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MANAGEMENT INVESTIGATION OF TWO SPECIES OF SPINY LOBSTERS, PANULIRUS JAPONICUS AND P. PENICILLATUS

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MANAGEMENT INVESTIGATION OF TWO SPECIES OF SPINY LOBSTERS, PANULIRUS JAPONICUS AND P. PENICILLATUS[1/]

INTRODUCTION

Concern over the decline in harvest of the commercial spiny lobster fishery in the State of Hawaii from 1948 to 1960 precipitated a study of the spiny lobster in the hope that information gained could be utilized in promulgating regulations for the proper management of the resource.

The spiny lobsters, Panulirus japonicus and Panulirus penicillatus, are the two lobster species of importance in the sport and commercial fisheries of Hawaii. Two other spiny lobsters, Justitia longimanus and Panulirus inflatus, have been reported in Hawaiian waters (Tinker, 1965; Chace and Dumont, 1949), but they are extremely rare.

This report presents results of: 1) sampling and tagging conducted on spiny lobsters in Maunalua Bay, Oahu (1960-62); 2) juvenile P. japonicus rearing (1966); 3) studies on egg development (1969); and 4) notes on the biology and the fishery (exploitation and management) of the two species. The biological findings for P. japonicus and P. penicillatus are presented separately by species whereas the discussion on the fishery has been combined for the two species.

IDENTITY

Panulirus japonicus De Siebold

Synonomy

Palinurus japonicus De Siebold (1824); De Haan (1841)
Palinurus marginatus Quoy & Gaimard (1824); H. Milne Edwards (1837)
Palinurus longipes A. Milne Edwards (1868)
Palinurus guttatus Pfeffer (1881)
Senex femoristriga Ortmann (1891)
Senex japonicus Ortmann (1891)
Panulirus japonocum Galtsoff (1933)
Panulirus japonicus marginatus Chace & Dumont (1949)
Panulirus marginatus George & Holthuis (1965)

Taxonomy

Affinities

1/ The Bureau of Commercial Fisheries provided support under P.L. 88-309, Project No. H-5-R.

Phylum Arthropoda
Subphylum Crustacea
Class Malacostracea
Subclass Eucarida
Order Decapoda
Suborder Reptantia
Tribe Macrura
Family Palinuridae
Species Panulirus japonicus

Taxonomic Status

It seems that five species, namely, P. japonicus, P. longipes, P. cygnus, P. marginatus, and P. pascuensis are frequently synonymized because they lack conspicuous distinguishing morphological features (George, 1965). P. japonicus also closely resembles the Eastern Pacific P. interruptus and the Atlantic P. guttatus and P. echinatus.

Standard Common Name

Spiny lobster, lobster, ula (Hawaiian term).

Morphology

External Morphology

The carapace is covered with spines that point forward (Figure 1). The spines about the head and eyes are particularly large. The antennae are large, long, rounded and covered with spines that also point forward.

P. japonicus has two large and many small spines on the anterior dorsal surface of the carapace between the antennae, while P. penicillatus has only four large spines in this location (Tinker, 1965).

Specimens of P. japonicus are variable in coloration. The carapace varies between light yellow, light brown and dark brown, in addition, the brown coloration is generally associated with a reddish tint. The base of some large spines are yellowish-white, other spines are dark purple or black including those protecting the eyes.

The first few segments of the antennae are violaceous or indigo, the flagella are black.

The pereiopods are dark purple or black.

The six segments of the abdomen are violaceous or indigo with transverse yellow bands along the posterior margin and transverse groove of each segment.

The telson and uropods are bordered posteriorly by a thin yellowish-white stripe followed by a larger black bank; the remaining anterior portion is bluish-green.

Definition of Carapace Length

The term "Carapace Length" as used throughout this report is defined as the linear measurement of the carapace along the mid-dorsal line from the transverse ridge between the supra-orbital horns to the posterior margin of the carapace.

DISTRIBUTION

Total Area

The geographic distribution of P. japonicus is tropical Indo-Pacific from East Africa to Japan and throughout Polynesia.

Differential Distribution

Larvae and Juveniles

P. japonicus phyllosoma (larvae) are planktonic. Johnson (1968) found P. marginatus phyllosoma (synonym for P. japonicus) distributed from Midway Island to the southwest of Hawaii. He also found that P. marginatus phyllosoma were lacking at 16 scattered stations to the south and southeast of Hawaii in more equatorial areas. Only late-stage larvae were found far at sea to the northeast of the Hawaiian Archipelago and to the southwest of Hawaii in the vicinity of Johnston Island.

Juvenile lobsters are found in inshore reef areas during the entire year.

Adults

Adults are found in contact with the substrate from a few feet below the surface to depths of 100 fathoms. Rathbun (1906) reported a recovery off the north coast of the island of Maui at 69-78 fathoms. Strasburg et.al. (1968) reported seeing lobsters at 55 fathoms from the submersible "Asherah" occuring on the open bottom rather than in caves and beneath ledges. P. japonicus were recently captured off the north and west coast of the island of Molokai in depths ranging from about 60 to 100 fathoms (Bureau of Commercial Fisheries, 1968).

SCUBA observations reveal P. japonicus occuring under ledges and in caves either singly or in concentrated groups at moderate depths (from 1 to 100 feet).

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality

P. japonicus is heterosexual and exhibits dimorphism. Males have a genital orifice located on the coxopodite of the fifth pereiopod. Females have a genital orifice located on the coxopodite of the third pereiopod, and in addition, the terminal end of the fifth pereiopod on females is chelate (Figure 2).

Maturity

The smallest female P. japonicus carrying eggs had a carapace length of 53 mm and weighed 134 gm. This is probably close to the minimum size at maturity for this species.

Samples obtained in the Maunalua Bay, Oahu, tagging experiment ranged in carapace length from 56 to 132 mm and did not contain females less than 70 mm in carapace length or 227 gm in weight (Figure 3).

Mating

Lobsters are promiscuous. Males deposit a spermatophore on the ventral surface of the female's thorax between the fifth pair of pereiopods. Spermatophoric masses are found on females in berried condition and on females in all stages of ovary development. Samples from Maunalua Bay, Oahu, showed that 34 percent of the females were carrying spermatophoric masses during the year. Mating seems to be random and unrelated to ecdysis.

Fertilization

Fertilization is external and probably occurs at the time of egg laying or soon thereafter, provided a spermatophore (Figure 4) has been acquired by the female.

Fecundity

An estimate of the number of eggs laid at each spawning varies from 150,000 for a lobster with a carapace length of 70 mm to 575,000 for a lobster with a carapace length of 110 mm (Figure 5).

Development of internal eggs may occur while a female is berried; upon hatching of the external eggs, new eggs may then be laid. However, this phenomenon was observed infrequently and how often it occurs is not known.

Spawning

Spawning takes place throughout the year with peak activity occurring during May, June, July and August and low activity being apparent during November, December and January (Figure 6). An average of 41 percent of the P. japonicus females in Maunalua Bay, Oahu, were berried during the year with a range of 31 to 48 percent berried during January and June respectively.

It seems probable that females lay eggs four or five time a year. Tag recoveries (Table 1) indicate that females spawn at least twice a year.

A female P. japonicus was berried twice in 92 days indicating that at this rate of egg laying, four spawnings a year are possible. Unfortunately female lobsters were rarely recovered four times and none were recovered four times within the span of a single year.

Spawn

The longest egg incubation period observed during rearing experiments for lobsters taken with eggs was 30 days. Eggs are bright orange upon being laid and remain so for approximately three weeks before developing a brownish coloration (22 days observed). Hatching occurs approximately one week after the eggs turn brown.

Growth

Forty-nine juvenile P. japonicus ranging from 10 to 49 mm in carapace length were collected from Waimea Bay, Oahu in July, 1966 and reared at the Kewalo Fisheries Station for approximately six months. The young lobsters molted frequently with an increase of about 1-2 mm in carapace length at each molt (Appendix A). After several molts, 27 juvenile P. japonicus increased a total of 5 mm or more in carapace length (Appendix B).

