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ABSTRACT

Project goals for federal fiscal year 1986 included working at sea and shoreside to collect data regarding the fishery and biology of Loligo opalescens. Squid catch in 1986 was low despite adequate market demand for the product. Catch was low primarily because most of the squid fishing fleet switched gear to fish for pink shrimp (Pandalus jordani). Few intrafishery and interfishery conflicts occurred due to the low effort. Biological data collected from market samples indicate that the squid spawning in 1986 had similar morphometric characteristics as squid caught from 1983 to 1985.

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INTRODUCTION

Commercial landings of the market squid (Loligo opalescens) doubled or tripled each year from the beginning of the fishery in 1982 until 1985 when 1.8 million lb were landed. The rapid increase in squid landings, coupled with a strong demand for squid in the world seafood market, caused processors and fishermen to plan for a large scale fishery. In response to the interest in the squid resource, we designed a research project to obtain data needed to manage the new fishery. The primary goals of the research project are:

1. To collect and consolidate existing information pertaining to squid life history and management;
2. To develop a squid information retrieval and data analysis system;
3. To evaluate the selectivity, efficiency, and impact of gear used to harvest squid; and
4. To collect, analyze, and summarize data from commercial harvest and research cruises to describe the biology and life history of L. opalescens in Oregon waters.

Federal fiscal year 1986 (FY 86) was the third year of our research project. In FY 84 and FY 85 we worked primarily on the first two goals to collect existing information and establish methods to study and evaluate the squid resource. We conducted an extensive literature review, produced an annotated bibliography of squid references (McCrae and Starr 1986), set up a vessel logbook reporting program, and designed and implemented a data compilation and analysis system. We also began work on the last two goals.

Fishery observers worked at sea to gather information about the selectivity, efficiency, and impact of gear used to harvest squid, and also collected data regarding the biology and life history of squid in Oregon. The tasks outlined for 1986 included work on the goals pertaining to fishery monitoring and biological data collection. This report summarizes our progress in 1986.

FY 86 Objectives

A few gear conflicts occurred in the 1984 and 1985 seasons and warranted closer investigation. At the same time we wanted to verify initial assumptions that the squid fishery by-catch is minimal. Therefore, in FY 86 observers continued to monitor fishing activity to learn about interfishery and intrafishery conflicts and quantify the composition and abundance of incidentally caught species. Additionally, we planned to learn more about the biology and life history of L. opalescens. Accordingly, objectives outlined for FY 86 were:

1. To collect harvest data to obtain catch, effort, and by-catch estimates;
2. To work at sea to evaluate gear impacts, efficiencies, and conflicts;
3. To collect market samples from various harvest areas; and
4. To measure and record morphometric parameters to delineate stock characteristics.

FY 86 Accomplishments

We accomplished all our objectives in FY 1986 with respect to the limited nature of the fishery this year. We collected logbooks and fish tickets to obtain information about fishery catch and effort, spent 12 person-days at sea observing the fishery, collected market samples from the landed catch, and recorded morphometric characteristics from squid sampled.

Most industry representatives expected to see a large volume of squid on the docks in 1986 since landings doubled or tripled each of the first four years of the fishery. Also, despite a large squid harvest in Southern California, the market demand for squid was high. Unfortunately, the commercial catch and effort in 1986 was not as large as expected, and limited the amount of data collected this year.

COMMERCIAL HARVEST

Effort

In 1986, seven vessels had experimental gear permits that allowed them to fish for squid with trawl gear. Four boats, using currently legal gear that did not require a permit, made a number of trips searching for squid. The skipper of one other boat indicated he would fish for squid when sufficient quantities were located, but did no searching.

The January and February 1986, harvest of squid off Southern California proved to be the most successful of any squid catch in that area in the last 10 years. Because of the strong season in the Channel Islands, fishermen and processors became pessimistic about the prospects for a fishery in Oregon in 1986. The large volume of squid landed in California drove the

price down to $200 per ton and left Oregon fishermen wondering if they could profitably fish at that price.

Despite the large landings in Southern California, local processors were anxiously awaiting the harvest of squid by the middle of March. The commercial fishery for Loligo vulgaris around the Falkland Islands off Argentina was extremely poor in 1986, resulting in a strong world market for most species of Loligo. Processors did not indicate what they would pay for local squid, but remarked they could sell all the food grade squid that fishermen could deliver.

The strong market and prior agreements with fish plants kept several vessels searching for squid in February and March, but without success. By the end of March most skippers were thinking about changing gear to fish for pink shrimp (Pandalus jordani), as the ex-vessel price for shrimp promised to be $0.50/lb or greater. In April, the shrimp season opened on a strong note. Early shrimp landings averaged 15,000 lb and fishermen expected the catch per trip to increase as the size of shrimp increased. Despite requests by processors, the remaining vessels in the squid fleet capable of trawling left to fish for shrimp. Several of the skippers of vessels that changed to shrimp gear said they would switch back to fish for squid when large concentrations were located.

Weather was poor in April and May; the few vessels that remained in the squid fishery were frequently stuck in port. When the vessels did get out, squid schools were difficult to locate. Often fishermen mistook echosounder markings of herring and smelt for traces of squid. The squid that were located were also harder to catch than in previous years. Squid were aggregated in smaller schools and fishermen were neither able to

successfully surround squid in the daylight hours nor able to attract squid to lights at night.

By the middle of April, search effort for squid slowed to the point that just two boats were doing the majority of the searching, each making a search trip once or twice a week. The searching continued until the latter part of May when the first landing was made. By the middle of June, there were no more landings, nor was there any effort put into searching for more squid.

Harvest

Landings in 1986 totalled slightly over 26,000 lb (Table 1), most of which came from one area just south of Newport (Table 2, Figure 1). A small amount came from an area near Heceta Head. Both of these areas have been areas of harvest in past years (Figure 2). This year's harvest was much less than any in the past four years in Oregon, considerably less than in California, but more than the ten year average in Washington (Table 1).

Three of the five landings of squid (99.3% of the total pounds) were made by vessels using purse seines during a one week period in May. Incidental landings of squid were made by two vessels using trawl gear fishing for pink shrimp in March, from an area between Newport and Waldport. None of the trawl vessels with experimental gear permits made landings of squid.

During the main week of fishing in May, two boats made three landings, averaging 8,700 lb per trip. Count per pound averaged 9-11 squid (Figure 3) and ex-vessel price averaged $200 per ton.

Table 1. Annual L. opalescens landings (thousand pounds) for Oregon, Washington, and California.

Year	Oregon	Washington (*)	California (**)		
			Monterey	Channel Islands	Total
1976	0	1.1	5,038	15,320	20,358
1977	0	0.5	5,092	14,498	19,590
1978	0	1.9	20,812	16,590	37,402
1979	0	4.0	23,196	12,102	35,298
1980	0	3.6	13,572	11,630	25,202
1981	0.2	11.6	27,842	21,834	49,675
1982	113.1	4.3	23,200	12,600	35,800
1983	297.4	89.0	2,104	2,800	4,904
1984	946.7	29.0	1,076	168	1,244
1985	1,741.8	3.2	8,572	13,190	21,762
1986	26.2	8.5	6,000	5,090	11,090

(*) 1976-1982 from Bettinger (1986).
1983-1985 Washington Dept. Fisheries (1984).
1986-personal communication, D. Ward, Wash. Dept. Fisheries, Olympia.
(**) 1976-1980 from Bettinger (1986).
1981-1986 personal communication, J. Hardwick, Calif. Dept. Fish & Game, Monterey. 1896 figures are estimates.

