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NATIONAL MARINE FISHERIES SERVICE
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REPORT OF THE SQUID WORKSHOP

Sponsored by
Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii
and
University of Hawaii Sea Grant Program
Honolulu, Hawaii
16 February 1982

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INTRODUCTION

In recent years there has been a growing interest by the domestic fishing industry in the southeastern and northeastern United States in the potential for a squid fishery in their respective areas. In Hawaii also the National Marine Fisheries Service's (NMFS) Southwest Fisheries Center (SWFC), Honolulu Laboratory has demonstrated its interest in squids by initiating in January 1981, a cooperative squid research venture with the University of Hokkaido, which included a series of squid assessment cruises in Hawaiian waters. To more fully understand the status of squids in the marine ecosystem around Hawaii, the NMFS Honolulu Laboratory, with support from the University of Hawaii Sea Grant Program, held a squid workshop on 16 February 1982 at the Honolulu Laboratory. The workshop was timed to take advantage of the presence in Honolulu of Dr. Tsuneyoshi Suzuki, Faculty of Fisheries, University of Hokkaido, an acknowledged expert in squid fishing and research. The workshop was co-chaired by Dr. Suzuki and Mr. Richard S. Shomura, Director, Honolulu Laboratory.

The workshop agenda is shown in Appendix 1 and the participants are listed in Appendix 2.

PROCEEDINGS

I. Opening Address

Mr. Shomura welcomed the participants to the workshop. He gave a brief account of the background of the cooperative squid research venture between the Honolulu Laboratory and the University of Hokkaido and suggested that the workshop focus on three major areas:

(1) The status of squid fisheries in the Pacific basin with emphasis on Hawaii.

(2) Results of the first two cooperative research cruises in Hawaiian waters.

(3) The future (need and strategy) of squid research in the Hawaiian and Northwestern Hawaiian Island (NWHI).

II. Status of Squid Fisheries in Pacific Basin

A. Eastern and Central Pacific

Mr. Walter M. Matsumoto, SWFC Honolulu Laboratory, presented background information describing the present squid fisheries in the eastern and central Pacific. The three fisheries he mentioned were those off California, Hawaii, and Peru. The California fishery, which is by far the largest squid fishery in the United States, landed 1,200-9,000 metric tons (mt) annually between 1950 and 1967. Since 1967 the landings have averaged 11,000 mt, reaching highs of 17,000 mt in 1978 and 16,000 mt in 1979. The squid taken was reported as the common market squid, Loligo opalescens. A few tons of jumbo squid, Dosidicus gigas, have been landed occasionally from southern California, but not in large enough quantities to sustain a fishery.

Mr. Matsumoto further reported that the California fishery was essentially two fisheries: The first, off Monterey with annual landings of 3,000-9,000 mt in the 1963-74 period, which dropped to 2,000 mt in 1975 and 1976; and the second, located mainly around the islands off the Los Angeles area with annual landings of 3,000-8,000 mt. The catches at Monterey were made almost entirely by lampara nets, since purse seines were outlawed by the State and in the Bay area in 1953 and the use of lights to attract and aggregate squids was banned in 1959. The latter action practically eliminated the use of brail in the Monterey fishery. In the southern California fishery, the catches were made mostly by purse seines (80-95% in most years), but in some years, as much as 56-66% of the catches were made by power-assisted brail, used in conjunction with attracting lights.

Part of the squid catches in California was canned with nearly all of the canned product being exported to Europe, Latin America, and the Orient, particularly the Philippines, and part of the catch was utilized domestically as frozen food products and as bait in both commercial and recreational fisheries. In 1976 California canned 3,299 mt of squid and processed 3,076 mt as frozen or fresh products. The remaining 3,000 mt were most likely used as bait.

Mr. Matsumoto reported that the only other fishery for squids in the eastern Pacific was that off Peru, which had an annual catch of 1,092 mt in 1976, but is now around 250 mt. The catches there were composed mostly of Loligo sp. He also reported that

the squid fishery in Hawaii was small, with annual catches of about 3.6 mt. Of this total, 3.2 mt were reported from the island of Hawaii and 0.4 mt from Kauai. Nearly all of the catch, 3.4 mt, were taken by handlines.

