Recent Developments in the Squid, *Illex illecebrosus*, Fishery of Newfoundland, Canada

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Introduction

Since 1975 the nominal catches of the short-finned squid, *Illex illecebrosus* (LeSueur), in the northwest Atlantic have risen dramatically to a high of almost 100,000 t in 1978[1]. This increase was due in part to the worldwide development of fisheries for underutilized marine species such as squid. In 1976 the catch of *Illex* in the northwest Atlantic (65,000 t) represented 8 percent of the total world catch (800,000 t). Because of extended offshore fisheries jurisdiction, Canada recorded sales of offshore-caught squid worth $20-25 million in 1978. Newfoundland inshore fishermen have also reaped the benefits of strong foreign demand for squid as they earned $8-9 million in 1978.

The Newfoundland squid fishery has undergone many changes over the past century. Recent developments in this fishery regarding the management, harvesting, processing, and marketing of squid caught in Newfoundland inshore and offshore waters are discussed below.

The Resource

Life History

The short-finned squid is a summer migrant to inshore Newfoundland waters. They are thought to spawn offshore in the warm waters of the Gulf Stream since juvenile squid have been caught there in plankton tows in late April-early May[2]. Historically squid have been observed on the outer edge of the Grand Banks during May and June (Personal obs.; Mercer, 1973a; Mercer and Paulmier, 1974; Squires, 1957). Sometimes they have appeared inshore as early as May but more commonly in late June or early July. They migrated offshore again in October-November. While inshore they were found in water of between 5° and 20°C (Frost and Thompson, 1933; Personal obs.). Occasionally mass strandings have occurred on Newfoundland beaches. The strandings were thought to have been caused by entrapment of the squid in unfavorable environmental conditions or by predators (Lux et al., 1978; Templeman, 1966).

Squid occupy a rather unique position in the marine food web. They are prey for such species as the pilot whale, *Globicephala melaena* (Squires, 1957), bluefin tuna, *Thunnus thynnus* (Butler, 1971), and spiny dogfish, *Squalus acanthias* (Templeman, 1944), while they are predators on euphausids (Mercer and Paulmier, 1974) and such fish species as capelin, redfish, cod, haddock, mailed sculpin, and flounders (Squires, 1957).

A complete review of the food and feeding of *Illex* in Newfoundland waters is given by Ennis and Collins (1979). They pointed out that observations on feeding were difficult due to maceration of food by squid before it entered the stomach. The squid grew rapidly during the inshore season in spite of the fact that a great percentage of the stomachs were found to be empty (Personal obs.; Mercer, 1965; Squires, 1957). By late season (October-November) the average mantle length approached 25.0 cm (9.75 inches) and the body weight approached 300 g (10.5 ounces), although there have been reports of individual squid caught in September of up to 1,100 g (38.5 ounces) (Doug Bradbury, H. B. Nickerson Co., St. John's Nfld., personal commun.). By late fall, females were found to have grown to a larger size than males (Squires, 1957).

Landings, Distribution, and Economic Value

The inshore landings of *Illex* in Newfoundland have varied greatly from year to year (Mercer, 1973b; Squires, 1957). Templeman (1966, fig. 62) presented a breakdown of squid landings for inshore Newfoundland into various processing categories up to 1964. Figure 1 brings this summary up to date (1965-78). Coincidentally the latter period corresponds to the widespread use of the more efficient Japanese mechanical drum jigger in the inshore fishery. Figure 1 shows that in some years the inshore catch was almost negligible (1968-70; 1972-74) while in other years, particularly since 1975, landings have increased substantially (to over 40,000 t in 1978).

Historically most squid have been caught along the northeast coast in Bonavista, Trinity, and Conception Bays and along the south coast in Placentia, Fortune, and Hermitage Bays (Templeman, 1966). Since 1965 the distribution of squid landings has

[1]Data from the joint Canada-USSR research cruise aboard the Soviet RV *Belogorsk*, 13 Feb.-4 June 1979. On file at Dep. of Fisheries and Oceans, Government of Canada, Halifax, N.S., and St. John's, Nfld.

[2]Unpublished data on file at Dep. of Fisheries and Oceans, Government of Canada, St. John's, Nfld.

ABSTRACT–Developments in the squid fishery in Newfoundland over the past few years have included noteworthy changes in the management, harvesting, processing, and marketing of squid. The implications of international involvement in the squid fishery and Canada's increased offshore fisheries jurisdiction are discussed.