Table 2. Annual harvest of L. opalescens off Oregon by area, 1982-1986.

Area	A	B	C	D	Total (*)
1982	N/A				113,138
1983	N/A				297,410
1984	585,241	361,262			946,725
1985		1,750,441			1,751,773
1986		26,088			25,126

(*) Includes incidental catches from other areas.

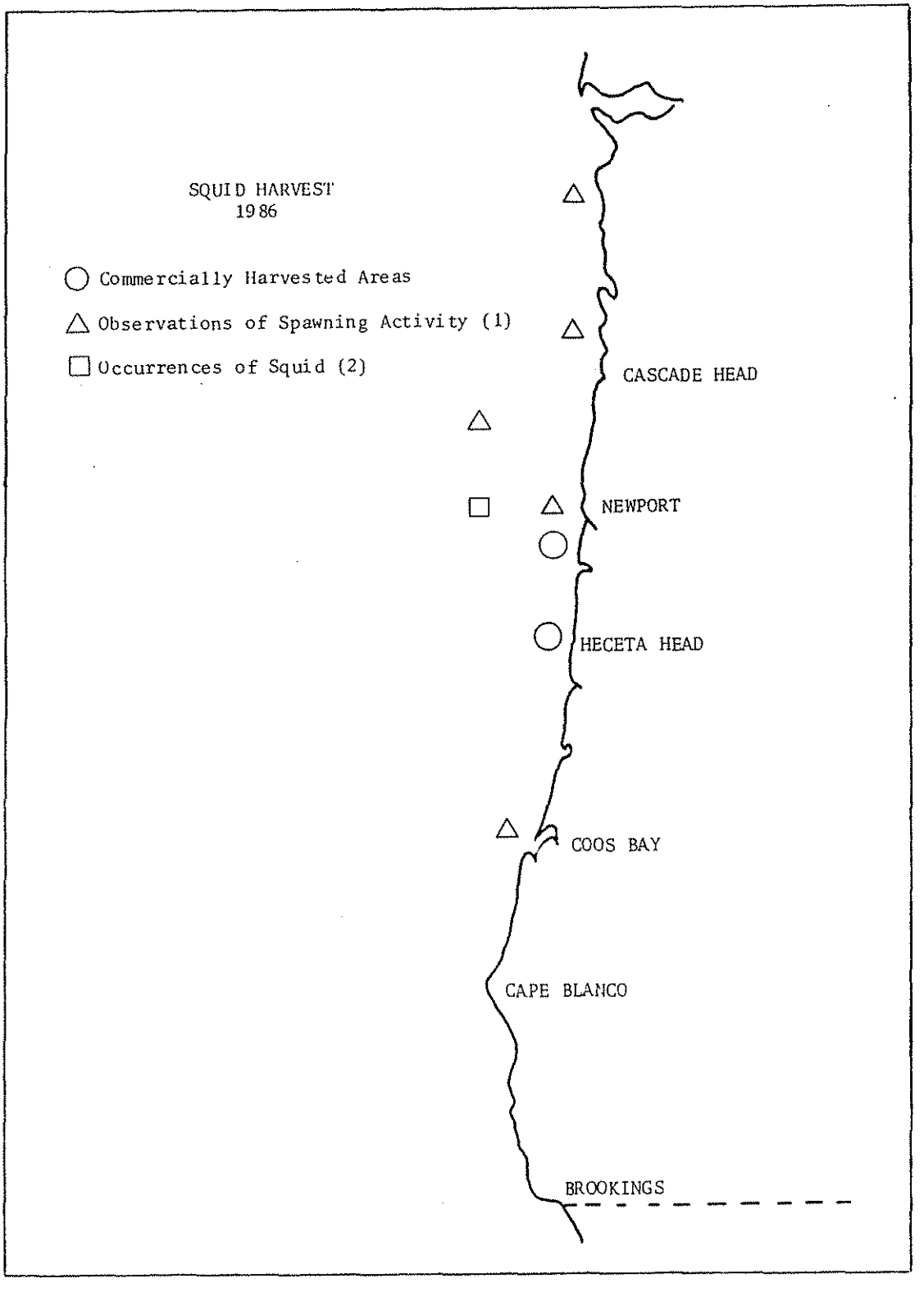

Figure 1. Locations of commercial harvest and observations of L. opalescens in 1986. (1) Observations of large concentrations of adult squid or eggs. (2) Unverified reports of small quantities of adult squid.

