# MANAGEMENT AND DEVELOPMENT INVESTIGATIONS OF THE KONA CRAB, *Ranina ranina* (Linnaeus)

## FINAL REPORT

# MANAGEMENT AND DEVELOPMENT INVESTIGATIONS OF THE KONA CRAB, Ranina ranina (Linnaeus)

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by

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## INTRODUCTION

The State of Hawaii, Division of Fish and Game, has been conducting studies on the biology and fishery of the kona crab, Ranina ranina (L.), directed toward the management and development of the fishery in Hawaiian waters (State of Hawaii, 1966-1969).

The Waimea Bay and Waialua Bay (Haleiwa) crabbing grounds off the Northern Coast of the Island of Oahu were used for the field sampling and tagging studies. A rearing study was also initiated to gather data and supplemental information on the life history of the crab.

## IDENTITY

### Nomenclature

#### Valid Name

Ranina ranina (Linnaeus)

#### Synonymy (from Sakai, 1937)

Cancer raninus Linnaeus
Ranina dentata deHaan
Ranina serrata Lamarck
Ranina scabra (Fabricius)
Ranina ranina (Linnaeus)

### Taxonomy

#### Affinities

Phylum: Arthropoda

Class: Crustacea
Sub-class: Malacostraca

Order: Decapoda
Sub-order: Reptantia

Tribe: Brachyura
Sub-tribe: Oxystomata

Family: Raninidae

Genus: RANINA

Raninidae

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1/ The U.S. Bureau of Commercial Fisheries (presently National Marine Fisheries Service) provided support under P.L. 88-309, Project No. H-6-R.

The family Raninidae is separated from the other Oxystomatid crabs by having an elongated carapace and broad shaped last two segments of each leg (Hiatt, 1954).

Ranina ranina is the only species of this genera in Hawaii.

Ranina ranina (Figure 1) has a broad carapace, the dorsal surface of which is convex and covered with flat sharpened spines. The rostrum is large and triangular shaped. The carapace has four major anterior-lateral processes on both sides of the rostrum. The first major processes, located on each side and closest to the rostrum is not divided. The next two major processes are divided into three points, and the outer most processes are divided into three or four points. The antenna has a large basal segment with a very small flagellum. The eye stalk has three segments with the cornea folded longitudinally.

The chilipeds are strong and covered dorsally with flattened spines like that found on the carapace. The propodus is flattened vertically forming the palm bearing two sharp teeth on the outer margin and five teeth on the inner margin. Each of the dactylus of the chela are armed with cutting edges formed by seven or eight triangular teeth. The chela opens medially.

The other legs all have paddle-shaped dactyli (Figure 2).

The abdomen of both sexes contain seven segments.

Standard Common Names

KONA CRAB is the common name used in Hawaii. Other names used are frog crab, red frog crab and spanner crab (Tinker, 1965).

Morphology

The color of the dorsal surface of the kona crab is orange or blueish with white patches on its ventral surface.

Distribution

Total Area

The crab is found in Hawaii and throughout the tropical Pacific Ocean, Japan, Formosa, Philippine Islands through the East Indies and into the Indian Ocean to South Africa (Tinker, 1965 and Sakai, 1937).

Differential Distribution

Kona crab is found in sandy ocean bottoms of Hawaiian waters throughout the year.

## BIONOMICS AND LIFE HISTORY

### Reproduction

#### Sexuality

Kona crabs are heterosexual and sexually dimorphic. The females can be distinguished from the males by their roundish-shaped abdominal segments, well developed abdominal pleopods with numerous cetae (Figure 3) and by the presence of a spermathecal orifice located on the anterior portion of the seventh sternite behind the genital openings of the coxae of the third pleopods (Gordon, 1963).

The abdominal segments on the male is narrow and pointed, and covers the intromittent organs (Figure 4). Males grow larger in size than females and develop larger anterior-lateral processes that give the anterior section of the carapace a squared appearance (Figure 1).

#### Maturity

To determine maturity, all female kona crabs sampled during May to August were examined for external eggs and internally developing ovaries. Only the months of May to August were used as most of the female crabs had eggs during this period. It is assumed that the crabs are mature when their ovaries, located in the anterior-dorsal portion of the carapace, contain developing eggs (Figure 5) or when eggs are present externally. It is also assumed that the males attain maturity at about the same size as the female crabs.

Of 381 female kona crabs examined (Table 1), 352 crabs or 92 percent were categorized as being mature. Females that were smaller than 58 mm carapace length lacked developing ovaries or external eggs. Eighty-three percent of the females with 60 mm average carapace length (58 to 62 mm) were mature and 87 percent of the females with 65 mm average carapace length (63 to 67 mm) were mature. Gordon (1963) found that females of 63 mm carapace length were immature.

#### Mating

The kona crab is believed to be promiscuous in its mating.

#### Fertilization

Fertilization of the eggs is external and probably accomplished as the eggs pass the spermatheca during extrusion and attachment to the cetae of the abdomen.

#### Spawning

Since it was previously determined that kona crabs mature at about 60 mm carapace length, females of that size and larger were examined monthly to ascertain more accurately when spawning occurs. As shown in Table 2, berried females (with external eggs) occur in May (2%), June (67%), July (67%), August (22%) and September (5%). The females were not berried during the remainder of the year.

Rearing studies indicate that female kona crabs carry at least two separate batches of eggs in succession per spawning season. The spherical eggs are orange colored when newly laid, then turn brown and become eyed about 24 days after laying. Hatching occurs approximately five days after the eyed stage. The average duration from laying to hatching is 29 days, with a range of 24 to 35 days. After an interval of about nine days, the second batch of eggs are extruded onto the cetae.

The number of eggs carried by female kona crabs of various sizes was volumetrically determined from 19 crabs (Table 3 and Figure 6) and is shown to increase with size. The estimated number of eggs ranged from nearly 27,000 to over 145,000 for a 63 and a 114 mm (carapace length) female crab, respectively.

The average size of orange colored eggs was 0.72 mm.

## Preadult Phase

### Larval Phase

The larvae are planktonic.

Attempts to rear the larvae hatched from berried females were unsuccessful.

### Adolescent Phase

Very little is known of the juvenile crabs. A few immature crabs were caught during the sampling trips and these had the external appearance of adults except for less prominent anterior-lateral processes. Sakai (1937) shows a juvenile female kona crab with the anterior-lateral processes unbranched. The smallest specimen observed during this study was 22 mm in carapace length and 17 mm in carapace width. This crab was caught at approximately 50 fathoms depth.

## Nutrition and Growth

### Feeding

Kona crabs are carnivorous and seem to feed at any time of the day. They normally lay buried with their eyes protruding out of the sand and seize any unwary prey, usually small fish and other food (Grant, 1965).

### Growth Rate

Growth in crustaceans is attained after a process of molting and therefore, a determination of the growth rate involves an understanding of not only the amount of growth at each molt, but also the frequency of molting.

Information on the growth increment at each molt was obtained from rearing and tagging experiements conducted since 1964. From the relationship of carapace length before molt and the amount of growth attained at each molt, it is estimated that mature males grow an average of 9.9 mm and mature females grow an average of 7.5 mm per molt.

The increase in carapace length during each molt, when compared as a percentage of the original size, is about the same for both male and female kona crabs below 40 mm carapace length. However, as the crabs go through several molts and grow to larger sizes, the percent increase from the original carapace length seems to be less for females than for the males (Figure 7). The result of this difference in growth rate is the presence of larger sized male crabs than female crabs of the same age.

To determine the frequency of molting, monthly sampling at Waialua (Haleiwa) and Waimea Bays were conducted during the period from February, 1965 to June, 1968. This sampling operation provided 3,729 specimens for an estimate of the percentage of crabs in the new shelled condition which would indicate very recent molting (Figure 8). The data show that there is a large percentage of new shelled female kona crabs during January and March (67 and 54%) which suggests that most of the mature females in the population probably molt at least once during this time of the year before the egg bearing period which begins in June. The male crabs, on the other hand, did not show peaking of new shelled condition during January through March. However, the data suggested that molting among the adult male population may occur over a protracted period possibly between January through August.

Since we were unable to secure juvenile specimens, no information on the growth increment and molting frequency of the young crabs could be obtained, and hence, it was not possible to develop a relationship between age and size of kona crabs.

## Behavior

### Migrations and Movements

A total of 1,304 kona crabs were tagged and released at Waialua (Haleiwa) and Waimea Bays on Oahu in 1966 to determine migration and intermingling of the crabs between the two heavily fished bays located approximately 3-1/2 nautical miles apart (Figure 9).

Of the 782 kona crabs tagged and released at Waialua Bay, all of the 155 (19.8%) recoveries came from within the limits of the same bay. Similarly, at Waimea Bay, of the 522 kona crabs tagged and released, all of the 56 (10.7%) recoveries were also made from within the same bay.