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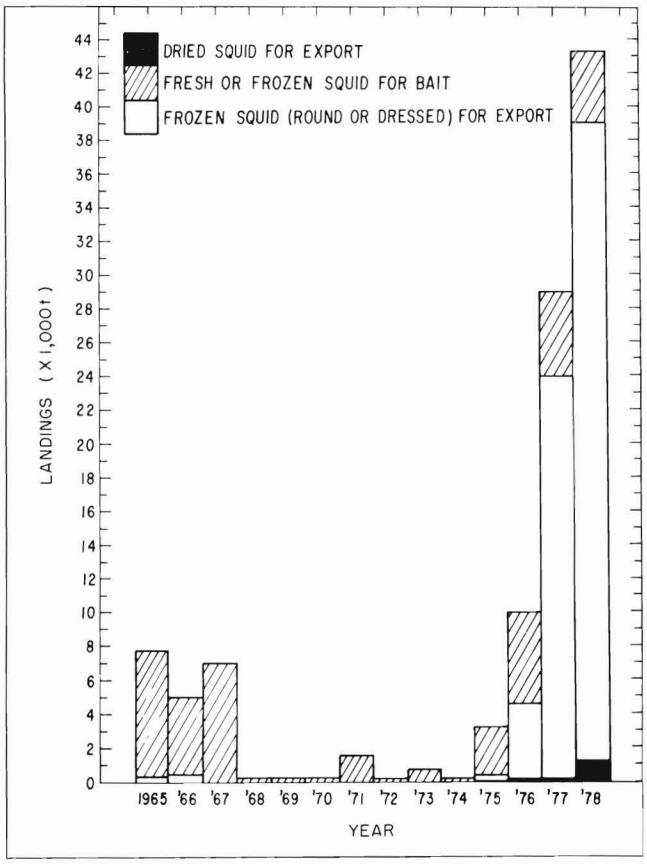

Figure 1.—Newfoundland *Illex* landings, 1965-78, by processing category.

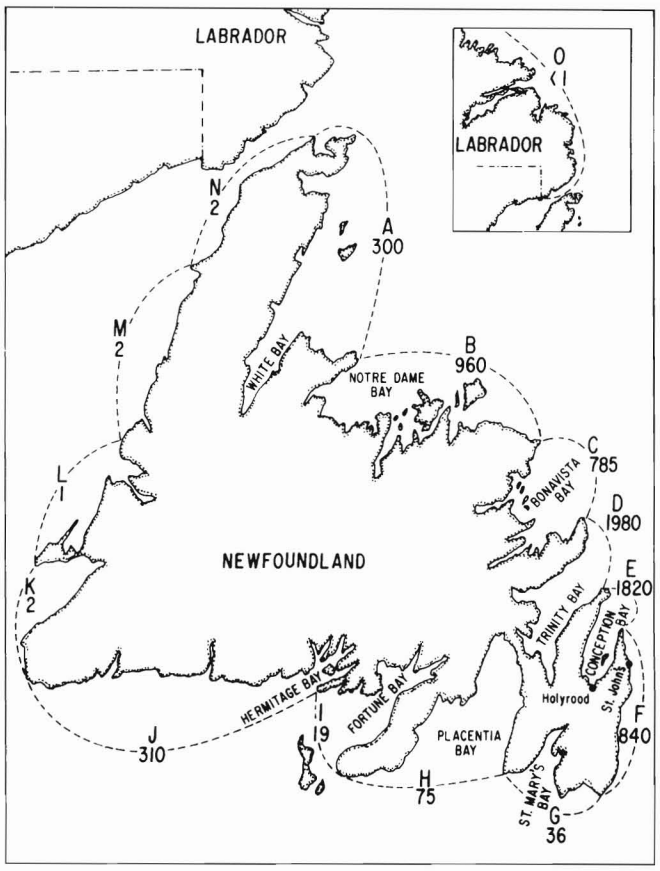

Figure 2.—Average *Illex* landings, 1965-78, by sea fisheries areas (in metric tons).

been much the same as in earlier years (Fig. 2) with the highest landings recorded on the eastern and southern coasts of the island from Notre Dame Bay to Hermitage Bay. The use of the landings to reflect the true distribution and abundance must be viewed with some caution.

Fishermen in some localities have only recently become interested in fishing squid for economic reasons. During the 1970's the landed value of squid in Newfoundland increased from $4,100 in 1976 to nearly $9 million in 1978 (close to 8 percent of total landed value of all marine species in Newfoundland). The unit price per pound of squid received by the fishermen rose from $0.03 in 1973 to $0.09 (from $0.07 to $0.20/kg) in 1978.