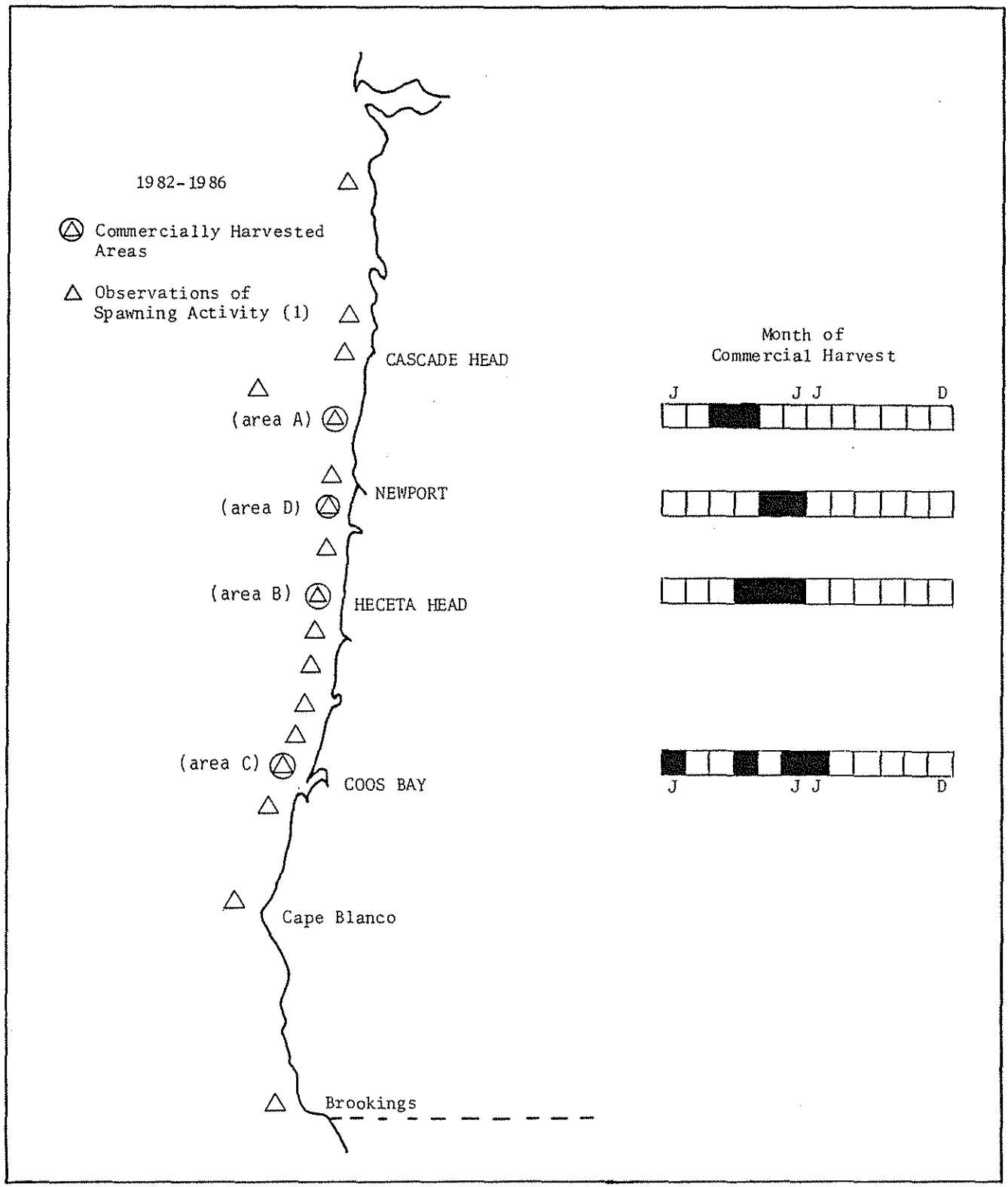

Figure 2. Locations of commercial harvest by month, and observations of spawning activity of L. opalescens, 1982 - 1986. (1) Observations of large concentrations of adult squid or eggs.

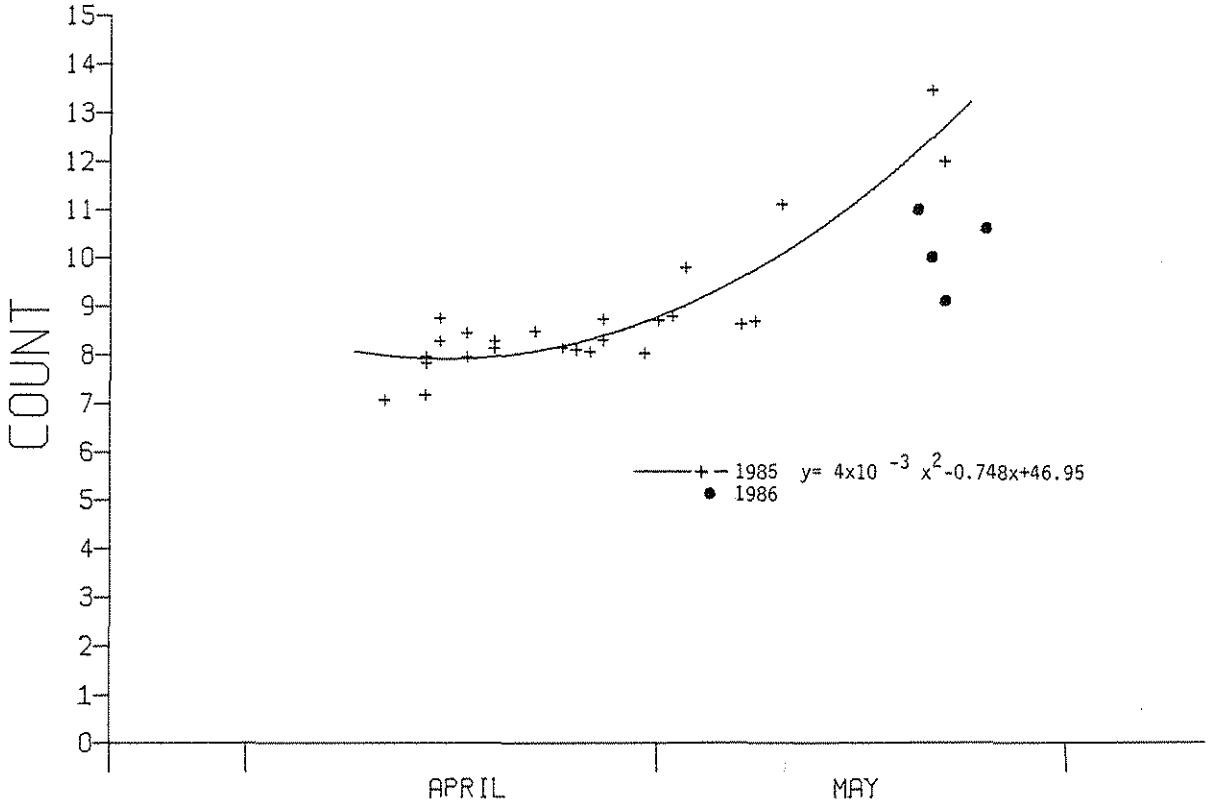

Figure 3. Average count per pound of squid sampled in 1985 and 1986.

Observer Program

Our objectives in 1986 for the observer program were similar to past years: to document gear conflicts between different types of squid gear, to document conflicts within the squid fishery and between the squid fishery and other fisheries, and to identify problems associated with gear impacts on squid egg capsules or incidental catch.

We placed observers on a total of six fishing trips, all of which were by vessels using purse seines. No squid were landed on observed trips, therefore, no incidental catch was observed. The potential for incidental catch was high, however, because of large amounts of herring and smelt in squid fishing areas. In 1984, our observer program showed incidental catch was high in speculative tows, and low in tows on known squid. This year fishermen were making speculative sets. One day, 92,000 lb of small herring were caught when a boat set on a presumed school of squid. Skippers commented they thought herring, smelt, and squid were mixed together more in 1986 than in previous years.

There were minimal conflicts between squid boats, or between squid boats and boats in other fisheries due to the small numbers of squid boats on the grounds. There were no reports of crab pots being caught in squid nets as there had been in the past.

Squid or squid eggs were observed in other locations along the coast (Figure 1). Draggers reported seeing squid off Newport in January. Shrimpers reported seeing more squid in deeper waters (60-80 fm) than in past years. Shrimpers reported seeing squid in April from Newport to Cascade Head, and north of Coos Bay in April. Squid were also observed south of

Tillamook Bay in April and May. Salmon trollers reported seeing small squid off Heceta Head in July.

Egg capsules were observed on crab pots south of Newport in January, between Alsea Bay and Cape Perpetua in March and April, and north of Coos Bay in May. Capsules were found on the beach north of Newport in March, and in Alsea Bay and south of Yachats in June.

