

AQUATIC SURVEY
OF
KONA COAST PONDS

HAWAII ISLAND

University of Hawaii
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for

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Terminal Report: Aquatic Survey of Kona Coast Ponds, Hawaii Island.

Introduction

Background and Objectives.

This survey was originated to provide an aquatic inventory of shoreline ponds associated with the geologically newer lavas of Hawaii Island's leeward coast. The inventory was designed to include not only numbers and locations of ponds, but also their physicochemical and biological characteristics. Need for such an inventory was scientific, social and urgent, developing from the following considerations:

1. Recent investigations of the Cape Kinau lava, Maui, showed that water exposures near the shore had peculiar physical and biological features that made them a distinct type of aquatic ecosystem not previously described. New, rare and endemic species of invertebrates were discovered.
2. These "lava" ponds are unique to the State and occur only along portions of shorelines of East Maui and Hawaii Islands.
3. The leeward coast of Hawaii Island, endowed with fresher lava flows was known to have such water exposures. Information on them was scant; only the more obvious ponds had been surveyed for anthropological, geological and waterbird habitat values.
4. Current and proposed cultural development along the Kona coastal zone threatens the obliteration and modification of many ponds before their aquatic resource values can be assessed or appreciated.

This survey describes the aquatic qualities of more than 300 leeward coastal ponds for the combined scientific, educational and use-planning purposes which it might serve.

Scope of Survey.

Field crews, at times numbering up to six members, examined most of the Kona Coast shoreline from a point north of Kawaihae to the east side of Ka Lae (South Point)--a distance of about a hundred miles. Some of this area already has been developed; some is exceedingly remote. Easy vehicular access to some locations contrasts with long, tortuous hikes over trackless lava in others. In

all, 304 water exposures were sampled. Roughly, this represents about half the total ponds in the leeward coastal zone. All detectable water exposures were sampled in areas of pond scarcity; only selected waters were sampled in areas of pond abundance.

Initial strategy was to conduct a preliminary inventory of the entire leeward coast, then return to important ponds and locations for repetitive, intensive sampling. The preliminary phase was completed but the latter was accomplished at only a few locations because of cutbacks in support facilities, arrangements that did not materialize, and the unexpected departure of crew members. The initial assessment of various water quality parameters was soon limited to measurement of salinity and temperature in order to properly accomplish the principal survey objectives. Aquatic biota was sampled extensively and preserved for reference. Unknown organisms were delivered to taxonomic authorities for identification. Because many organisms proved to be new species, present taxonomic listings are incomplete.

Data Treatment.

Much of the value of this report resides in the primary field data. Yet, it would be extremely difficult (and perhaps incomprehensible) to describe in total detail each of the 304 water exposures sampled. Therefore, summary, grouping, and cross-reference of information characterizes most of the tabular and figure presentations contained herein. So that individual ponds might retain their identity for future reference and investigational purposes, their features are described as line items in Tables 1 and 2; Fig. 2 (indexed in Fig. 1) shows the location of each water body on a large-scale map. Similarly, aquatic organisms defy individual description and habitat discussion, but are related to ponds and pond features via Table 3 (check list) with reference to earlier tables.

Physical and Riparian Features

Geology and Basin Origin.

The term "pond" is employed here in its broadest sense to include all exposures of water near the coastline whose surfaces correspond to the sea-level water table. Besides typical ponds, these exposures include all visible waters in fissures, cavernous irregularities in lava, and lava tubes. Nearly all ponds surveyed were associated with recent lava flows; only 5 occurred in ancient lava (Pleistocene or earlier). Of the ponds in post-Pleistocene lavas, 19 were in historic (dated) flows. Most pond basins are cryptodepressions within a lava mass, but some occur between two flows, or between the front of a lava flow and the ocean. In the latter case, the pond basin may be formed entirely within sediments, or be retained against the lava front by a beach bar. Although ponds generally occur very near the shoreline, a few were located nearly 600 meters inland.

Because of relative youth, most pond bottoms (2/3 of total) consist of significant amounts of lava fragments and bedrock. About 1/2 of the ponds contain unconsolidated sediments. Because surrounding lavas are relatively recent and rainfall is low, riparian vegetation is absent from many (20%) of the pond banks. Trees (kiawe, etc.) and shrubs (*Pluchea*, lantana, etc.) occur around 60% of the ponds, and 30% of them also have grasses, succulents and vines.

Pond Morphology.

Most ponds are irregular in shape (reflecting lava surface topography) and fluctuate noticeably in water level with tidal cycles. Because of fluctuating water levels, surface areas and depths are variable. At the lower extreme, some ponds appear only at high tide and have surface areas less than one square meter; at the other extreme, some ponds maintain minimal areas of several hectares. Nearly half of the ponds surveyed were between 10 and 100 m² in area; 40% of them were smaller and 10% were larger. Maximum depths were noted for 228 ponds; more than half of them were less than 0.5 m deep and only 10% were deeper than 1.5 m.

Tidal fluctuations may be more or less damped, depending upon basin (lava or sediment) porosity. Although all ponds have some subterranean connection to the water table and therefore to the ocean, only 13 of the 304 ponds surveyed had an open, surface connection to the sea. Some of these connections are natural (a few existed only at high tide) and others are man-made (e.g., a makaha). Those with surface connections are referred to herein as "open" ponds, those without as "closed" ponds. This factor has a profound effect on pond biota.

Water Character.

Temperature was measured (pocket mercury thermometer) in 208 ponds. Observed surface temperature varied from 19° to 35°C, with 70% of the ponds falling within the 24° to 28° range. High temperatures resulted from solar heating of shallow water exposed over black lava. This may have little effect on most animals which are motile and able to retreat into cooler interstitial waters of the lava substratum.

Salinity in the mixohaline range (0.5-30 ‰) is a primary characteristic of the "lava pond" ecosystem. With one exception, surface salinities measured refractometrically in 286 ponds fell within this range--distributed as follows:

<u>Salinity, ‰</u>	<u>% of ponds</u>
<3	13
3-4	29
5-10	42
11-15	13
>15	3

Biological Features

Open Ponds.

Ponds having surface connection to the sea are accessible to most inshore marine organisms. Successful invaders are those organisms that can tolerate the pond environment, particularly mixohalinity. Species present in such ponds number in the hundreds and include a few that are more characteristic of closed ponds (e.g., Palaemon debilis, Theodoxus cariosa, Eleotris sandwicensis). The more obvious macrofauna of the 13 open ponds is given in Table 4 as a composite taxonomic list. Algae of open ponds were not surveyed.

Closed Ponds.

Biota of 291 closed ponds was sampled as thoroughly as possible at most locations, but microscopic organisms (plankton, unobtrusive epilithon) were ignored. Speciation was less diverse than in open ponds, but more distinctive. Species occurrence is listed in Table 2--fauna by major taxon and flora by community groups. Frequency of occurrence is summarized below:

<u>Biota Category</u>	<u>% of Closed Ponds</u>
Flora	
a) Emergent (sedges, etc.)	35
b) Submersed (pond weeds and filamentous algae)	31
c) Benthic (bottom algae)	52
Fauna	
a) None	2
b) Worms	15
c) Mollusks	72
d) Amphipod crustaceans	39
e) Decapod crustaceans	80
f) Insects	18
g) Fishes	26
h) Others	18

The above tabulation indicates that benthic algae (encrusting and non-encrusting), mollusks, and crustaceans are the most common organismic groups.

Considerably more than 10 species of macrophytic algae were found, but only a few of them have been identified (Table 3). At least 42 species of invertebrate animals were distinguished; 10 of them are mollusks and 9 are shrimps. Eighteen species of fishes were found. Among these organisms, certain native species can be considered characteristic or representative of closed ponds.

The ones identified are:

- a). Ruppia maritima--submersed pondweed that occurred in 42 (14%) ponds and is virtually restricted in distribution to closed pond ecosystems.
- b). Melania sp.--a snail usually identified as M. mauiensis, occurred in 180 (62%) ponds. It is known also from streams and hyperhaline waters.
- c). Theodoxus cariosa--a black, limpet-like neritid snail was found in 56 (19%) ponds and also appears in some estuarine situations.
- d). Halocaridina rubra--a minute, red endemic atyid shrimp (opaeula) was present in 182 (62%) ponds. It is known only from closed, mixohaline waters where fish predators are scarce or absent.
- e). Metabetaeus lohena--a small, reddish, endemic alpheid shrimp occurred in 92 (32%) ponds. It is known to prey on H. rubra and has the same habitat requirements.
- f). Macrobrachium grandimanus--a larger, endemic palaemonid prawn (opae-oehaa) was present in 37 (13%) ponds. Previously, it was considered characteristic only of stream ecosystems.
- g). Palaemon debilis--a medium-sized palaemonid shrimp (opaehuna) occurred in 64 (22%) ponds. It is also found in estuaries and protected inshore waters.
- h). Eleotris sandwicensis--a large, endemic, predaceous gobioid fish (oopu-akupa) was found in 15 (5%) ponds. Because it is secretive and difficult to detect, its pond distribution probably is broader. It is known more commonly from streams and estuaries.
- i). Kuhlia sandwicensis--a silvery, carnivorous endemic fish (aholehole) occurred in 22 (8%) ponds. It is more common to inshore marine waters but may reach a larger size in mixohaline ponds. Juveniles of the species also occur in streams.

Besides being animals distinctive of closed ponds, the above species are broadly euryhaline apparently able to tolerate salinities throughout the mixohaline range (0-30‰). Kona Coast distribution of the most characteristic species from the above list are shown in Fig. 4. Certain species of amphipod crustaceans, presently unidentified, also appear to be characteristic of (perhaps limited to) closed mixohaline ponds.

Waterbirds.

Documentation of coastal ponds as waterbird habitat was secondary to the principal aquatic inventory. Field notes, however, indicate that waterbirds utilize the coastal ponds more extensively than previously known. Bird sightings are summarized in Table 3. More sightings were made than those, but not recorded because of difficulty in associating birds with a particular pond. For example, Wandering Tattlers often were seen perched on rocks between or among ponds; several kinds of waterbirds were observed in flight in some areas of pond abundance (as Waiulua-Anaehoomalu). Subjectively, the most important waterbird location on the Kona Coast, in terms of species abundance and diversity, seems to be Aimakapaa. Next in importance are Opaepa pond, the numerous water exposures between Waiulua and southern Anaehoomalu Bays, and the various ponds immediately south of Kona Airport.

Cultural Influences

The intrinsic natural character of coastal ponds, both physical and biological, is inevitably altered by the presence of man. Such alteration is usually severely destructive to the natural ecosystem. These alterations include physical modifications that at the extreme are manifest as total obliteration. Litter addition and nutrient enrichment are other degrading factors. Apart from complete physical obliteration, the most severe human alteration is the introduction of foreign species that upset the natural ecological balance. Tilapia and poeciliid fishes are particularly inimical to native species through predation, competition and fecundity. Ponds and pond areas thus modified were only partially sampled. Such areas include ponds at Puako, Kona Village, and Kailua.

Minor pond alteration by early Hawaiians seems not to have altered the natural ecosystem significantly--perhaps they became restored with time from ancient use depletion. Some of the water exposures included in this survey are not natural ponds. A few are known to have been constructed by early Hawaiians--such as wells excavated in loose lavarubble and marine embayments enclosed by rock bars (e.g., Kaloko Pond). Some of these ponds have been modified further by man in recent years. At least two of the ponds surveyed were constructed lately by excavation machinery; one was bulldozed in clinkery lava near Kaloko Pond and the other was quarried into massive lava inland from Aimakapaa. Both are of great interest because they contain self-colonizing native fauna, substantiating the hypothesis that many species inhabiting closed ponds must arrive by migration through subterranean interstitial waters. At the J-43 site, for example, H. rubra appeared in the pond within a year after it had been bulldozed.

Noteworthy Ponds and Pond Areas

A final interpretation of survey data was made by consideration of ponds and pond systems having important natural values for future study and preservation. Criteria used in this evaluation were: exceptional natural quality in terms of geological or biological representation; uniqueness in terms of rare or unusual species; or of geological formation; high natural quality threatened by imminent development. The following are brief descriptions of 12 locations thereby deemed important.

1. Lahuipuaa (Ponds C-10 to D-5; Fig. 4a). This is an area of diversity in pond size and geological character; it also has representative fauna. Ponds occur in both pahoehoe and aa lavas. Typical exposed ponds occur as well as waters in cave-like basins. It has some exceptionally large ponds; although culturally modified, they represent the best preserved "traditional" Hawaiian fishponds. Recently purchased by Tokyu Land Co.
2. Waiulua-Anaehoomalu (Ponds D-7 to 46; Fig. 4b). Although incompletely surveyed, sufficient information was gleaned from this area to suggest that it is the most outstanding Kona Coast pond location. Principal features are the great number of ponds (> 100) in a relatively small area, representivity of aquatic fauna and flora, peculiarity of many marine fishes (at least 8 species) in water of extremely low salinity, occurrence of a rare eel (Gymnothorax hilonis), and the substantial use of ponds by Ae'o and other waterbirds. Unfortunately, the developer (Boise-Cascade/Waikoloa Resorts) has destroyed a few ponds and altered the shoreline of Waiulua Bay by bulldozing. An intensive pond and marine survey of this significant area is urgently needed.
3. Puuwaawaa (Pond F-5). This large single pond (Luahinewai) represents a classical example of basin formation by a beach bar. It is deep and clear, shows strong vertical salinity stratification and has the most luxuriant growth of the native pondweed, Ruppia maritima.
4. Awakee-Makalawena (Ponds H-2 to 28). An interesting array of ponds occurs on both recent aa and older pahoehoe. Value here centers on Opaepa Pond, primary habitat of Hawaiian Stilt on Hawaii Is. Representative closed-pond fauna occur. An unusual feature is the presence of shrimp and mollusk ecotypes (morphologically different populations of the same species, probably resulting from different environmental conditions) in adjacent ponds.