In years when landings were exceptionally high or low, the landings probably reflected abundance levels. In certain years, the Newfoundland *Illex* resource has been estimated to be on the order of several hundred thousand tons (Mercer, 1975). Squires (1957) could not detect any cycles of abundance; however, Templeman and Fleming (1953) suggested that hydrographic conditions may have been important in explaining the annual fluctuations in abundance. Since the life cycle of *Illex* is relatively short, 12-18 months (Mesnil, 1977; Squires, 1967), it is difficult to make year to year predictions of abundance. However, forecasts of inshore Newfoundland abundance of squid during July-November have been made from same-year offshore trawling surveys done in May-June (Hodder, 1964; Squires, 1957, 1959). The forecast index (Table 1) for the most part has been based on incidental catches of squid during annual haddock surveys along the southwest slopes of the Grand Bank and St. Pierre Bank. A short-term recruit survey has been used also in the Japan Sea to forecast abundance of the Japanese squid, *Todarodes pacificus* (Kasahara, 1975.) This preseason forecast has enabled the Newfoundland fishing industry to better prepare for the upcoming fishing season inshore.

Management Initiatives

The *Illex* stock(s) off the Canadian and American Atlantic coasts was originally managed as a unit by the International Commission for the Northwest Atlantic Fisheries (ICNAF). From 1975 to 1977 an open-ended TAC of 25,000 t was in effect for the area off the Canadian coast only, with 10,000 t to Canada, 15,000 t to the U.S.S.R.,

and 3,000 t to each of the other countries which participated in the fishery. Very few countries reached their quotas in 1975 and the total catch was only 18,000 t. However, due to high abundance of *Illex* and expanded markets, the catches rose to 42,000 t in 1976 and 80,000 t in 1977. In 1977 the establishment of the 200-mile fishing zone gave Canada jurisdiction over the management of all marine resources within this zone including *Illex*.

At Canada's request ICNAF provided advice on the management of *Illex* in 1978 and 1979. For 1978 a quota allocation of 100,000 t for the Canadian zone was recommended. Partitioning of this allocation allowed for 45,000 t to be caught in Newfoundland inshore and offshore waters (Grand Bank). A regulation of fishing effort in the offshore fishery was imposed to guard against over-exploitation in the event of a year of low abundance. Similarly, for 1979 the TAC of 120,000 t for the Canadian zone will be partitioned to allow for 50,000 t to be caught in the Newfoundland area.

The Inshore Fishery

The Newfoundland squid fishery has been conducted on the "squid jigging grounds" for over a century. This well-known fishery is steeped in folklore (Ronayne, 1955) and the presence of small boats 4-14 m (13.1-45.9 feet) long operated by one to four men is a familiar sight in coastal bays (Fig. 3).

Developments in Fishing Strategy

The jigger fishery has evolved from the use of a single homemade jigger on a line to the semi-automatic Japanese drum jigger (Fig. 3) introduced in the mid-1960's (Kasahara, 1965; Quigley, 1964) which has allowed for the use of numerous jiggers on a single line. The homemade jiggers were quite effective and varied from ordinary auto spark plugs (Fig. 4a) (usually painted red and used to attract squid over a type of lampara net which was then hauled aboard the boat) to molded lead jiggers with a single cluster of barbless hooks (Fig. 4b). The most common jiggers in recent use are made of durable plastic with a double cluster of barbless hooks. Some of these have a lead core and are used singly on a line (Fig. 4c) while the most popular solid plastic ones come in various colors and are used in series of up to 40 on a single line (Fig. 4d, e, f). The jigger fishery has been essentially a passive one, i.e., the boats anchored and waited for the squid to strike. Some successful attempts have been made to "actively" search for squid with echo-sounding equipment and to capture

Table 1.—Incidental early season captures of squid by the *Investigator II* on the Grand Bank, 1946-58, and reported occurrence of squid inshore (from Squires, 1957,1959).