BIOLOGICAL STUDIES

Sampling Methods

During the commercial season, our goal was to collect three samples a week from each major gear type. Samples were collected and processed as previously described (Starr and McCrae 1985). Whole weight, dorsal mantle length (DML), mantle weight, sex, and maturity stage (from Kashiwada and Recksiek 1978) were recorded for individual squid. Vessel name, date of landing, type of gear used, time, area, and depth of harvest were recorded for each sample. Area of harvest was recorded as Pacific Marine Fisheries Commission statistical block number. Area A refers to block 1226 (located between Cascade Head and Cape Foulweather), area B is block 1206 (between Cape Perpetua and Heceta Head), area C is block 1143 (just north of Coos Bay), and area D is block 1216 (between Yaquina Head and Seal Rock) (Figure 2). Stomach samples were taken for species composition analysis by Oregon State University researchers.

Six samples of adult squid were sent to Washington Department of Fisheries for electrophoretic studies. Some differences in the enzyme composition of squid were found between Oregon and Washington squid, but no definite conclusions were drawn (Bettinger 1986).

Fecundity Estimates

From captured live squid that spawned in an aquarium in 1985, we found that the average number of egg capsules laid per female was within the range of values reported by Fields (1965). However, the number of squid eggs per capsule was much lower than the average reported in the literature for squid from California (Fields 1965). We collected samples of egg capsules in 1986 to confirm these findings.

Egg capsules were collected from clumps found on the beach on two occasions (fifteen days apart). None were collected from commercial fishing boats (as was done in 1985). Capsules were processed as described by Starr and McCrae (1985); capsules were measured, cut longitudinally, and eggs gently removed. Only eyed embryos were counted to avoid double counting any broken eggs.

Two separate samples, from a total of 49 capsules, contained an average of 79 $\pm$ 7 (95% CI) eggs/capsule (Table 3). This is lower than last years average (98) and much lower than the range reported by Fields (1965) for California squid (180 - 300).

Table 3. Mean length and number of eggs per squid egg capsule, by sample, 1986.

Sample Date	6-10-(68)	6-25-86	Total
Average capsule length	52.5	76.6	56.9
Sample size (N)	40	9	49
95% C.I.	2.9	9.0	3.8
Average number eggs/capsule	71.9	111.1	79.1
Sample size (N)	40	9	49
95% C.I.	6.0	23.2	7.5

Morphometric Results

In 1986, we sampled over 500 squid, mostly from one area near Heceta Head. Squid taken from the main sampling area were caught in 20 fm or less. Samples taken from the incidental catch of shrimp trawlers came from deeper waters (70-80 fm). One incidental trawl sample was high-graded and is not included in total average lengths and weights but is included in total sex ratio.

The between sample sex ratio varied less in 1986 than in past years (Figure 4). The overall sex ratio of 51:49 shows a slightly higher percentage of females than in past years (Table 4). The decrease in variation between samples and the overall higher percentage of females may be due to the small number of samples taken this year, but may also be due to samples taken in the early part of the spawning activities. During the last two years, we noticed a shift in the sex ratio toward males near the end of the spawning activities, possibly because females were dying sooner. Samples taken only in the beginning of spawning activities would not show this shift and have a balanced ratio with more females than samples taken later in the spawning season.

Table 4. Total sex ratio (% M:F) of *L. opalescens* by year, by area, 1983-1986 (N).

Area	A	B	C	D	Total (*)
1983				73:27(589)	71:29 (1290)
1984	57:43(1801)	59:41(3894)	51:49(552)		57:43 (6643)
1985		56:44(3214)	9:91(106)		54:46 (3652)
1986		55:45 (352)			51:49 (541)
Total	57:43(1801)	58:42(7460)	45:55 (658)	73:27 (589)	57:43(12126)

(*) Includes incidental catches from other areas.

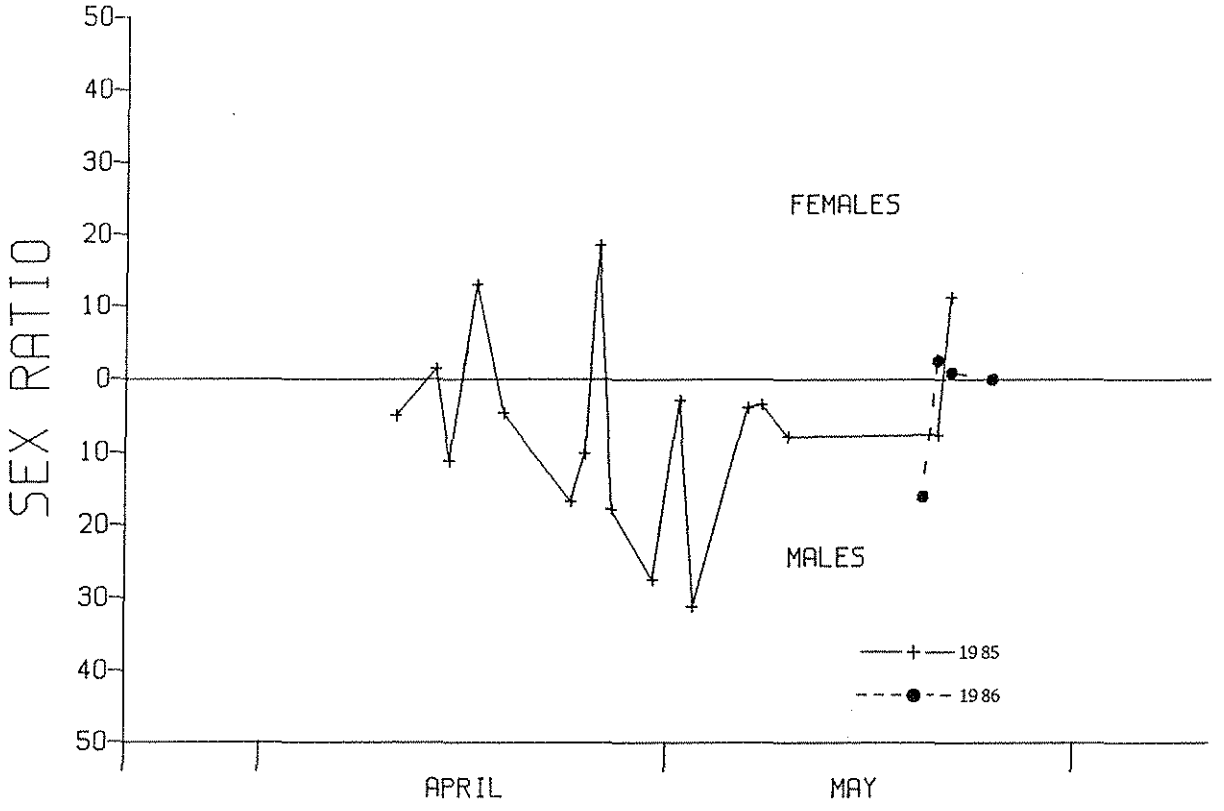

Figure 4. Sex ratio (%) of L. opalescens sampled in 1985 and 1986 (standardized to purse seine gear only).

This year, mantle lengths were distributed around a mode of 125 mm (Figure 5). This is a smaller mode than in 1985 (130 mm) but larger than in 1984 (115 mm). The average dorsal mantle length (DML) of all animals collected in 1986 was 122.9 ± 1.4 mm (95% CI) (Table 5); DML ranged from 60-160 mm. Averages were less than in 1985 but greater than in 1984. Average lengths of males and females were 123.3 ± 2.0 and 122.4 ± 3.1 mm, respectively.