# POPULATION

## Structure

### Sex Ratio

The sex ratio of the kona crabs caught at the crabbing grounds of Waialua (Haleiwa) and Waimea Bays during 1963 to 1968 were found to be approximately 55 percent males and 45 percent females.

### Size Composition

A total of 6,464 kona crabs were caught during the sampling trips to Waialua (Haleiwa) and Waimea Bays. The size frequency (Figure 10 and Table 4) indicates that slightly larger crabs were present at Waialua Bay as compared to Waimea Bay and that the females were smaller than the males at both locations.

The largest male and largest female kona crabs caught during our sampling was a male of 136 mm (5.4 inches) carapace length with a carapace width of 127 mm and a female of 113 mm (4.5 inches) carapace length with a carapace width of 101 mm. Edmundson (1946) reports that the largest specimen at the Bishop Museum in Honolulu, Hawaii has a carapace length of seven inches (178 mm) and a width of six inches (152 mm). Grant (1965) reports that adults grow to at least nine inches in length.

A length-weight relationship calculated from 1,566 male and 1,410 female kona crabs is presented in Figure 11.

## Mortality and Morbidity

No information is available on mortality and morbidity.

# EXPLOITATION (FISHERY)

## Fishing Equipment

### Gear

Hawaii's commercial and sport fishermen harvest kona crabs with nets especially designed to entangle the legs of the crab. Our search through literature indicates that Queensland (Australia) may be the only other area, besides Hawaii, where the kona crab is exploited commercially, but there, bottom trawls and trot lines are used (Grant, 1965).

The frames of the kona crab nets used in Hawaii are usually constructed of about 3/16 inch (6 or 7 gauge) galvanized fencing wire, shaped either into a ring of about 2-1/2 to 3 feet diameter or bent into a square with sides about 2-1/2 to 3 feet length. The frame is covered with one or two layers of small gauge netting (legal minimum netting, two inch stretched mesh) tied onto the wire frame. The overlapping layers of netting is used to enhance entanglement of the legs of the crabs as they walk over the netting to reach the bait tied in the center of the net. The size and type of netting material varies with fishing locations and individual fishermen. Figure 12 illustrates the gear used during our sampling program. We used two layers of two-inch mesh kuralon (vinylon) netting of number 2 or 3 thread size. Other netting material usedwere cotton, nylon and monofilament nylon. The present trendis toward the use of kuralon material because of its ready availability, low cost and easy maintenance.

Boats

Small outboard powered skiffs to larger inboard powered sampans up to 40 feet or more in length are used to fish kona crabs. The size and type of boat influence the distance that the fisherman travels to the crabbing grounds as well as the number of nets that can be fished conveniently. Recently, even the smaller boats have begun to use depth finders to locate the crabbing grounds.

Depth Ranges

Stebbings (1893) reports that members of the family Raninidae live in depths down to 300 fathoms (1,800 feet). Grant (1965) reports that these crabs are frequently sighted by anglers while wading in the waters of Queensland, Australia. In Hawaiian waters, kona crabs are known to inhabit depths of less than 20 feet to over 300 feet. The depth of the Waialua (Haleiwa) and Waimea Bays crabbing grounds range between 90 to 300 feet. Even when taken from relatively deep waters (depths of about 300 feet), the crabs have survived for periods of up to eight months in less than a foot of water in our rearing tanks.

Fishing Seasons

Although kona crab fishing is permitted throughout the year, commercial fishery statistics show more effort and greater landings during the months of March through June (probably due to good weather). The recreational crab fishing activity probably follows the same trend.

Catches

The commercial kona crab harvest of the State over a 19-year period from 1950 to 1968 (Table 5) show considerable fluctuation in landings ranging from a low of 659 pounds in 1952 to a high of 37,241 pounds in 1968. The records also show an increasing trend in the quantity of kona crabs sold as well as a rising price per pound (Figure 13), thereby reflecting an increasing demand for the crab.

The highest commercial catches for the period 1950 through 1968 were made at the Penguin Banks (off the Western Coast of Molokai) and off the Northern shores of Niihau (Figure 14). Over the 19-year period, the total catch at Penguin Banks amounted to 81,746 pounds with an average annual landing of 4,302 pounds (ranged from 28 to 31,923 pounds) while 23,583 pounds were caught off Niihau during the same period with an annual average of 1,241 pounds (ranged from 9 to 6,349 pounds).

## PROTECTION AND MANAGEMENT

Regulations presently affecting the harvest of the kona crab include restrictions against the taking of berried females and the selling of crabs less than four inches in length or width measured across the back.

Because the law prohibits the possession of berried female kona crabs, they must be released whenever captured. However, since the crabs are caught by a net that entangles the legs, there is a question as to the survival of crabs that are returned to the water, particularly of those with legs that are damaged or broken off while being removed from the nets. A study was therefore undertaken to determine (1) the number of legs entangled and (2) the mortality rates induced by the various types of legs damaged. In respect to leg entanglement during capture, records were kept on the specific legs and segments that became entangled.

Results of this study showed that kona crabs are most commonly entangled by the broad dactyli of the first, second and third pairs of walking legs (Tables 6 and 7). Of the 357 crabs examined, an average of 3.7 legs per crab were entangled.

Undamaged crabs were then reared in our aquaria and leg damages simulated by breaking off an entire leg or the dactyli from one, four and eight legs. Results of the experiement indicate that mortality rates increase as more dactyli are removed and become significant with the removal of an entire leg (Table 8).

In view of these results, it appears desirable to minimize the mortalities caused by undue leg breakage perhaps through an information and education program whereby crab fishermen would be informed that excessive leg damages result in the death of the crabs thrown back and that by keeping leg breakages down to a few dactyli only, the crabs can survive.

The other prohibition, that of the selling of crabs less than four inches, does not seem to adequately afford the protection intended for the small immature crabs in that, although not used for commercial purposes, they are taken for home consumption and are thus removed from the population before attaining sexual maturity.

## RECOMMENDATIONS

1. The current regulation that prohibits the taking of berried females throughout the year should be retained.

2. The current restriction on the sale of crabs less than four inches across the back should be changed to prohibit the taking of all crabs less than four inches carapace length.

3. Studies related to the development of a relationship between age and size of kona crabs should be continued.

4. A short informative handout should be prepared for the local commercial and recreational crab fishermen emphasizing the importance of minimizing leg damages to maximize survival of crabs thrown back.

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TABLE 1. Frequency of mature female kona crabs (bearing external eggs and/or developing ovaries) caught during May to August at Waialua (Haleiwa) and Waimea Bays, Oahu.

| Carapace Length (mm) | Total No. Females | Number Mature | Percent Mature |
|---|---|---|---|
| 50 | 3 | 0 | 0 |
| 55 | 4 | 0 | 0 |
| 60 | 6 | 5 | 83 |
| 65 | 83 | 72 | 87 |
| 70 | 109 | 103 | 95 |
| 75 | 95 | 92 | 97 |
| 80 | 50 | 50 | 100 |
| 85 | 17 | 16 | 94 |
| 90 | 12 | 12 | 100 |
| 95 | 1 | 1 | 100 |
| 100 | - | - | - |
| 105 | 1 | 1 | 100 |

TABLE 2. Percent of berried female kona crabs of all mature females caught by months.

| Months | Number Females | Number Berried | Percent Berried |
|---|---|---|---|
| Jan. | 358 | 0 | 0 |
| Feb. | 288 | 0 | 0 |
| Mar. | 212 | 0 | 0 |
| Apr. | 360 | 0 | 0 |
| May | 560 | 9 | 2 |
| Jun. | 433 | 291 | 67 |
| Jul. | 101 | 67 | 66 |
| Aug. | 303 | 68 | 22 |
| Sept. | 82 | 4 | 5 |
| Oct. | 7 | 0 | 0 |
| Nov. | 91 | 0 | 0 |
| Dec. | 141 | 0 | 0 |

TABLE 3. Relationship of number of eggs to carapace lengths for female kona crabs.

| Carapace Length (mm) | Estimated No. Eggs |
|---|---|
| 63 | 26,992 |
| 63 | 27,846 |
| 69 | 34,584 |
| 70 | 24,596 |
| 75 | 48,246 |
| 75 | 58,170 |
| 77 | 52,326 |
| 79 | 54,560 |
| 79 | 55,844 |
| 83 | 60,424 |
| 84 | 65,580 |
| 84 | 68,976 |
| 88 | 67,200 |
| 89 | 51,680 |
| 90 | 65,644 |
| 104 | 95,648 |
| 105 | 97,864 |
| 108 | 130,644 |
| 114 | 145,392 |