Eight hundred ninety-three P. japonicus measuring 53 to 131 mm in carapace length were tagged and released from September, 1960 through August, 1962 in Maunalua Bay, Oahu. Dart tags (FM-5, Floy Tag Manufacturing Co.) were inserted into the abdominal musculature between the transverse groove of the first and second abdominal segments. Data on carapace lengths and body weights of 221 recaptured P. japonicus are given in Appendix C.

Thirty-one P. japonicus, 22 males and 9 females showed increases of 5 mm or more in carapace length during the tagging study (Appendix D). The data suggests that the growth rate of sexually mature females may be somewhat slower than for mature males.

Since growth during the tagging study was negligible and other information related to growth, such as molting frequency and growth per molt were inadequate, a relationship between size and age of P. japonicus could not be developed.

Movement

Of the 221 tagged P. japonicus that were recaptured, 220 (99.5 percent) came from within Maunalua Bay (where they were released) and one was reported to have been caught at Makapuu Point (Approximately 7 miles east of the release site). The Makapuu Point recovery was reported 4-3/4 years after the tagging and release of the lobster and since the specimen was not returned to the Division of Fish and Game this recovery is regarded as being questionable.

POPULATION

Structure

Sex Ratio

The sex ratio of P. japonicus in Maunalua Bay, Oahu, seems to be approximately one to one. One thousand one hundred and fourteen animals were examined, 521 were males and 593 were females.

Size Composition

In Maunalua Bay, Oahu, the size composition of 1,114 P. japonicus ranged in carapace length from 56 to 132 mm with 97.5 percent between 65 and 115 mm (Figure 7).

Ninety two percent of the lobsters examined measured greater than 76 mm in carapace length and weighed more than 454 gm (one pound). Nineteen percent had carapace length greater than 99 mm and weighed more than 908 gm (two pounds).

The size distribution and length-weight relationship of males and females were similar (Figure 8).

IDENTITY

Panulirus penicillatus Olivier

Synonomy

Astracus penicillatus Olivier (1791)
Panulirus penicillatus Bate (1888)
Senex penicillatus Ortmann (1891)

Taxonomy

Affinities

Phylum Arthropoda
  Subphylum Crustacea
    Class Malacostracea
      Subclass Eucarida
        Order Decapoda
          Suborder Reptantia
            Tribe Macrura
              Family Palinuridae
                Species Panulirus penicillatus

Taxonomic Status

P. penicillatus seems to be a well defined species and is not synonymized with other closely related species.

Standard Common Name

Spiny lobster, lobster, ula (Hawaiian term)

Morphology

External Morphology (Figure 9)

P. penicillatus may be distinguished by the presence of four major spines on the anterior dorsal surface of the carapace between the antennae, while P. japonicus has only two major spines in this location.

The body coloration of P. penicillatus is green and may be replaced by blue on the anterior region of the carapace.

The carapace is divided into anterior spiny region, and a posterior relatively unarmed region bearing numerous nodules. The tips of all spines in the anterior region of the carapace are brown in color and their bases are yellow.

The second antennae are brown in color.

The pereiopods are green with yellowish-white stripes running along their lengths.

Each of the six abdominal segments is transversely grooved, the posterior portion being light reddish-brown in color.

The pleopods are green in color with white lines along their margins.

DISTRIBUTION

Total Area

From East Africa and the Red Sea to Korea, Polynesia, and the Galapagos Islands.

Differential Distribution

Larvae and Juveniles

P. penicillatus phyllosoma (larvae) are planktonic. Johnson (1968) found P. penicillatus phyllosoma to the southwest of Hawaii at long. 174 W. lat. 6 N., to the southeast of long. 113 W. lat. 5 N., and to the northeast at long. 155 W. lat. 26 N.

Adults

Adult spiny lobsters are found in shallow waters. De Bruin (1962) found the majority of them in areas above three fathoms. Adults seek shelter in crevices and under boulders along the reef.

BIONOMICS AND LIFE HISTORY

Reproduction

Sexuality

P. penicillatus is heterosexual and exhibits dimorphism. Males have a gental orifice located on the coxopodite of the fifth pereiopod. Females have a genital orifice located on the coxopodite of the third pereiopod, and in addition, the terminal end of their fifth pereiopod is chelate.

Maturity

The minimum size at maturity in this species is unknown.

Mating

Males deposit a spermatophore on the ventral surface of the female's thorax between the fifth pair of pereiopods. Lobsters are promiscuous. Spermatophoric masses are found on females in all stages of ovary development and in berried condition. Samples from Maunalua Bay, Oahu showed that 25 percent of the females were carrying spermatophoric masses during the year. Mating seems to be random and unrelated to ecdysis.

Fertilization

Fertilization is external and probably occurs at the time of egg laying or soon thereafter provided a spermatophore has been acquired by the female. Matthews (1951) hypothesizes that the female releases the spermatozoa by scratching and breaking the spermatophore with its pereiopods.

Fecundity

An estimate of the number of eggs laid at each spawning varies from 120,000 for a lobster with a carapace length of 70 mm to 440,000 for a lobster with a carapace length of 120 mm (Figure 10).

Spawning

Spawning occurs throughout the year with an average of approximately 38 percent of the females berried during the year (Figure 11). Tag recoveries indicate that females spawn at least twice a year with more frequent spawning being probable.

Spawn

The longest incubation period observed for P. penicillatus taken with eggs was 30 days. Eggs are bright orange upon being laid and remain so for approximately three weeks before developing a brownish coloration. Hatching occurs approximately one week after the eggs turn brown.

Growth

Seven hundred fifty-four P. penicillatus measuring 69 to 140 mm in carapace length were tagged and released from September, 1960 through August, 1962 in Maunalua Bay, Oahu. Dart tags (FM-5, Floy Tag Manufacturing

Co.) were inserted in the transverse groove between the first and second abdominal segments into the abdominal musculature.

Data on carapace lengths and body weights of 110 P. penicillatus recaptured during the tagging study is given in Appendix E.

Growth in males and females during the tagging study was negligible. Only 3 male P. penicillatus (tag numbers 242, 901 and 1137) increased 5 mm or more in carapace length during the tagging study.

Movement

None of the 110 tagged lobsters that were recaptured were caught outside of Maunalua Bay. Significant movement was not observed.

POPULATION

Structure

Sex Ratio

In the Maunalua Bay, Oahu, tagging experiment, 864 P. penicillatus were examined, of which 543 were males and 321 were females. However, tag recoveries indicate that the traps used in the experiment may have been selective, since the percentage of male tag recoveries (15.3 percent) was more than twice that of females (6.6 percent); this probably indicates that females are not as susceptable to trapping as males.

Size Composition

Size of 864 P. penicillatus caught in Maunalua Bay, Oahu, ranged in carapace length from 69 to 140 mm. Ninety eight percent of the lobsters had carapace lengths greater than 80 mm and weights more than 454 gm (one pound). Almost 48 percent of the males had carapace lengths greater than 112 mm and weights over 908 gm (two pounds), whereas only 26 percent of the females fell within this size category (Figure 12).

Males and females had a similar length-weight relationship (Figure 13).

EXPLOITATION

Fishing Equipment

Gear

Spiny lobsters are fished commercially with nets and traps. In the net fishery, gill nets measuring up to 100 feet long by 3 feet deep and with mesh sizes up to seven inches are used.

In the trap fishery, a rectangular trap, measuring 6 feet by 4 feet by 3 feet is generally used. The trap is constructed of one inch mesh

poultry wire stretched over a rectangular reinforcing rod frame-work with a funnel-shaped entrance located at one or both ends of the trap. Traps usually are not buoyed. The primary purpose of the use of traps is to catch fish and only incidentally to catch lobsters.