The average DML of squid from the main sampling area was slightly larger (126.1 ± 1.3 mm) than the overall average (as it was last year), with a range of 89-161 mm. This difference is significant at the 95% level. The average

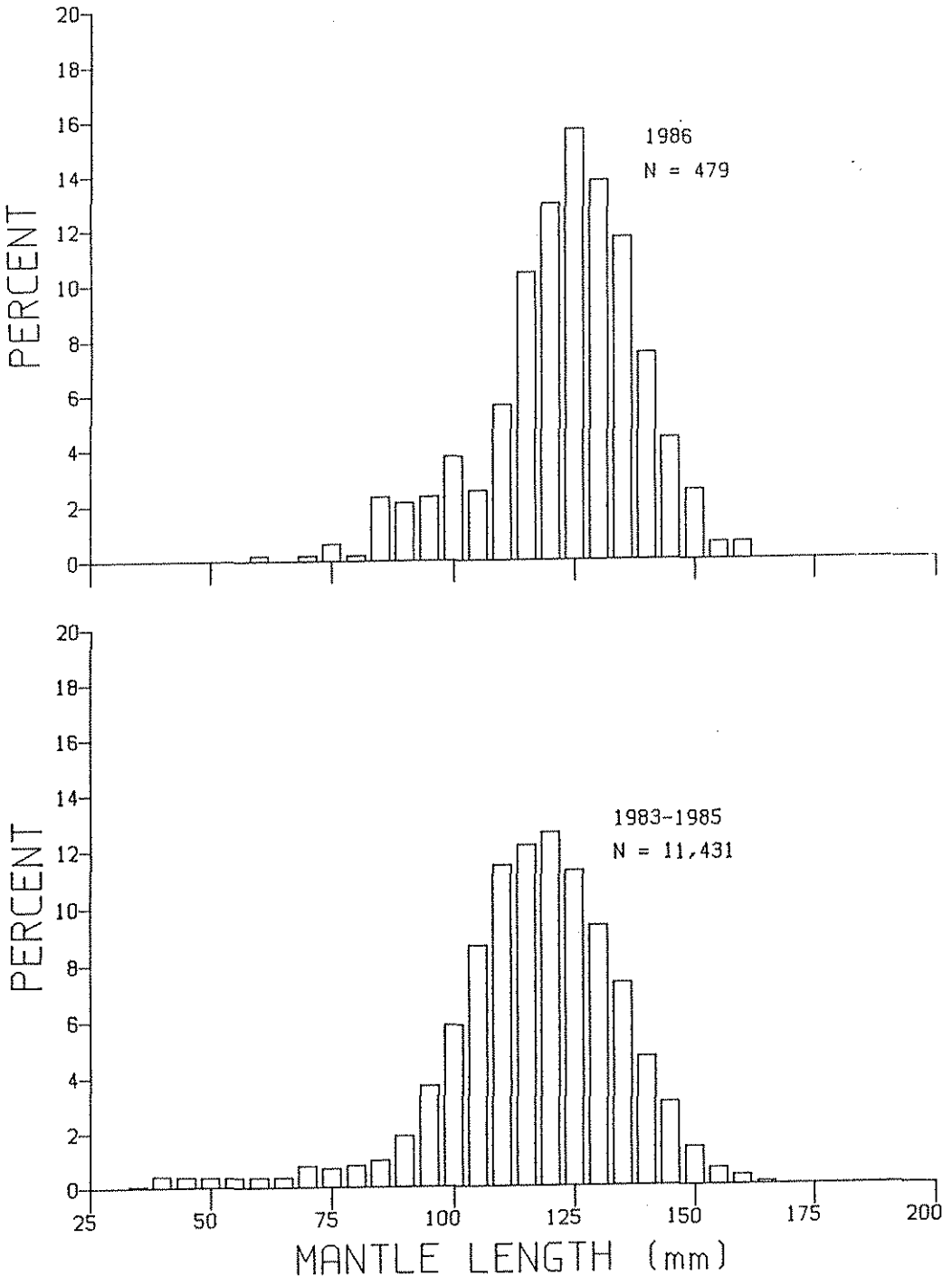

Figure 5. Length frequency (%) of all L. opalescens sampled in 1986 and 1983-1985.

Table 5. Average dorsal mantle length (mm ± 95% C.I.), whole weight and mantle weight (gm ± 95% C.I.) of L. opalescens, by area, through time, 1986 (N).

	Date	Length	Whole weight	Mantle weight
Area B	5-19	127.3 ± 2.0 (127)	41.5 ± 2.1 (127)	19.6 ± 1.1 (127)
	5-20	132.1 ± 3.4 (40)	45.6 ± 4.8 (40)	22.3 ± 2.7 (40)
	5-21	129.4 ± 3.4 (57)	49.8 ± 3.7 (57)	24.9 ± 2.0 (57)
	5-24	121.5 ± 2.1 (128)	43.0 ± 2.0 (127)	22.0 ± 1.2 (126)
	Average	126.1 ± 1.3 (352)	43.9 ± 1.4 (351)	21.7 ± 0.8 (350)
Other areas	4-15	114.1 ± 3.5 (127)	36.3 ± 2.7 (127)	18.5 ± 1.4 (127)
Overall average		122.9 ± 1.4 (479)	41.8 ± 1.3 (478)	20.8 ± 0.7 (477)

lengths for males and females from the main sample area were 126.3 ± 2.0 and 125.8 ± 1.4 mm, respectively. In 1985, the larger length of squid from the main sample area was due to very small squid in the catches from other areas. This year, the difference in lengths may be because the incidental samples from other areas were taken more than a month before the samples from the main area were collected, giving the squid from the main area time to increase in size.

As would be expected from average lengths, average whole and mantle weights were less than in 1985, but greater than in 1984. Average whole and mantle weights, for 1986, were 41.8 ± 1.3 (95% CI) and 20.8 ± 0.7 gm, respectively, (Table 5). Lengths, weights, and ratio showed the same pattern between maturity conditions as in past years; increased between conditions 1-3, then dropped in condition 4 (Figures 6-8).