During the discussion that followed, it was brought out that experimental fishing by the Japanese in the Gulf of Mexico in 1971 was a stimulus for the development of a fishery for D. gigas in Mexico. The abundance of squids off Chile in some years was mentioned; however, the prospect of developing a squid fishery there in the immediate future was discounted, since squids are reportedly not favored by the population.

B. Western Pacific

Dr. Suzuki presented the status of the squid fishery in Japan, where the most intensive utilization of the cephalopods is being practiced. In 1968 the cephalopod catch by Japan was 887,000 mt, which was almost 10% of the total Japanese catch of all marine animals and represented approximately 72% of the total world cephalopod catch of 1.2 million mt. He stated that the most important species taken was Todarodes pacificus, which yielded annual catches ranging from 200,000 to 700,000 mt. In the last few years (up to 1979) the catch has declined to slightly over 200,000 mt.

Dr. Suzuki reported that in the 1940's T. pacificus was exploited by nonpowered boats of 1 to 2 tons. Powered boats of 10 to 30 tons, using many more jig lines and battery-powered lamps were introduced in the 1950's, and 50- to 100-ton boats equipped with motor-driven jigging machines, powerful lights, and quick-freezers were introduced in the 1960's. These were followed by even larger vessels in the 100- to 300-ton class in the 1970's. The rapid development of the fishery was made possible by intensive study of the biology of the species and technological advances in vessel hull and engine design, and particularly in the light-attracting system and the automated jigging machines.

He reported that the study of T. pacificus has far outstripped that of other squid species and has been instrumental in extending the fishery into offshore waters. He cited as an example the development of the offshore fishery in the Sea of Japan, where dense schools appear in the surface layer along the Polar Front formed by the warm Tsushima Current and the cold Liman Current off Korea. The area yielded some 200,000 mt in 1975, but has now fallen to less than 100,000 mt. He further reported that the lifespan of T. pacificus is only 1 year, during which time the squid migrates north in summer from southern Japan to the Kurile Islands and Sakhalin and returns south in autumn and winter. Dr. Suzuki then described the three squid subpopulations in Japanese waters, the first breeding in

winter (December to March), the second breeding in summer (July to August), and the third breeding in autumn (October to December), and the specific route taken by each in the north-south migration.

Dr. Suzuki then focused on another species, Ommastrephes bartramii, harvested commercially in Japan. He stated that this species is distributed widely in the world's temperate and tropical zones, that it grows to about 40.0 cm, and that it is usually found in more offshore waters than T. pacificus. He reported that the main fishing grounds are in the southern part of Hokkaido in the North Pacific, in the transitional zone between the warm Kuroshio and cold Oyashio. The catch of this species increased from 30,000 mt in 1975 to between 120,000 and 150,000 mt in more recent years.

III. Species of Squids in Hawaiian Waters

Dr. Richard E. Young, Department of Oceanography, University of Hawaii, presented information about the species of squids found in Hawaiian waters. He reported that there were about 62 squid species here and that while most of these were small midwater forms, some Cranchia approached 2.7 m (9 ft) in length, while other deepwater forms with gelatinous bodies were as large as 1.8-2.4 m (6-8 ft). He also noted that the giant squid, Architeuthis sp., which grows to 7.6 m (25 ft) or more, was occasionally taken, but this species was not very good eating. He described the following edible species as being present in Hawaii:

(1) Sepioteuthis (loliginid) - A good eating squid growing to about 60 cm, but not common in shallow waters.

(2) Thysanoteuthis rhombus - A squid that appears occasionally and is believed to be responsible for the large masses of eggs seen floating on the ocean surface. It is extremely tasty and grows to about 1 m.