Traps or nets may or may not be baited.

Boats

Boats used in the lobster fishery vary in size from sixteen foot outboards to forty foot diesel-powered sampans with hydraulic winches to pull up traps.

Fishing Area

General Geographic Distribution

Spiny lobster fishing is conducted in waters off the eight major islands of the State of Hawaii.

Geographic Ranges

The catch around Oahu is approximately four times greater than all of the islands combined for the period 1948 through 1968 (Table 2) and may be attributed to the greater fishing effort expended around Oahu.

TABLE 2. LOBSTER CATCH IN HAWAII
FROM 1948 to 1968

Island	Total Landings (Pounds)
Hawaii	14,417
Maui, Molokai, Lanai	39,934
Oahu	253,248
Kauai	4,699
Leeward Islands	1,610
Total	313,908

Net fishermen on Oahu fish primarily along the northern shore of the island between Kahuku and Kaena Point in depths ranging between one and five fathoms.

The trap fishery on Oahu is conducted for the most part along the leeward shores between Kaena Point and Koko Head in depths between five to thirty fathoms.

Fishing Season

The fishing season is opened for nine months and closed from June through August. Generally due to sea conditions, the north shores are fished primarily during the spring and late summer, while the leeward coast is fished year around, except for the period of closure.

Fishing Operations and Results

Catch and Effort

During the 21-year period from 1948 to 1968, the statewide commercial lobster catch declined drastically from 39,861 to 4,751 pounds respectively. The net fishermen captured 173,745 pounds of lobster (55.3 percent of the total catch) and the trap fishermen landed 136,023 pounds (43.3 percent of the total catch). Another 4,140 pounds (1.3 percent of the total catch) were taken by miscellaneous fishing methods (Table 3).

The greatest decline in the commercial lobster fishery between the years 1948 through 1968 took place during the period from 1948 through 1951 when the catch dropped 59.4 percent, from 39,861 pounds to 16,167 pounds respectively (Figure 14).

During the four years, 1948 to 1951, the number of fishermen reporting lobster catches dropped 31.2 percent. Effort, in terms of fisherman months (each fisherman that reported a catch, regardless of the number of trips or the amount caught during a particular month, was counted as one fisherman month), dropped 35 percent from 306 fisherman months to 200 fisherman months. Catch per unit effort dropped 37.7 percent from 130 pounds per fisherman month to 31 pounds per fisherman month.

The lobster net fishery landings (Table 4) declined 66.2 percent, from 27,273 pounds to 9,215 pounds during the four year period between 1948 to 1951. The number of net fishermen reporting catches dropped 41 percent from 83 in 1948 to 49 in 1951. The net fishery had a 44 percent drop in fisherman months and a 39 percent decline in catch per unit effort. Fifty seven percent of the drop in the commercial net landings occurred in 1951. This happened after the highest catch per unit effort of 138 pounds per fisherman month in 1950. Subsequently, the catch per unit effort fell to 77.4 pounds per fisherman month in 1951.

During the same four year period, the lobster landings of the trap fishery declined 44 percent from 12,263 pounds to 6,882 pounds. The number of fishermen reporting lobster catches fluctuated annually with an overall decline of 13.6 percent. Catch per unit effort in the trap fishery declined 33.1 percent from 139 pounds per fisherman month in 1948 to 93 pounds per fisherman month in 1951. In 1949 the highest number of fishermen, 26, for this period had the lowest catch per unit effort recorded at 85 pounds per fisherman month.

In order to test whether or not this trend in reduced catch per unit effort persisted throughout the 21 year period, a spot analysis of the 1951 and 1965 catch reports of the net and trap fisheries was made (Table 4). The landings continued to decline from the 1951 level and were 49.6 percent lower by 1965. Following the same trend, the number of fishermen reporting lobster catches dropped from 68 in 1951 to 23 in 1965, a 64 percent loss, and the number of fisherman months dropped by 61 percent. Contrary to this trend however, the catch per unit effort increased from 81 pounds per fisherman month in 1951 to 101 pounds per fisherman month in 1965, a 20 percent increase as a result of the increased catch per unit effort realized in the net fishery.

A break down of the lobster landings by fishing method showed that the lobster trap fishery landings are being influenced by a decrease in the abundance of lobsters available in the trapping grounds located along the leeward coast of Oahu. This is suggested by the decline in catch per unit effort of the trap fishermen from 93 pounds per fisherman month in 1951 to 52 pounds per fisherman month in 1965. However, at the same time, the net fishery catch per unit effort tripled from 77 pounds per fisherman month in 1951 to 230 pounds per fisherman month in 1965. The trebling of the net fishery catch per unit effort which was accomplished by 14 fishermen fishing a total of 24 fisherman months indicates that net fishing for lobsters on the windward shores of Oahu is more profitable than the trap fishery. It is possible that the net fishing grounds may be capable of withstanding a heavier fishing pressure.

A segment of the lobster fishery, for which there is no available catch data, is the sports fishery. The amount of lobsters taken by this segment may be equivalent to the commercial fishery catches and until this data becomes available the actual total spiny lobster landings will not be known.

PROTECTION AND MANAGEMENT

Protection of Portions of the Population

Season Limitations

The taking of lobsters is not allowed during the months of June, July and August but is permitted during the remaining nine months of the year.

Gear Limitations

Spiny lobsters may not be taken in traps that exceed 6 feet in height, 6 feet in width and 10 feet in length. Nets or screens covering the traps must not have a stretched mesh length of less than 2 inches. All traps must be portable.

Nets used to catch spiny lobsters have no size limitations, however they must have a stretched mesh length of at least 2 inches.

Spearing of spiny lobsters is prohibited.

Size and Sexual Condition Limitations

It is illegal to possess lobsters weighing less than a pound, except on the island of Kauai where the minimum size for the noncommercial fisherman is three-fourths of a pound.

It is illegal to possess a female lobster bearing eggs at any time.

RECOMMENDATIONS

1. It is recommended that the present season on the taking of lobsters be retained and that the restriction on the taking of berried females be maintained. It is also recommended that the restriction on spearing of lobsters be retained since it is virtually impossible to determine the oviparous condition of a female lobster without close examination.

2. It is recommended that a carapace measurement of three and one-fourth (3¼) inches, measured in a straight line along the dorsal center of the carapace from the base of the eyestalks to the posterior margin of the carapace, be adopted to delineate the minimum legal size of lobsters that may be harvested (Figure 15). A linear measurement rather than a weight restriction is much more readily determinable by lobster fishermen.

3. A provision that only whole lobsters can be possessed by fishermen should be included in the lobster regulation. The removal of the tail section from the carapace should be made an illegal act to stop spearing of lobsters in the carapace with subsequent retention of the tail sections only.

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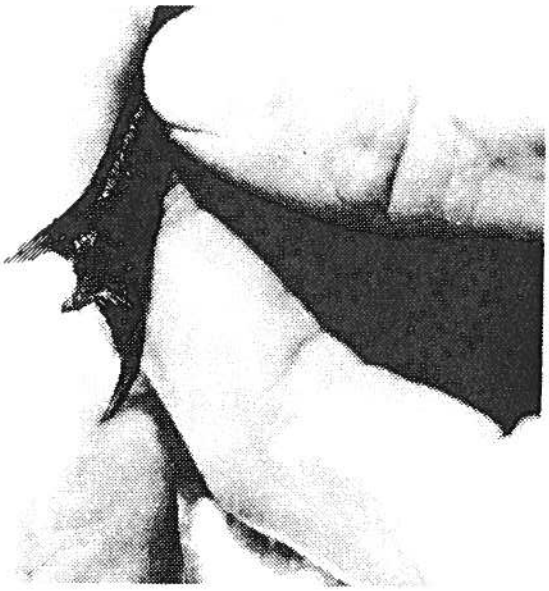

Figure 2. [illegible]late fifth pereiopod of a [illegible] spiny lobster.