Year	Dates fished	Total trawling time (hours)	Percentage trawling time in which squid were taken	No. of squid per 100 hours trawling	Squid landed (t)	Relative abundance
1946	May and June	81	10	385		Moderate numbers
1947	May and June	91	3	>70		Very abundant
1948	May and June	67	1	3		Scarce
1949	June	31	0	0		Few
1950	June	24	14	95		Moderate numbers
1951	May	21	42	5,683		Very abundant
1952	May and June	22	21	3,523		Abundant
1953	5-21 and 23-29 May 18-26 June	53.0	15.7	68	4,460	Abundant
1954	8-17 May 30 May-1 June 22-29 June	43.8	44.2	4,212	6,700	Very abundant
1955	17-23 May 13-19 June	34.3	26.2	1,024	6,700	Very abundant
1956	12-19 May 31 May-8 June 20-27 June	43.7	9.2	1,554	7,600	Very abundant
1957	19-24 May 11-15 June 25 June-1 July	35.1	11.4	330	2,680	Abundant
1958	30 April-8 May 18-24 May 25 June-1 July	44.0	4.5	30	890	Few

Figure 3.—Fishermen in small boats on the "squid jigging grounds" along the south coast of Newfoundland. Note the Japanese drum jiggers and rollers in each boat.

them with jiggers (Aldrich, 1964). Personal observations and discussions with fishermen indicated that echo sounders were able to detect squid adequately. The lower frequency signals were more useful because attenuation losses in deep water were reduced compared with the higher frequency signals. The detection of squid in inshore waters was best accomplished at night when the squid were found most commonly in midwater. An echo tracing of squid in inshore waters is shown in Figure 5.

Other types of fishing gear which have been tried successfully to capture squid inshore include modified cod and mackerel traps for which daily catches up to 5 t have been reported and purse seines, operated in conjunction with powerful overhead mercury vapour deck lights, which have caught up to 15 t in a haul.

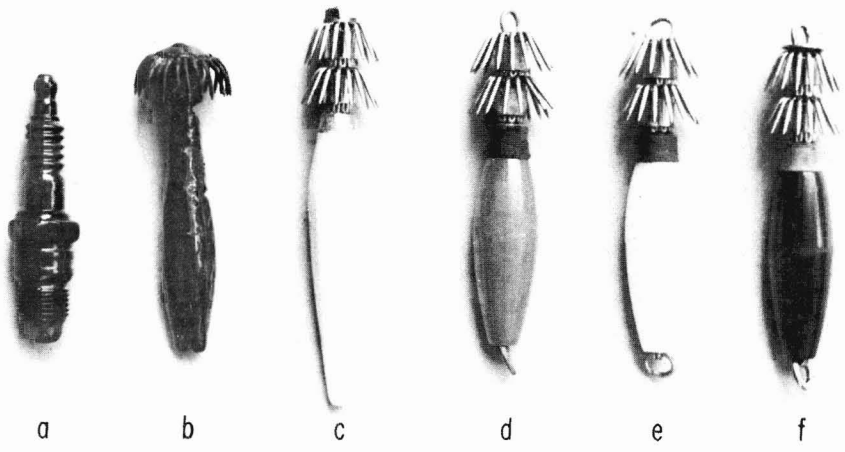

Figure 4.—Various jigs used to catch squid: a) painted spark plug used to attract squid over a dip net, b) homemade molded lead jig with a single cluster of barbless hooks used singly on a line, c) factory-made lead core plastic jig with a double cluster of barbless hooks used singly on a line, d), e), f) durable plastic jigs of various colors used in series on a line

Factors Influencing Inshore Catch Rates

Squires (1957) stated that "even in years of greatest abundance it is probable that temperature, turbidity and other physical or chemical factors under the influence of local weather may cause sporadic appearances inshore in some areas." This seemed to be the case at Holyrood, Conception Bay (Fig. 2), in 1978. Throughout most of the fishing season, July-November, water temperatures approximated the preferred range for *Illex* inshore (7° -15 °C) (Frost and Thompson, 1933), yet daily catch rates varied greatly (Fig. 6). Squires (1957) suggested that wind direction may have been an important factor in influencing inshore catch rates. He observed that when the wind changed to an onshore direction, the "squid seemed to leave the vicinity and no more were jigged while the wind continued in this direction." It can be seen in Figure 7 that the highest catch recorded in 1978 was during offshore moderately strong southwest winds. However, a rather high catch was also recorded when the wind blew moderately strong from a northeasterly direction (onshore). Because both these winds parallel the axis of Conception Bay opening to the ocean (Fig. 2) they can cause the water to become turbulent within a very short time. Perhaps the turbulence forced the squid off the bottom and they were jigged more readily. Local fishermen often stir up the bottom with heavy chains particularly during daylight hours to achieve the same result. It can also be seen in Figure 7 that low catches were recorded when wind speeds from all directions were >60 km/hour (37.2 miles/hour). Perhaps high speed winds increased the turbidity of the water and obscured the jiggers. Since vision is important to squid while feeding (Squires, 1966), this may have

Figure 5.—An echo tracing of squid in inshore Newfoundland waters.

been a factor in the squid not being jigged. Also in very rough water fishermen often do not attempt to fish for comfort and safety reasons.

