Squid Catches Resulting From Trawl Surveys off the Southeastern United States

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Introduction

The importance of the squid fishery off the northeastern United States has grown considerably since 1964 with recent squid catches by foreign fleets averaging 50,000 t (110,231,000 pounds) annually (Rathjen et al., 1977). Due to rising value of this fishery and increased interest in expanding the domestic fishery, underexploited squid stocks south of Cape Hatteras and in the Gulf of Mexico are being more closely examined.

However, few studies have examined the distribution and abundance of squids common to these areas. Whitaker (1978) examined several aspects of the biology of *Loligo pealei* and *L. plei*, and Wenner et al. (1979a, 1979b) briefly discussed cephalopod catches from otter trawl surveys in the South Atlantic Bight.

Four species are common in the continental shelf waters off the southeastern United States. Three species, *Loligo pealei, L. plei* and *Lolliguncula brevis* belong to the family Loliginidae. *Loligo pealei*, the long-finned squid, is intensively fished by foreign vessels between Georges Bank and Cape Hatteras (Kolator and Long, 1979) and is the most widely distributed loliginid in the western Atlantic (Cohen, 1976). Seasonal distribution off New England as related to water temperature has been examined by Summers (1969), Vovk (1969) and Serchuk and Rathjen (1974). Information of this type is limited for populations south of Cape Hatteras (Whitaker, 1978).

Loligo plei, the arrow squid, rarely occurs north of Cape Hatteras and current commercial catches off the southeastern United States are not substantial. *Lolliguncula brevis*, the brief squid, is coastal and is often taken in estuaries. Its known range is from Maryland to Rio de la Plata (Voss, 1956). Incidental catches in the shrimp trawl fishery constitute most of South Carolina's squid landings (4,600 kg or 10,120 pounds in 1978) and are sold locally as bait[1].

Illex illecebrosus, the short-finned squid, is also common off the southeastern United States. This species, which supports a large fishery in Canada, has been collected from the continental shelf north of Cape Hatteras during fall but is restricted to the shelf edge during spring (Rathjen, 1973). Roper et al (1969) reported it from deeper waters south of Cape Hatteras. Although this species grows to relatively large size, it is considered inferior in taste and texture to *L. pealei* which reduces its price on the foreign market (Kolator and Long, 1979).

The surveys conducted in the Atlantic Ocean off the southeastern United States since 1973 have provided the first comprehensive trawl data for squid in these waters. In this paper I present some observations on distribution and abundance of *Loligo* and *Illex*.

Materials and Methods

Squid data came primarily from groundfish cruises of the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program[2]. Specimens were collected during 1973-77 with all seasons represented by at least one cruise. Stations from Cape Fear, N.C., to Cape Canaveral, Fla., were selected using a stratified random sampling design with a set number of stations in each of six depth zones: 9-18 m (29.5-59 feet), 19-27 m (62.3-88.6 feet), 28-55 m (91.8-180.4 feet), 56-110 m (183.7-360.8 feet), 111-183 m (364-600.2 feet), and 184-367 m (603.5-1,203.8 feet). All samples were collected using a ¾-scale version of a Yankee No. 36 trawl with a 16.5-m (54.1-foot) footrope, 11.9-m (39-foot) headrope, and a 1.3-cm (0.5-inch) stretch-mesh cod end liner. Although this net is not designed for efficient squid capture, it does collect enough specimens for relative abundance and distribution analysis. Trawl tows were 0.5 hour long and made during daylight and darkness.

Additional data were obtained by MARMAP personnel during an exploratory cruise aboard the Spanish FV *Pescapuerta Segundo* from 31 May to 15 June 1978. Trawls were made on the continental slope from lat. 38.5 ° to

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Table 1.—Percent occurrence of *Loligo* in different seasons and depth zones. Parentheses enclose the total trawls per season per depth zone. Means represent percent occurrence in all trawls pooled by season or depth zone.

Depth (m)	Spring	Summer	Fall	Winter	$\bar{x}$
9-18	79(28)	85(48)	83(18)	60(50)	75
19-27	79(24)	68(50)	94(18)	87(45)	80
28-55	86(35)	64(66)	84(19)	90(59)	79
56-110	79(28)	63(41)	79(14)	71(41)	71
111-183	71(21)	93(29)	100(10)	81(21)	85
184-367	30(20)	28(29)	62(8)	39(23)	35
$\bar{x}$	73	68	85	74	

Table 2.—Catch rates >10 kg/tow of *Loligo*, 1973-77.