Figure 4. [illegible]phore on the ventral surface [illegible] female's thorax between the [illegible] of pereiopods.

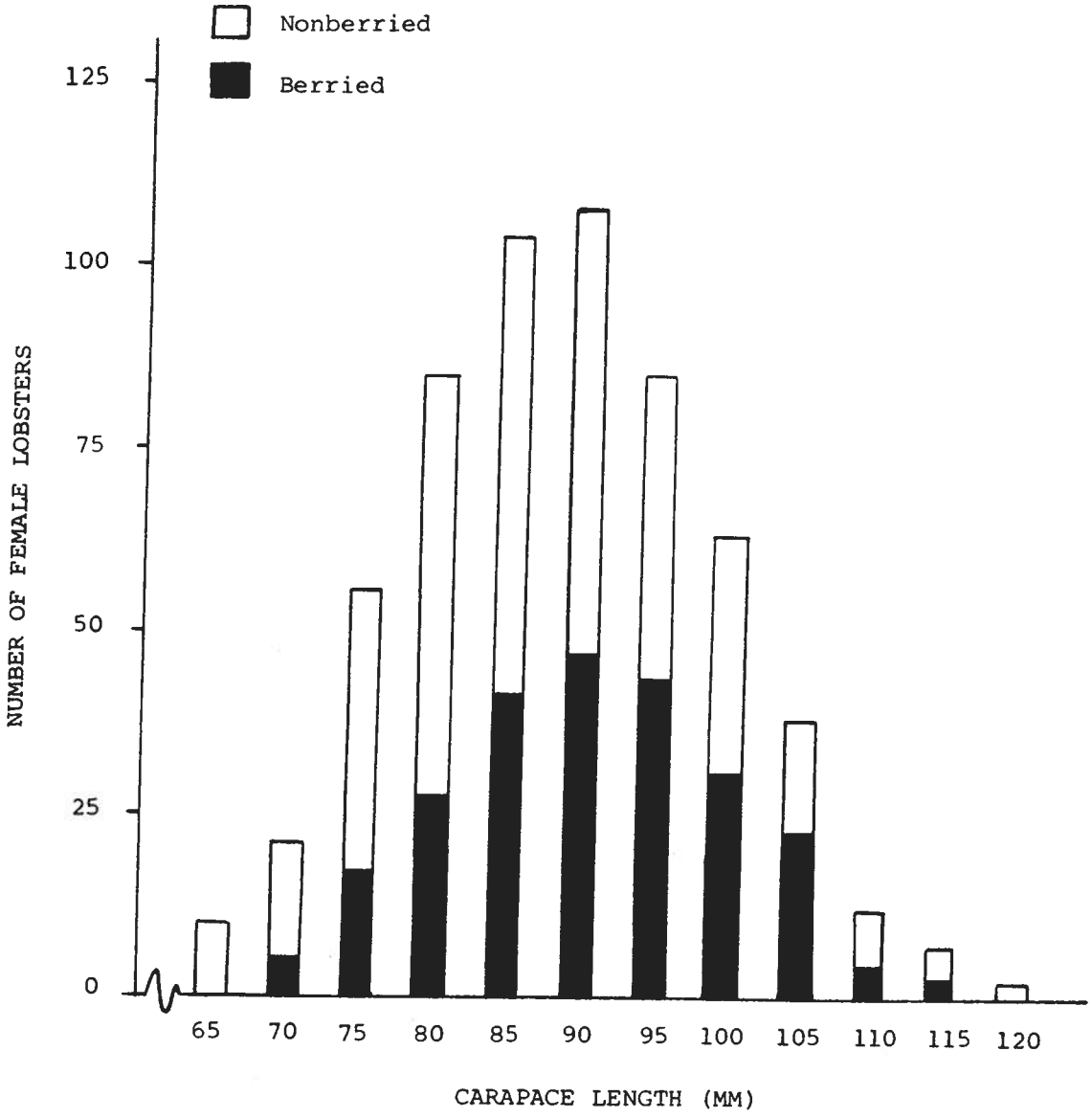

Figure 3. Number of berried and nonberried *P. japonicus* females per size group in Maunalua Bay.

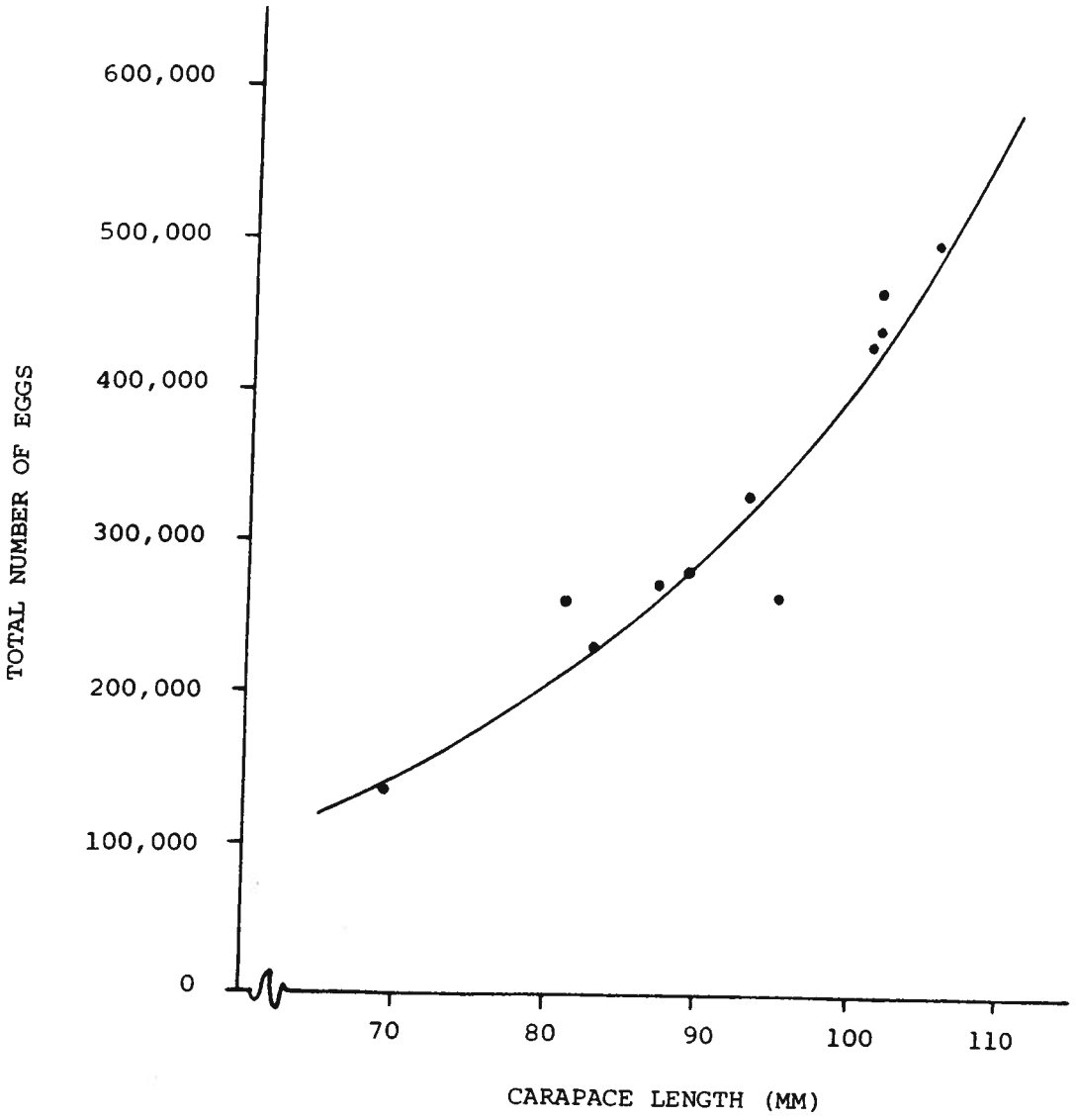

Figure 5. Relation in P. japonicus between the total number of eggs carried and carapace length.