The Offshore Fishery

There is little information on commercial catches of *Illex* offshore on the Newfoundland banks. In 1978 nearly 4,000 t were taken in the offshore Newfoundland area (versus 55,000 t offshore Nova Scotia, Canada) by the fishing fleets of six foreign nations. Hodder (1964) and Mercer (1973a) reported that the highest catches of squid on the Newfoundland banks occurred in water temperatures >5 °C. Figure 8 shows a summary of bottom trawl catches and temperatures in depths ranging from 50 to 300 m (from 164 to 984 feet) during an offshore research cruise on the Newfoundland banks in June 1978. It is clear that the highest catches of squid were made in water warmer than 5 °C and that the optimal temperatures for finding concentrations of squid at that time of year were between 8 ° and 10 °C. There also seemed to be a diurnal periodicity in catches of *Illex* offshore similar to that reported by Froerman (1979) on the Scotian Shelf. Figure 9 shows that the highest percent of the catch by bottom trawls was made during daylight hours particularly from dawn to noon, while the greatest percentage of the catch by midwater trawls was taken during the dark hours of the day. Because of this diurnal vertical migration many commercial vessels that bottom trawl for *Illex* restrict their actual fishing effort to daylight hours only.

Because there were few Canadian-owned freezer trawlers to harvest squid offshore during 1978, the Canadian government allowed foreign-owned and operated freezer vessels to fish under contract to Canadian companies. Among the stipulations of these so-called "developmental charters" were that representatives of the Canadian fishing company be aboard during fishing operations and secondly that a certain percentage of the catch (25-50 percent) be processed onshore in Canadian plants. It was hoped that in this way the Canadian fishing and processing sectors would gain valuable experience in handling squid while at the same time product development and improved market access would be assured.

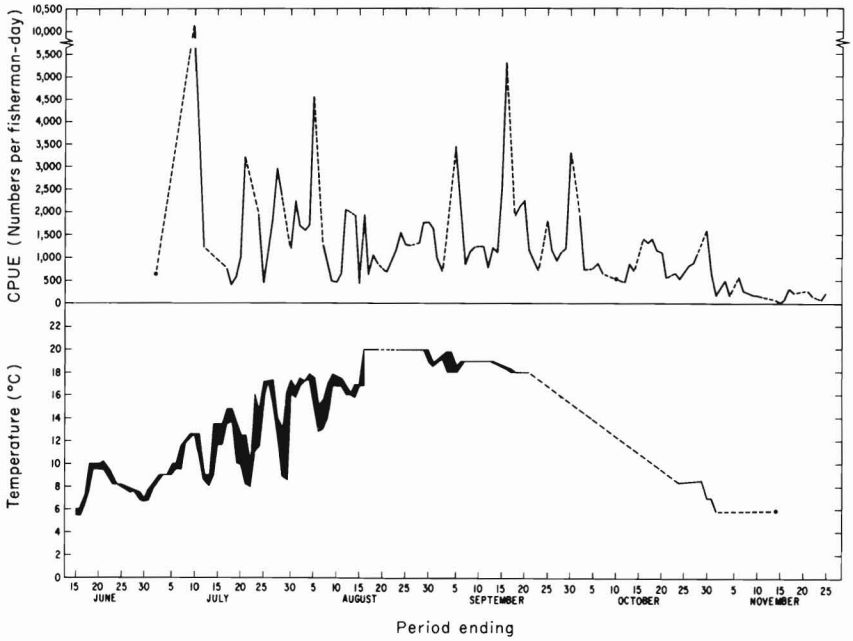

Figure 6.—Variability of catch rates in the jig fishery and bottom water temperatures (at a depth of 10 m) over the fishing season at Holyrood, Conception Bay. Dashed lines represent extrapolated values.

Processing and Marketing Developments

Historical Background

Over the past century *Illex* has been primarily an export commodity. Prior to 1950, large quantities of dried squid up to 700 t (1,543,220 pounds) (3,500 t or 7,716,100 pounds round weight) were exported mainly to Oriental countries for human food. The best markets were China and Hong Kong, although sales were also made to Singapore, Thailand, the Philippines, Burma, United States, Jamaica, Cuba, Trinidad, and the mainland of Canada. Until recent years the primary use of squid had been as bait in both the local and foreign (Portuguese, Norwegian,