Depth (m)	kg/tow	Bottom temp. (°C)	Date
22	13.6	25.7	Aug. 1974
59	12.2	21.8	Sept. 1976
68	13.9	19.1	Jan. 1976
75	11.4	25.6	Nov. 1973
155	10.4	12.8	Aug. 1974
155	10.9	13.5	Aug. 1974
155	18.1	16.8	Nov. 1973
157	11.2	13.5	Feb. 1976
172	24.3	14.1	Aug. 1975
174	17.2	27.3	Nov. 1973
179	36.6	10.0	Aug. 1976
194	27.7	14.2	Nov. 1973
198	41.7	13.1	Aug. 1975

30.2°N at depths ranging from 99 to 375 m (from 324.7 to 1,230 feet). The net used most often during this cruise was a bottom trawl with a 78-m (255.8-foot) headrope and numerous steel floats.

All squid were counted, weighed, and measured (mantle length to the nearest centimeter). Larger samples were often representatively subsampled. Hydrographic data were recorded at each trawl station. Data for *L. pealei* and *L. plei* were combined due to questionable identification of specimens from several samples and to facilitate biomass and distribution analysis. Since preliminary analysis showed little north-south variation between catches, I made no latitudinal distinction. Data from all years are combined for analysis of seasonal effects.

Results and Discussion

Loligo were present at 543 (73 percent) of the 745 bottom trawl stations occupied from 1973 to 1977. Frequency of occurrence appeared to be uniform during all seasons and in all depth zones, except at the 184-367 m (603.5-1,203.8 foot) zone where squids were consistently less common (Table 1). Squid appeared to move to the deeper continental slope waters during summer and fall when water temperatures on the shelf exceeded 20 ° C (Fig. 1). Catch per effort (kg/tow) in the 9-18 m (29.5-59 foot) zone was greatest during the warmer months.

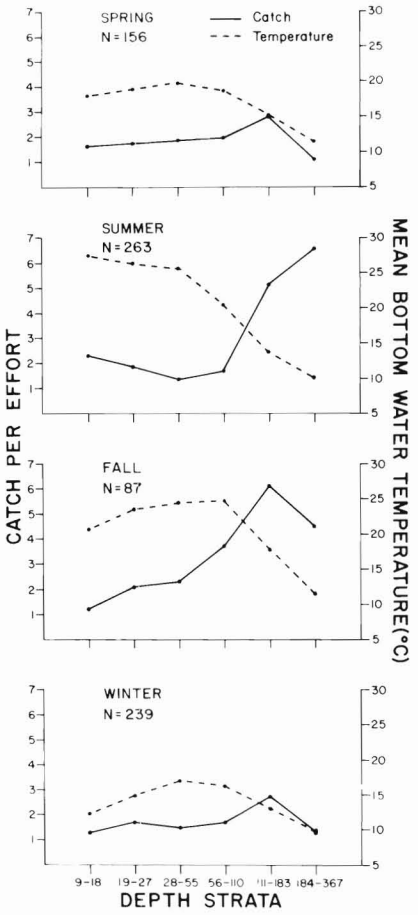

Figure 1.—Mean catch per effort (kg/tow) compared with bottom water temperature for all seasons and depth strata. Catch per effort was estimated for each depth stratum following the methodology of Bliss (1967) and Wenner et al. (1979a).

Catches were more uniform across the shelf during winter and spring which indicates dispersal and a possible movement towards shallower water, perhaps in response to reduced temperatures. Only 13 samples contained a catch biomass >10 kg (>22 pounds); 12 of these stations were in waters >50 m (>164 feet) and nine occurred at depths >150 m (492 feet) (Table 2). From a total of 96.7 kg (212.7 pounds) of *Loligo* taken in the 184-367 m (603.5-1,203.8 foot) zone, 18.4 kg (40.5 pounds) (19 percent) were taken at ≥200 m (≥656 feet) and only 4.4 kg (9.7 pounds) (4 percent) were taken at ≥250 m (≥820 feet).

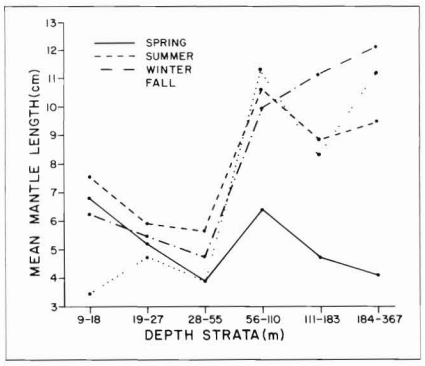

Figure 2.—Mean mantle lengths of *Loligo* by season and depth. Each point is the mean of at least 98 specimens.