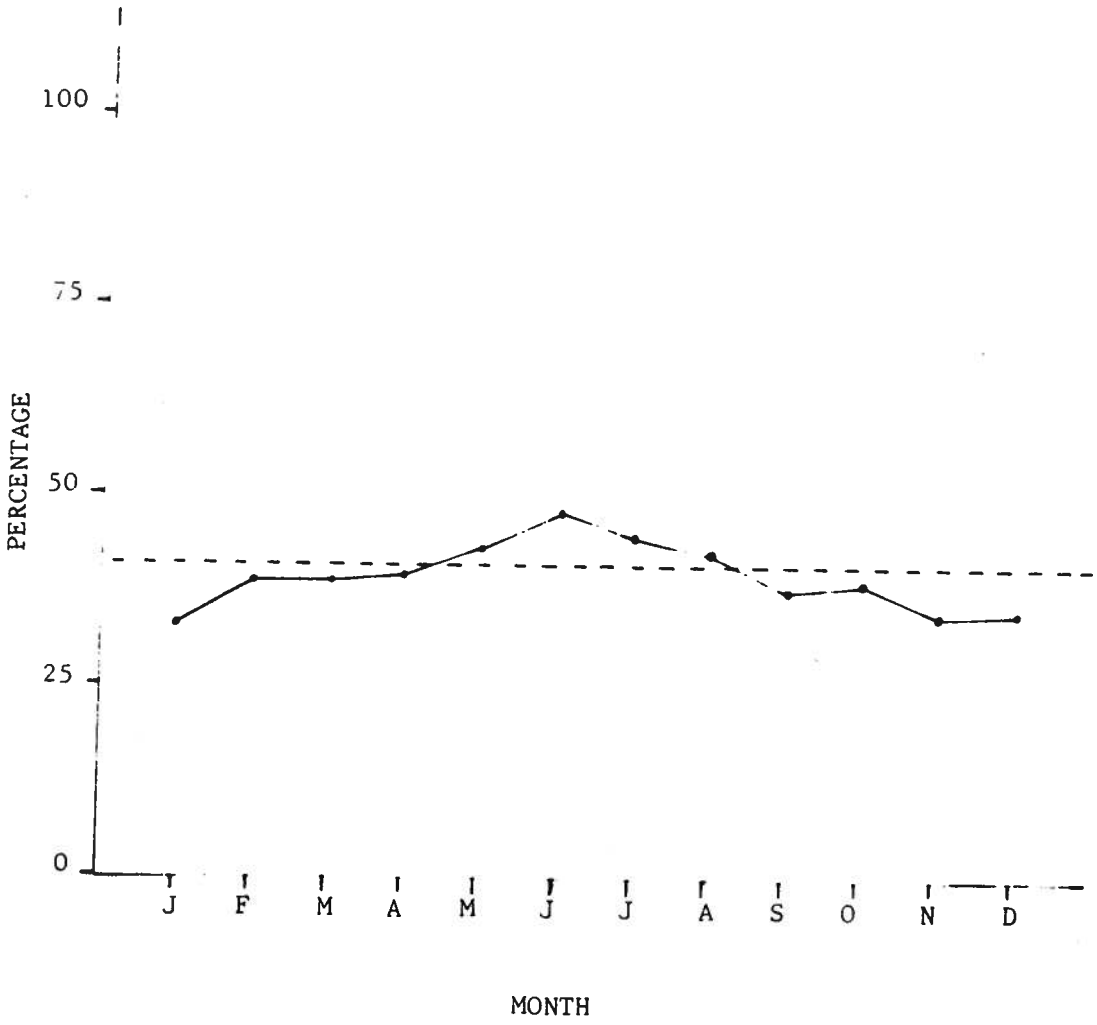

Figure 6. Percentage of berried P. japonicus by months. An average of 41 percent (broken line) of the female lobsters were berried.

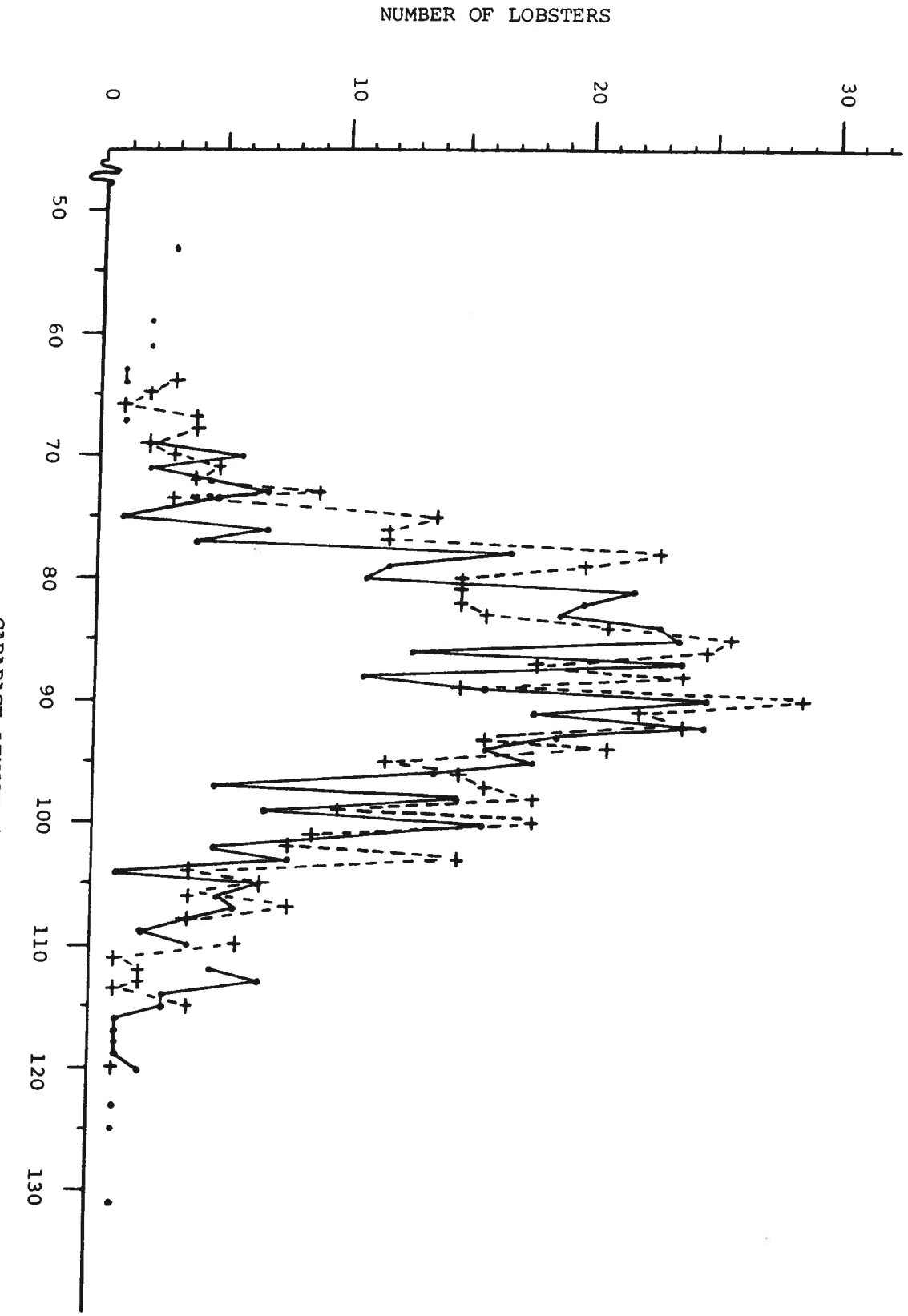

Figure 7. Carapace length frequencies for male (broken line) and female (solid line) P. japonicus.