TABLE 4. Size frequencies of the kona crabs caught during sampling at Waialua Bay (Haleiwa) and Waimea Bay, Oahu

| Carapace Length (mm) | Waialua Bay | | Waimea Bay | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| 35 | - | - | - | 1 |
| 40 | - | - | 5 | 4 |
| 45 | - | - | 24 | 25 |
| 50 | - | - | 64 | 64 |
| 55 | 5 | - | 289 | 285 |
| 60 | 7 | 2 | 328 | 243 |
| 65 | 47 | 48 | 358 | 525 |
| 70 | 93 | 105 | 484 | 476 |
| 75 | 86 | 119 | 335 | 372 |
| 80 | 98 | 120 | 378 | 231 |
| 85 | 101 | 76 | 282 | 119 |
| 90 | 75 | 21 | 120 | 56 |
| 95 | 35 | 5 | 68 | 18 |
| 100 | 44 | 2 | 61 | 4 |
| 105 | 17 | - | 49 | 5 |
| 110 | 14 | - | 23 | 1 |
| 115 | 5 | 1 | 13 | 1 |
| 120 | 7 | - | 11 | - |
| 125 | 2 | - | 3 | - |
| 130 | - | - | 1 | - |
| 135 | 1 | - | 2 | - |

TABLE 5. Kona crab commercial landings for the State of Hawaii, 1950-1968.

| Year | Lbs. Caught | Pounds Sold | Value | Average Price/Lb. |
|---|---|---|---|---|
| 1950 | 4,547 | 3,536 | $ 1,427.78 | $0.40 |
| 1951 | 2,214 | 2,214 | 823.60 | .37 |
| 1952 | 669 | 669 | 284.45 | .43 |
| 1953 | 1,509 | 1,509 | 738.48 | .49 |
| 1954 | 2,753 | 2,401 | 1,308.91 | .55 |
| 1955 | 6,063 | 5,324 | 2,299.60 | .43 |
| 1956 | 7,254 | 7,138 | 4,673.97 | .66 |
| 1957 | 12,559 | 11,975 | 7,060.42 | .59 |
| 1958 | 3,856 | 3,818 | 1,832.10 | .48 |
| 1959 | 6,036 | 5,997 | 3,121.64 | .52 |
| 1960 | 11,062 | 11,061 | 6,380.68 | .58 |
| 1961 | 17,741 | 17,741 | 13,134.82 | .74 |
| 1962 | 31,542 | 30,623 | 20,794.61 | .68 |
| 1963 | 17,865 | 16,750 | 10,560.48 | .63 |
| 1964 | 9,595 | 8,612 | 5,102.06 | .59 |
| 1965 | 13,452 | 13,132 | 8,672.15 | .66 |
| 1966 | 9,294 | 8,758 | 6,215.03 | .71 |
| 1967 | 19,425 | 18,871 | 18,086.13 | .96 |
| 1968 | 37,241 | 36,618 | 35,920.00 | 1.02 |

TABLE 6. Leg entanglements recorded for 357 kona crabs examined during the sampling trips between April, 1967 and October, 1968.

| Leg No. | No. of Times Leg Entangled | Percentage Leg Entanglement |
|---|---|---|
| 1 (chela) | 21 | 1.6 |
| 2 (first walking) | 539 | 40.9 |
| 3 (second walking) | 456 | 34.6 |
| 4 (third walking | 265 | 20.1 |
| 5 (fourth walking) | 38 | 2.9 |

TABLE 7. Joint entanglements recorded for 357 kona crabs examined during the sampling trips between April, 1967 and October, 1968.

| Joint No. | No. of Times Joint Entangled | Percentage Joint Entanglement |
|---|---|---|
| 1 (dactyli) | 1,243 | 94.2 |
| 2 (propodus) | 69 | 5.2 |
| 3 (carpus) | 7 | 0.5 |
| 4 (merus) | 0 | 0.0 |
| 5 (ischium) | 0 | 0.0 |

TABLE 8. Mortality rates for kona crabs affected by leg damage.

| Leg Damage | Total Animals | Number Dead | Percent Mortality |
|---|---|---|---|
| CONTROLS | 94 | 6 | 6.4 |
| EXPERIMENTALS WITH DACTYLI REMOVED FROM: | | | |
| 1 Leg | 13 | 1 | 7.7 |
| 4 Legs | 54 | 5 | 9.3 |
| 8 Legs | 15 | 3 | 20.0 |
| EXPERIMENTALS WITH 1 LEG REMOVED | 10 | 7 | 70.0 |

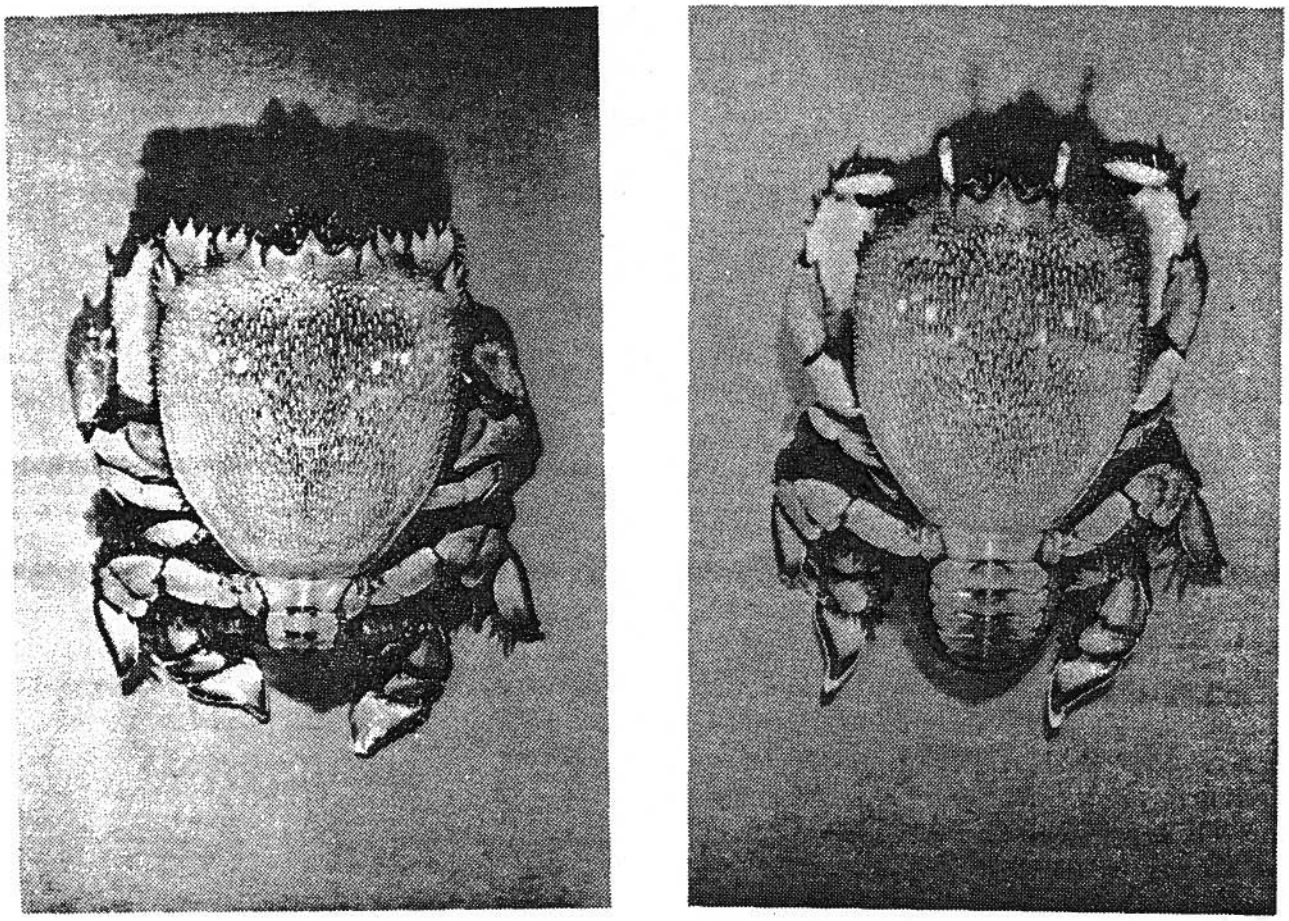


FIGURE 1. Mature male (carapace length - 122 mm) and mature female (carapace length - 85 mm) kona crabs, Ranina ranina (L).