(3) Onychoteuthis borealijaponicus - In Hawaii only small individuals of this species have been taken occasionally in drift gill nets. Some species of Onychoteuthis are caught commercially in other areas of the Pacific.

(4) Ommastrephes bartramii - A squid that is widely distributed over the subtropical and temperate waters of the Pacific and is caught commercially by the Japanese. It is not uncommon in Hawaiian waters, where large individuals over 30 cm have been taken.

(5) Hyaloteuthis pelagicus - A small squid with adults ranging from 4.4 to 8.1 cm or larger. It is generally distributed north of the Hawaiian Islands.

(6) Symplectoteuthis oualaniensis - A squid which occurs in greatest numbers in offshore waters. This is a small to medium squid (generally below 30 cm) which inhabits the tropical and subtropical areas of the Pacific and whose biomass is considered to be extremely large.

(7) Nototodarus hawaiiensis - A species found in inshore waters during summer, particularly off Hilo, where it is fished for and used as bait in the ika-shibi fishery. It disappears in winter and this has led to speculation that it dies after spawning.

Dr. Young also mentioned that Gonatus and Gonatopsis may be of commercial value, but squids of both these genera are not being fished by the Japanese due to poor eating quality.

IV. Role of Squids in Hawaiian Ecosystem

A. Squids as Food of Seabirds

Mr. Thomas S. Hida, SWFC Honolulu Laboratory presented the results of a study of squids regurgitated by seabirds in the NWHI from 1978 to 1981. A total of 4,315 samples from 18 seabird species from Oahu, French Frigate Shoals, Pearl and Hermes Reef, Necker, Nihoa, Laysan, Lisianski, Midway, and Kure Islands were processed. Squids were found in samples from all 18 seabird species. They were not considered important in the diet of the blue-gray noddy and the gray-backed terns, but were considered the most important prey items for the Laysan and black-footed albatrosses, sooty storm petrel, Bonin petrel, Christmas shearwater, wedge-tailed shearwater, and sooty tern. Importance was determined by a ranking system which considered total numbers, percent frequency, and average of percent volumes of each prey item in each sample.

Mr. Hida reported also that most of the identifiable squids were of the Family Ommastrephidae, of which the bulk were Symplectoteuthis. Symplectoteuthis oualaniensis was the most abundant species, followed by S. luminosa and a few Hyaloteuthis pelagicus. Other squids present in the samples in lesser amounts and lower frequencies were of the Families Cranchiidae, Lepidoteuthidae, Mastigoteuthidae, Onychoteuthidae, Histioteuthidae, and Octopoteuthidae. In addition, he stated that large numbers of beaks were found most frequently in the Laysan and black-footed albatrosses; the highest number, representing 171 squids, was from a Laysan albatross.

Most of the measurable squids had mean mantle lengths ranging between 50 and 100 mm and the largest squid measured was a 208-mm specimen from a red-footed booby. Even larger squids, with mantle lengths estimated in excess of 300 mm, on the basis of beak size, were eaten by albatrosses.

During the discussion that followed, it was noted that Nototodarus was not listed among the squids consumed by seabirds, and a suggestion was made to extend the sampling to the area off Hilo. However, the bird population there was considered small and difficult to sample, since nesting occurred predominantly along the face of cliffs and sharp drop-offs. To a question concerning marine mammals as possible predators of squids, Mr. William G. Gilmartin, SWFC Honolulu Laboratory, stated that monk seals were not feeding on squids in the NWHI area and suggested the porpoise as a possible predator.