5. Kohanaiki (Ponds J-7 to 35; Fig. 4c). This is a system of scattered ponds in older pahoehoe lava in the vicinity of Wawahiwa Point. Ponds are notable for their morphological and basin diversity, lush growths of marine related algae (Ahnfeldtia), abundance of palaemonid shrimps, and waterbird habitat significance. Also, a dense stand of mangrove trees (exotic), occupying one of the larger pond basins, threatens to overrun adjacent ponds. Area should be studied further.
6. Honokohau (Ponds K-1 to 15). The primary feature of this area is Aimakapaa--an unusually large water expanse that is the most important waterbird habitat (all species considered) of the Kona Coast. Aimakapaa has a paucity of aquatic faunal species. Adjacent smaller ponds occur on very flat pahoehoe and are unusual in their shallowness and drastic surface area fluctuations with tide change.
7. Kealakehe (Ponds K-22 to 30). This is a small group of deep-set ponds in high pahoehoe. A few are overrun by exotic fish (tilapia). The remainder have a complement of representative fauna. Peculiarities appear in mollusk speciation and behavior. It is an area of significant natural value possibly threatened by the expansion of Honokahau small boat harbor.
8. Manuka (Ponds S-1 to 4). Three of the four "ponds" are deep fissures and the other is a cavern formation. One fissure is the most impressive encountered on this survey, paralleling the shoreline for several hundred feet with water lying fifty or more feet below land surface. Besides the unusual nature of these water exposures, value of the area lies in the spectacular, dynamic interaction of sea waves and lava formations between S-1 and S-2. Land consists of high pahoehoe with tubes or shafts extending considerable distances inland. Geyser-like sprays and many surge pools present dramatic displays. At one location, wave-compressed air emanates from a hole in the lava with a deafening roar. This is a remote area with difficult access.
9. Kahuku North (Ponds U-1, 2). This location was considerable esthetic appeal and contains the best representation of both mixohaline flora and fauna on the southern part of the Kona Coast. Encrusting algae form spectacular marl deposits in the clear water. An unusual feature is the absence of kiawe trees that appear ubiquitously on the southern coast in similar locations.
10. Kahuku South (Ponds V-1 to 12). These waters are a combination of open ponds and fissures. V-1 is a large, deep fissure containing several aquatic species that include

an unusual shrimp. Other fissures are in low flat pahoehoe (water level a foot or two below the surface) but are difficult to sample because of their narrowness. An additional feature of this area, especially in the southern end, is the notable diversity of tidepool and intertidal marine algae and fauna.

11. Pakini Nui (Pond X-1). This is not a pond per se, but an ancient littoral cone (Lohena Rock) rising above recent aa near the shore. The cone is heavily fractured and deep-lying water is found at two locations where fractures are large enough to enter. It is important as the type locality of the alpheid shrimp, Metabetaeus lohena. A peculiar feature is the occurrence of calcareous deposits including attached barnacles on lava walls deep inside the cone. Position of these deposits is well above present sea level and suggests origin during a Pleistocene interglacial period of higher sea level.
12. Kamoia Puueo (Pond X-5). Although this single pond (Lua o Palahemo) is not strictly on the leeward coast, it was surveyed because of its proximity of South Point (Kalae), the terminus of the project survey zone. It is the most important single-pond location from aquatic and geological standpoints. It occurs in an ancient lava flow and seems to be a collapse point in a large lava tube that extends a considerable distance inland. The water is deep (> 35 feet), turbid, and contains a diversity of aquatic invertebrates and marine-related algae. Its most noteworthy feature is the presence of several unusual crustaceans, two of which are rare and known only from one other location in the State (Maui). It is also the site of greatest abundance of the small red shrimp Halocaridina rubra (opae-ula). This location is in need of further study.

Acknowledgements

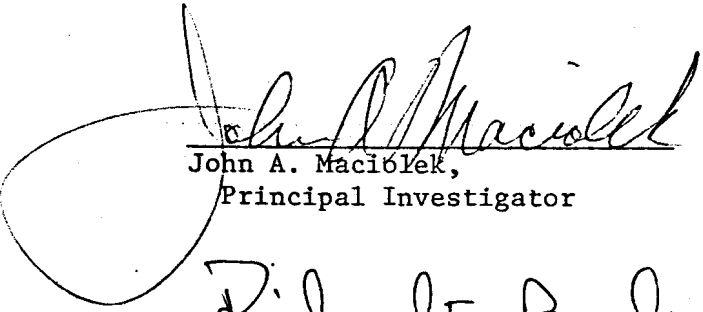
Several members of the University of Hawaii staff contributed to the accomplishment of this project. Special credit is due to Dr. J. H. Brock, marine zoologist, who spent considerable time on field survey and provided the identification of many invertebrates. Drs. E. A. Kay and M. Doty, malacologist and phycologist respectively, also assisted with identification. Other professional taxonomists who are handling new material collected include Drs. Barnard (Smithsonian), Bousfield (Canadian Natl. Museum) and Holthuis (Rijksmuseum). Dr. T. S. Newman, State Anthropologist, provided considerable field information and aerial photo facilities.

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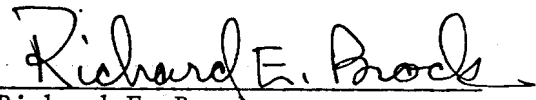
expenses. Mr. B. Harry, U. S. Natl. Park Service, provided a vehicle for part of the summer work. Thanks are extended to Messrs B. Machado and E. Sheppard for assistance in housing the summer crew.

Lastly, it would not have been possible to complete this survey without help from landowners and managers who provided survey crews with access to many areas. These include W. Akau, D. Carlsmith, N. Carlson, DeLeco, Duerr, H. Greenwell, D. Haserot, (Mrs.) P. Hunter, R. Rittmeister, G. Schatthauer, and M. Waddups. Mr. Haserot's continued cooperation and observational information deserve special mention.

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Attachments: 4 Tables, 5 Figures

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Addendum: the following is a continuation of page 3 text (bottom).

Overall average surface salinity was 6.7 ‰. Mixohalinity apparently results from the mixing of subterranean freshwater run-off with seawater that has perfused the lava far inland. Salinity variations within a pond were noted in a few instances, due either to vertical stratification (deeper ponds) or horizontal differences (localized landward influx of freshwaters in ponds with large surface areas).

Pondwater was generally clear, but a few ponds were noticeably turbid with plankton or silt. Such turbidity probably relates to slow exchange of water, abetted by disturbance of sediments (by birds or fishes) or nutrient loading (cultural influence).

Table 1. Physical and geographical data for 304 ponds and other water exposures on the Kona Coast, Hawaii, surveyed between July 1972 and May 1973.

Explanation of Table Format

1. Two general symbols used in table body are ditto mark (") indicating repeat entry of character immediately above it, and question mark (?) to note that a particular feature was either not observed, not measured, or not recorded.
2. Ponds are identified by Quad code described in Fig. 2.
3. Column 2 gives pond latitude in minutes and fractions thereof. All ponds are 19°N except those on Quads A and B (20°N) and V through X (18°N).
4. The age of lava flow associated with each pond is given by: year date if historic; R if recent but prehistoric; A (= ancient) if Pleistocene or earlier.
5. Riparian plants are categorized in three general groups: G = grasses and similar annuals; T = trees and shrubs; S = succulents and vines. The symbol "0" indicates the absence of bordering vegetation. Where more than one category is present around a pond, the items are arranged in order of decreasing abundance.
6. Pond bottom material is distinguished as: B = bedrock; R = rubble and gravel; Sc = calcareous and/or sandy sediment; Sm = mud sediment. Where more than one category is present in a pond, the items are arranged in order of decreasing abundance.
7. Surface area is given as one of four classes: VS = very small, $<2 \text{ m}^2$; S = small, $2-10 \text{ m}^2$; I = intermediate, $10-100 \text{ m}^2$; L = large, $>100 \text{ m}^2$.
8. Maximum depth is noted as: S = shallow, $<0.5 \text{ m}$; M = medium, $0.5-1.5 \text{ m}$; D = deep, $>1.5 \text{ m}$. A lower case "-t" suffix with any of the above indicates noticeably turbid water.
9. Surface temperature is given to the nearest whole degree (Celsius).
10. Salinity is given in parts per thousand. A range in salinity values indicates either horizontal or vertical (stratification) variation.
11. The last column cross-references ponds described by number in the Kikuchi-Belshe report: "Examination and Evaluation of Fishponds on the Leeward Coast of the Island of Hawaii. 1971. Hawaii County Planning Comm., Hilo".
12. Asterisk (*) following Pond No. (column 1) indicates open ponds (surface connection to sea).

Table 1. Shoreline ponds of the Kona Coast, Hawaii: physical and geographical data.

Pond No.	Latitude	Lava age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
A-1	6.12	A	T	R,Sm	S	S	26	2	
B-1 *	1.93	A	G,T,S	R,Sc	I	M	31	8-15	64
C-1	58.25	R	T	R,Sm	"	"	?	6.5	
2	"	"	"	Sm	"	"	?	6.5	
3	"	"	"	R	"	"-t	?	10.5	
4	"	"	"	R,Sm	"	"	?	4.5	
5	"	"	?	?	"	S	?	4	
6	58.19	"	T,G	Sm,R	"	M	34	9	63
7	58.14	"	"	"	L	"	25	5	62
8	57.71	"	?	R,Sc	I	"	?	27	
9	57.65	"	"	R	VS	?	?	?	
10	57.25	"	G,T	Sm	L	M	27	3	61
11	"	"	G,S,T	"	I	S	28	4	60?
12	"	"	"	"	"	"	29	4	60?
13	"	"	"	Sc,R	S	"	26	4	
14	57.23	"	T	R	VS	"	26	4	
15	57.20	"	O	Sc,R	I	"	26	4	
16	57.18	"	T	Sm,R	"	M	28	3	
17	57.17	"	O	R	S	S	26	4	
18	57.15	"	T	"	VS	"	25	4	
19	57.13	"	"	"	S	"	25	4	
20	57.12	"	"	R,Sm	VS	"	25	4	
21	57.10	"	T,G,S	Sm	I	M	30	5	
22	57.04	"	T	R	VS	S	26	4	

(Table 1. Kona Coast Ponds, physical/geographical data.)

[illegible]

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
D-16 *	55.48	R	O	B,Sc	I	M	28	?	
17	"	"	S	R,Sm	"	"	25	12-14	
18	"	"	"	R	"	S	25	12	
19	"	"	O	"	VS	?	25	12	
20	"	"	"	"	"	"	25	12	
21	"	"	S	R,Sc	I	M	26	12	
22	"	"	"	R	VS	S	25	11	
23	"	"	"	"	I	?	25	12	
24	"	"	S,T	"	I	?	25	9-11	
25	"	"	T,S	"	L	S	27	7-11	
26	"	"	"	R,Sm	I	?	?	7	
27 *	55.17	"	G,S,T	Sm,Sc	L	S	25	17	51
28 *	55.08	"	T,G,S	Sc,Sm	"	D-t	28	4-18	50
29	55.10	"	S	R,Sc	S	S	25	2	
30	"	"	S,G,T	R	I	"	26	4-7	
31	"	"	S,T	"	S	M	26	2-4	
32	"	"	S	R,Sm	I	S	26	2	
33	"	"	S,T	R	"	?	25	2	
34	"	"	"	"	VS	?	25	1	
35	"	"	"	Sm	I	M	27	1	
36	"	"	S,G,T	R	"	?	26	5	
37	"	"	"	"	VS	S	27	2	
38	"	"	S,G	"	S	?	28	2	
39	"	"	G,S,T	"	I	M	27	2	
40	"	"	T,S,G	R,Sc	"	S	26	2	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity ‰	K-B
D-41	55.10	R	G,S	R	S	M	27	3	
42	"	"	T,G,S	Sm	I	"	30	4-10	
43	"	"	T,S	Sc	"	?	28	3-10	
44	"	"	"	Sm	"	?	24	3-5	
45	"	"	T,G,S	R,Sm	"	?	25	5	
46	"	"	T,S	Sm	S	?	25	5	
47	54.98	"	"	Sm,R	I	S	25	2	
48	54.97	"	O	R	VS	D	23	1	
49	54.78	"	T	R	"	S	26	3	
50	"	"	"	"	I	M	23	4	
51	54-72	"	"	"	"	"	26	5-6	
52	"	"	"	"	"	"	26	5	
53	"	"	T,G,S	Sc,R	L	"	32	12	48?
54	"	"	"	R,Sm	"	"	26	4-6	48?
55	"	"	S,T	R	I	"	26	5	
56	"	"	T,G	R,Sm	"	"	26	5	
57	54.70	"	T	R	VS	S	23	2	
58	"	"	O	"	S	?	24	5	
59	"	"	S	?	"	S	26	4	
60	54.37	"	O	R	I	D	24	4	47
61	"	"	T	"	L	?	25	4	
E-1	54.16	"	T,S	Sm	I	S	25	4	
2	"	"	"	R	"	?	26	4-5	
3	54.07	"	T	"	L	?-t	26	4	
4	53.85	"	"	"	I	M	24	2	45