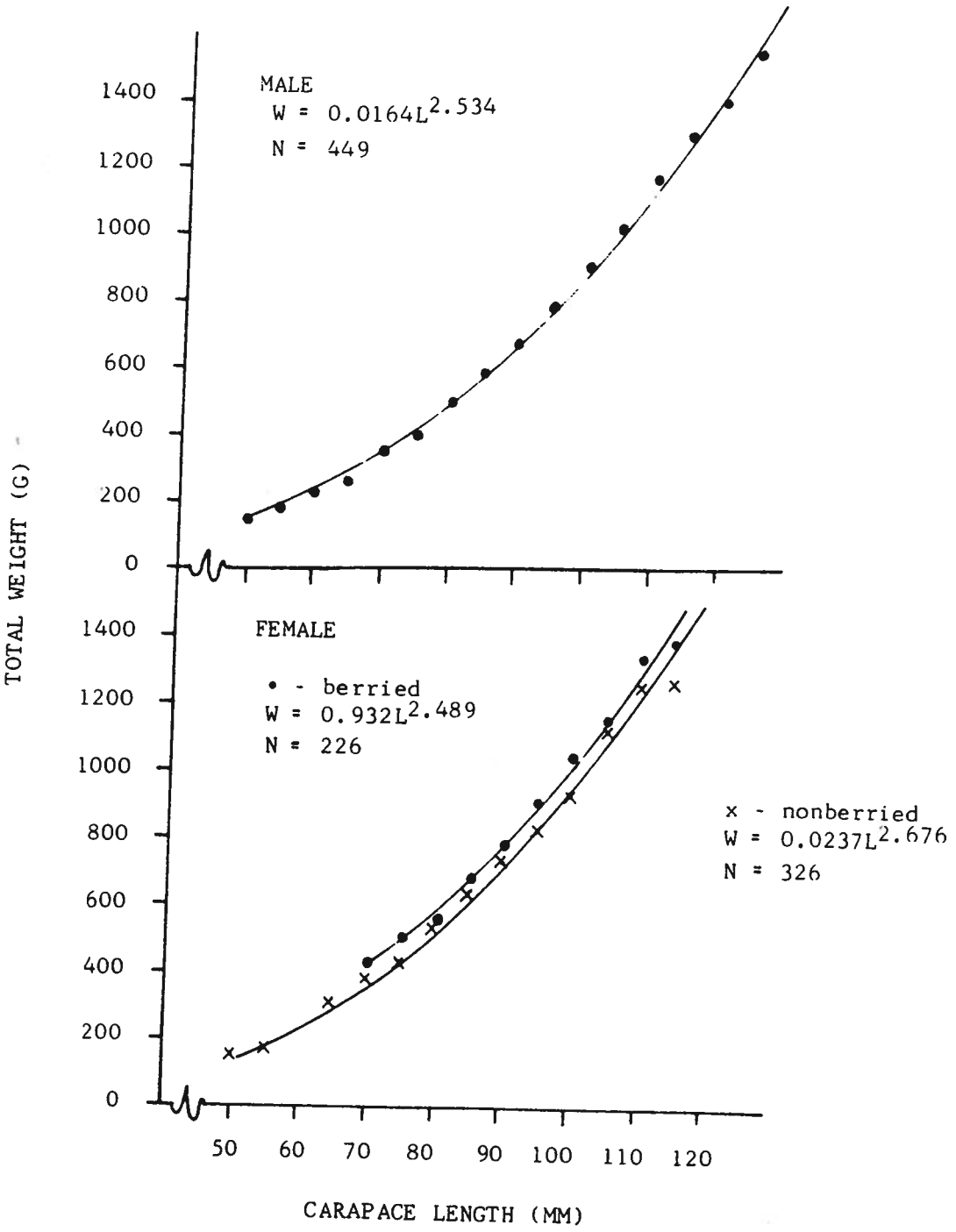

Figure 8. Length-Weight relationship of male and female Panulirus japonicus in Hawaii. Dots and x's represent observed average weight of each five millimeter size group.

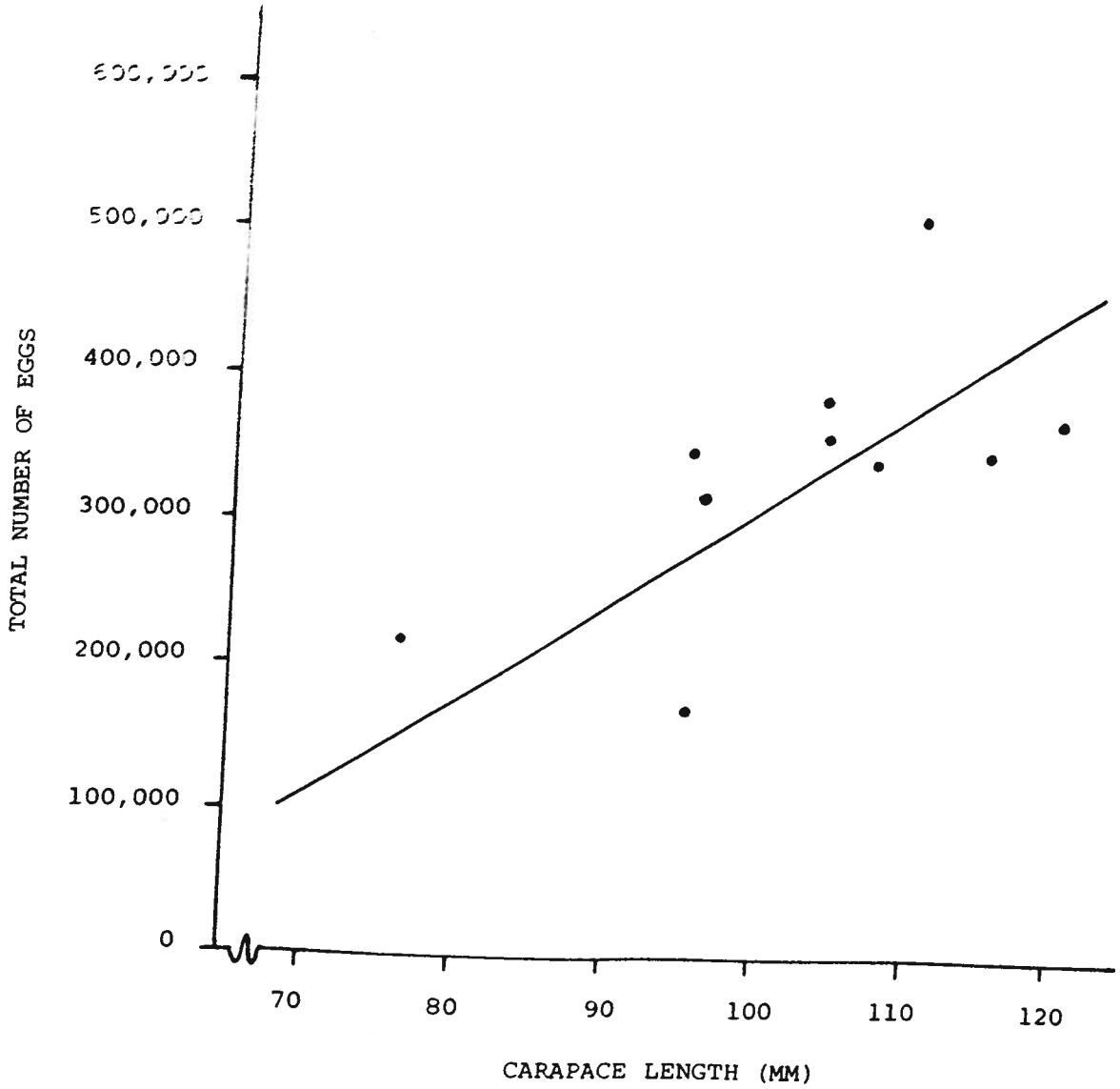

Figure 10. Relation in P. penicillatus between the total number of eggs carried and carapace length.