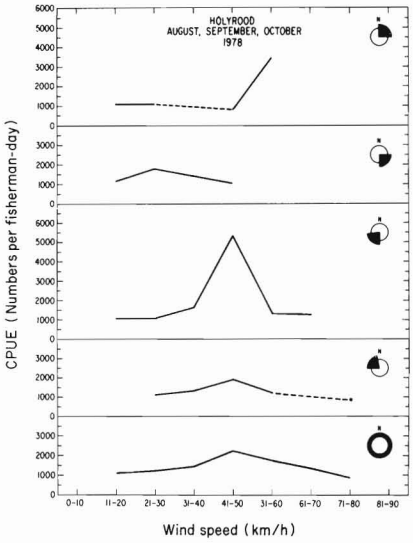

Figure 7.—Relationship of catch rates in the jig fishery and wind vectors recorded at Holyrood, Conception Bay, over the 1978 fishing season. Dashed lines represent extrapolated values. Pie diagrams indicate the wind direction quadrant(s) considered in each graph.

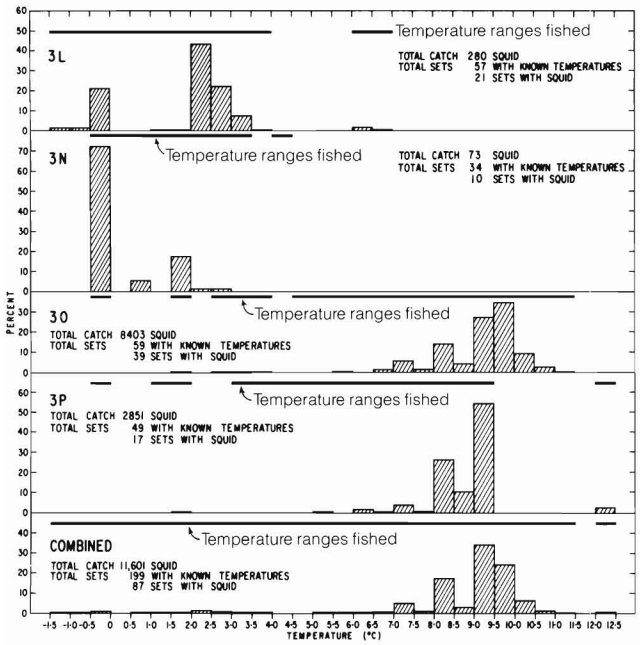

Figure 8.—A summary of bottom trawl catches of squid and water temperatures by ICNAF division (offshore on the Newfoundland banks) during a research cruise in June 1978.

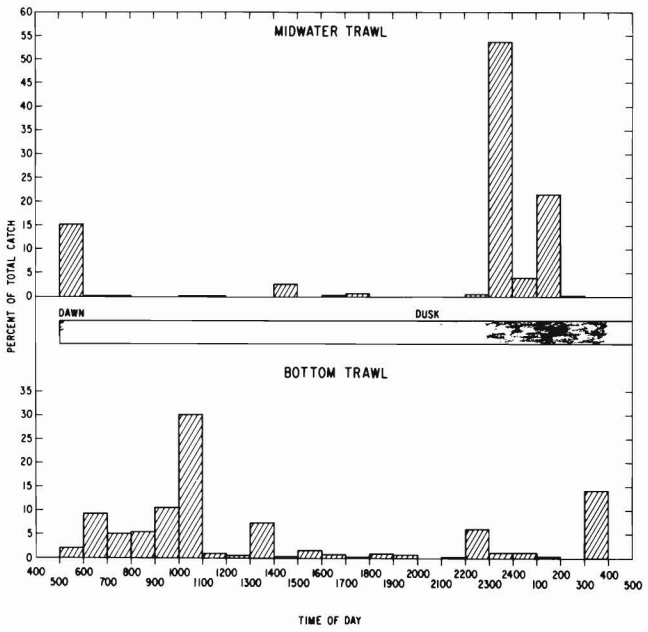

Figure 9.—A summary of the diurnal distribution of bottom and midwater trawl catches of squid during an offshore research cruise on the Newfoundland banks during June 1978.

and Faroese) line fisheries for cod in the northwest Atlantic. The government constructed bait depots, located in various ports around the island, for freezing and storing the squid. Most of these depots are still in use to serve the local line fishery for cod.

There were many reasons for the upsurge in sales of squid abroad for human consumption. Many fishing nations had lost their traditional far-seas fishing grounds because of the worldwide trend toward national jurisdiction over coastal fishing areas. With the universal demand for seafood, and the dwindling supplies of traditionally fished species, the cephalopods (octopus and squid) had been identified as a vast virtually unexploited resource (Gulland, 1971; Voss, 1973). The increased abundance of *Illex* since 1975 coupled with the decline in catches of the Japanese squid, *Todarodes pacificus*, during the 1970's (Okutani, 1977) gave rise to an intense interest in foreign supplies of squid, particularly by Japanese and eastern block countries.