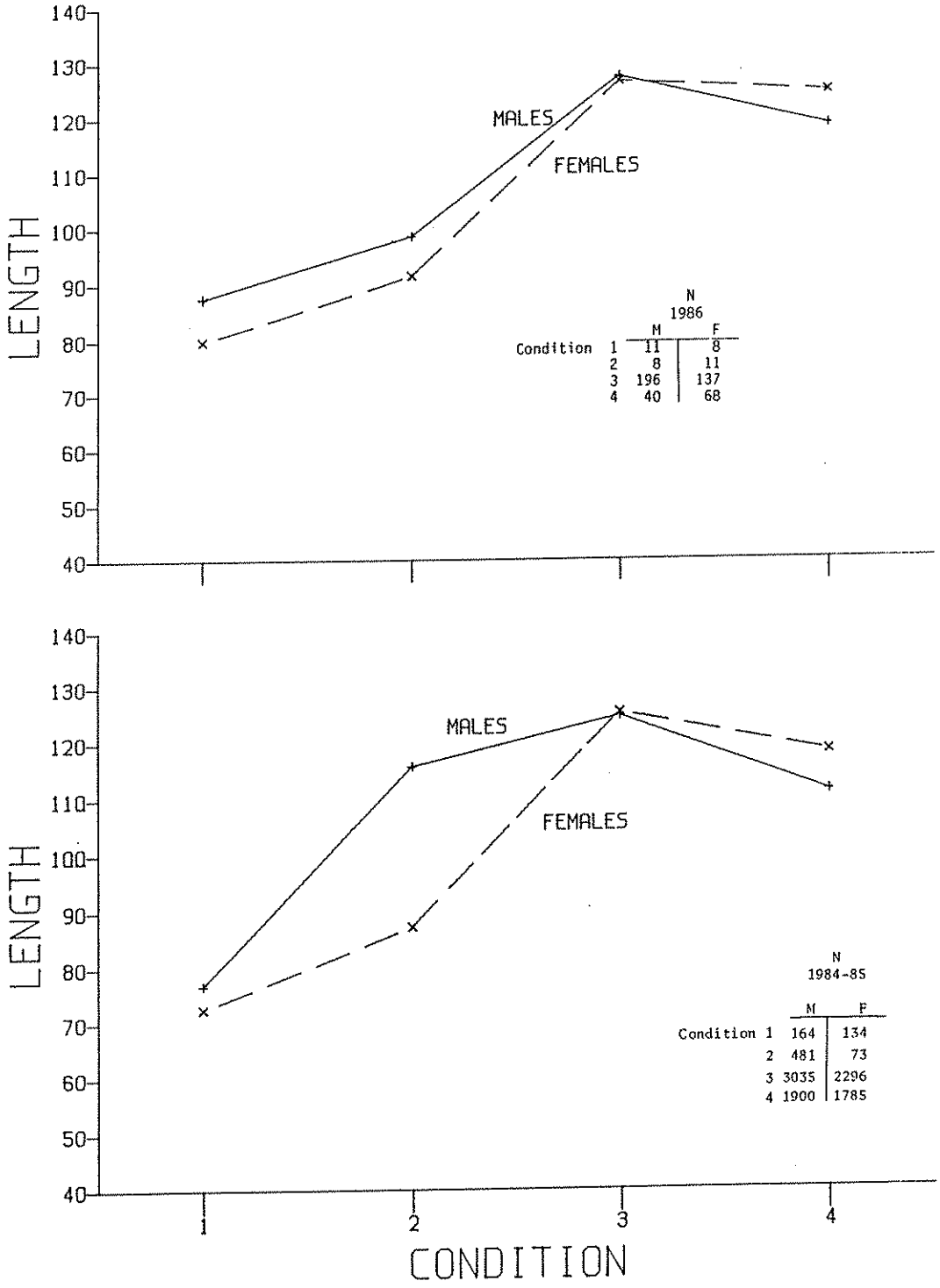

Figure 6. Average dorsal mantle length (mm), by maturity condition and sex, for all squid sampled from the commercial fisheries, 1986 and 1984-1985.

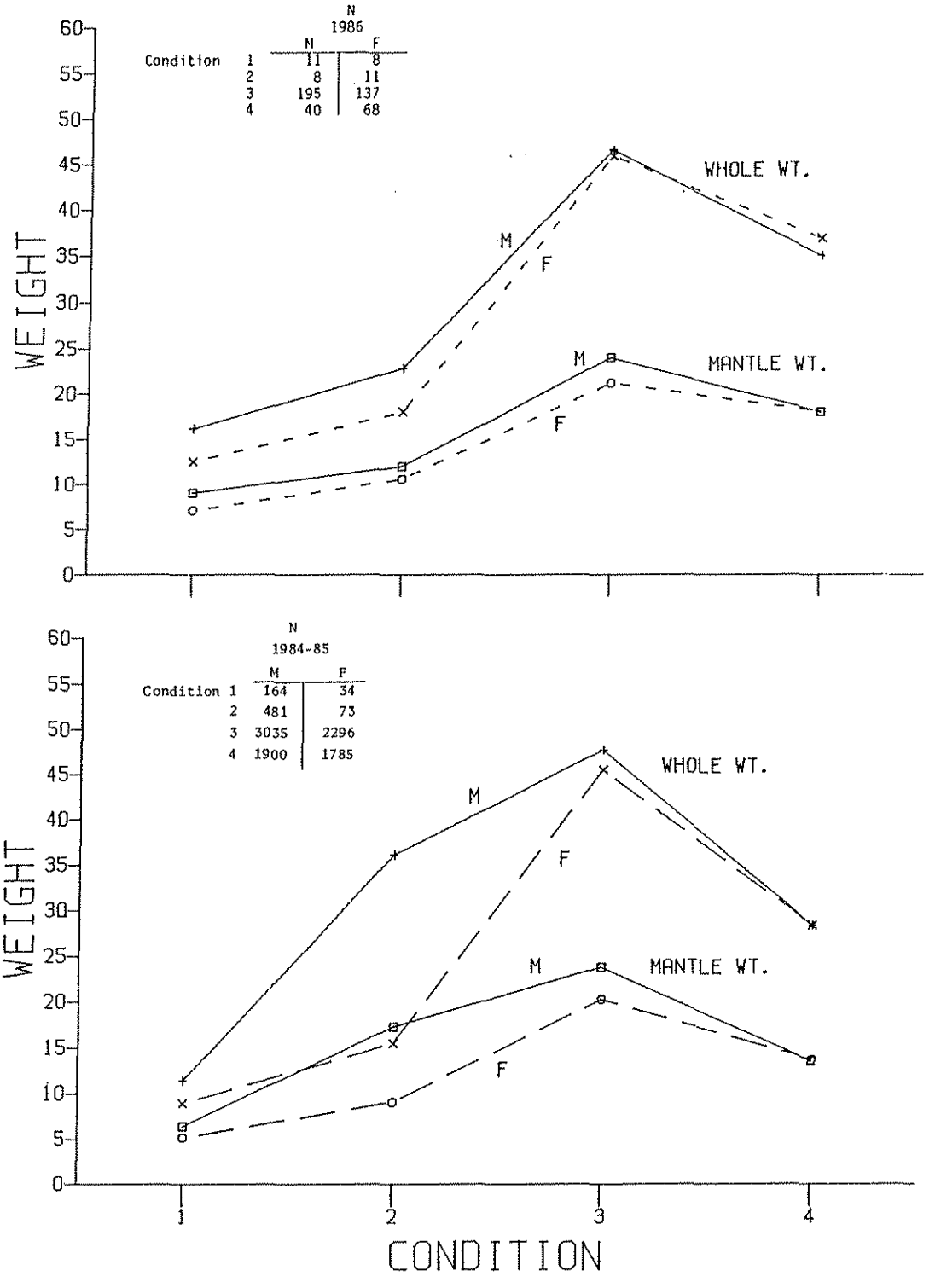

Figure 7. Average whole and mantle weight (gm) by maturity condition and sex, for all squid sampled from the commercial fisheries, 1986 and 1984-1985.