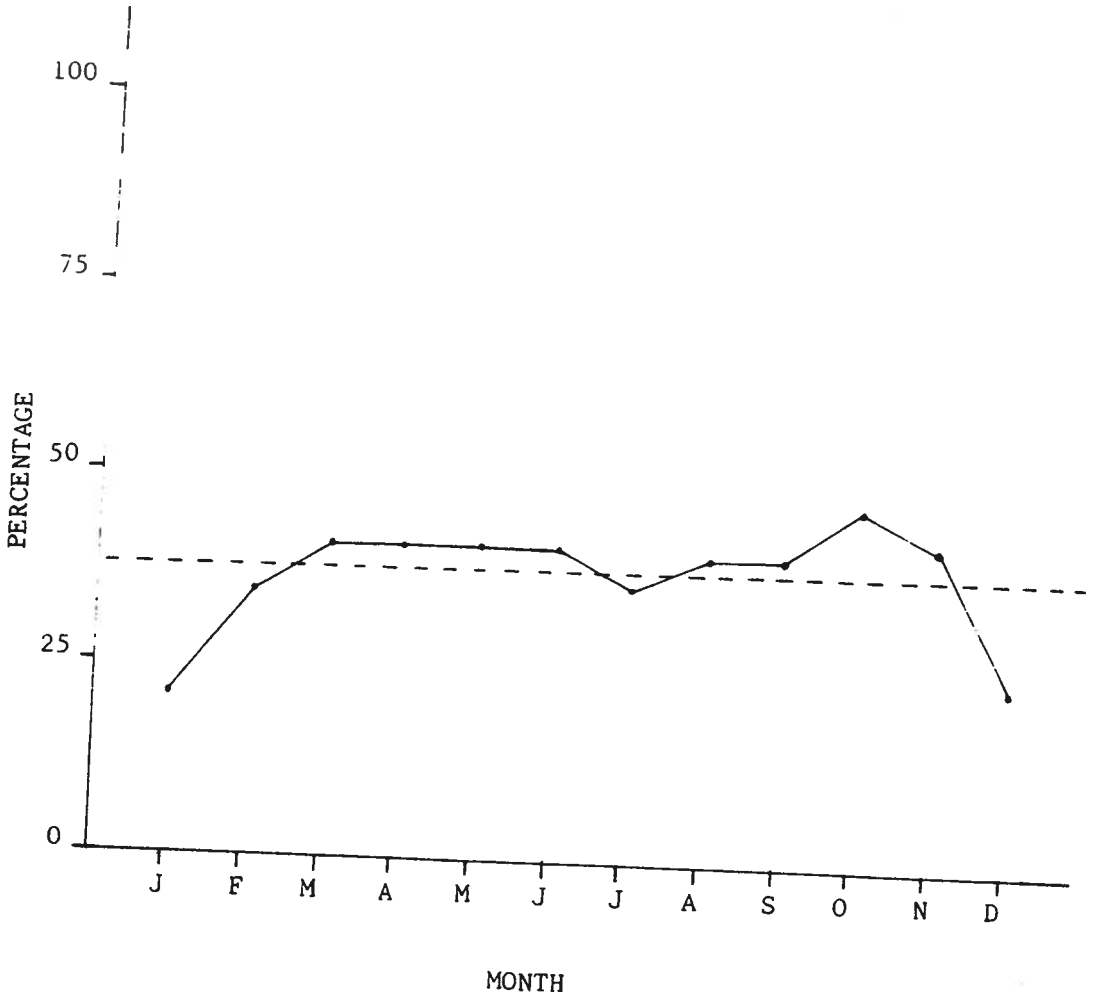

Figure 11. Percentage of berried P. penicillatus by months. An average of 38 percent (broken line) of the lobsters were berried.

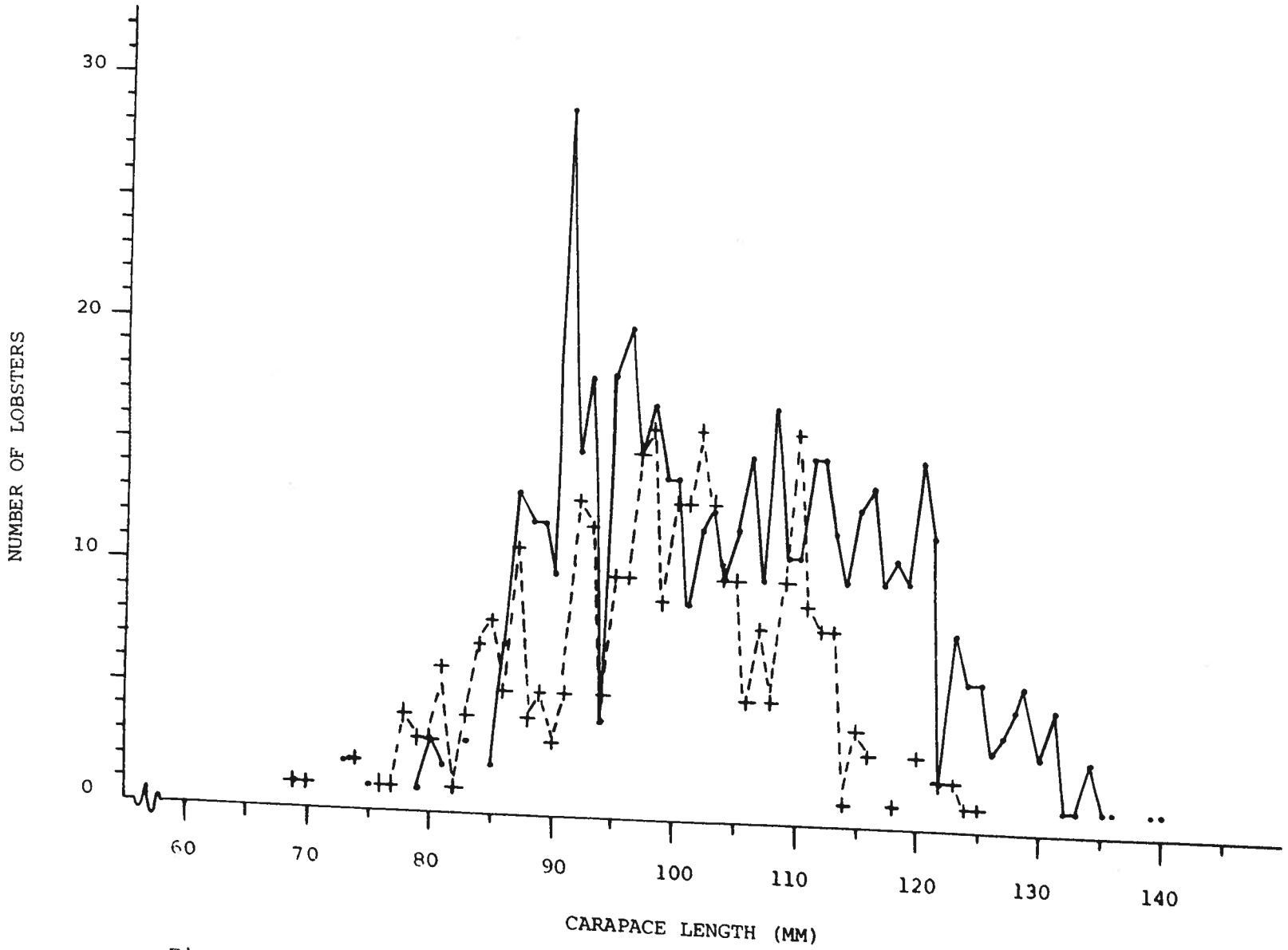

Figure 12. Carapace length frequencies for male (solid line) and female (broken line) P. penicillatus.