B. Squids as Bait in Ika-Shibi Fishery

Mr. Walter N. Ikehara, SWFC Honolulu Laboratory, discussed the squids as bait in the ika-shibi fishery off Hilo. He pointed out that the ika-shibi fishery landed 816 mt (1.8 million lb) of yellowfin tuna, 44 mt (96,000 lb) of albacore and 29 mt (64,000 lb) of bigeye tuna in 1980, valued at $2.8 million, and that the amount of squid used as bait was 2.6 mt (5,632 lb), valued at $4,300. He reported that although squid was reported to last longer as bait than opelu, most fishermen preferred the latter. However, squid was used as bait whenever it was caught. Fishing for squid was done at a maximum depth of 55 m (30 fathoms) with the aid of a 25-W incandescent lamp placed underwater near the surface. Symplectoteuthis oualaniensis was the most prevalent species observed in November, with the largest being about 28- to 30-cm mantle length. The typical squid catch, however, consisted of smaller sizes. He also reported that a few Thysanoteuthis were also caught occasionally during his observation. Mr. Ikehara reported that the squid fishery off Kauai was seasonal, as in Hilo, and that the catches were centered off Port Allen during the summer and fall months.

V. Results of Cooperative Squid Research

Mr. Matsumoto presented the results of the two Honolulu Laboratory-Hokkaido University cooperative squid cruises made in Hawaiian waters in January-February 1981 and 1982. Fishing on both cruises was done with automatic squid jigging machines, supplemented by handlines, rod and reels, drift gill net, and midwater trawl. For the most part, 3 jigging machines, each consisting of 2 lines with 30 jigs spaced 1 m apart on the first 30 m of line, were fished on the first cruise and 4 machines were fished on the second. The machines were set to fish at maximum depths of 40 to 80 m. The gill net consisted of 64 shackles of monofilament net, with mesh sizes ranging from 25 to 233 mm. Units of 3 shackles of each mesh size were arranged randomly by mesh size with both ends of the string consisting of 5 shackles of 121-mm mesh nets. The midwater trawl had a mouth opening of 15 x 15 m and a cod end made of 2-mm square mesh liner.

Mr. Matsumoto reported that on the first cruise (1981), 661 squids were caught at 15 stations by jigging and fishing with handlines and rod and reels around the main Hawaiian Islands between Lanai and Kauai. The best catches (100-200 squids per station) were obtained in calm seas south of Oahu and Lanai, where the bottom was 900 m or greater. Stations fished in rough seas resulted in less than 20 squids per night. Only 11 squids were caught in the NWHI where 4 stations were fished for 1 to 2 hours only. Mr. Matsumoto noted that S. oualaniensis comprised the bulk of the catch for the entire cruise (659 squids), with the remaining catch consisting of 12 O. bartramii and 1 N. hawaiiensis. Mantle lengths of squids caught by jigging ranged between 10.0 and 26.0 cm and all squids over 28 cm were taken on rod and reel. He further reported that 8 gill net stations yielded 9 S. oualaniensis (13.5-25.5 cm), 5 O. bartramii (22.3-35.5 cm), and 3 Onychoteuthis borealijaponicus (8.5-10.6 cm). Two midwater trawl hauls with the net towed at 100 and 600 m in the afternoon off Penguin Bank failed to catch any squid.

On the second cruise (1982) 14 automatic jigging stations produced 135 squids, all S. oualaniensis, of which 8 were caught by rod and reel. No squid was taken at 2 stations, both stations in depths of less than 600 m. Six large squids estimated at 75 to 100 cm and identified as Thysanoteuthis were observed at the surface off Kaneohe at one of the shallow stations. The poor catches on this cruise were probably due to continuous rough seas and winds of 18-15 knots throughout most of the sampling period.

Mr. Matsumoto noted that the gill net catches were about the same as that obtained on the first cruise. The catch included nine S. oualaniensis, three O. bartramii, and four Onychoteuthis spp. Four hauls with the midwater trawl, with the net towed well above and in the deep scattering layer, produced 53 small squids, all less than 50 mm, representing the genera Abralia, Abraliopsis, Cranchia, Eledonella, Heteroteuthis, Histioteuthis, Hyaloteuthis, Leachia, Liocranchia, Megalocranchia, Onychoteuthis, Pyroteuthis, and Sandalops.