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity ‰	K-B
E-5	53.85	R	T,S	R,Sc	I	?	24	2-3	45
6	"	1859	T	"	L	S	25	2	45
7	53.64	"	"	R	I	?	?	?	44
8	53.46	"	S	"	"	D	24	2	
9	"	R	T,S	Sc	L	?-t	25	2	43
10	"	"	T	Sm	I	S	27	2	
11	52.71	1859	"	B	"	M	24	4	
12	52.30	"	O	R	"	S	27	4	
13*	51.64	"	T	Sc,R	L	D-t	?	12	42
14	51.58	R	T,G	Sc,Sm	"	M-t	26	0-3	41
15	51.40	"	T	R,Sm	I	S	25	2-4	39
16	51.46	"	"	R,Sc	"	M	25	2	
17	51.48	"	"	Sm	L	"	24	2	40
F-1	51.30	"	"	Sc,Sm	I	S	24	4	
2	51.12	"	"	Sm,R	"	"	35	1	38
3	"	"	"	Sm	"	"	28	2	38
4	51.17	1800	"	B,R	"	M	23	3-4	
5	"	"	T,S,G	R,Sm	L	D	24	4-3	37
G-1	50.03	R	S,T	Sm	I	S	26	2	
2	"	"	T,S	"	"	?	?	?	
3	"	"	"	Sm,R	VS	S	26	4	
4	"	"	S	R	I	"	26	3	
5	"	"	"	Sc,R	VS	"	25	3	
6	"	"	S,T	Sm	I	"	28	4	
7	"	"	T	R	VS	"	26	2	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
G-8	50.03	R	T,S	Sm	L	M-t	25	4	36
9	"	"	T	Sc	I	M	23	4	
10	"	"	"	"	"	S	24	4	
11	49.83	"	T,S	"	"	"	25	2	
12	49.70	"	"	B,Sc	L	M	25	3	35
13	49.46	"	S,G,T	Sm	I	S	30	2	
14	49.37	"	T,S	R	VS	"	25	4	
15	"	"	S,T	Sm	I	"	27	3	
16	"	"	"	"	"	?	27	2	
17	"	"	T,S	Sm,R	"	?	?	?	
18	49.28	"	S,T	R	L	M	31	3-5	34
19	49.06	"	S	"	VS	?	25	4	
H-1	48.85	"	S,T,G	Sc	I	M	29	7	33
2	47.90	"	S,T	Sc,R	"	"	28	6	32
3	"	"	O	Sc	"	"	30	6-7	
4	"	"	T	"	"	"	27	6	
5	"	"	O	R	I	M	26	6-8	32
6	"	"	T	"	S	"	24	6	32
7	"	"	"	Sc	I	"	24	6	32
8	47.82	"	O	R	"	"	23	6	
9	"	"	"	"	"	S	23	7	
10	"	"	"	"	VS	?	24	6	
11	"	"	"	"	S	?	24	6	
12	"	"	"	"	"	"	24	6	
13	"	"	"	"	"	?	23	6	

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
H-14	47.82	R	O	R	I	?	23	6	
15	"	"	"	"	S	?	24	6	
16	"	"	"	"	I	?	24	6	
17	"	"	"	"	S	?	24	6	
18	"	"	"	"	"	?	24	6	
19	"	"	"	"	"	?	23	6	
20	47.76	"	S,T	"	I	M	25	8	31
21	"	"	T	"	"	"	25	8-12	30
22	"	"	O	Sm	"	S	23	8	29
23	47.70	"	T,S,G	Sc	L	M-t	27	6	28
24	47.67	"	T	Sm,R	I	S	29	4	
25	"	"	S,T	"	"	M	26	4	
26	"	"	T	R	"	"	25	4	
27	"	"	T,S,G	Sm	"	S	26	3	
28	"	"	T	R	S	M	26	4	
29	47.48	"	O	"	VS	S	?	4	
30	"	"	S	Sc	I	M-t	?	4	27
31	47.20	"	T,G	R	S	S	?	3	
I-1	46.97	1801	T,S	Sm	I	M	?	9	26
2	46.95	1801	T,G	Sm	S	S	?	8	
3	44.07	"	O	R,Sm	I	"	?	8	
4	"	"	"	B,Sm	S	"	?	7	
5	"	"	T,S	Sm,R	I	"	?	8	24
J-1	43.17	R	T,G	R	VS	"	?	5.5	
2	"	"	"	"	"	"	21	5.5	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
J-3	43.17	R	T,G	R	VS	S	?	5	
4	"	"	"	"	"	"	?	5	
5	"	"	"	"	S	"	?	4	
6	"	"	"	"	VS	"	?	5	
7	41.91	"	G	R,Sc	S	M	23	13	
8	"	"	"	R,Sm	"	?	?	13.5	
9	"	"	"	"	I	?	?	12	
10	"	"	T,G,S	Sm,R	L	?	?	13	23
11	"	"	G	R	S	?	?	11.5	
12	41.75	"	O	"	I	M	?	11.5-12.5	
13	"	"	G	"	S	"	?	10-11	
14	"	"	?	?	"	?	?	11	
15	"	"	?	?	"	?	24	10.5	
16	"	"	?	?	"	?	?	10	
17	"	"	G	R	"	?	?	11.5	
18	"	"	?	?	"	?	?	14	
19	"	"	T	Sm	"	?	?	?	
20	"	"	"	"	I	M	22	11.5	22
21	"	"	"	"	"	S	?	12.5	
22	"	"	?	?	S	?	?	9	
23	"	"	?	?	VS	?	24	9	
24	"	"	?	?	S	?	26	10	
25	"	"	?	?	"	?	30	10	
26	"	"	T,S	R,Sm	"	S	?	9	
27	"	"	?	?	?	?	?	9	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
J-28	41.75	R	S,T,G	Sm	L	M	?	11-13	21
29	"	"	"	"	"	"	"	10	
30	"	"	S,G	Sm	I	S	?	13	
31	"	"	T,G	R	"	?	?	12	
32	"	"	"	"	S	S	28	10	
33	"	"	T	"	"	"	25	9.5	
34	"	"	T,S	Sm	"	"	25	10	
35	"	"	T,S,G	R	I	"	26	9.5	
36	41.67	"	T,S	Sm	I	M	?	8.5	20
37	"	"	T,G	R	S	S	20	8.5	19
38	41.53	"	T,S,G	"	I	"	26	12-14	
39	"	"	S	Sm	S	"	?	7.5	
40 *	41.50	"	T,S,G	Sm,Sc	L	D-t	28	7-18	18
41	41.53	"	?	R	VS	S	?	?	
42	"	"	?	"	S	"	?	?	
43	41.20	"	S	"	I	?	?	?	
44	"	"	T,G	B	"	D	19	7.5	
45	41.04	"	T	Sm	"	"	?	9.5	17
46	"	"	T,S	Sc,R	"	M	?	9.5	
47	"	"	T,S,G	R	"	"	?	9-9.5	
K-1	40.93	"	T	"	"	"	23	5-6	
2	"	"	T,G	"	"	D	24	4	
3	40.84	"	T,S	Sm	"	S	35	12.5	
4	"	"	T	R	"	"	25	5	
5	"	"	"	Sm	"	M	25	5.5	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
K-6	40.84	R	T,S	R	I	S	25	5.5	
7	"	"	"	"	S	?	25	5.5	
8	"	"	T	Sm	"	?	30	6.5	
9	"	"	G,S	B	I	?	30	7.5	
10	"	"	G,T,S	Sm	L	S	?	?	16
11	"	"	T	"	"	D	27	7-7.5	16
12	"	"	"	Sm,B	S	S	25	6	
13	"	"	"	"	"	"	23	6	
14	"	"	"	Sm	"	"	22	7.5	
15	"	"	"	"	"	"	25	7	
16	40.38	"	T,S,G	?	VS	"	?	17	14
17	"	"	"	?	"	"	?	15	14
18	"	"	"	?	"	"	?	17.5	14
19	"	"	S,G,T	Sm	S	M	20	12.5-16.5	14
20	"	"	T,G	?	"	S	?	13.5	14
21	"	"	T,S,G	?	"	"	?	11	14
22	40.21	"	S,T	Sm	I	M	?	30	
23*	"	"	G,T,S	"	"	?	?	30	13
24	"	"	T	R	"	S	?	10	
25	"	"	"	"	VS	?	?	6	
26	"	"	"	?	S	?	?	7.5	
27	"	"	"	?	"	?	?	10	
28	"	"	"	Sm,R	"	?	?	9	
29	"	"	"	?	VS	?	?	6	
30	"	"	G	Sm,R	S	?	22	11.5	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
K-31	39.13	R	T,G	Sm	S	S	?	7	12
32	39.08	"	O	R	VS	"	?	7	
L-1	38.58	"	S,T,G	Sm	I	?-t	?	?	11?
M-1	35.04	"	G,T	R	VS	M	?	?	
2	"	"	T,S	Sm	I	S	25	9.5	
3	34.96	"	"	Sc,R	"	M	24	5	5
4	34.81	"	O	Sc	VS	?	?	3.5	6?
5	"	"	?	?	"	?	?	3	
6	"	"	?	?	I	?-t	?	?	7
N-1	31.74	"	?	?	VS	?	22	5	
2	31.72	"	?	?	"	?	22	6	
3	30.65	"	?	?	"	?	25	2	
O-1	28.75	A	G,T	Sm	I	S	24	6	4
2	28.75	"	"	"	"	"	29	12	
P-1	24.68	R	T	"	"	"	?	2.5	
Q-1	11.08	"	"	"	"	"	?	5	1
2	10.98	"	G,T	"	"	"	?	6	
3	"	"	T	"	S	"	?	5	
R-1	"	"	"	Sc,R	VS	M	?	5	
2	8.70	"	"	Sm	I	S	?	4	
3	"	"	"	"	VS	"	?	6	
4	"	"	"	R	S	?	?	5	
5	8.47	"	"	Sm	I	S	24	5	
6	8.30	"	"	R	S	M	24	3.5	
7	8.29	"	"	?	VS	?	?	3.5	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
S-1	3.02	R	O	R	I	S	?	6	
2	2.33	"	"	B	"	?	?	9	
3	2.27	"	"	"	"	D	?	9	
4	"	"	"	"	"	"	?	8	
T-1	1.40	"	?	R	"	M	24	16	
2	"	"	?	?	"	"	26	15	
3	"	"	?	Sc	S	"	28	14.5	
U-1	0.93	"	T,S	R	L	D	25	3	
2	0.91	"	T	"	I	M	?	?	
3	"	"	T,S	"	"	"	?	3	
4	"	"	"	Sc,R	"	D	24	3-3.5	
V-1	59.92	"	O	B	"	"	23	2.5-3.5	
2	59.68	"	"	R	S	S	24	4	
3	"	"	"	"	VS	"	24	4.5	
4	59.60	"	S,G	"	"	"	23	4	
5	"	"	O	?	S	?	?	?	
6	"	"	"	R	VS	S	24	4.5	
7	"	"	"	"	S	"	24	4.5	
8	59.35	1887	"	B	VS	"	?	2.5	
9	"	"	"	R	"	?	23	4.5	
10	"	"	"	"	"	S	26	3.5	
11	"	"	"	B	"	?	23	4	
12	59.60	"	"	"	"	M	23	3	
W-1	58.47	R	"	Sc,R	"	S	?	6	
2	58.34	"	"	?	"	?	?	4.5	

(Table 1. Kona Coast Ponds, physical/geographical data.)

Pond No.	Latitude	Lava Age	Riparian Plants	Bottom Type	Surf. Area	Depth	Temp., °C	Salinity, ‰	K-B
X-1	57.08	1868	O	B	S	D	?	5.2	
2	56.87	R	S,T	Sm	I	M	?	9	
3	56.88	"	T	Sm,R	VS	S	?	7	
4	56.83	"	T,S	Sm	I	M	27	11.5	
5	55.03	A	G	Sm,B	"	D-t	26	21.5-22	

Table 2. Number of species of plants and animals found in each of 304 Kona Coast ponds, Hawaii Island, during the survey period, July 1972 to May 1973.

Explanation of Table Format

1. Ponds are identified by Quad code described in Fig. 2. An asterisk (*) following code number indicates relatively incomplete biota sampling.
2. Numerical values in table body are the number of species observed or collected in each major taxon of column heading.
3. Worms include both polychaetes and oligochaetes of phylum Annelida.
4. Mollusks include gastropods (snails, limpets, etc.) and bivalves (oysters, mussels, etc.)
5. Amphipods include all members of that crustacean order (beach hoppers, etc.)
6. Shrimps and crabs include all members of the crustacean order Decapoda.
7. Insects include orders Odonata, Coleoptera, Collembola, Heteroptera.
8. Fishes include naturally-occurring and introduced native species, as well as exotics.
9. Miscellaneous includes mostly marine-derived invertebrates coded as follows:
 - A = other arthropods (e.g., isopods, mites)
 - B = bryozoans
 - C = coelenterates (anemones and hydroids)
 - E = echinoderms (urchins, sea cucumbers, brittle stars)
 - P = sponges (phylum Porifera)
 - S = peanut worms (Sipunculida)
 - T = sea squirts (Tunicata)
 - Va = waterbirds (Vertebrata, class Aves)
 - Vr = green sea turtle (Vertebrata, class Reptilia)
10. Emergent plants include sedges, rushes, and similar flora.
11. Submersed plants include all soft waterflora (filamentous algae, pondweeds, etc.).
12. Benthic plants include crustose and mat-forming bottom algae, epilithic algae, etc.

Table 2

Shoreline ponds of the Kona Coast, Hawaii; numbers of aquatic species present according to major floral and faunal groups.