Larger-sized *Loligo* were located offshore during all seasons except spring (Fig. 2). The greatest change in mean mantle length with depth occurred during fall when squid in the 9-18 m (29.5-59 foot) zone were much smaller ($\bar{x}$ = 3.5 cm or 1.4 inches) than those collected during the other seasons ($\bar{x}$ = 6.2-7.6 cm or 2.4-3 inches). Mean values are somewhat misleading, however, because size ranges were very large and length-frequency modes were often less than the means. Modes were ≤5 cm (≤2 inches) in 18 of 24 observations (four seasons at six depth zones). Small squid (≤5 cm or 2 inches) were absent only in the 184-367 m (603.5-1,203.8 foot) zone during summer, fall, and winter.

Catch per effort in relation to bottom temperature also showed seasonal differences (Fig. 3). Although bottom

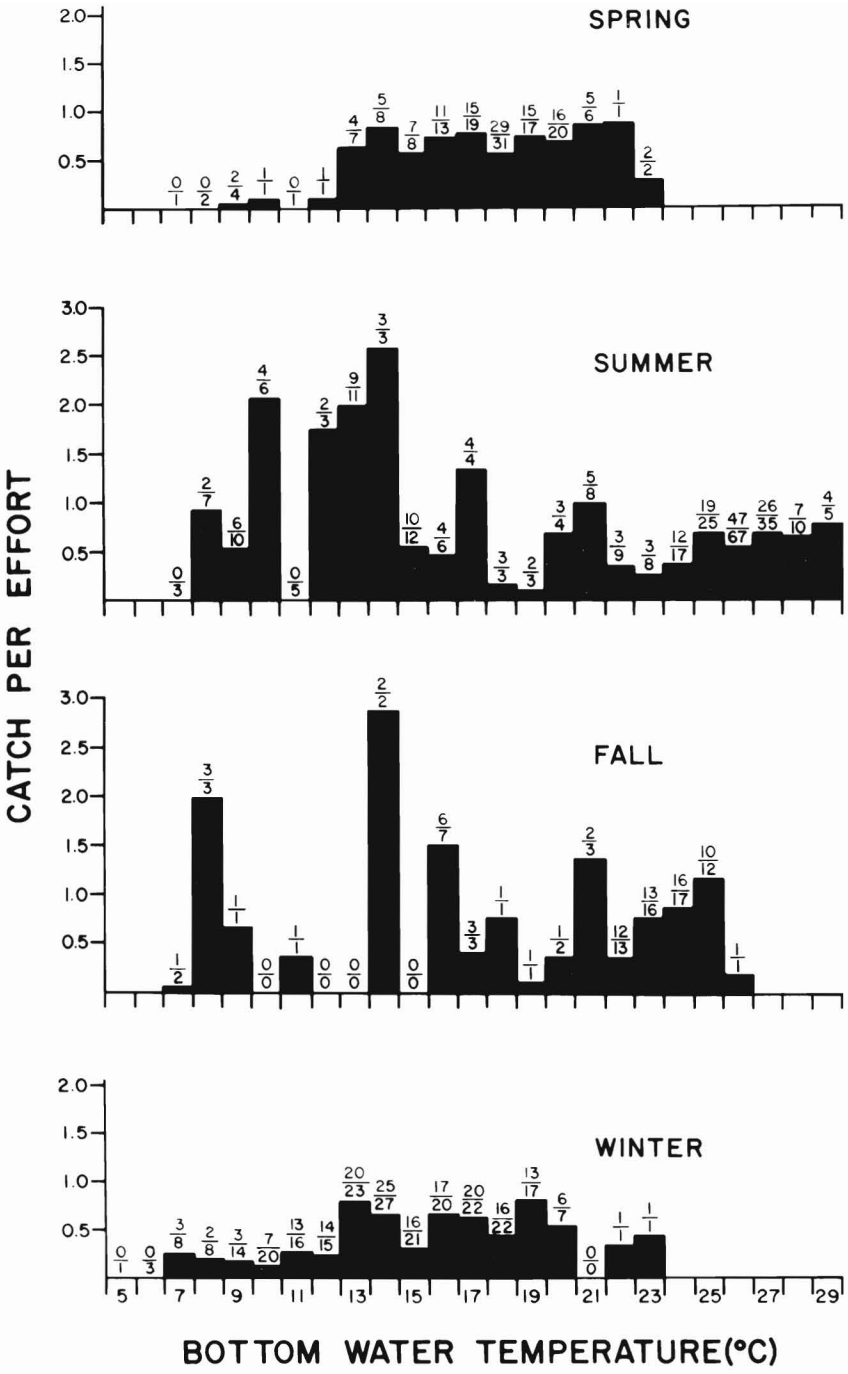

Figure 3.—Catch per effort of *Loligo* as $\ln(x + 1)$ where x is mean catch (kg) per tow for stations at each temperature degree. Each fraction shows the total number of stations with *Loligo* over the total number of stations at that temperature and season.