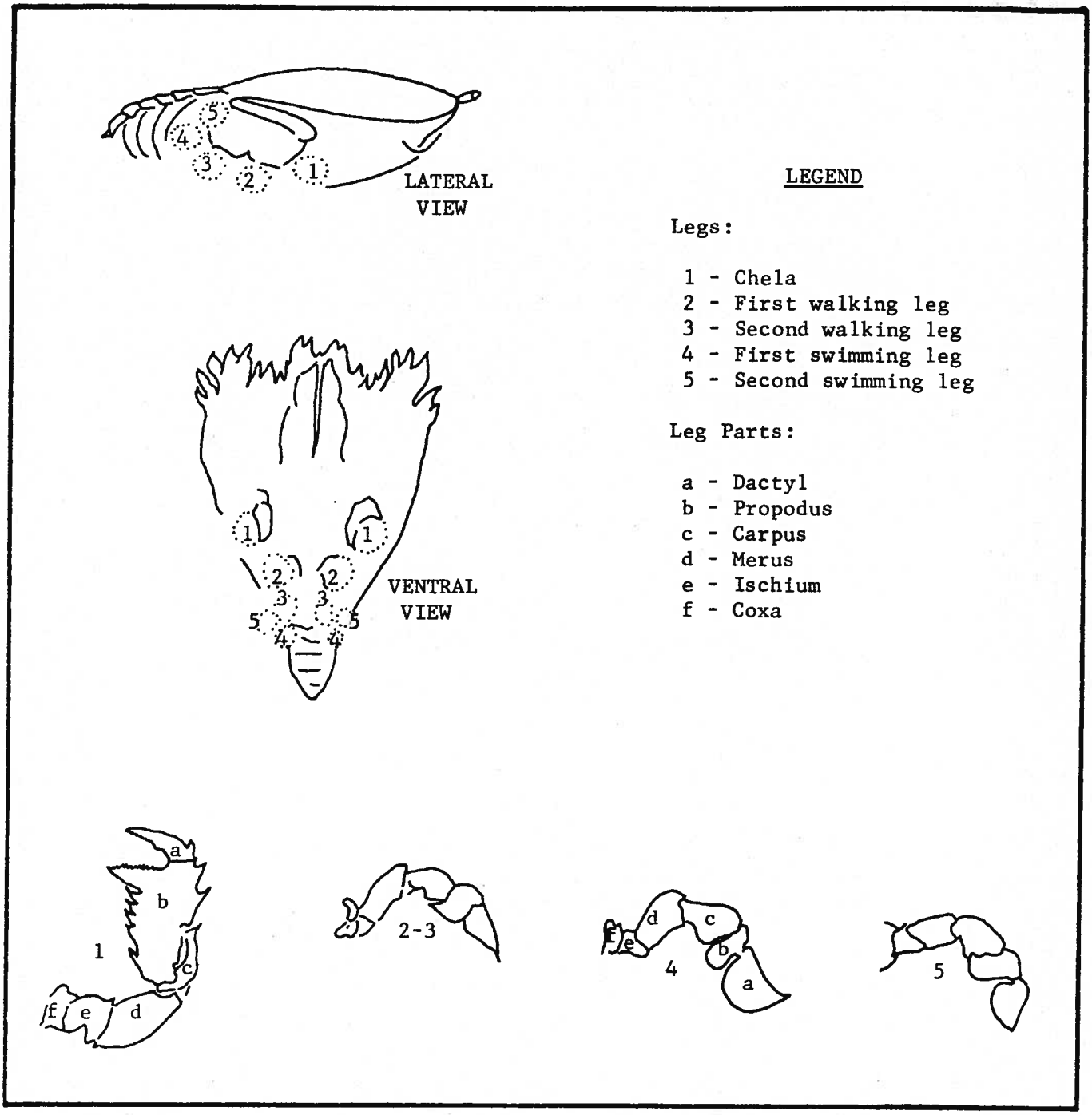



FIGURE 2. The body parts of the kona crab.

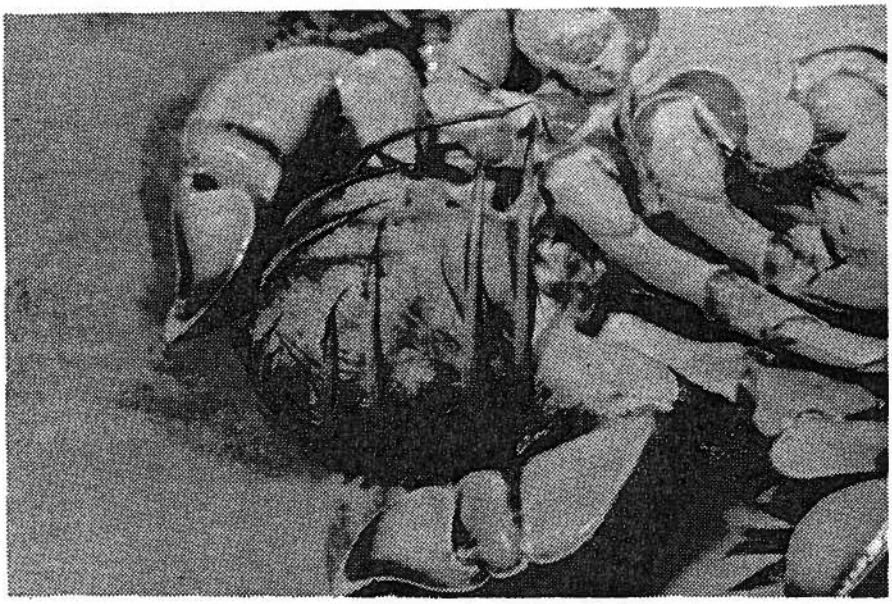


FIGURE 3. Cetae on the abdomen of a berried female kona crab.

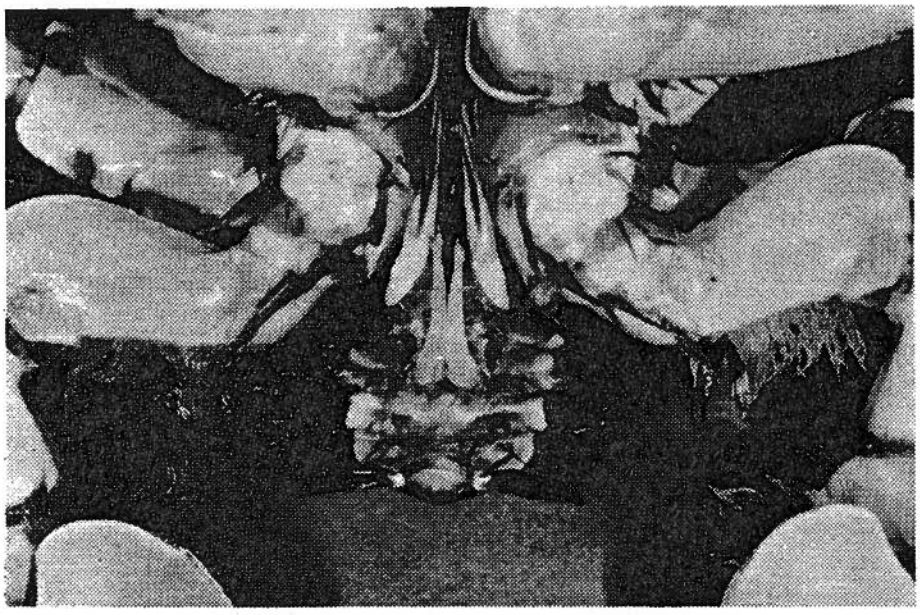


FIGURE 4. Intromittent organs located under the abdomen of a male kona crab.

FIGURE 5. Female kona crab with dorsal portion of carapace removed to show ovaries (O), hepato-pancreas (HP) and gills (G).