The extent of foreign involvement in Canadian onshore processing operations has been substantial. Many foreign factory vessels have been contracted by Canadian companies to provide extra processing capability by docking alongside existing onshore plants. These "over the side sales" allowed fishermen to sell traditionally underutilized species such as squid, mackerel, and turbot during periods when Canadian plants could not handle them.

Frozen Squid

Japanese technicians, inspectors, and buyers have worked with Canadian processors and government researchers to produce the desired type and quality of squid products. For instance, Japanese quality control inspectors were placed in some Canadian plants processing squid in 1978 to inspect the packing and quality of the squid. This kind of cooperation helped to ensure that the proper transfer of processing technology would be made.

Since squid quality deteriorates rapidly after they are caught, laboratory experiments have been conducted recently by Canadian researchers to examine optimal methods of short-term storage of *Illex* (Botta et al., 1979). Results indicated that circulating chilled seawater, freshwater ice with plastic between the squid and the ice, and refrigerated seawater were satisfactory methods for preserving the sensory quality of the subsequently cooked squid. This kind of information is critical to the squid industry in Newfoundland as many squid at present are trucked long distances to plants for processing and deterioration of quality is inevitable.

Most of the squid processed in onshore facilities in Newfoundland were packaged round or as "tubes" in 10-kg (22-pound) boxes then flash-frozen in blast, plate, or sharp freezers. These boxes were shipped to major ports around the island such as St. John's where they were loaded aboard cargo vessels (Fig. 10) for transport to foreign markets.

Dried Squid

In 1978 there was a rejuvenation in the art of drying squid. Spurred on by

competition among a few entrepreneurs who secured access to Oriental markets, the price paid to fishermen for dried squid rose to $2.42/kg ($1.10 per pound) in 1978 and promised to exceed $4.40/kg ($2.00 per pound) in 1979. Nearly 500 t (1,102,300 pounds) (the equivalent of 2,500 t or 5,511,500 pounds round) were dried by fishermen and their families in 1978. Some women who spent the summer drying squid generated enough income to qualify for unemployment insurance over the winter. Squid was either dried on lines (Fig. 11) or on ordinary chicken wire stretched over a wooden frame (Fig. 12). In both cases the squid was "piped" or gutted, the head split open, the eyes and beak removed. If the squid was very fresh, it was soaked in fresh water for 5-10 minutes to prevent blackening when dried. Finally it was washed in salt and then fresh water to remove the slime and salt respectively. The squid required 3-4 days to dry completely and needed to be flattened by hand when they were about two-thirds dry. If squid are to be dried artifically, i.e., in a mechanical dryer or in a building, it has been recommended that they be given a final day's exposure to the sun in order to retain its palatability and desired color (Ewbank, 1937; Norm Haard, Memorial University of Newfoundland, St. John's. Personal commun.).

Some processors have expressed interest in specialized processing equipment such as splitting machines, cookers, skinners, and shredders. Further processing of squid would be advantageous since there have not been import quotas in Japan on fully processed products such as Daruma (skinned, seasoned dried tubes) or saki-surume (shredded dried squid) although a duty was paid on them. One product marketed locally with some success was a package of two lightly smoked tubes which were sold as a pub snack.

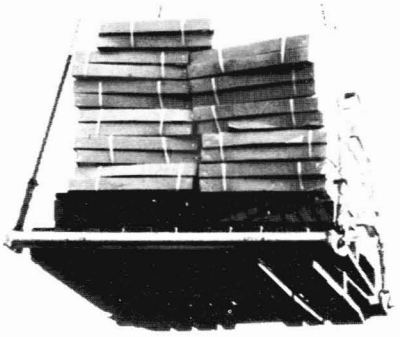

Figure 10.—A crate of 10-kg (22-pound) boxes of frozen squid is loaded aboard a foreign cargo vessel at St. John's, Newfoundland.