Pond: No.	Animals						Plants			
	Worm	Mol- lusk	Amphi- pod	Shrimp, Crab	In- sect	Fish	Miscel- laneous	Emer- gent	Sub- mersed	Ben- thic
A-1				2						
B-1			1	6	1	5		1	1	
C-1*		2				1			1	1
2*		2				1			1	1
3*						1			1	1
4*				1		1		1		
5*				2						
6*						3				1
7*						3				1
8*				2					1	1
9*		1								
10		2		1		1		3	1	
11		2		1				2	1	
12		1		2				1		2
13		1		3						
14		1	1	2						
15		1		3						
16		2		3	1	1		1	2	
17		1	1	2	1				1	1
18				1						
19		1	1	1		1				2
20		3		2	1					2
21	1	2	2	2				2		1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscellaneous	Emergent	Submersed	Benthic
C-22		1	1	2				2		
23		1		2			1A	2		1
24		1	1	2						3
25		2		2				1		1
26			- N O F A U N A -							
27	1	1		2				2		
28*		4	1	2		6	1A	2	1	
29		2	2	3				1		2
30*		2		4		6				1
31	1	2		3						1
32		1		2						1
D-1			1	1						
2		1	1			2				2
3		1	1	3		2				3
4			1	1						1
5			1	2					1	
6			1	2					1	1
7	2	6		6		13	2P	1	2	1
8	1	5		4		13	1P,2A	2	2	1
9				2				1		
10				1				2		
11			- N O F A U N A -							
12			- N O F A U N A -							
13				1						

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals							Plants		
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscellaneous	Emer-gent	Sub-mersed	Ben-thic
D-14*	2	11	1	4			**			
15*	3	9		6			1C,3E,2P			3
16*	2	8		5		3	2C,4E			2
17		3		3				1		1
18	1	1	1	2	1			1		1
19				2						
20				2						
21			1	2				2		2
22		1		2				1		
23			1	2				2		2
24			2	2				2		2
25	1	3	1	2	1			3	1	2
26*				1				3		2
27	2	4		5		5		2		
28		4	1	6		9	1P	2	2	
29		2		2				1		1
30		2		2		2		2	1	
31		2		2		1		1		
32		2		1		4			1	
33		2		2		2		2		
34		2	1	2				1		

**Pond #D14 - Misc. fauna: 1A, 1C, 4E, 4P, 1T.

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merged	Ben-thic
D-35		2		4				3		2
36		1		3		3		2	1	1
37		2	1	4				1		
38			2	4				1		
39		2	1	3				2		
40		1	1	3				1		
41		1	1	3				1		
42		2		2				2		
43			1	3				1		1
44		1		4			1A	2		1
45		1	1	2		1		2		
46		2		3			1A	2		
47		1	2	2	1	2	1A	2		1
48				1						
49				2						
50			1	2					1	
51		2	2	2		1		2	2	3
52		1	1	3			1A			2
53	2	1	1	3	1	1	1A	2	1	1
54		3	1	3		2		3	2	2
55		3	1	3		2	1A	2		1
56		2	2	3		2		1		2
57			1	2						
58				1						

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merged	Ben-thic
D-59			1	2				1		
60			1	3						
61		2		4		2				2
E-1			1	2						
2		1	1	2				1		
3*		2		2		5			1	
4			1	2						
5		1	1	2						
6		1	1		1	1		1		1
7*				1						1
8		1	1	1		2				1
9*		1				3				
10		1						1	1	
11			1	3						2
12				3			1A			
13	6	10	1	6		17	**		3	2
14	1	3	1	4	2	2	1A,1Vr	1	2	
15	1	2	2	4	2		1A		1	
16		1		2		2				2
17	1	1	1	2			1Vr		2	1
F-1	1	1			4				1	

**Pond #E13 - Misc. fauna: 1B, 1C, 2E, 1Vr.

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals							Plants		
	Worm	Mol-lusk	Amphi-pod	Shrimp Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-mersed	Ben-thic
F-2	1	1			3				1	
3	1	1	1	3	1					2
4				1		1				1
5		2	1	3	1	1		2	1	1
G-1		1	2	1				2		
2	1	1			1	1		2	1	
3		1	1	2						1
4	1	1	1	2			1A	2		
5		1		1						
6		2	3	2				1		
7		1		1						1
8	2	1	1		2	2		1		1
9				1		1				1
10		1		2						1
11		1	1	1				1		1
12		1	1	2	1			2		1
13		1	1	2			1A	2	1	
14		1	1	2						1
15		1		2	1		1A	1		
16		1	1	2	1			1		1
17		2	1	2						1
18		1	1	4		1			2	4
19		1		2						1
H-1		1	1	2		2		1	2	1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-mersed	Ben-thic
H-2		2	2	3	2	3		1	1	4
3	1	1		2			1A	1	1	3
4		3	2	3	1		1A	1	1	2
5		1		2			1A			1
6		1		2			1A			1
7	1	1	2	2	1					1
8		1	2	2		3				3
9		2	2	3		3				1
10		1								1
11		1	1	1						
12		1					1A			
13				2						1
14		1	1	2			1A			1
15			1	3						
16			1	2						1
17			1	1						1
18			1	1						1
19				1						1
20		1		2		5	1A			2
21		2	2	2		4			1	4
22		1	2	3	1				1	3
23	1	1	1	1		4	1A, 1Vr	3	1	
24		2	1	2					1	2
25		1		2		1	1A	1	1	1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merse	Ben-thic
H-26		1		1		3	1A		2	2
27		1	1	3						2
28	1	1		1		2			2	1
29										2
30		1		2		2		1		2
31			1	2						2
I-1		2		2	2		1A	2	2	
2		2	1	1	1				1	1
3		3		2					1	3
4		1		1					1	2
5	1	1						2	1	1
J-1*		2		2						1
2*		"		"						"
3*		"		"						"
4*		"		"						"
5*		"		"						"
6*		"		"						"
7		2	2	2			1C		1	2
8		2		2			1A	1		
9		2		1				1		
10		2		1				1		
11		2		1						
12		1		1					1	
13		1	2	3					1	1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol- lusk	Amphi- pod	Shrimp, Crab	In- sect	Fish	Miscel- laneous	Emer- gent	Sub- mersed	Ben- thic
J-14*										
15*										
16*										
17		1		1						1
18*										
19*										
20		1		2						
21		1								
22*										
23*										
24*										
25*										
26		1		1				1		1
27*										
28		3	1	4	1	1	1A	3	1	
29*										
30		3		3			1A	1	1	
31		2	1	2			1A			2
32		3	2	2						2
33		2		2						1
34		1		2						
35		2	1	3	1				2	2
36		2							1	
37				1						1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals							Plants		
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merged	Ben-thic
J-38		1	2	3						1
39				1		1		1		
40	3	10	3	11	3	14	2A,1C,2P	1	2	2
41		1		4		1				
42		1		4		1	1A			
43	1	1	1	3				1		1
44				2		1				
45	1	5	1	1	2		1A			1
46		2	4	2		3		1	1	1
47		2	1	2	1		1A	1	2	
K-1		1	1	3			1C			1
2			1	2					1	1
3	1	4	4		2		1A	2	2	1
4		2	1	1	1		1A		1	1
5		1		2	1	1			2	
6	1	2	2	1				2	1	1
7		2	1	2	1			2	1	2
8		1		1	2		2A		1	
9		3			1		1A	3	2	1
10	1	4	2	2	3		1A	2	1	
11	1	2	1	2	2	1	1A	2	2	
12		1		2	1					
13		1	1	1						1
14	1	2	1	2		1	1A		1	1

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merged	Ben-thic
K-15		2	2	2						1
16*	2	2			3			2	3	
17*	"	"			"			"	"	
18*	"	"			"			"	"	
19*	"	"			"			"	"	
20*	"	"			"			"	"	
21*	"	"			"			"	"	
22		4		1		1	1A	1		
23	2	6	1	1		5	1A,1E	2		
24		4	2	2		2				1
25*										
26*		1	1	1						
27*		1	1	2						
28*		2		1						
29*				1						
30	1	2		1	1				1	1
31		2		1		1				1
32		2	1							1
L-1*		1				2				
M-1*										
2		2			1			1		1
3		2		1	1	1				1
4		2		1	2				1	
5		1								

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals						Plants			
	Worm	Mol-lusk	Amphi-pod	Shrimp, Crab	In-sect	Fish	Miscel-laneous	Emer-gent	Sub-merged	Ben-thic
M-6*				1		1				
N-1*		1				1				
2*				1						
3*						1				
O-1		1			1					1
2		2	1		2					1
P-1			1	2						1
Q-1		2							1	
2		3		1					1	
3		1								
R-1		1		1						
2*				2						
3*		1		2						
4*				2						
5		1		2						
6		1		1						1
7		1		2						
S-1		6		2			1S			2
2										
3										1
4				1						1
T-1		1		1						1
2	1	1		2					1	2
3	1								1	

-N O F A U N A -

(Table 2. Kona Coast Ponds; aquatic species occurrence.)

Pond No.	Animals							Plants		
	Worm	Mol- lusk	Amphi- pod	Shrimp, Crab	In- sect	Fish	Miscel- laneous	Emer- gent	Sub- mersed	Ben- thic
U-1		1		1	1					1
2			1	1				2	2	1
3		1		1		2		1	3	1
4		3		3	2	1		1	2	
V-1		1		3					1	1
2		1		2					3	1
3				1					1	2
4		1		1						1
5			- N O F A U N A -							
6		1		2						1
7		1								2
8		1		1						
9				1						1
10		1		1						1
11		1		1						1
12		1		2						2
W-1			- N O F A U N A -							
2*										
X-1				3						
2		2	1	1				1		
3		1		1						
4		2	2	2				1	1	1
5	1			4		1	1A,1P		2	2

Table 3. Checklist of aquatic biota found in 291 closed ponds and other water exposures on the Kona Coast, Hawaii, during the period July 1972 to May 1973. Eight pages following.

Explanation of Checklist

1. Aquatic flora and fauna are listed systematically in separate sections, by sequentially-numbered species or morphologically-similar species groups where identification was not possible.
2. Flora includes only submersed aquatics (soft waterflora), most of which have been collected but not identified.
3. Fauna includes all macroscopic species seen or collected. Many are new species being described by taxonomic authorities.
4. Ponds in which each species or group occurs are listed by Quad code described in Fig. 2 and can be cross-referenced in Tables 1 and 2. These include only water exposures having subterranean connection to the open sea (13 other ponds with direct surface connection have very diverse biota).

Aquatic Plants

I. Cryptogams (algae).

A. Algae of uncertain taxonomic position.

1. Soft Epilithon (non-encrusting algae forming thin sessile communities on rock--probably several species of Chlorophyta and Cyanophyta).

C-1, 2, 3, 8, 12, 25, 29, 31; D-2, 4, 29, 37, 51; G-3, 7, 9, 11, 12, 14, 16-19; H-3, 5-8, 10, 14, 16, 20, 29-31; I-3; J-1, 2-7, 13, 17, 26, 31, 32, 37, 38, 43, 45; K-2, 6, 7, 9, 24, 32; M-3; P-1; S-1, 3, 4; V-1, 2, 3, 6, 7, 9, 11, 12.

2. Encrusting Epilithon (massive formations of attached algae, evident by orange or white mineral precipitates--Cyanophyta or Chlorophyta).

C-32; D-2, 3, 5, 6, 17, 18, 23-26, 29, 36, 43, 44, 51, 52, 54-56, 61; E-6, 7, 8, 11, 16; F-3, 5; G-18; H-1, 2-4, 8, 9, 20-22, 24, 26-28, 30, 31; I-3, 4; J-7, 32, 33, 35; K-1; T-3; U-1, 2, 3; V-3, 7, 10, 12.

3. Benthic Mat (algae forming tough but loosely-attached felt-like layer on mud and rock).

C-19, 20, 21, 23, 24, 29; D-21, 23-26, 47, 50, 53, 54, 56; E-16, 17; F-3; G-8, 10, 18; H-2, 4, 21, 22, 25, 26, 28; I-2, 3-5; J-31, 35, 36; K-3, 4, 7, 13, 30, 31; M-2; R-6; T-3; X-5.

B. Cyanophyta (blue-green algae).

4. Unidentified filamentous species.

C-8, 17; D-52; E-11; F-4; G-18; H-2, 8; J-46; K-14, 15; T-1, 2; V-1, 2, 3; X-5.

C. Chlorophyta (green algae).

5. Cladophorales--several unidentified filamentous species.

C-1, 2, 3, 10, 11, 16, 27; D-51, 54; E-10, 14, 15, 17; F-1, 2; G-2; H-23; I-1, 5; J-36; K-2, 3-5, 7-10, 16-21, 30; M-4; Q-1, 2; U-2, 3, 4; V-2; X-4, 5.

6. Ulva sp.

K-16, 17-21.

7. Chara sp.

D-51; E-3; G-18; H-1, 26, 27; K-14.

D. Rhodophyta (red algae).

8. Hildenbrandtia sp.--thin reddish-black layer on rock surface.

C-12, 19, 20, 24; D-3; H-21; V-4.

9. Ahnfeldtia sp.--stiff sessile, yellow-brown or olive-green fronds, often in large masses.

J-7, 13, 35; U-3.

II. Phanerogams (higher plants).

1. Ruppia maritima.

C-16; D-25, 30, 32, 36, 53, 54; E-14, 17; F-5; G-13, 18; H-1, 2-4, 21, 22, 24-27; I-1, 2-4; J-28, 30, 35, 46; K-3, 5, 6, 9, 11, 16-21; U-2, 3, 4.

2. Potamogeton sp.

K-11.

Aquatic Animals

I. Porifera (sponges).

1. Unidentified species.

X-5.

II. Coelenterata.

A. Hydrozoa (Hydroids).

2. Ostroumovia horii.

K-1.

B. Anthozoa (Anemones, corals, etc.)

3. Unidentified species.

J-7.

III. Annelida (segmented worms).

A. Oligochaeta

4. One or more unidentified species.

C-21, 31; D-18, 25, 53 (2 species); G-8; H-1, 3, 7, 23, 27; I-5; J-43, 45; K-3, 6, 11, 16-21, 24, 30; T-3.

B. Polychaeta.

5. Mercierella enigmata.

X-5.

6. Unidentified species.

E-14, 15, 17; F-1, 2, 3; G-2, 4, 8, 10, 14, 16-21.

IV. Mollusca (snails, clams, oysters, etc.)

A. Gastropods (Snails, etc.)

7. Melania sp.

C-1, 2, 10-18, 20, 21, 23-25, 27, 29, 31, 32; D-3, 17, 22, 25, 29-35, 37, 39-42, 44, 46, 47, 51-56; E-2, 3, 5, 6, 8-10, 14, 15, 17; F-1, 2, 3, 5; G-1, 2-4, 6-8, 10-19; H-1, 2-4, 7, 10, 12, 20-28; I-1, 2-5; J-1, 2-6, 8-13, 17, 20, 21, 26, 28, 30-36, 38, 43, 45, 46; K-1, 3, 4, 6, 7, 9-11, 13-22, 24, 28, 30-32; L-1; M-2, 3-5; N-1; O-1, 2; Q-1, 2, 3; R-1, 5-7; T-2, 3; U-1, 3, 4; V-1, 2, 4, 6-8, 10-12; X-2, 3, 4.

8. Assiminea sp.

C-1, 2, 10, 11, 16, 20, 22, 25, 29; D-25, 54, 55; G-6, 8, 17; H-24; I-1, 2, 3; J-1, 2-11, 28, 30, 32, 33, 35, 36, 45; K-3, 4-12, 14-22, 24, 30-32; M-2, 3, 4; O-2; Q-1, 2; R-3; U-4; X-4.