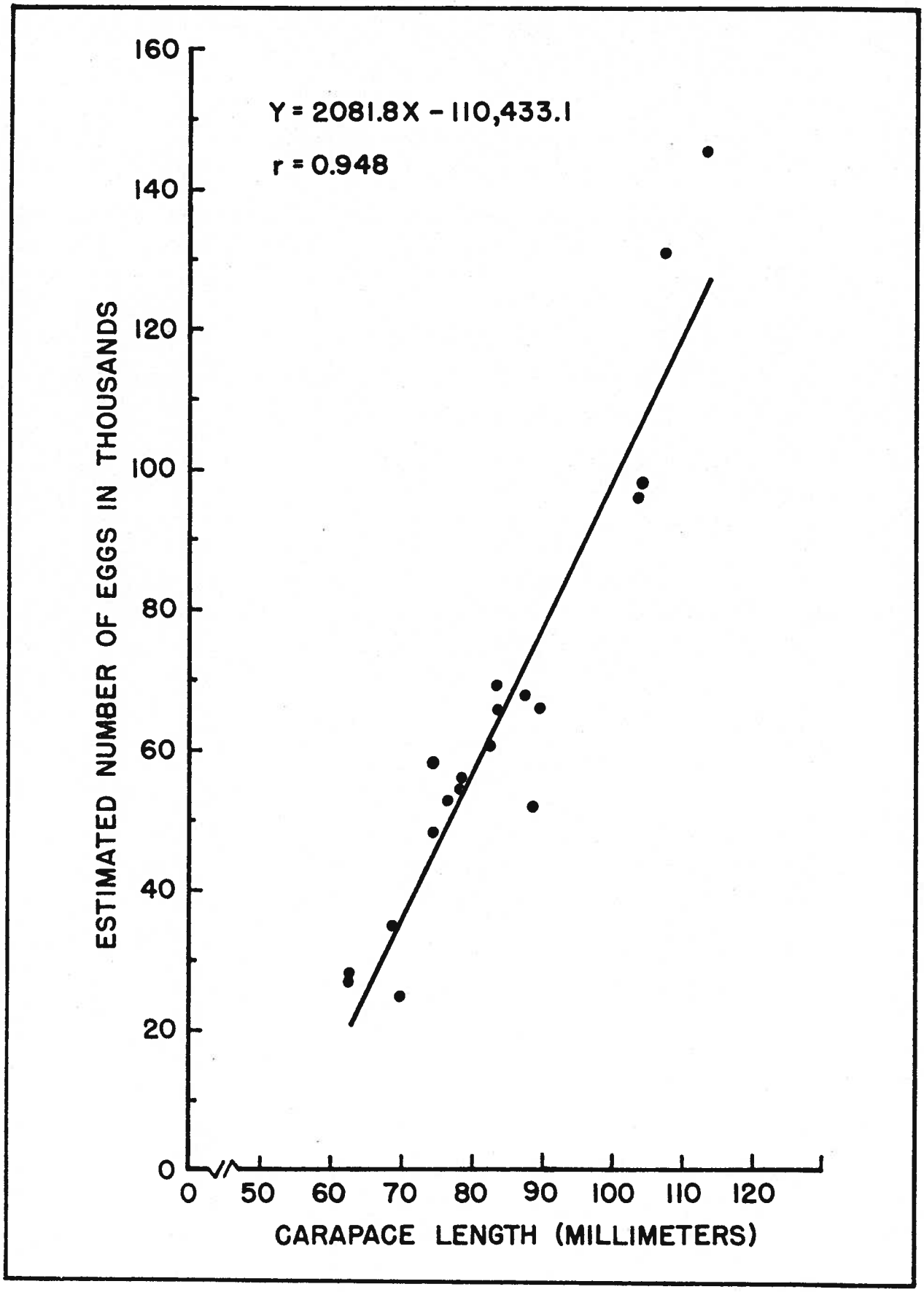



FIGURE 6. Relationship of number of eggs to size of female kona crabs.

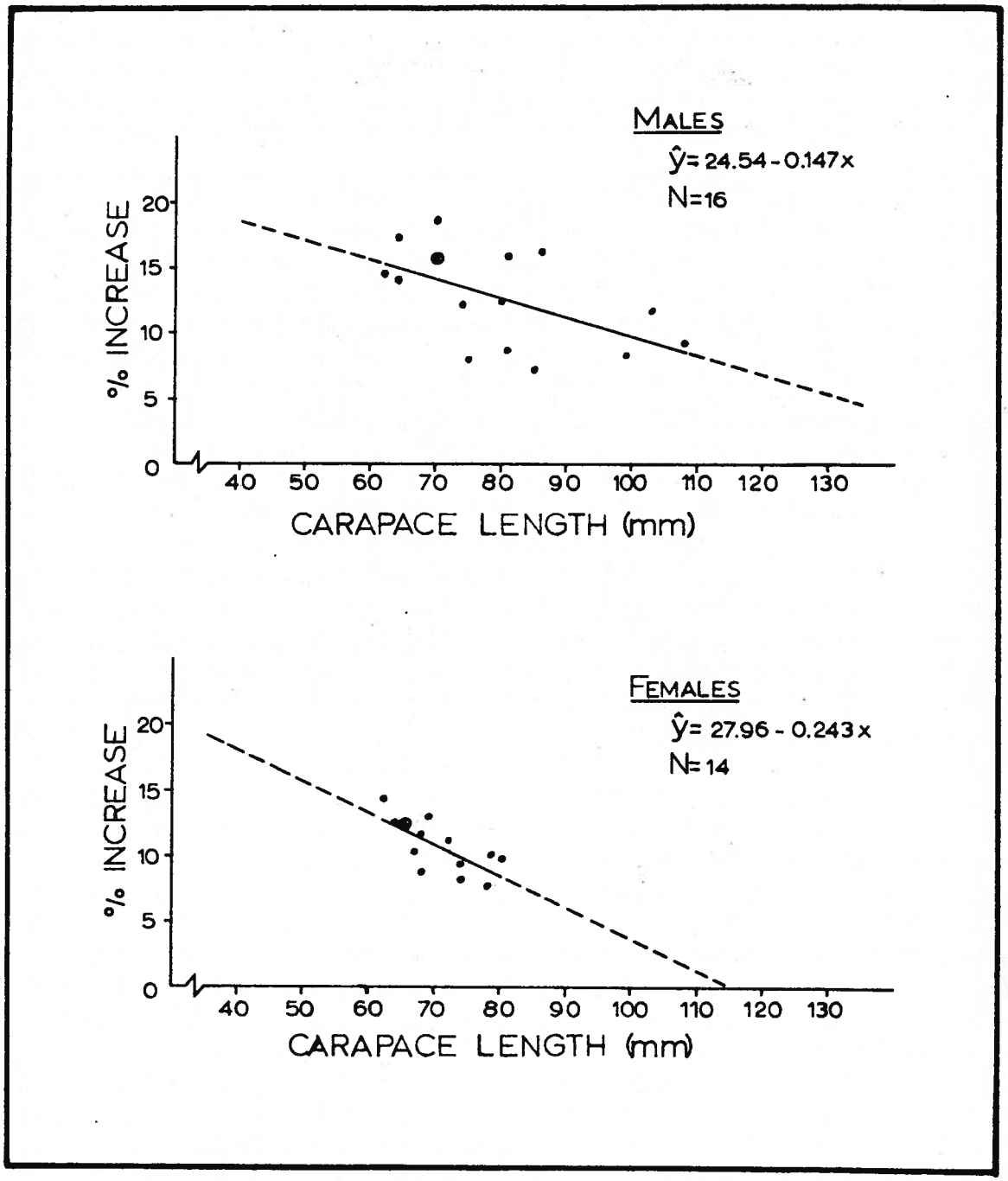



FIGURE 7. Relationship of carapace length increase as a percentage of the original size during each molt for male and female kona crabs.