Mr. Matsumoto ended his presentation by saying that on the basis of size alone, both S. oualaniensis and O. bartramii could be likely candidates for commercial development and that the small catches obtained on the two cruises were likely due to poor fishing conditions and unfavorable seasonal timing. He noted that the near absence of N. hawaiiensis, one of the species taken in the ika-shibi fishery during summer and a likely candidate for commercial development, may well have been due to unfavorable timing also.

VI. Biological Results of First Cooperative Cruise

A. Analysis of Squids Caught

Dr. Suzuki presented the results of some of the analyses made of the squid data collected on the first cruise. Of 400 squids

(S. oualaniensis) analyzed, about 25% (99) were males and 75% (298) were females. Of the males, 9% (9) were immature, 8% (8) were maturing, and 82% (81) were mature. Of the females, 96% (286) were immature and 4% (12) were mature. A further breakdown of the females indicated that of the immature group, 9% (26) showed signs of having undergone coition, 90% (257) had not, and 1% (3) was undetermined; and of the mature group 50% (6) showed positive signs of coition, 42% (5) were negative, and 8% (1) were undetermined. Males with evidence of coition ranged in sizes from 10.0 to 17.8 cm, with a mean of 13.9 cm; whereas the lengths of females ranged from 11.0 to 25.0 cm, with a mean of 15.5 cm. Dr. Suzuki noted that males of S. oualaniensis in Hawaii matured at smaller sizes than females, not unlike T. pacificus taken in Japanese waters.

Dr. Suzuki also reported that there were significant positive correlations ($P = 0.05$) between liver weight and mantle length, liver weight and body weight, and liver weight and gonad weight in both males and females grouped in coition B category.

B. Gonad Studies

Dr. Young presented preliminary results of a study conducted aboard the Hokusei Maru on the first cruise in collaboration with Dr. Raymond Hixon, Universty of Texas-Galveston. Dr. Young reported that the study was done to determine whether S. oualaniensis spawn more than once during the season. From their examination of gonads and oviducts they noted (1) that the fully matured squids ranged widely in sizes; some were mature at 20 cm, while others were mature for the first time at 30 cm, (2) that unlike squids in temperate waters, where spawned-out individuals have no eggs remaining in the ovary, squids that spawn in Hawaiian waters had eggs remaining in the ovary, some with the ovaries fully packed, (3) that the oviduct was a repository for eggs freed from the ovary, (4) that this species of squid spawns as the oviduct fills up, (5) that there was no evidence that the ovaries decreased in size as eggs were spawned, and (6) that, as expected, there was no significant correlation between egg volumes in the oviduct and mantle length.

Dr. Young felt that some squids they had examined were not mature for the first time, i.e., that they may have spawned before.

On the basis of these findings, Dr. Young believed that this species spawns continuously throughout the season in Hawaiian waters but that further work was needed to determine this more conclusively. He reported that Dr. Hixon is now in the process of examining the size frequencies of eggs in the ovary for additional evidence of multiple spawning.

VII. Future Squid Research in Hawaiian Waters

Mr. Shomura led the discussion on the future of squid research in Hawaiian waters. The discussion dwelled on the following points:

(1) State of knowledge of squids in Hawaiian waters.--It was felt that the identification of squids was fairly well in hand for Hawaiian waters, but that there was practically no information on spawning, spawning grounds, growth, and other aspects of squid life history and biology. Much of this was due to the lack of effort and the difficulty of obtaining squids in the younger stages up to the sizes taken by jigging. It was pointed out that extension of sampling in the NWHI will introduce yet another species of Symplectoteuthis, of which equally little is known.

(2) Sampling for squids.--To overcome the difficulty of obtaining squids for study, it was suggested that sampling be done off Hilo, since low cost support could be available from the ika-shibi fishing boats and because of the occurrence of both S. oualaniensis and N. hawaiiensis there.

It was further suggested that the Townsend Cromwell be used for squid sampling, particularly during the summer, to complement the winter cruises made by the Hokusei Maru. It was felt that the use of the Cromwell would lessen the objection by ika-shibi fishermen to squid research in local waters. The sampling gear recommended for the Cromwell included at least one or two automatic jigging machines, rod and reel or handline, gill net, and midwater trawl.