9. Theodoxus [=Neritina] cariosa.

C-20, 21, 31; D-2, 17, 18, 25, 29-37, 39, 42, 45, 46, 51, 54-56, 61; E-3, 14; H-2, 4-6, 8, 9, 11, 14, 30; I-3; J-28, 30-32, 41, 42, 45-47; K-3, 9, 10, 22, 24, 26-28; Q-2; U-4.

10. Theodoxus [=Neritina] vespertina.

E-14, 16; H-9; K-3, 10, 24.

11. Melampus parvulus.

H-4; J-45, K-22.

12. Nerita polita.

K-16; X-2.

13. Unidentified white species.

F-5; J-45, 47.

14. Unidentified red species.

E-15

B. Pelecypoda (oysters and other bivalves).

16. Isognomon californicum.

D-17.

17. Unidentified bivalve species.

S-1.

V. Arthropoda (crustaceans, insects, etc.).

A. Acarina (mites, etc.).

18. Unidentified red species.

C-23; D-44, 46, 47, 52, 53, 55; G-4, 13; H-4, 14, 25; K-8.

19. Unidentified red and white species.

D-55.

B. Isopoda (pill bugs, etc.).

20. Ligia sp.

E-12, 14; G-15; H-3, 4-6, 12, 20, 23, 26; I-1; J-8, 28, 30, 31, 42, 45, 47; K-3, 4, 8-11, 14, 22.

21. Isopod sp.

X-5.

C. Amphipoda (beach hoppers, etc.).

22. Unidentified small reddish species.

C-17, 19; D-1, 6, 47, 52; E-4, 5, 8, 11; G-3, 6, 8, 9, 11, 14-18, 21, 22, 24; J-35, 38, 43, 46, 47; K-1, 3, 7.

23. Various unidentified species.

C-14, 18, 21, 22, 24, 29, 31; D-2, 3-5, 18, 21-25, 34, 37, 38, 39-41, 43, 45, 47, 50-57, 59-61; E-1, 2, 6, 14, 15, 17; F-1, 3, 5; G-1, 4-6, 8, 11-14, 16-18; H-1, 2, 4, 7-9, 21-23, 28, 31; I-2; J-7, 13, 28, 31, 32, 38, 43, 45-47; K-2, 3, 4, 6, 10, 13-15, 24, 26, 27, 32; O-2; P-1; U-2; X-2, 4.

D. Decapoda (shrimps and crabs)

24. Halocaridina rubra (Opaeula).

A-1; C-5, 10, 12-18, 20-25, 27, 29, 32; D-1, 3-6, 9, 13, 17-26, 35, 37-44, 46, 48-61; E-1, 2, 4, 5, 7, 8, 11, 12, 15, 17; F-3, 5; G-3, 4, 6, 7, 10-15, 17-19; H-1, 2-7, 13, 15-19, 21, 22, 24-26, 28, 31; I-3; J-1, 2-9, 11-13, 17, 20, 28, 30-35, 38, 41-44, 47; K-1, 2, 4-8, 10, 12-15, 24-27, 29, 30; N-2; P-1; Q-2; R-1, 2-5, 7; S-4; T-2, 3; U-1, 2-4; V-1, 2-4, 6, 8-12; X-1, 2-5.

25. Metabetaeus lohena.

A-1; C-5, 12-16, 20-25, 27, 29, 31, 32; D-9, 17-25, 37, 39-41, 43, 44, 49, 50, 52-55, 57, 59, 60; E-1, 4, 5, 12, 15; F-5; G-1, 3-6, 10-18; H-7, 22, 25, 28; J-1, 2-6, 20, 28, 33, 35, 38, 41-43; K-7, 10, 27, 31; R-2, 3-5, 7; T-3; X-1, 4.

26. Palaemon debilis (Opaeuhuna).

C-8, 31; D-6, 17, 29-31, 33-36, 44-46, 51-56, 61; E-3, 14; F-5; G-18; H-1, 2-6, 8, 9, 15, 16, 20-24, 28, 30, 31; I-1, 2; J-7, 8, 10, 13, 26, 28, 30-32, 34, 35; K-1, 5, 11, 12, 14, 15, 28; U-4.

27. Macrobrachium grandimanus (Opaeoehaa).

C-13, 15; D-3, 5, 37, 38, 47, 56, 61; E-2, 11, 14-16; F-3, 4; G-9, 18; H-14; I-3, 4; J-13, 37, 39, 41, 42, 44; K-24; M-3; P-1; R-6; S-1; V-1, 2, 6, 12; X-1.

28. Macrobrachium lar (exotic--Tahitian prawn).

C-4, 8, 19, 29; D-3, 35, 36, 38, 47; E-11, 14-17; F-3; K-2.

29. Alpheus crassimanus (snapping shrimp).

J-46.

30. Antecaridina lauensis.

V-1; X-5.

31. Unidentified shrimp, family Procarididae.

X-5.

32. Unidentified shrimp, family Hyppolytidae.

X-5.

33. Metopograpsus thukuhar (black "land" crab).

C-11, 16, 31; D-10, 29-46, 61; E-3, 12, 14; G-19; H-2, 4, 8, 9, 11, 13-15, 20, 27, 30, 31; J-28, 30, 38, 41-44, 46, 47; K-1, 22; M-6; S-1; U-4.

34. Unidentified crab, family Xanthidae.

D-60.

E. Insecta.

35. Unidentified springtail, order Collembola.

C-17; G-16; J-46, 47; K-3, 10, 16-21.

36. Unidentified waterstrider, family Veliidae.

F-2; H-2, 23; J-35; K-4, 7-9, 12, 16-21, 30; M-2, 3, 4; O-2.

37. Trichocorixa reticulata (waterboatman).

D-53; E-14, 15; H-22, 23; I-1; K-3, 10, 11, 16-21; O-2; U-1.

38. Unidentified damsel- and dragonflies, order Odonata (piinau).

C-16; E-6, 14; F-1, 2, 3, 5; G-2, 8, 12; I-1, 2; J-28, 45, 47; K-8, 10, 11; M-4; U-4.

39. Unidentified water beetle, order Coleoptera.

F-1; G-15; H-23.

40. Unidentified mosquito, family Culicidae.

F-1; O-1.

41. Unidentified midge larvae, family Chironomidae.

D-47.

VI. Sipunculida (Peanut worms).

42. Unidentified species.

S-1.

VII. Chordata (Vertebrates).

A. Pisces (Fishes).

43. Chanos chanos (awa, milkfish)

E-3

44. Conger sp. (Puhiauha).
C-10.
45. Adioryx sp. (Alaihi).
D-55.
46. Sphyræna barracuda (Kaku).
E-14.
47. Neomyxus chaptalii (Uouoa).
H-9, 20.
48. Mugil cephalus (Amaama).
C-6, 7; D-32, 36, 61; E-3, 16; G-8; H-20, 21, 23, 26; J-28, 46;
K-24.
49. Kuhlia sandvicensis (Aholehole).
D-2, 30-33, 36, 51, 53-56; E-3, 8; H-1, 2, 8, 9, 20, 21, 26;
J-46; U-3.
50. Abudefduf sordidus (Kupipi).
D-3, 54; E-3; H-1, 20, 30; U-4.
51. Abudefduf abdominalis (Mamo).
D-61; F-5.
52. Acanthurus sandvicensis (Manini).
D-2, 3, 56; H-2, 8, 20, 21; U-3.
53. Acanthurus achilles (Pakuikui).
H-9.
54. Eleotris sandwicensis (Oopu-akupa).
C-10, 16, 19, 30; E-14, 16; F-4; G-9, 18; H-2, 21; J-44; K-5,
14, 24.
55. Kelloggella oligolepis.
D-32, 33, 45.
56. Awaous [=Chonophorus] genivittatus (oopu-kanio).
D-36.

57. Bathygobius fuscus (ooppu-kai).

D-32; H-8, 30; J-46; M-6.

58. Tilapia mossambica (Exotic).

C-1, 2-4, 6, 7; D-47; E-6, 8, 9; G-2, 8; H-27; K-22; L-1; M-3.

59. Unidentified top minnows, family Poeciliidae (mosquitofish, guppy, etc.--Exotic).

C-6, 7; D-47; E-9; H-25, 26, 27; J-39, 41, 42; K-31; L-1; N-1, 3.

60. Cyprinus carpio (koi--Exotic).

E-3, 9.

B. Reptilia

61. Chelonia mydas (green sea turtle).

E-14, 17; H-23.

C. Aves (birds--waterbirds only).

62. Himantopus himantopus knudseni (oeo--Hawaiian stilt).

D-51; H-23; J-10, 28; K-11.

63. Nyctocorax nyctocorax (aukuu--black-crowned night heron).

E-6, 13; K-11.

64. Fulica americana alai (alae keokeo--Hawaiian coot).

H-23; K-11.

65. Various wading birds (sanderlings, tattlers, etc.).

D-8, 15; H-23; J-34, 43; K-11.

66. Various migratory waterfowl (ducks).

D-24; G-8; J-10, 34; K-11; U-2.

Table 4. Taxonomic list of aquatic macrofauna found in 13 open ponds, Kona, Coast, Hawaii, July 1972 to May 1973. List excludes open pond species appearing in Table 3. Open ponds (with surface connection to the sea) are: B-1; C-28, 30; D-7, 8, 14-16, 27, 28; E-13; J-40; K-23.

Phylum Porifera

Two unidentified sponges

Phylum Coelenterata (anemones, corals, etc.)

Anthozoa: Aiptasia sp.

Phylum Annelida (worms)

Polychaeta-Errantia

Namalycastis sp.

Protula atypha

Spiophanes bombyx

Eurythoe complanata

Polychaeta-Sedentaria

Pileolaria militaris

Pileolaria pseudomilitaris

Janua nipponica

Janua knightjonesi

Leodora knightjonesi

Salmacina dysteri

Mercierella enigmata

Phylum Mollusca

Gastropoda (snails and nudibranchs)

unidentified nudibranch

Dolobrifer olivacea

Nerita picea

Littorina pintado

Natica marochiensis

Hipponix sp.

Morula granulata

Teredo parksii

Mitra auriculoides

unidentified vermitid

Pelocypoda (clams, oysters, etc.)

Tellina rugosa

Isognomon costellatum

Isognomon sp.

Hormomya crebristriatus

Ostrea sandvicensis

Spondylus zonalis

Phylum Arthropoda

Crustacea-Cirrepedia (barnacles)

Chthamalus sp.

Crustacea-Decapoda (shrimps, crabs)

Clibanarius zebra

Calcinus laevimanus

Carpilus maculatus

Grapsus grapsus

Thalamita crenata

Portunus pubescens

Leptodius sanguineus

Epixanthus sp.

unidentified Xanthidae

Phylum Echinodermata

Opiuroidea (brittle stars)

Ophiocoma erinaceus
unidentified species

Holothuroidea (sea cucumbers)

unidentified species

Phylum Chordata

Osteichthys (bony fishes)

Stolephorus purpureus (nehu)

Gymnothorax hilonis (puhi)

Flammeo sammara

Adioryx lacteoguttatus

Polydactylus sexfilis (moi)

Mulloidichthys samoensis

(weke)

Parupeneus porphyreus (kumu)

Parupeneus multifasciatus

(moano)

Microcanthus strigatus

Chaetodon lunula

Pomacentrus jenkinsi

Thalassoma duperryi (hinalea-
lauwili)

Gomphosus varius (akilolo)

Stethojulius axillaris (omaka)

Scarus dubius

Scarus perspicillatus (uhu)

Acanthurus nigrofuscus

Asterropteryx semipunctatus

Oxyurichthys lonchotus

Chonophorus stamineus (oopu-
nakea)

Istiblennius sp.

Diodon hystrix (oopu-kawa)

unidentified Gobiidae

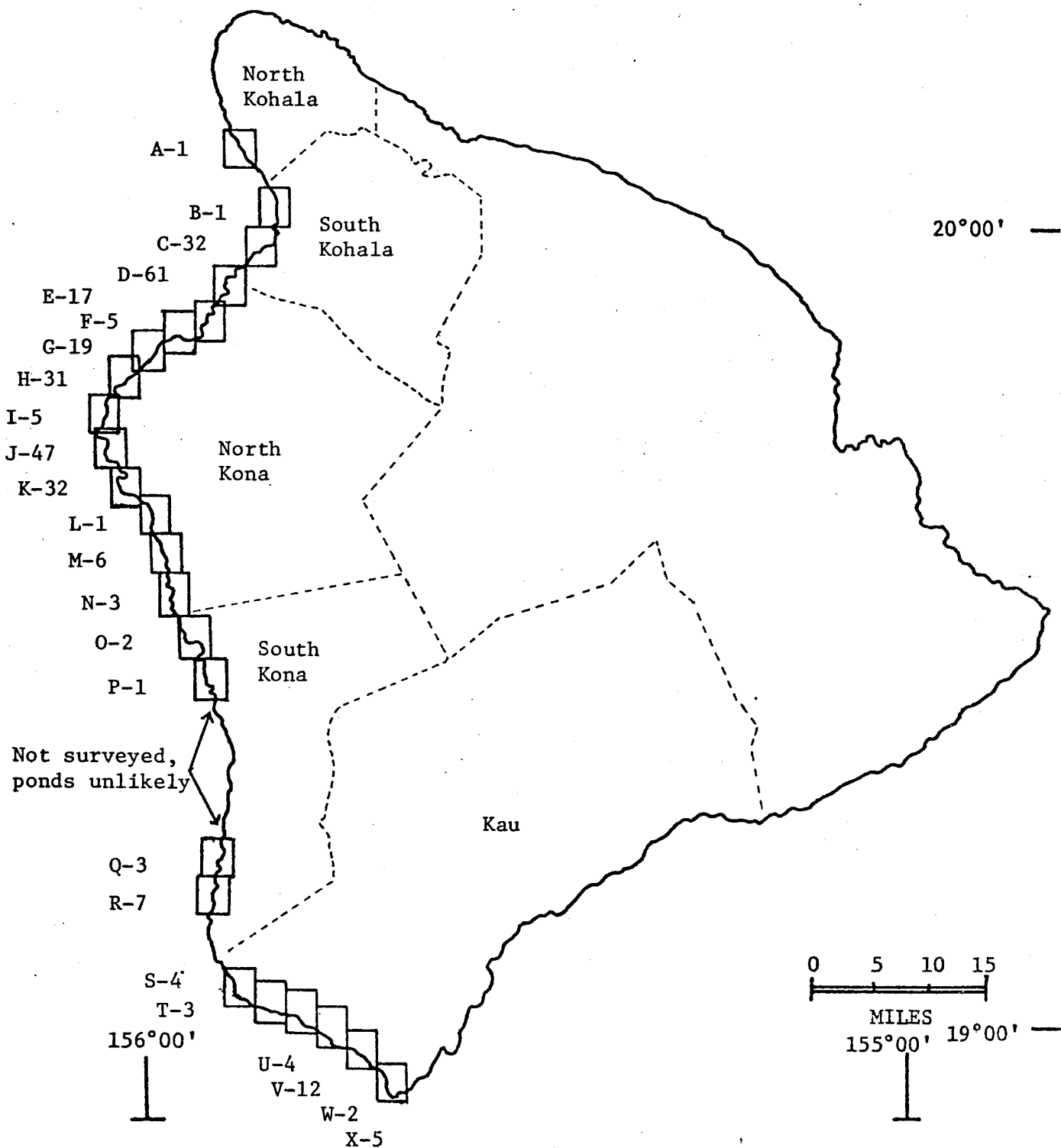


Fig. 1. Index map of Kona Coast pond survey areas, Hawaii Island. Rectangles represent large-scale maps ("Quads") contained in Fig. 2, coded by letter (A, B, etc.) and total number of ponds sampled in each. Gaps between Quads A-B and R-S are partially-surveyed zones where no ponds were found. Dashed lines designate boundaries of the 5 land districts comprising the Kona Coast.