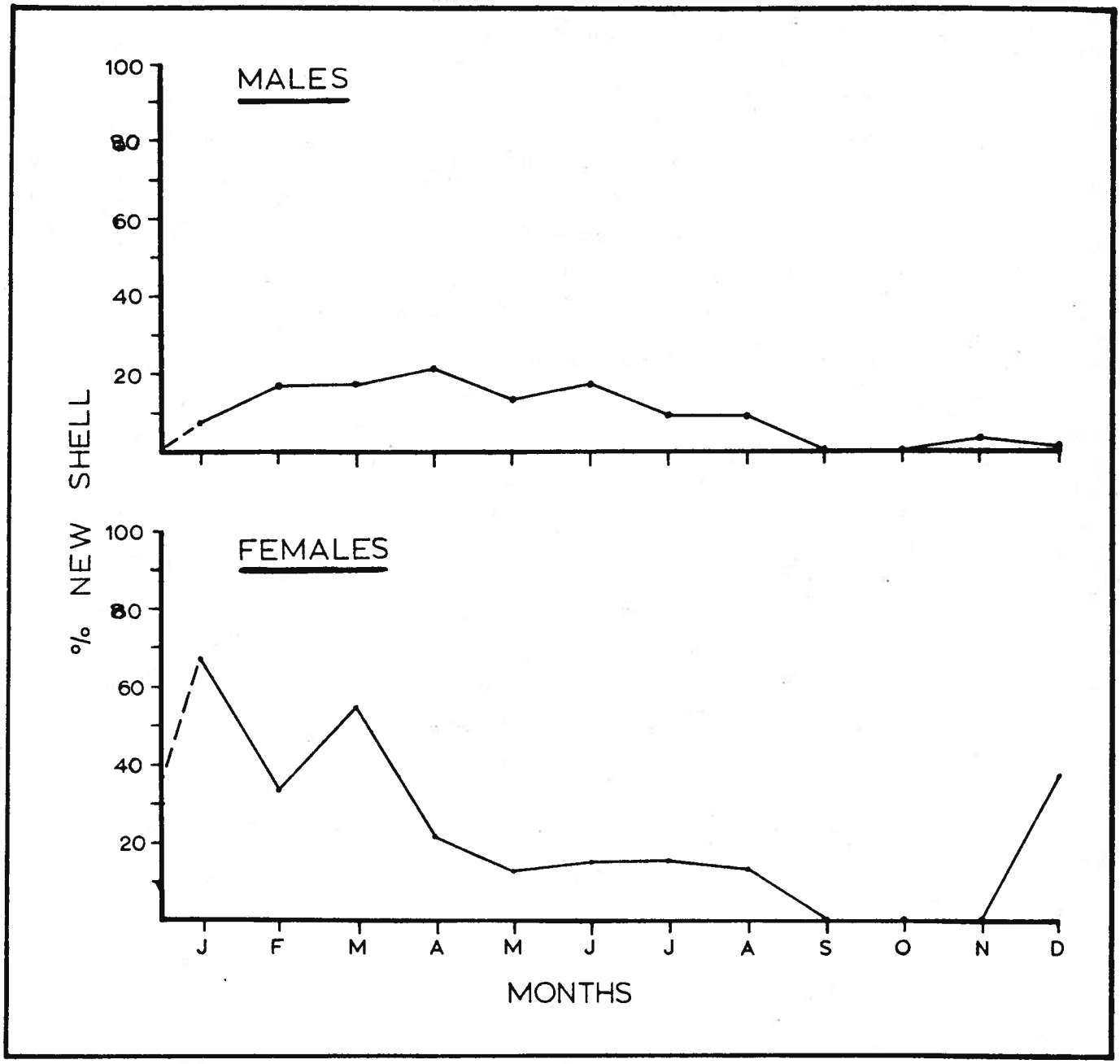



FIGURE 8. Percentages of new shelled kona crabs in monthly samples at Waialua (Haleiwa) and Waimea Bays, Oahu.

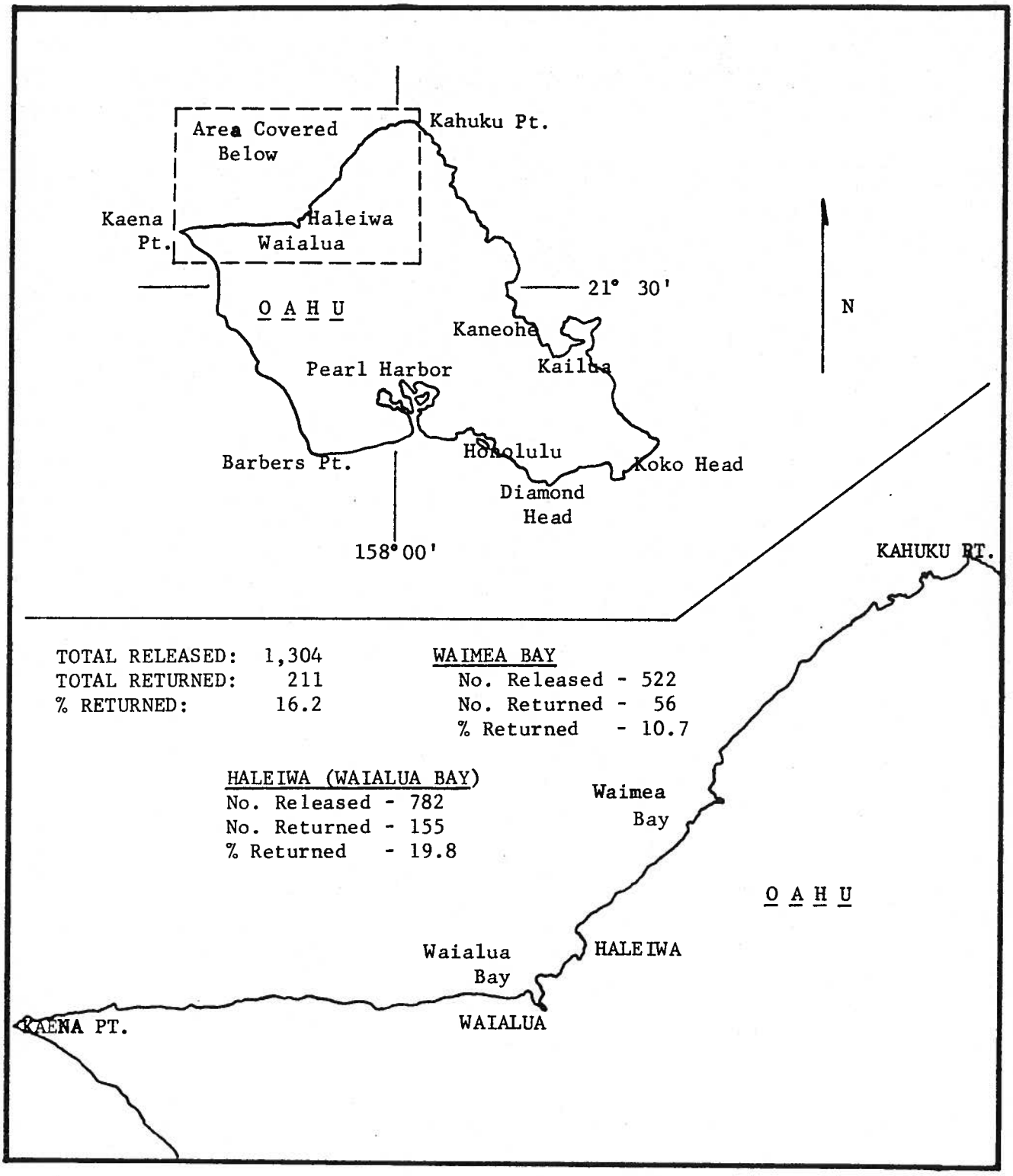



FIGURE 9. Locations of the 1966 tagging operations at Waialua (Haleiwa) and Waimea Bays, Oahu.

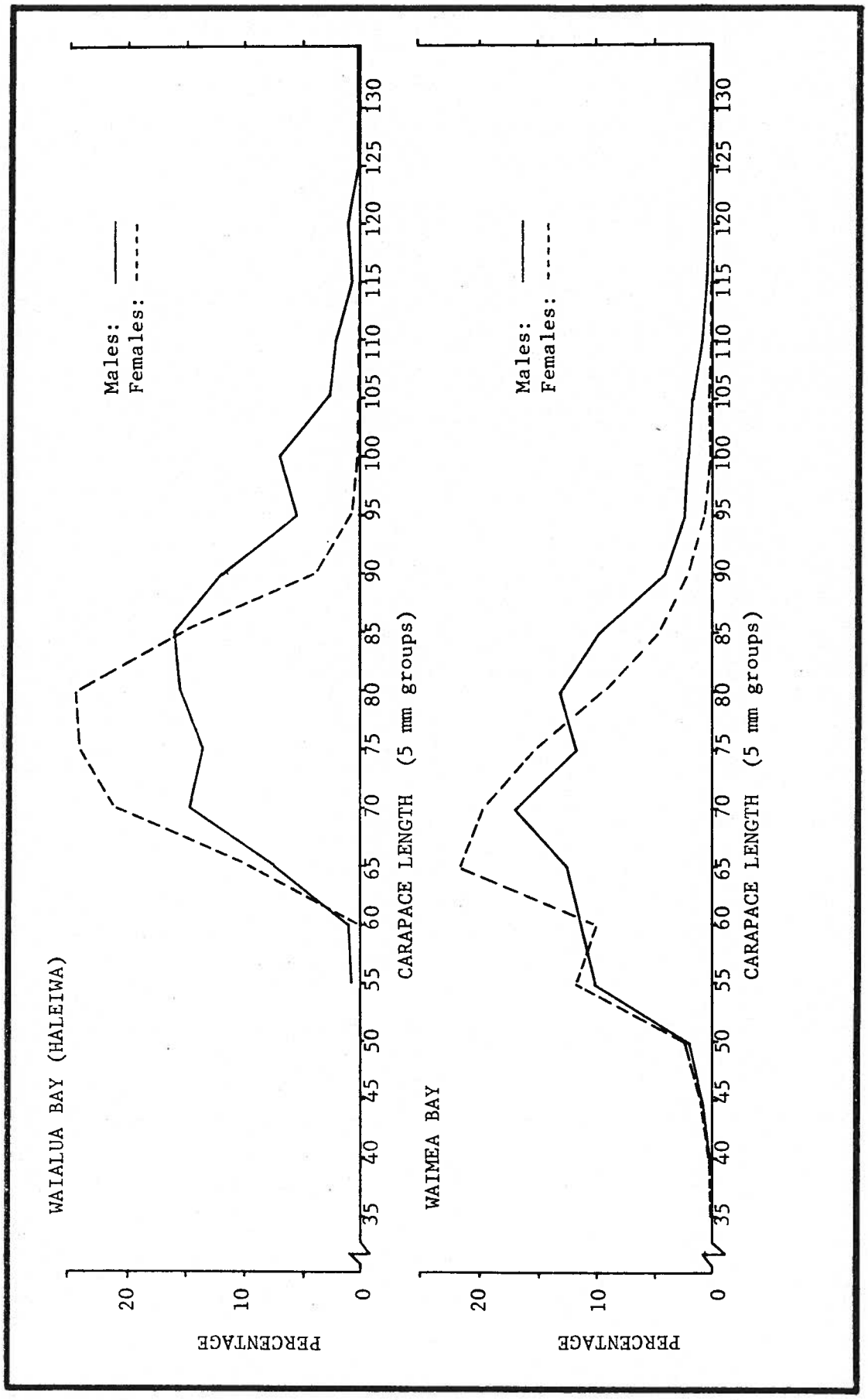



FIGURE 10. Size frequencies of kona crabs caught during sampling at Waialua (Haleiwa) and Waimea Bays, Oahu at each 5 mm size groups.