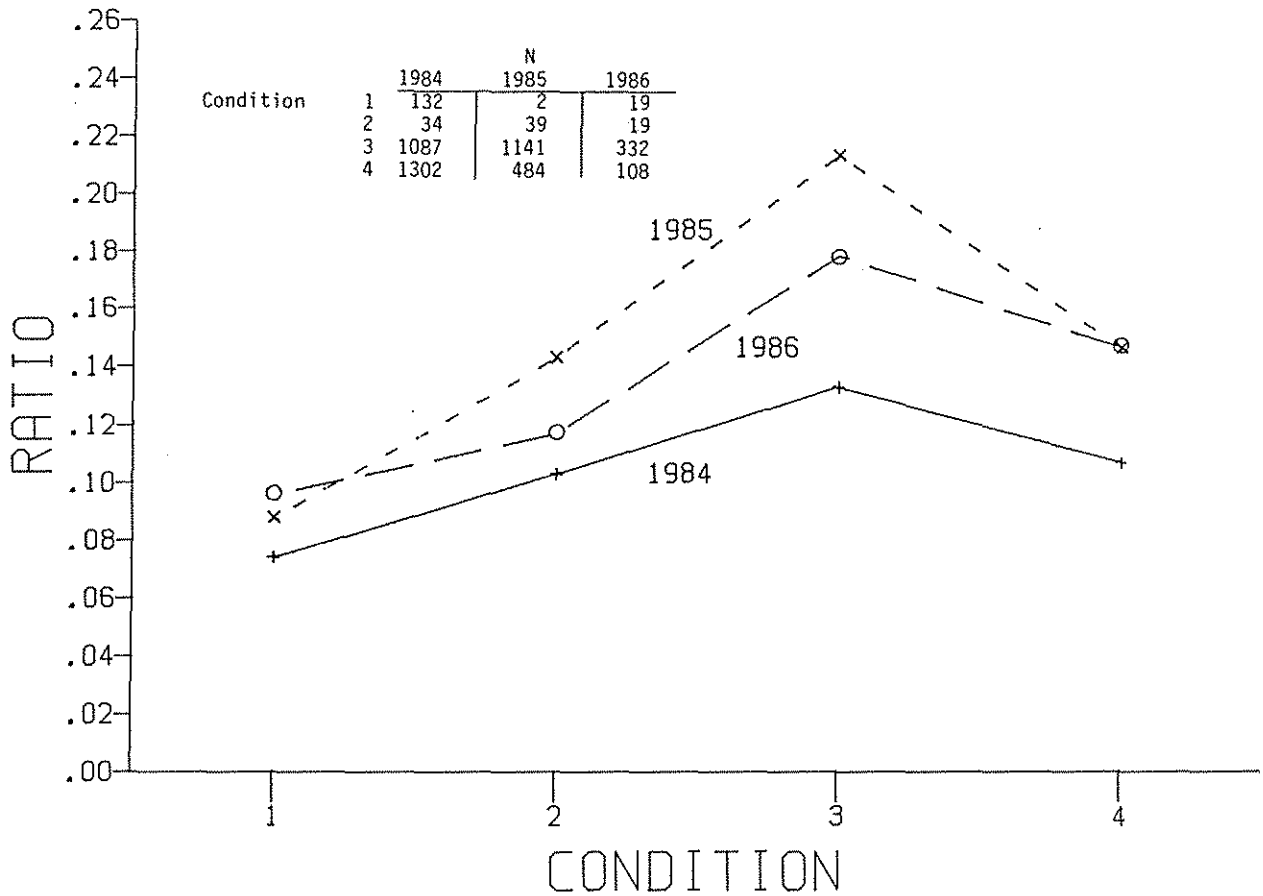

Figure 8. Average ratio of mantle weight to dorsal mantle length, for L. opalescens, by condition, 1984-1986.

With the short sampling period in 1986, we did not have enough data points to show any other trends over time as we have with previous year's data. We feel the data may have shown the same trend of decreasing values with a longer sampling period, because, in the last sample, all parameters showed a slight decrease (Figures 9-12).

More than a month before the main landings of squid, pink shrimp fishermen commented that they saw more squid than usual in their trawl catches. We collected two samples of squid taken as by-catch to the shrimp fishery. These squid were taken in relatively deep waters for spawning concentrations of squid to be located (70-80 fm). At first we reasoned these squid were beginning to school up on their way inshore to their shallower spawning areas; yet each sample contained a higher percentage of spawned animals than we would have expected (8.1 and 12.6%). We have not located any reference in the literature that L. opalescens spawn at these deeper depths. We will be taking more samples next year from shrimp by-catch to see whether spawning in deep water is a regular occurrence.

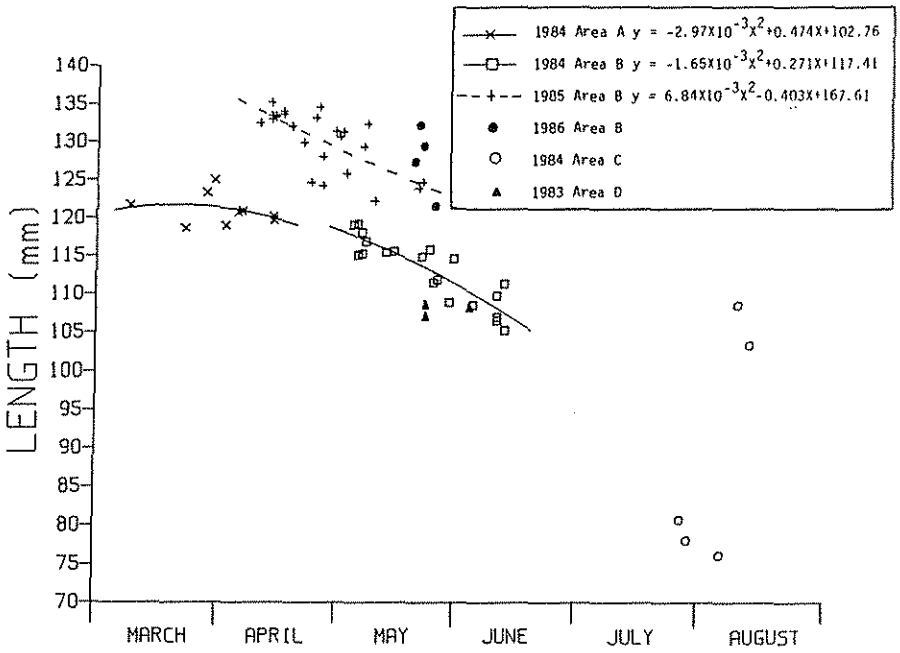

Figure 9. Average dorsal mantle length of squid sampled from each school, by year, 1983-1986.