Fig. 2. Detailed location maps of 304 ponds and other water exposures of the Kona Coastal Zone, Hawaii, surveyed during the period July 1972 through May 1973. Series consists of 24 "Quads", each being a direct tracing from 1 or more U. S. Geological Survey quadrangle maps and therefore retain the scale 1:24,000 (1 map inch = 2,000 feet; 2.65" = 1 mile; 1.65" = 1 km).

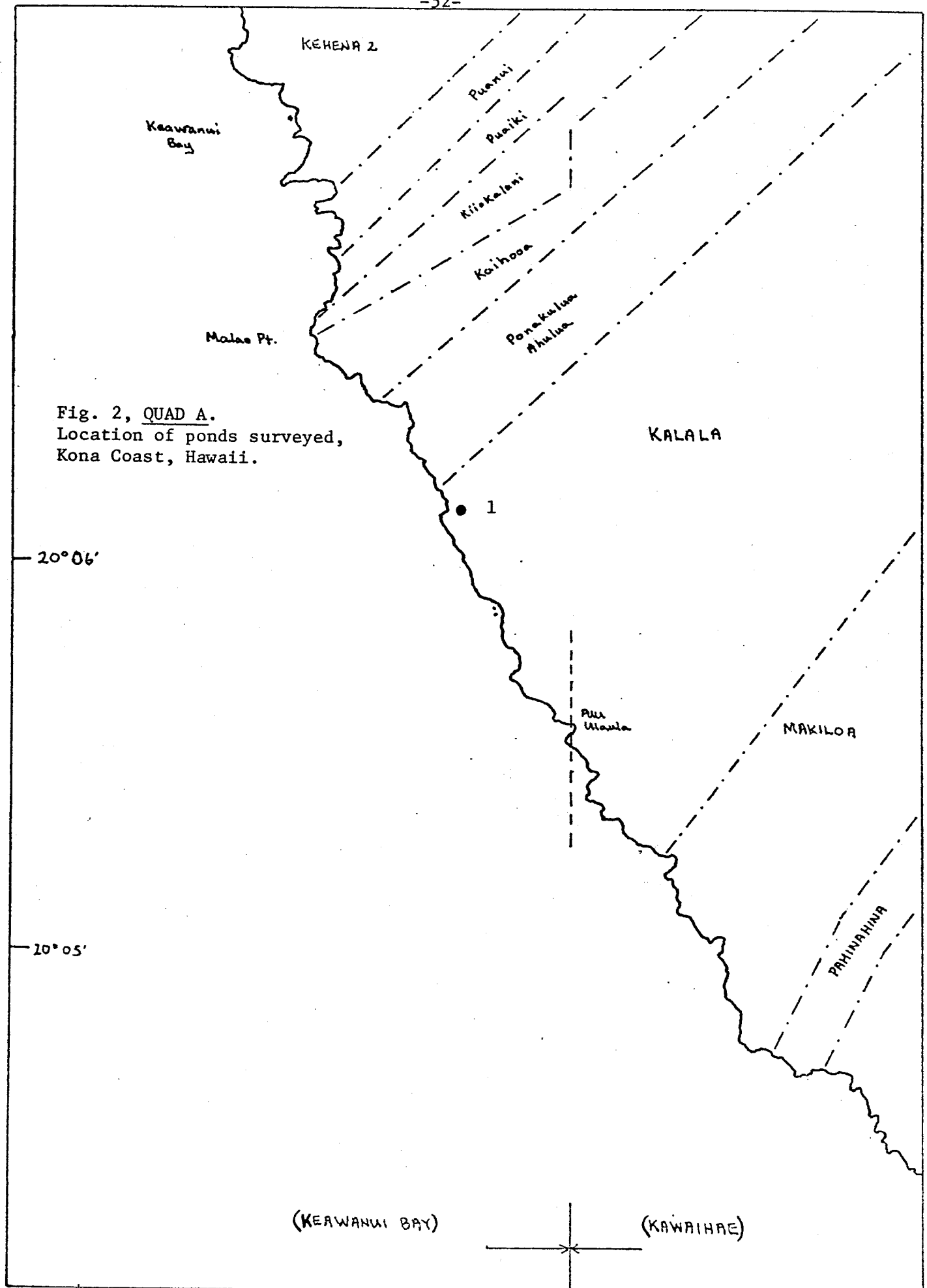
Explanation of Figure Format

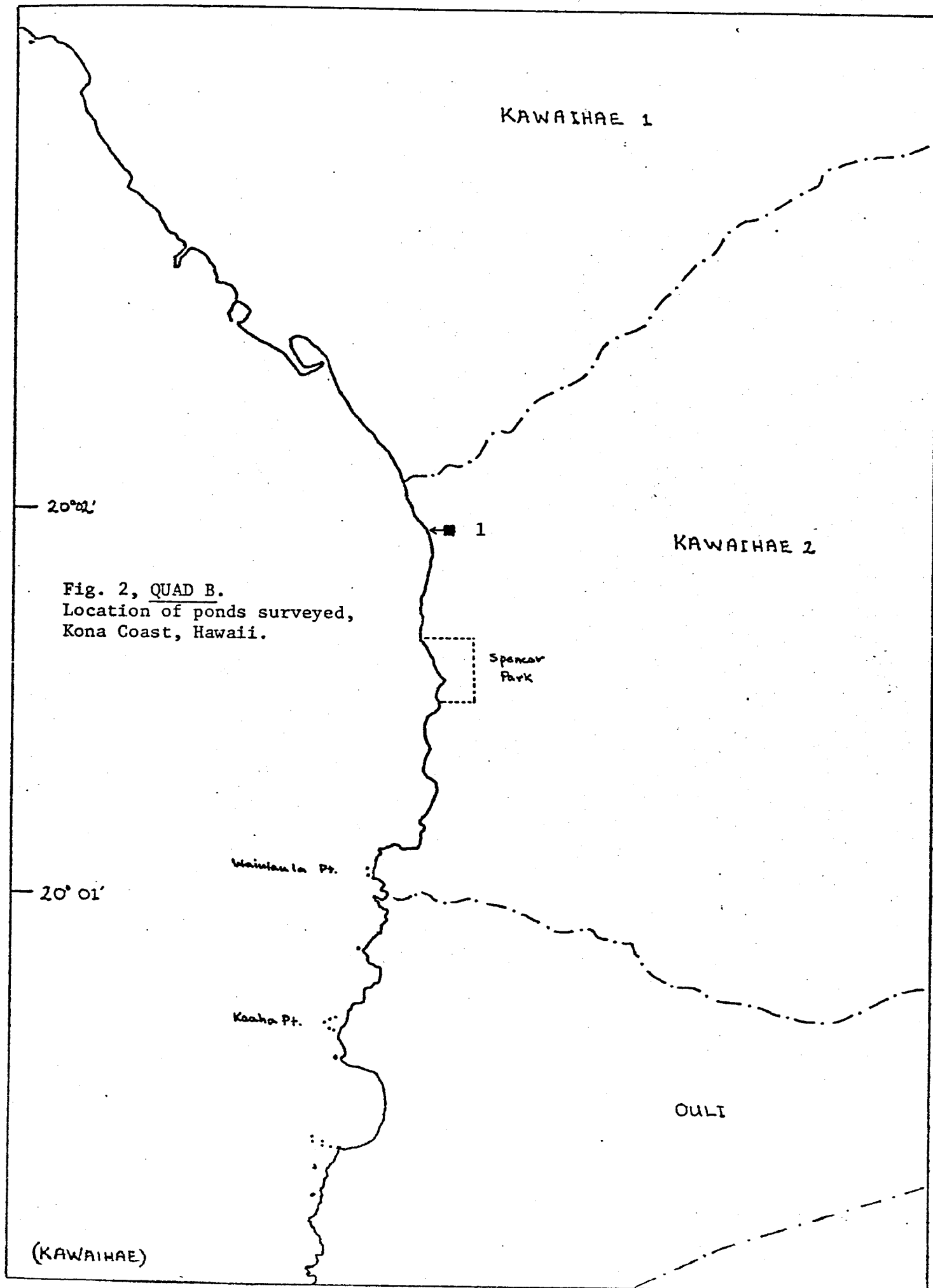
1. Quads are lettered sequentially, A through X, in a north-south direction as noted in Fig. 1.
2. Within each Quad, ponds are numbered sequentially in a north-south direction. Quad letter plus pond number identified each of the 304 water exposures described elsewhere in this report (cf., Table 1 and 2).
3. Surface area size classes of ponds are symbolized:

● = $<10 \text{ m}^2$

■ = $10-100 \text{ m}^2$

▲ = $>100 \text{ m}^2$
4. Other pond features are noted by symbol modifiers:
 - a. Diagonal line (●) indicates water in fissures or caves.
 - b. Arrow (←▲) indicates surface connection to sea ("open" ponds).
5. Land divisions or ahupuaa are named and delineated by interrupted lines (— · — ·).
6. Latitude (north) in degrees and minutes is shown on left margin.
7. Names of the relevant U.S.G.S. quadrangle maps are given in parentheses. Where more than one U.S.G.S. map was used to prepare a Quad, the junction is indicated by solid lines and arrows, and extrapolated as a dashed line (---) at the shore.
8. Prominent coastal features (Bays, Points, Puu's, etc.) are noted by proper name.

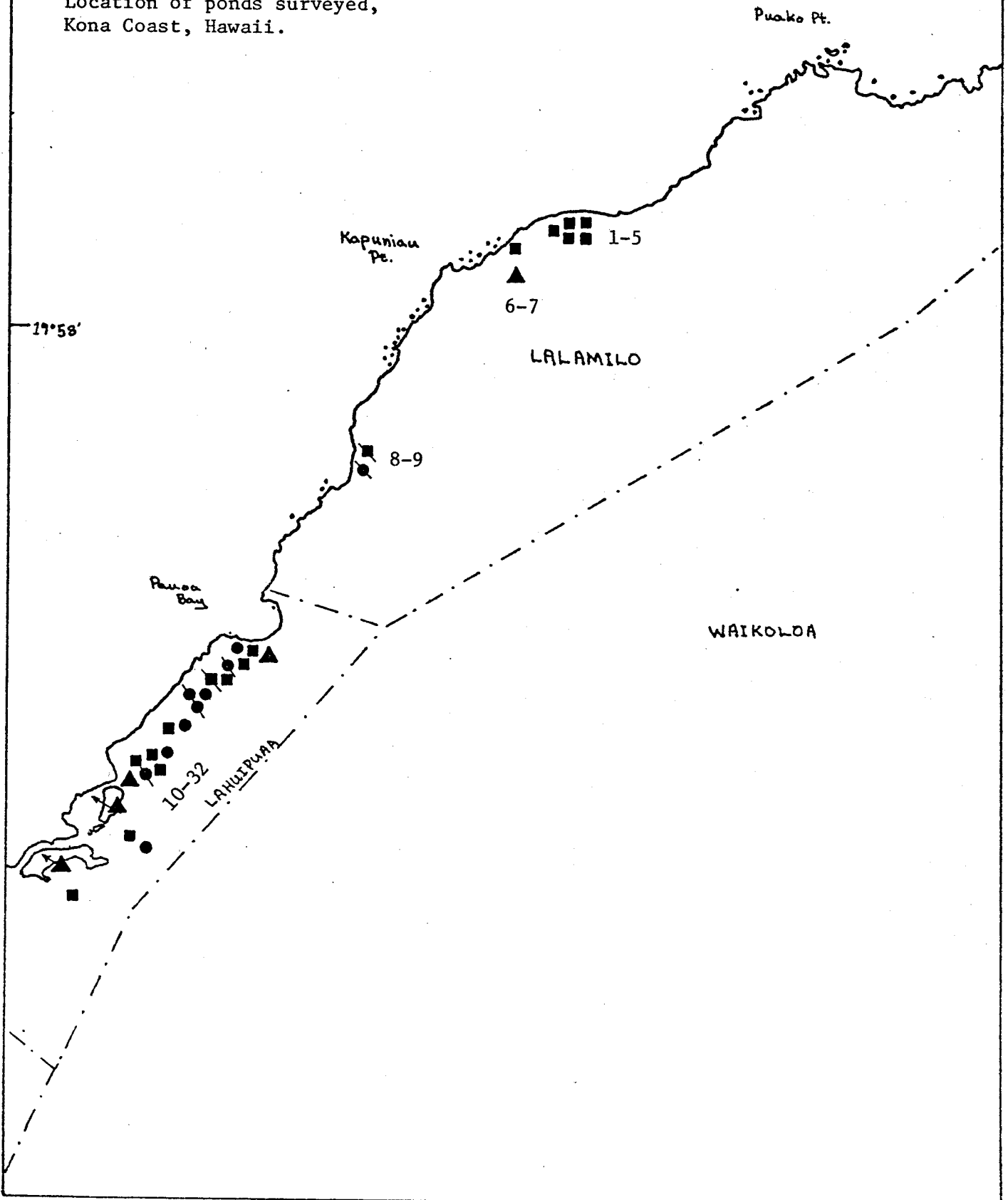




(Puu HINAI)