(3) Catches by the Hokusei Maru.--The small catches obtained on the two Hokusei Maru cruises were questioned. Dr. Suzuki responded by saying that the methods of sampling used were identical to gear used commercially in the Japanese squid fisheries. He felt that the clarity of the water here was largely responsible for the poor catch, since at many jigging stations squids were seen to pursue a jig to the surface, stop a few inches away, and depart, without attempting to take the jig. To improve the catch, chumming with bait during jigging was suggested.

(4) Future cruise by the Hokusei Maru.--The outlook for next year's Hokusei Maru cruise was discussed. Dr. Suzuki commented that they had committed the ship for this venture for 3 years and will honor their commitment. He suggested fishing off Kona or Hilo rather than to repeat fishing in the same areas fished on the past two cruises. A suggestion was made to fish off Pepeekeo and Kumakahi Point, Hawaii; however, this was not considered feasible with the Hokusei Maru because of the strong objections certain to be voiced by the Hilo fishermen, as they had done prior to the first cruise. Mr. Shomura felt that any work in the vicinity of local squid fishing areas would best be done with our own vessel.

(5) Alternate sampling strategy.--Alternate strategy to best sample squids in local waters was discussed. It was noted that squids are known to be fairly localized in certain areas, such as off Pepeekeo. Suggestions were made that the area be examined for any signs of unusual oceanographic features or to look for other areas with local upwelling and to concentrate sampling in such areas.

VIII. Summary

Mr. Shomura summarized the proceedings of the workshop. He touched upon the topics discussed, the general lack of information about growth, mortality, stock assessment, and other aspects pertaining to squids in local waters, and on the need for some preliminary work in areas off the island of Hawaii. He mentioned that some work on squids was in the Laboratory's plans in the near future, that he hoped to get the Cromwell to do some squid fishing next winter prior to the ship's departure for the west coast, and that he hoped the Hokusei Maru returns again for another cruise.

Submitted by:

Tsuneyoshi Suzuki
Co-Chairman

Richard S. Shomura
Co-Chairman

APPENDIX 1

AGENDA

0900 - Opening remarks (R. Shomura)

0910 - Status of squid fisheries in the Pacific basin (W. Matsumoto and T. Suzuki)

1020 - Species of squids in Hawaiian waters (R. Young)

1030 - Importance of squids in the Hawaiian ecosystem (T. Hida and W. Ikehara)

1100 - Results of two cooperative squid research cruises (W. Matsumoto)

1200 - Lunch

1330 - Biological results of first cooperative squid research cruise (T. Suzuki and R. Young)

1500 - Open discussion on future of squid research in Hawaiian waters (R. Shomura)

1545 - Summary and closing remarks (R. Shomura)

APPENDIX 2

LIST OF PARTICIPANTS

William G. Gilmartin, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Dr. Richard W. Grigg, Hawaii Institute of Marine Biology, University of Hawaii

Thomas S. Hida, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Walter N. Ikehara, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Alvin Katekaru, Division of Aquatic Resources, State Department of Land and Natural Resources

Bert S. Kikkawa, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Walter M. Matsumoto, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

John J. Naughton, Western Pacific Program Office, Southwest Region, National Marine Fisheries Service

Eugene T. Nitta, Western Pacific Program Office, Southwest Region, National Marine Fisheries Service

Tamio Otsu, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Dr. James D. Parrish, U.S. Fish and Wildlife Service/Hawaii Cooperative Fishery Research Unit, University of Hawaii

Dr. Jeffrey J. Polovina, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Dr. Richard E. Young, Department of Oceanography, University of Hawaii

Michael P. Seki, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Richard S. Shomura, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Dr. Tsuneyoshi Suzuki, Faculty of Fisheries, Hokkaido University

Dr. Satoru Taguchi, Hawaii Institute of Marine Biology, University of Hawaii

Richard N. Uchida, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service

Howard O. Yoshida, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service