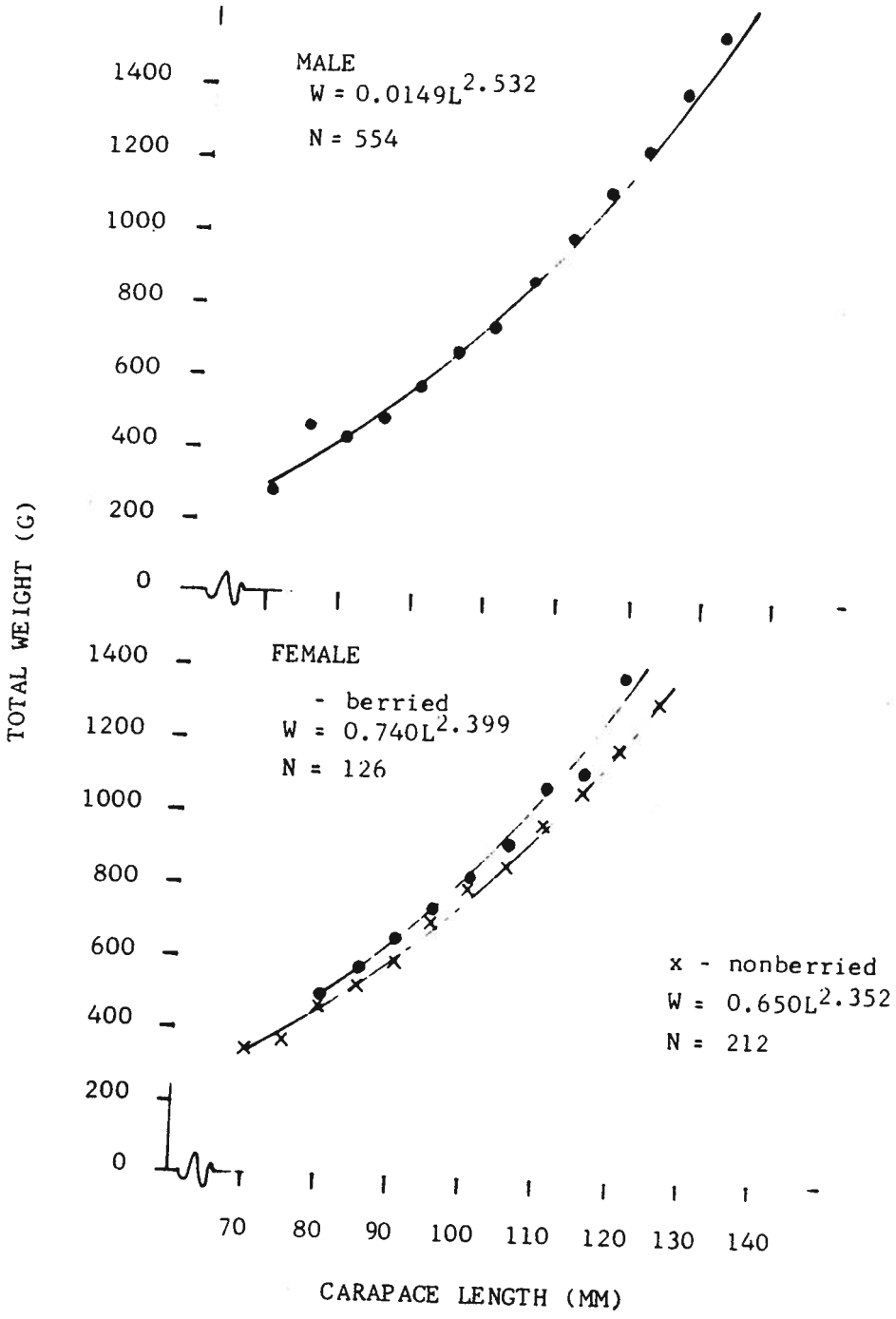

Figure 13. Length-Weight relationship of male and female Panulirus penicillatus in Hawaii. Dots and x's represent observed average weight of each five millimeter size group.

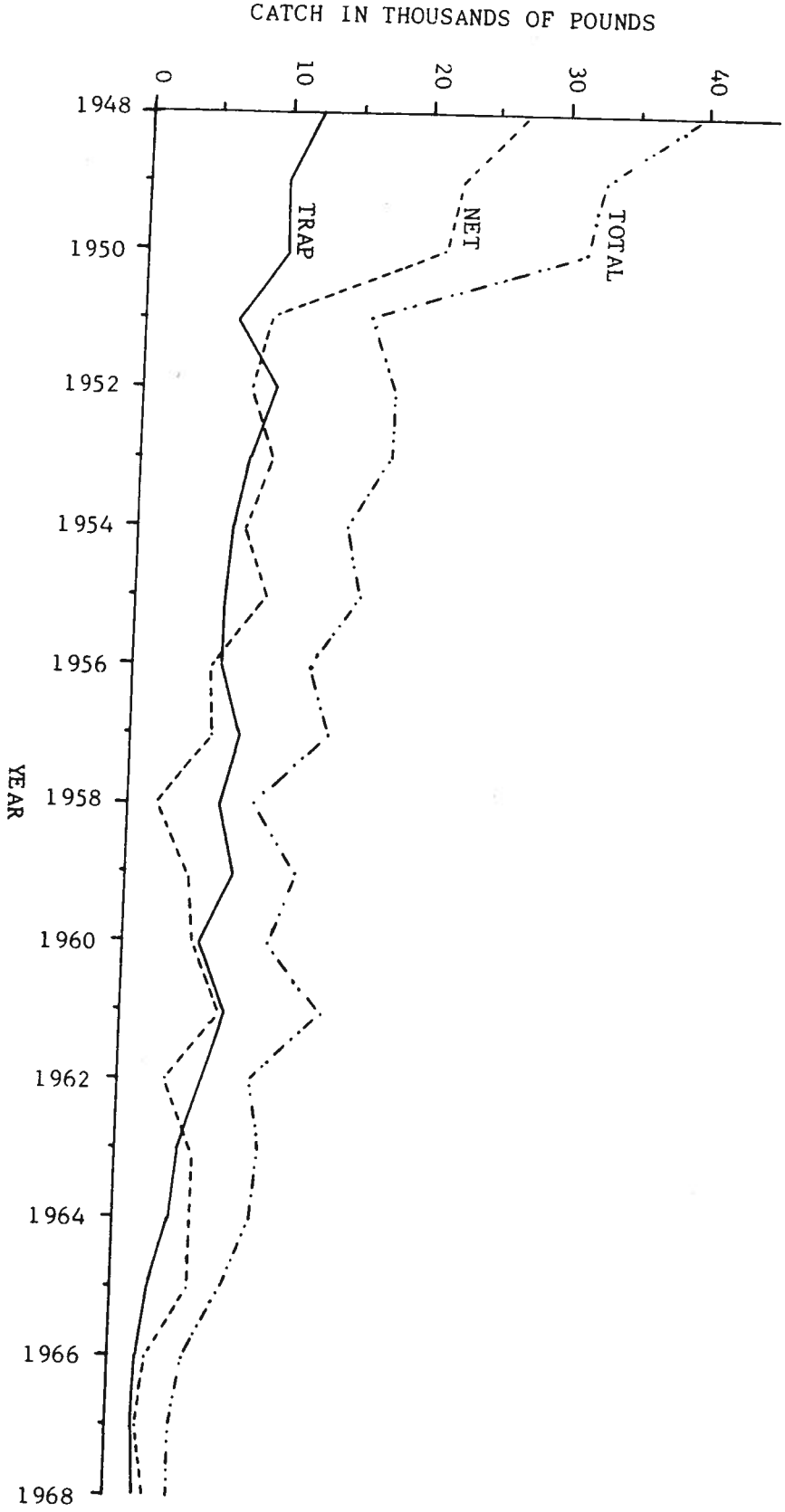

Figure 14. Commercial lobster landings from 1948 to 1968 in Hawaii.