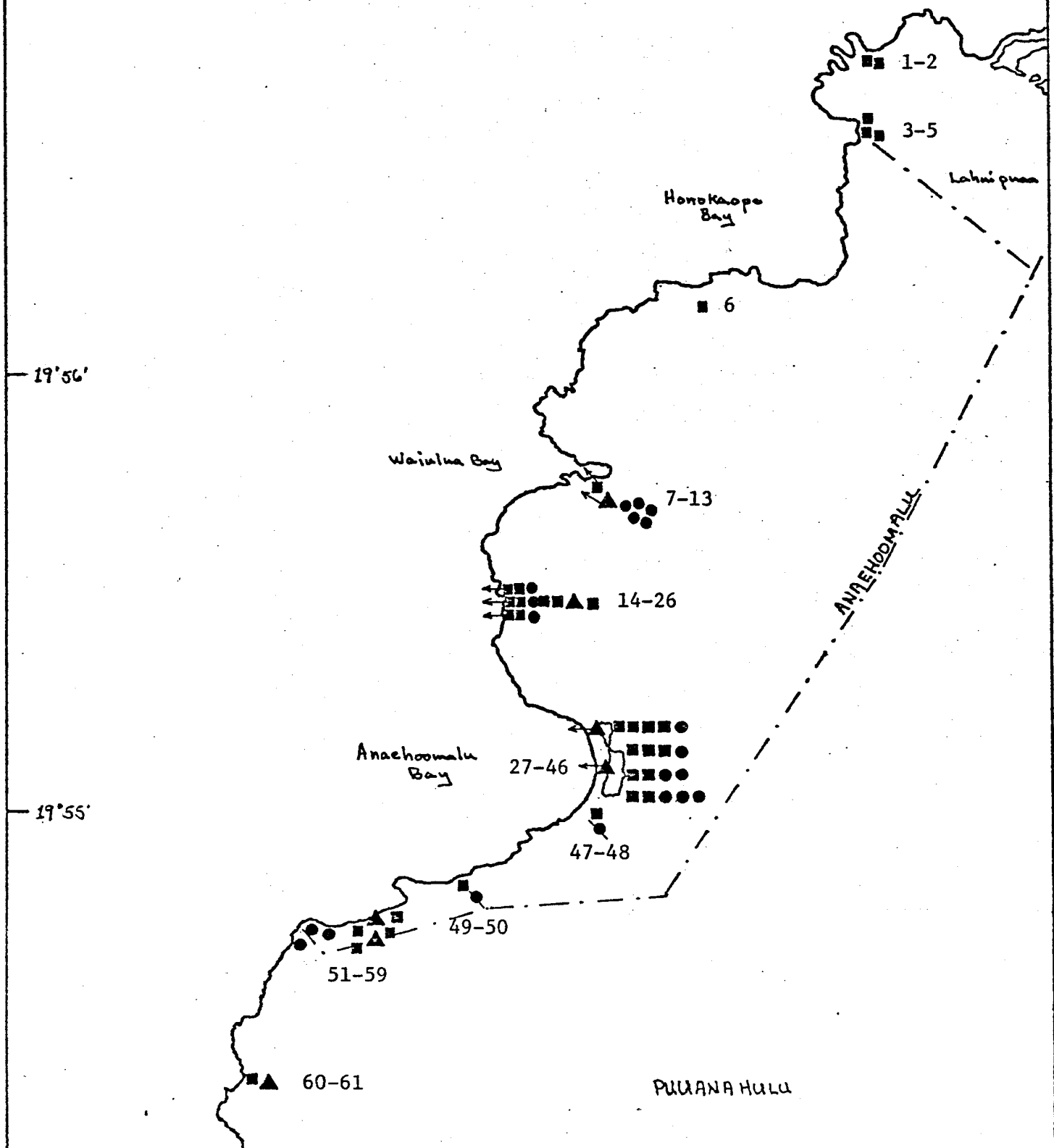
19°59'

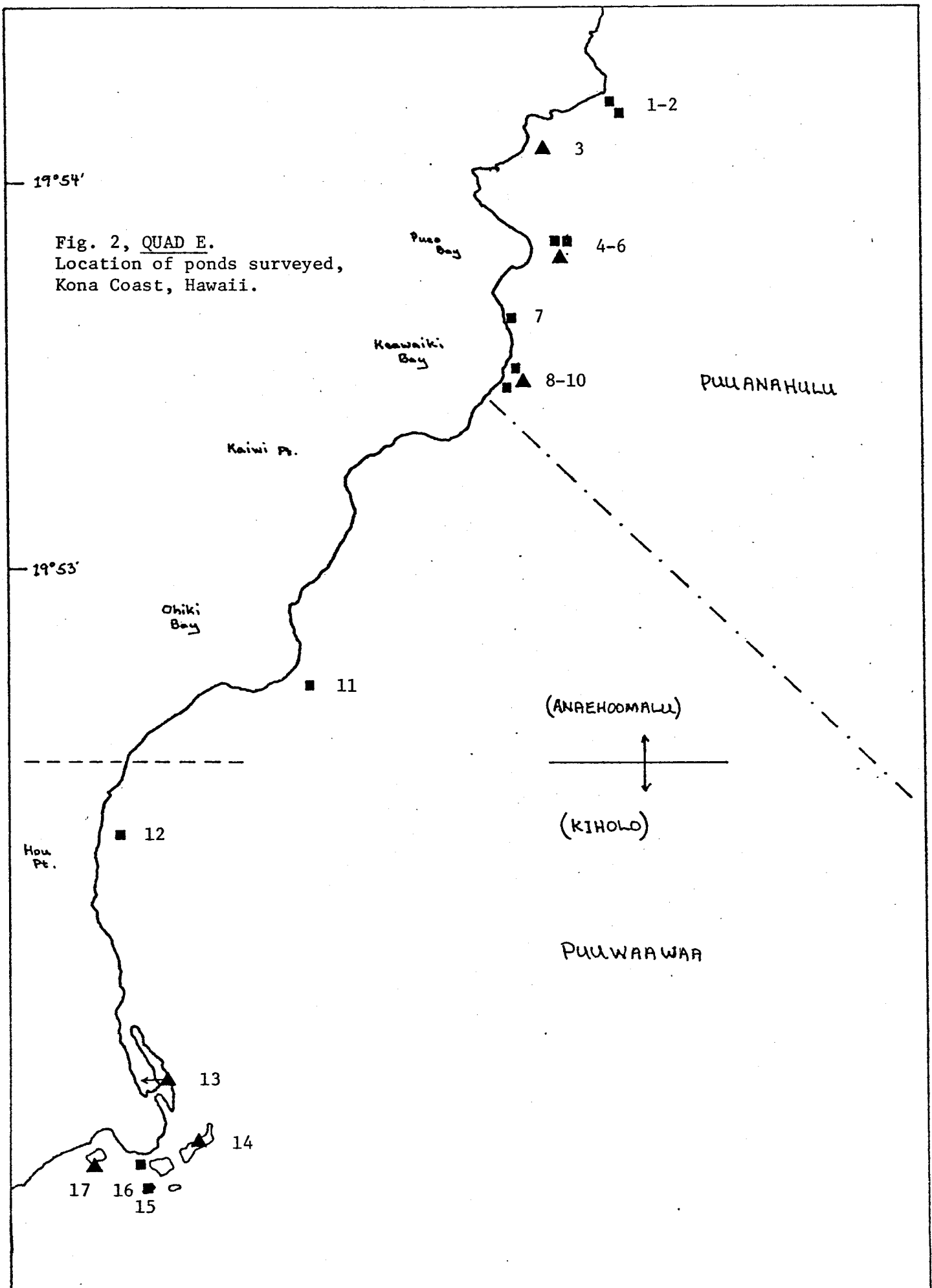
Fig. 2, QUAD C.
Location of ponds surveyed,
Kona Coast, Hawaii.



(ANAEHOOMALU)

Fig. 2, QUAD D.
Location of ponds surveyed.
Kona Coast, Hawaii.





(KIHOLO)

Fig. 2, QUAD F.
Location of ponds surveyed,
Kona Coast, Hawaii.

19°52'