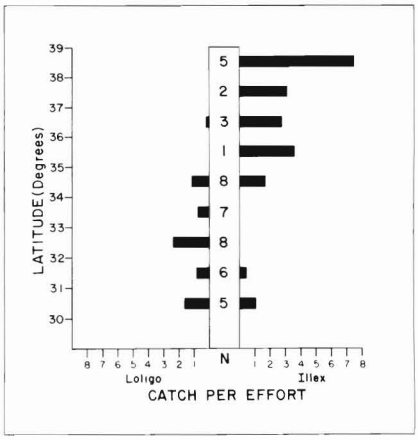

Figure 4.—Catch rates (kg/h) from the Spanish FV *Pescapuerta Segundo*, 31 May-15 June 1978. Data are shown as $\ln(x + 1)$ where x is the mean catch rate per degree of latitude. N is the number of trawls per degree of latitude.

temperatures where *Loligo* were taken ranged from 7° to 29°C, the greatest catch per effort was observed during summer and fall at stations with temperatures of 10°-14°C. Some *Loligo* were always present in the warmest temperatures available. During spring and winter, squid were more uniformly distributed with regard to temperature.

Trawls by the FV *Pescapuerta Segundo* did not find any substantial quantities of *Loligo* both north and south of Cape Hatteras (Fig. 4). Catches ranged from 0 to 33 kg (0 to 72.6 pounds) per hour.

Some of the inconsistencies in the above MARMAP data can be explained when *L. pealei* and *L. plei* are considered separately. Whitaker (1978) observed that temperature was the most important factor determining seasonal distributions. *Loligo pealei* appears to prefer cooler temperatures (7°-22°C) remaining on the continental slope during summer and fall and then migrating to the continental shelf in winter and spring. These seasonal distribution patterns are different from those of *L. pealei* off New England where squid are found in shallow waters during the warmer seasons (Summers, 1969; Vovk, 1969; Serchuk and Rathjen, 1974). *Loligo plei*, on the other hand, prefers warmer temperatures and usually remains in waters <50 m (<164 feet) deep. Larger *L. plei* apparently migrate

south with the seasonal drop in temperature (Whitaker, 1978).

Illex illecebrosus was often found in relatively deep water south of Cape Hatteras (Table 3). This species was present at less than 1 percent of all stations shallower than 56 m (183.7 feet) but occurred at 50 percent of all stations in the 184-367 m (603.5-1,203.8 foot) zone. A total of 78 kg (171.6 pounds) was collected in 40 of 80 trawls made between 184 and 367 m (603.5 and 1,203.8 feet) composing 89 percent (by weight) of all short-finned squid taken. In the deeper zone, 59 percent (52 kg or 114.4 pounds) were taken between 250 and 300 m (820 and 984 feet). Only 4 percent (3.6 kg or 7.9 pounds) were captured between 300 and 367 m (984 and 1,203.8 feet).

Illex illecebrosus catches were less than 2.7 kg (5.9 pounds) at each of the 68 stations where this species occurred except for a 25.4-kg (55.9-pound) catch made during summer 1974 at 293 m (961 feet). Seasonal differences in catch per effort were minimal but a single large catch in January 1978 (not included in the analysis) is worthy of mention. This catch, taken east of the Georgia-Florida border at 223 m (731.4 feet), consisted of 4,100 squid weighing 713 kg (1,568.6 pounds) and was 28 times larger than any previous *I. illecebrosus* catch. These squid were large, having a modal length of 22 cm (8.6 inches) and a 20-27 cm (7.8-10.5 inch) size range.

Illex illecebrosus prefers relatively cold continental shelf water. Water temperatures where this species was collected ranged from 7.3 ° to 27.3 °C but only 3.5 percent (by weight) of the total catch were taken in water ≥15 °C. Mean temperatures for the 184-367 m (603.5-1,203.8 foot) zone ranged from 9.8 °C in winter to 11.2 °C in spring. Of all *I. illecebrosus* collected, 79 percent were taken in 8 °-10 °C water. Squires (1957) jigged short-finned squid near Newfoundland when the surface temperature range was 8.9 °-14.4 °C. However, he found squid on the Grand Banks where bottom temperatures were 0.5 °-8.0 °C.