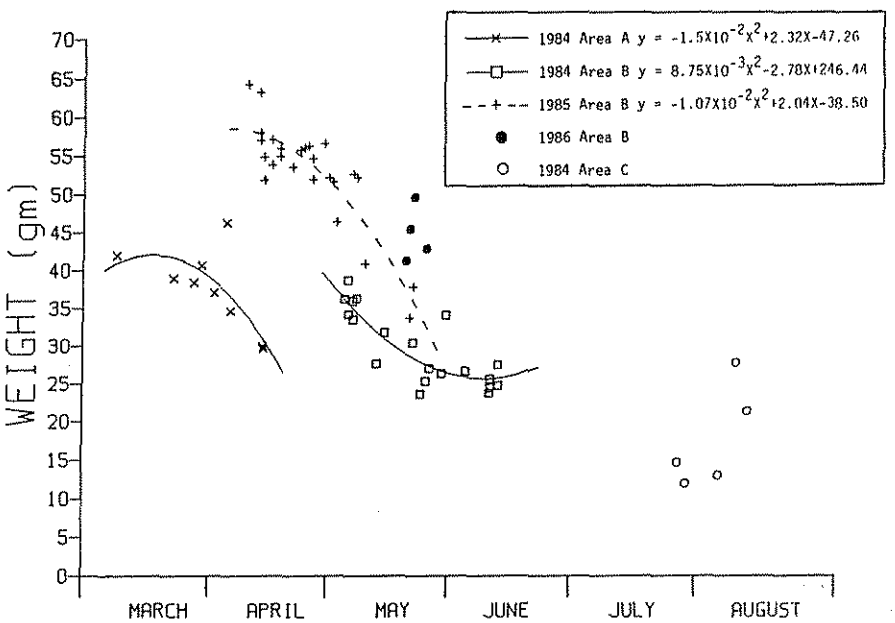

Figure 10. Average whole weight of squid sampled from each school, by year, 1984-1986.

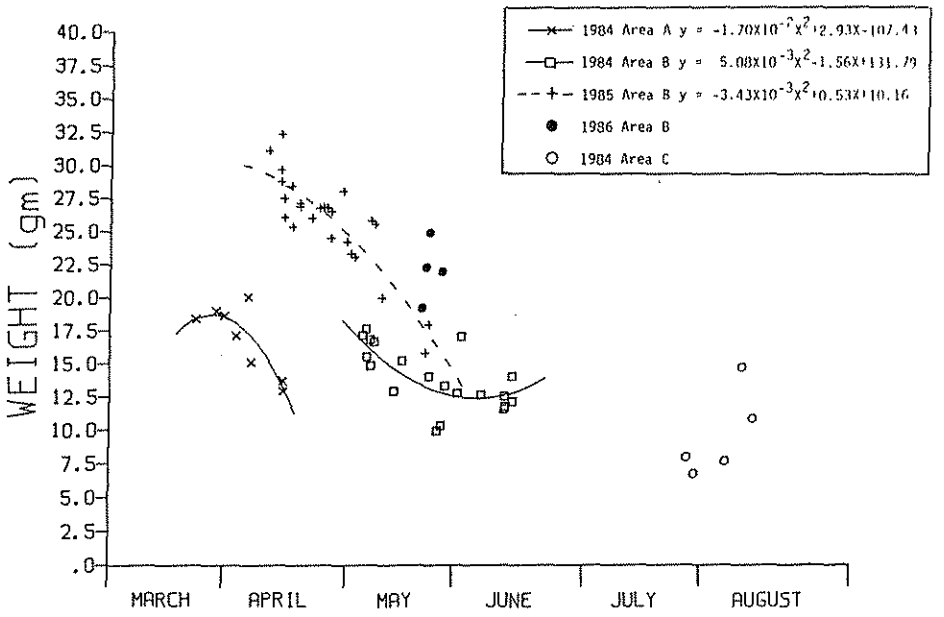

Figure 11. Average mantle weight of squid sampled from each school, by year, 1984-1986.

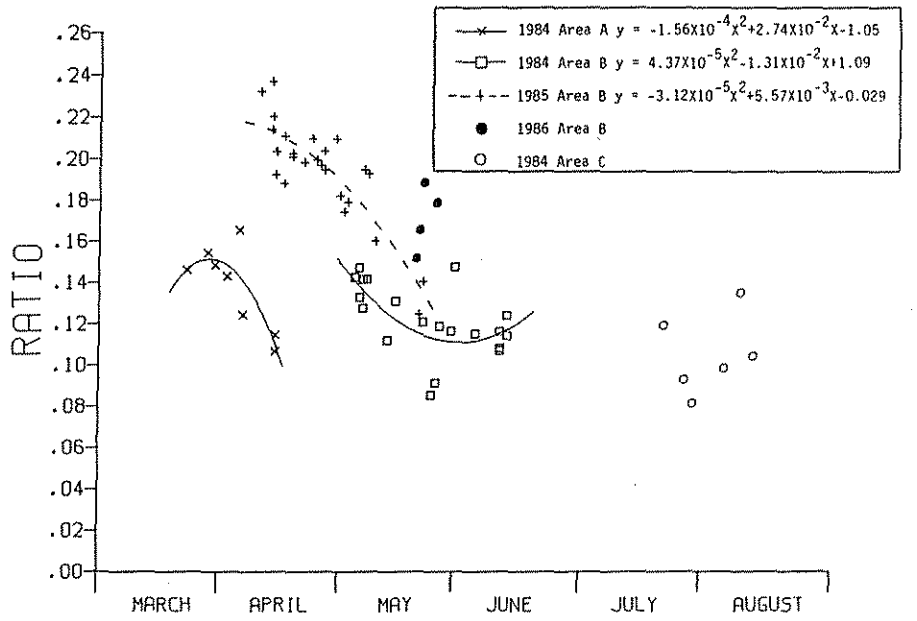

Figure 12. Average ratio of mantle weight to dorsal mantle length of squid sampled from each school, by year, 1984-1986.

SUMMARY

It is quite likely that squid arrived in large schools to spawn this year but were not detected. Large concentrations of squid could spawn undetected if vessels searched in the wrong place or at the wrong time. We had numerous reports from charter boat owners of large quantities of squid between Cape Meares and Cape Falcon. These reports were not investigated since only a few vessels searched for squid in April and May and they looked only in the central coast area. Also, those vessels were hampered by weather. On several occasions large schools of what was presumed to be squid were observed between Newport and Heceta Head, but the seas were too rough to safely fish. In each case, when the weather calmed enough to fish (usually days later), squid schools could not be relocated.

The biological data collected from market samples indicate that the squid caught in 1986 had similar characteristics as squid harvested from 1983 to 1985. Parameters measured also showed trends similar to those observed in previous years.

ACKNOWLEDGMENTS

Many people made contributions to collecting information for this report. We thank all the Marine Region personnel for their help in working up squid samples in the lab. Steve Jones spent many hours at sea observing fishing operations. All the crew members and skippers of squid vessels and personnel at the processing plants were very helpful and cooperative. We thank Tom Gaumer and Mark Saelens for their editing of the report.

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