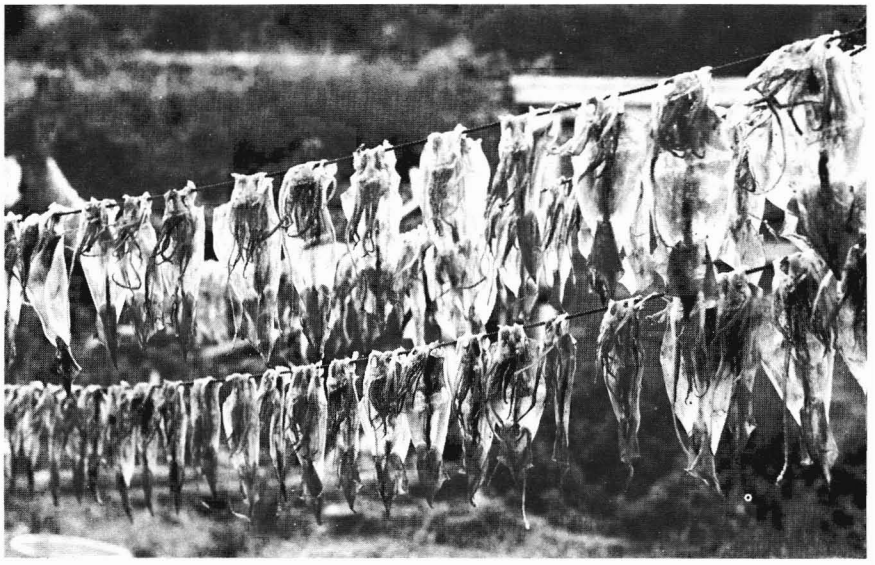

Figure 11.—Drying squid on lines.

Prospects for the Newfoundland Squid Fishery

The future development of the squid fishery in Newfoundland will depend on many factors.

Investment in the permanent expansion of the industry has been retarded by the lack of long-term forecasts of abundance. To date forecasts of inshore abundance have been made a few months before the onset of the fishery. At the very best this allows for lead time in arranging for the use of foreign freezer vessels as "developmental

charters" or as extended wharfage processing facilities. Also orders for packaging material for frozen squid and freight containers for dried squid have been made once the forecast was known.

Fishermen have become more experienced and innovative in their techniques for catching squid and the inshore fishery is evolving into a more "active" fishery in contrast to the "passive" one it has been for years. Increased Canadian participation in the offshore fishery will necessitate improvement in long-term storage capabilities on existing vessels and/or the aquisition of freezer trawlers.

Fishery managers will have to continue to make decisions based on reliable information concerning stock discrimination, status, and the causes of year-class fluctuations so that the resource can be managed in a rational way.

One of the biggest challenges facing the processing sector will be the attainment of desired quality standards for fresh, frozen, and dried squid. Increased sales of squid products will depend on the expansion and diversification of secondary processing capabilities along with improved access to foreign and domestic markets.

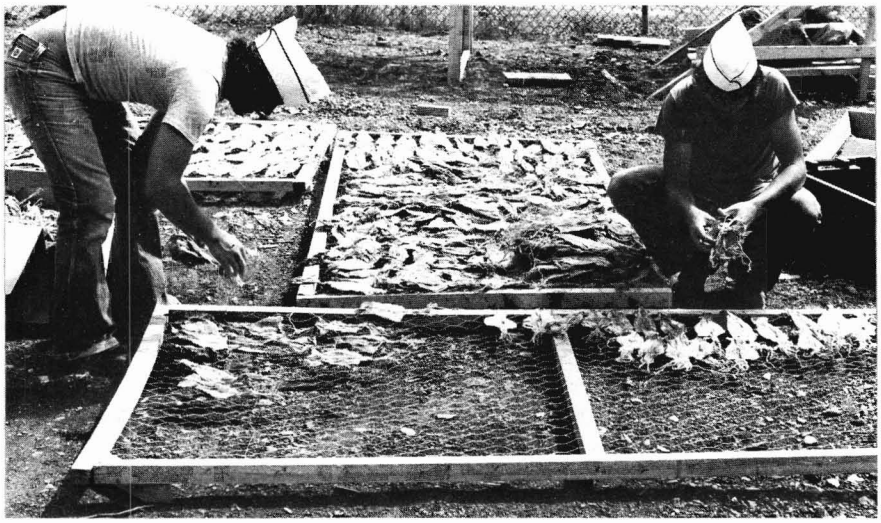

Figure 12.—Drying squid on chicken wire stretched over wooden frames.

Acknowledgments

P. Beck and J. Drew provided technical support for the collection and tabulation of the data. My appreciation for the efforts of H. Mullett, draftsman and G. King, photographer. F. Slade, Inspection Branch, Department of Fisheries and Oceans was consulted on the processing aspects of the paper. J. R. Botta and D. Taylor reviewed and criticized the manuscript.

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