The limited data available indicate that *I. illecebrosus* size increases with depth (Fig. 5). Squid caught in 111-183 m (364-600.2 feet) had a mean length of 11.7 cm (4.3 inches) while those collected at 184-367 m (603.5-1,203.8 feet) had a mean length of 18.9 cm (7.4 inches). Squid <6 cm (<2.3 inches) were conspicuously absent from my samples. The smallest *I. illecebrosus* collected off Newfoundland in May 1946-53 were rarely less than 10 cm (3.9 inches) and averaged 14 cm (5.5 inches) in mantle length (Squires, 1957). Juvenile short-finned squid, <6 cm (<2.3 inches), off the southeastern coast are either pelagic and not vulnerable to our gear, or, more probably, move into the sampling area after reaching 6 cm (2.3 inches). The smallest squid (modal length 10 cm or 3.9 inches) collected south of Cape Hatteras were most numerous during spring. Modal lengths ranged from 15 to 21 cm (from 5.9 to 8.2 inches) during other seasons.

Table 3.—Percent occurrence of *Illex illecebrosus* in different seasons and depth zones. Parentheses enclose the total trawls per season per depth zone. Means represent percent occurrence in all trawls pooled by season or depth zone.

Depth (m)	Spring	Summer	Fall	Winter	$\bar{x}$
9-18	0(28)	0(48)	0(18)	0(50)	0
19-27	0(24)	2(50)	0(18)	2(45)	1
28-55	3(35)	2(66)	0(19)	0(59)	1
56-110	4(28)	15(41)	7(14)	0(41)	6
111-183	10(21)	34(29)	20(10)	10(21)	20
184-367	45(20)	52(29)	50(8)	52(23)	50
$\bar{x}$	8	13	8	6	

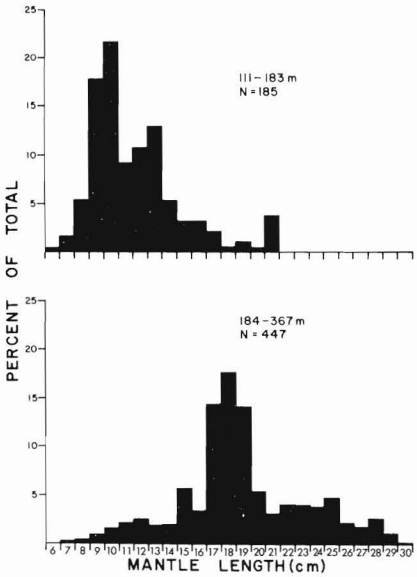

Figure 5.—Length-frequency distribution for *Illex illecebrosus* from all MARMAP samples at 111-183 m and 184-367 m. N is the number of squid measured.

No sexually mature males or females were collected in this study although some large males carried spermatophores. Although there may be a winter spawn south of Cape Hatteras with recruitment to the continental shelf in spring, more data are needed to substantiate this. Squires (1967) concluded that *I. illecebrosus* spawns in deep oceanic waters at an age of 1 year. Spawning occurs during winter, although some individuals may spawn as late as June.

Illex illecebrosus catches by the FV *Pescapuerta Segundo* were relatively small south of Cape Hatteras (lat. 35.2 °N), with the greatest catch rate equal to 67 kg/hour (147.4 pounds/hour). In contrast, catch rates near lat. 38.5 °N ranged from 4,000 to 15,000 kg/hour (from 8,800 to 33,000 pounds/hour) (Fig. 4). The short-finned squid were not only more abundant north of Cape Hatteras but were also generally larger. Modal sizes at stations where 40 or more individuals were present averaged 14.3 cm (or 5.6 inches) (range: 12-17 cm or 4.7-6.6 inches) south of Cape Hatteras as compared with 16.6 cm (or 6.5 inches) (range: 14-18 cm or 5.5-7 inches) north of Cape Hatteras.

Squid Fishery Potential

Development of a large-scale squid fishery off the southeastern U.S. coast appears highly improbable. MARMAP sampling results indicate that quantities of squid off the southeastern United States are small relative to those found in waters north of Cape Hatteras.

Sampling by the FV *Pescapuerta Segundo* further demonstrated this. There remains, however, the possibility for a small-scale seasonal squid fishery off the southeastern U.S. coast. Consistent monitoring of seasonal

water temperatures could maximize fishing effectiveness by identifying areas where *Loligo* and *Illex* seasonally aggregate. Fishing would probably be best during summer and fall on the continental slope between the 8 ° and 14 °C bottom isotherms. Before large-scale commercial operations begin, however, careful consideration by management agencies is needed to insure rational exploitation of the squid resources, since squid are important forage for economically important finfish (Fields, 1965).

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