polish vessels consumed only about half the fuel that would normally be consumed by a comparable vessel in a trawl fishery.

Good catches of squid were made from Cape Henlopen to Cape Cod along the continental slope. It would seem feasible that the catch rates of the Polish vessel could be substantially increased by the addition of more jig machines and a better lighting system, however.

Squid coming off the jigs are alive and in very good condition since the jig barbs put only a tiny hole in the tentacle. This leads to a high quality frozen product.

Light attraction jigging offers one more practical method to harvest squid. To outfit an existing vessel with squid jigging gear would be neither complicated nor costly as there are no specific vessel requirements that would necessitate any structural changes.

Acknowledgments

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