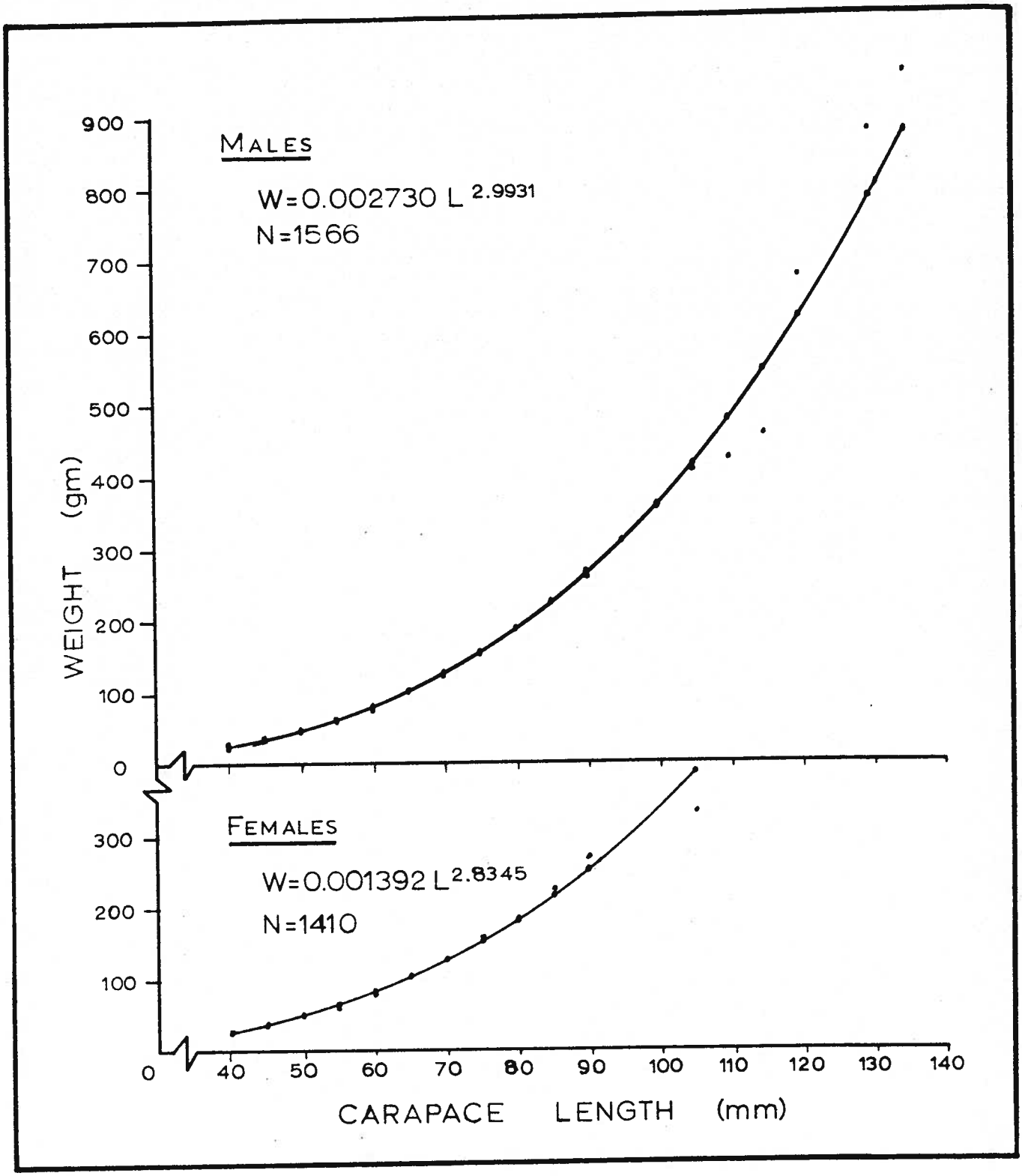
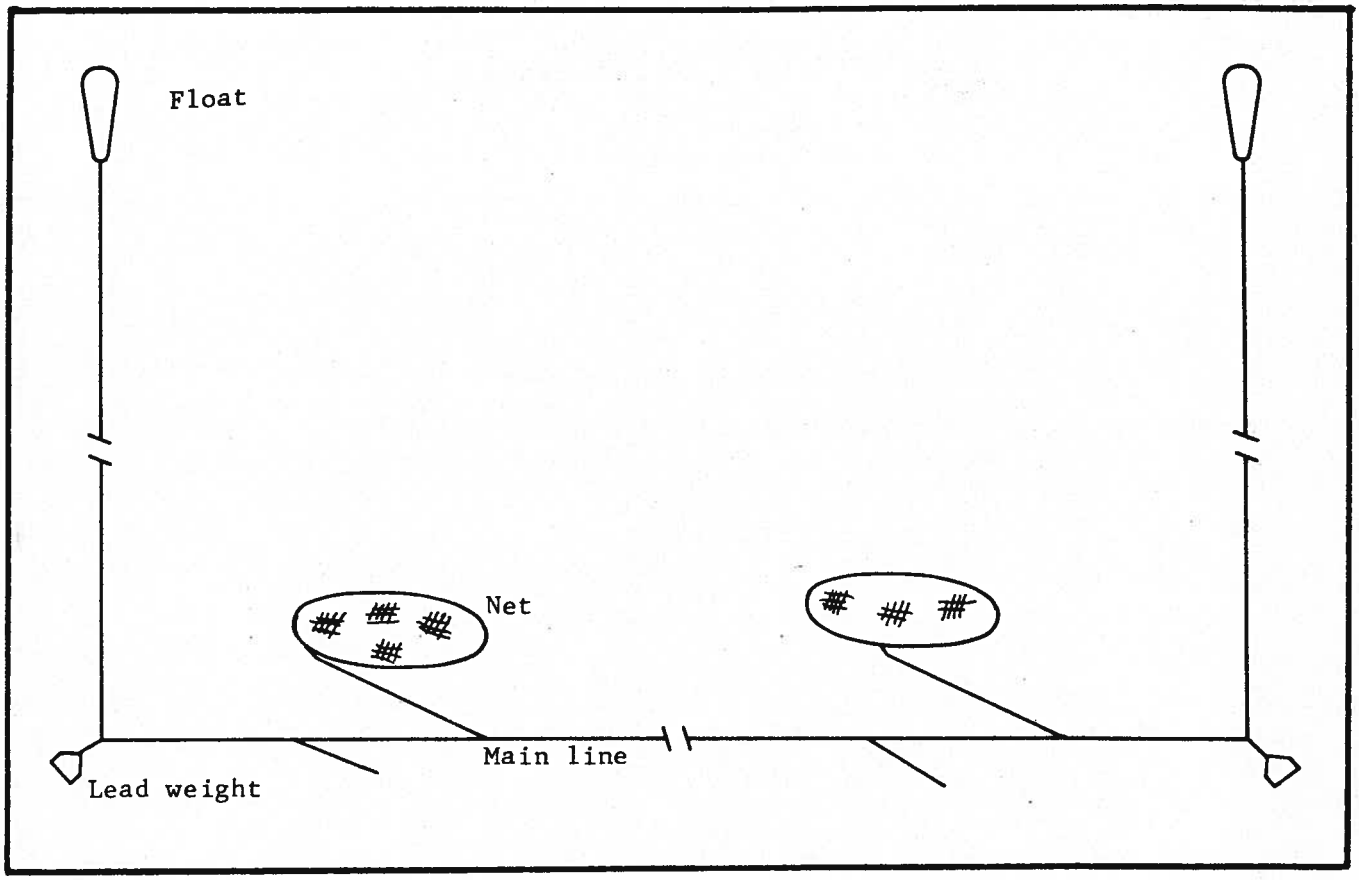



FIGURE 11. Length-weight relationship of male and female kona crabs.



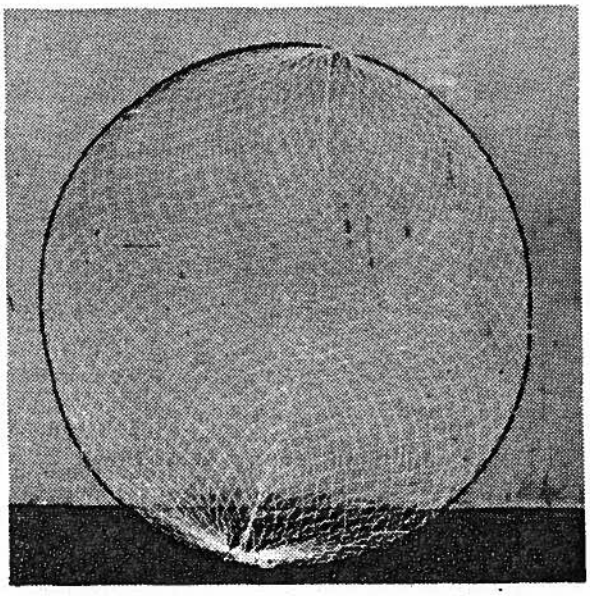



FIGURE 12. Sampling gear used for kona crab fishing.

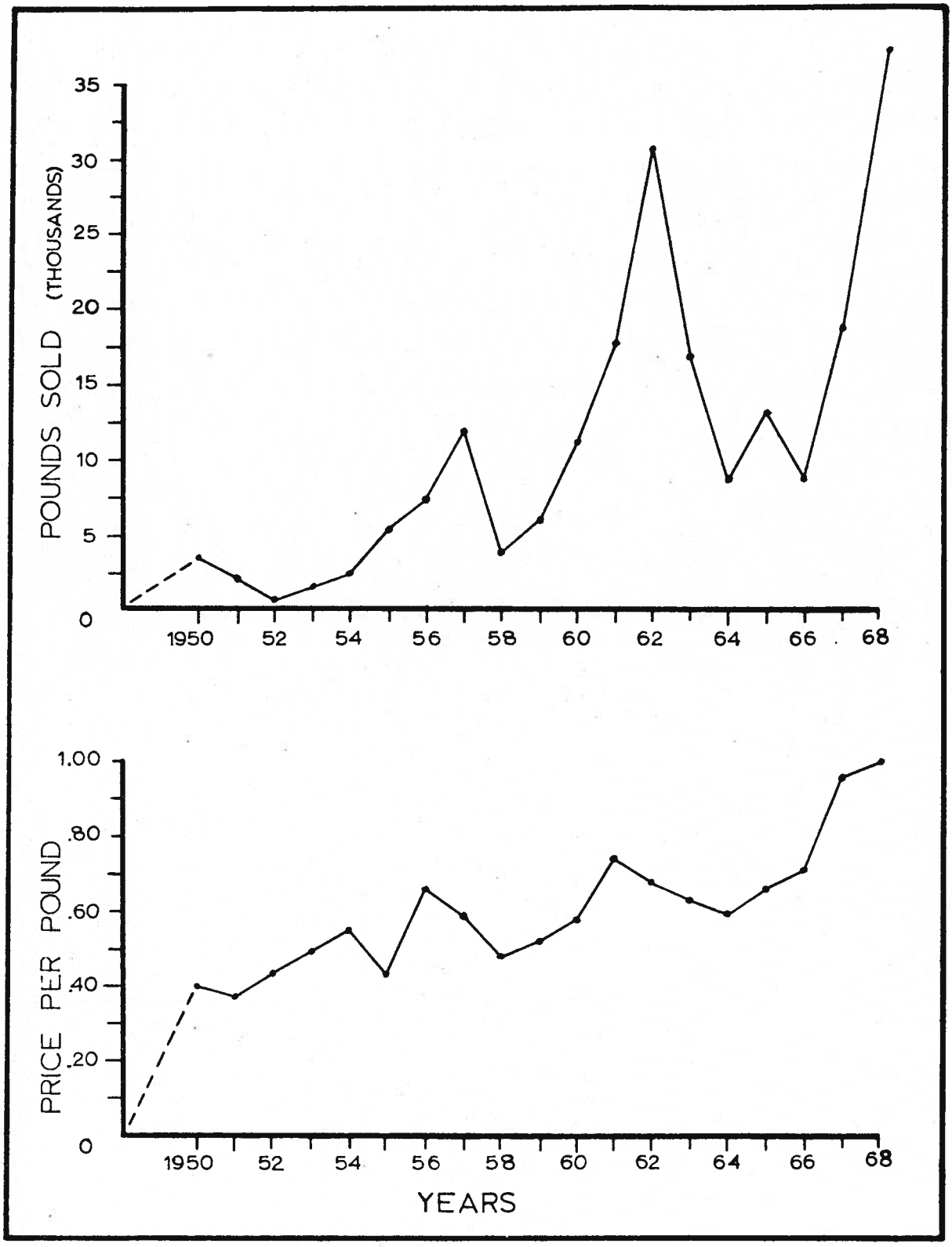



FIGURE 13. Annual State of Hawaii commercial kona crab production in pounds sold and price per pound during 1950 - 1968.

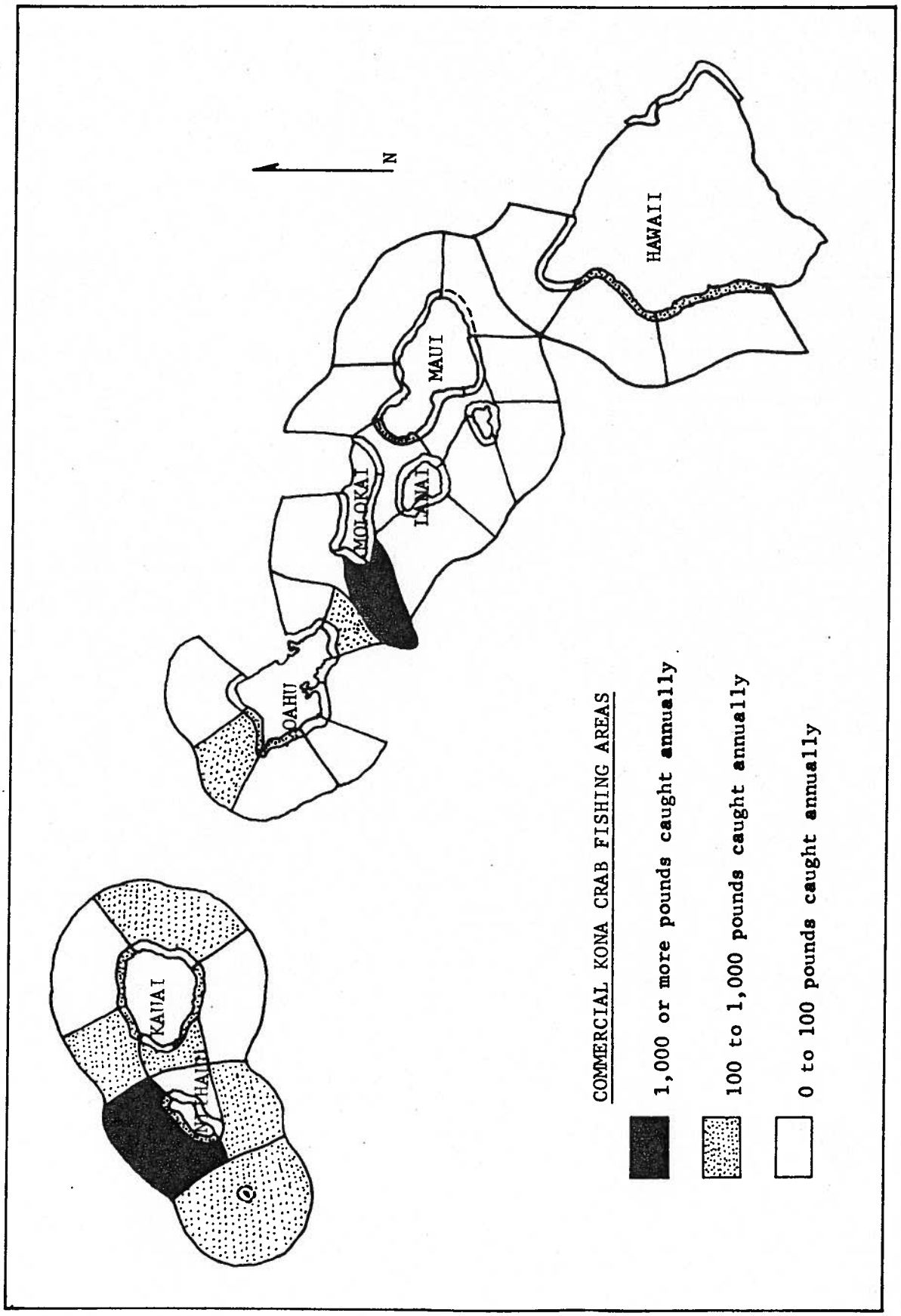



FIGURE 14. Commercial kona crab fishing areas in relation to average annual catches.