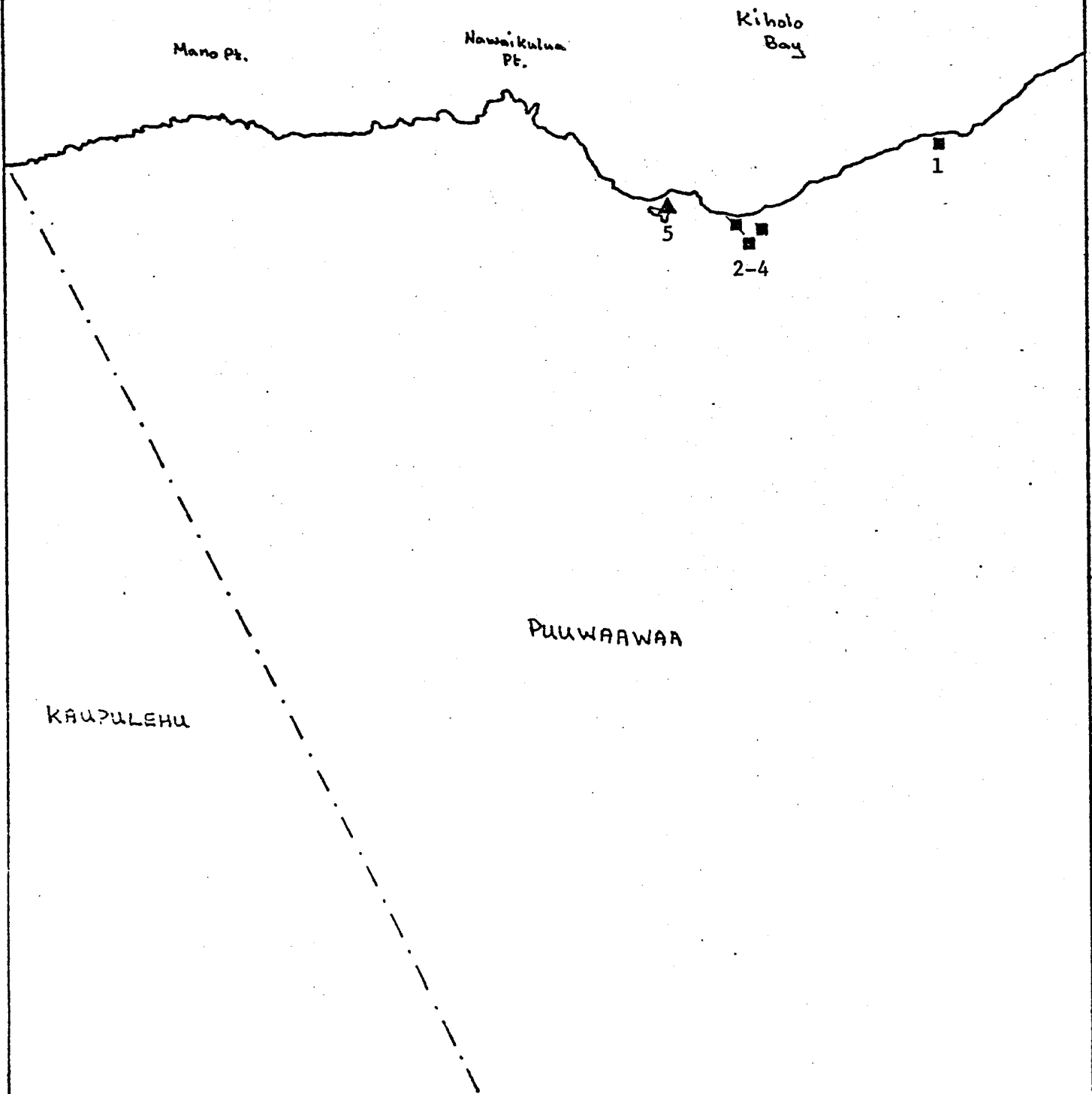
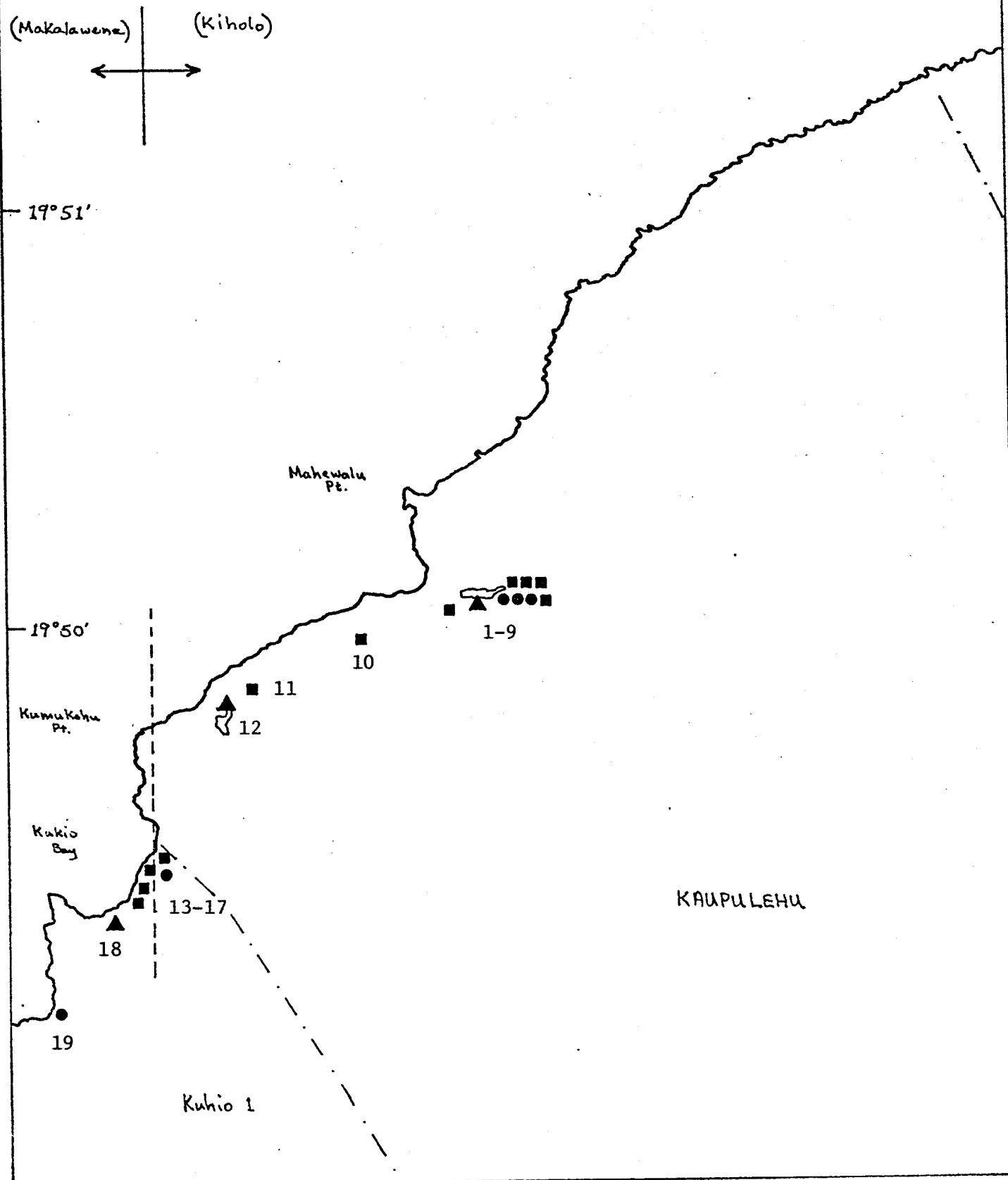
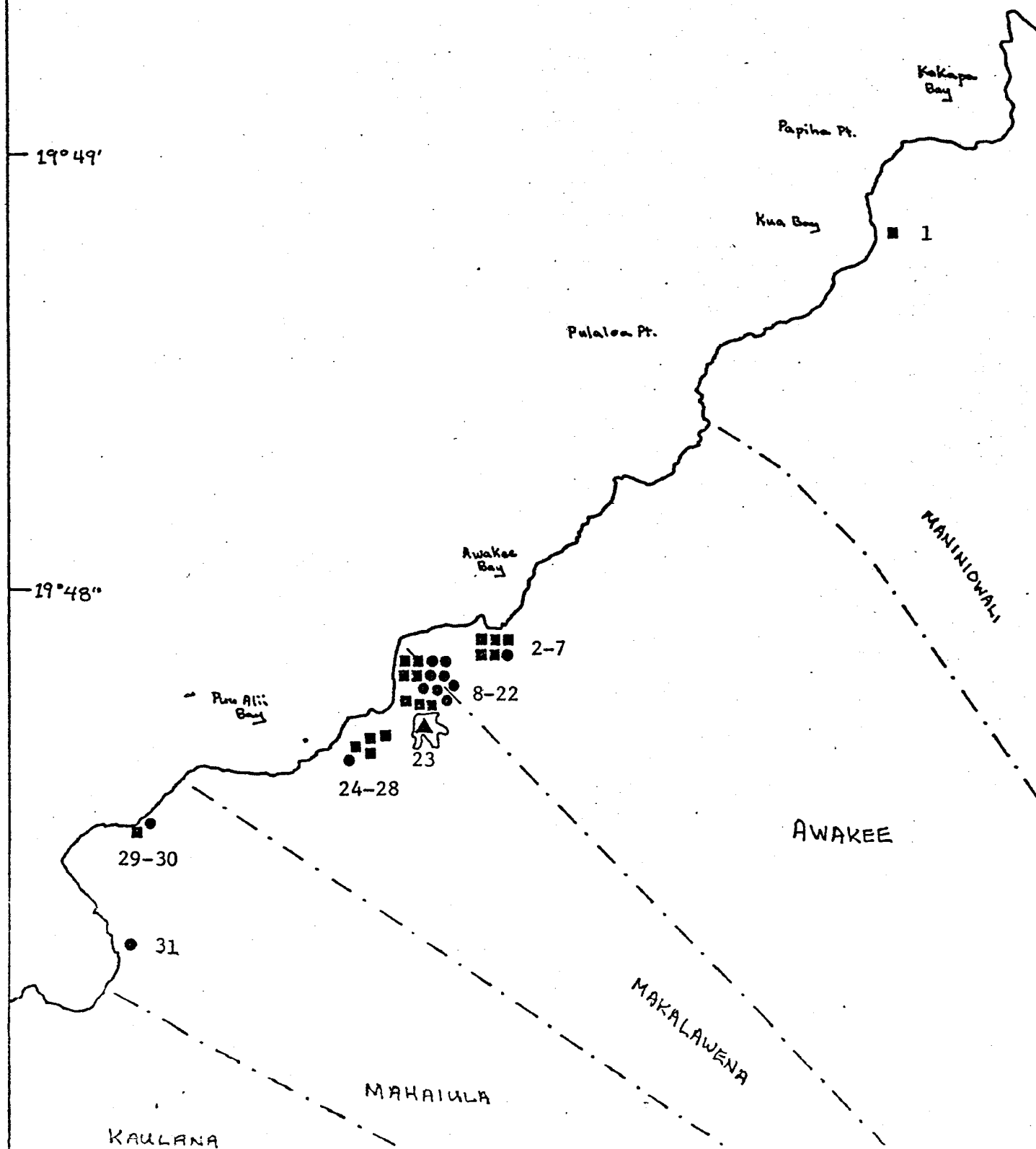


Fig. 2, QUAD G.
Location of ponds surveyed,
Kona Coast, Hawaii.



(MAKALAWENA)

Fig. 2, QUAD H.
Location of ponds surveyed,
Kona Coast, Hawaii.



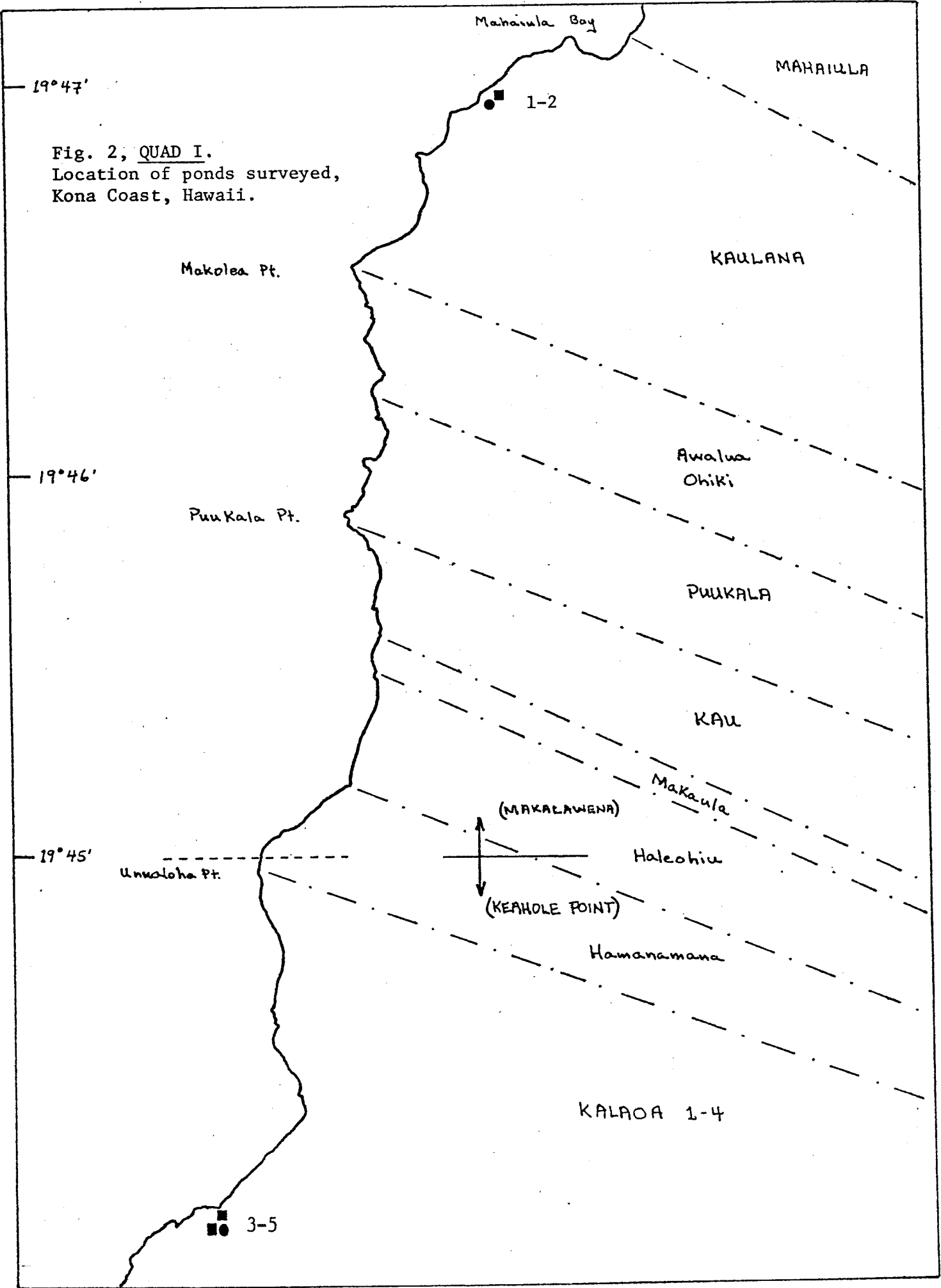
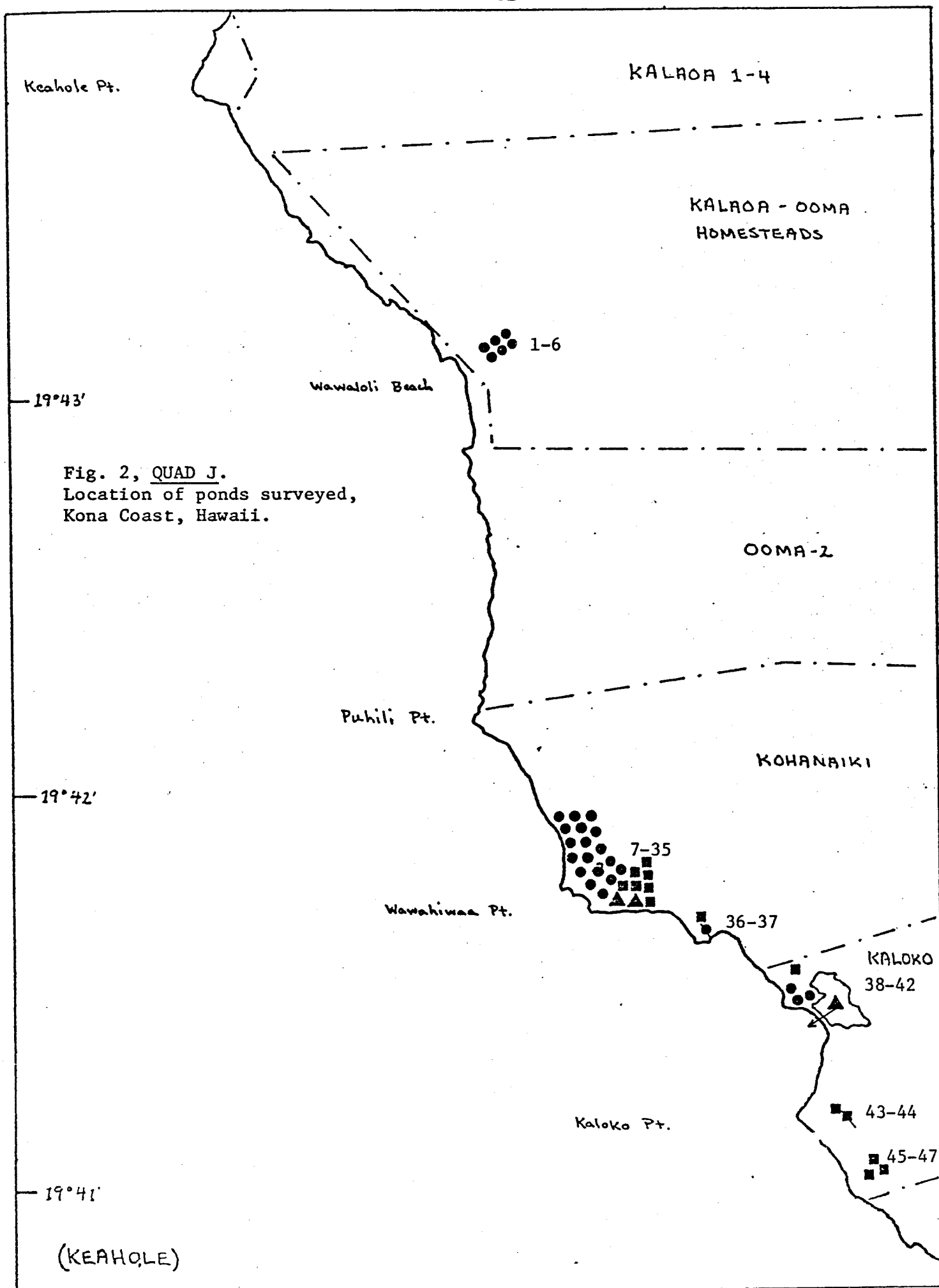
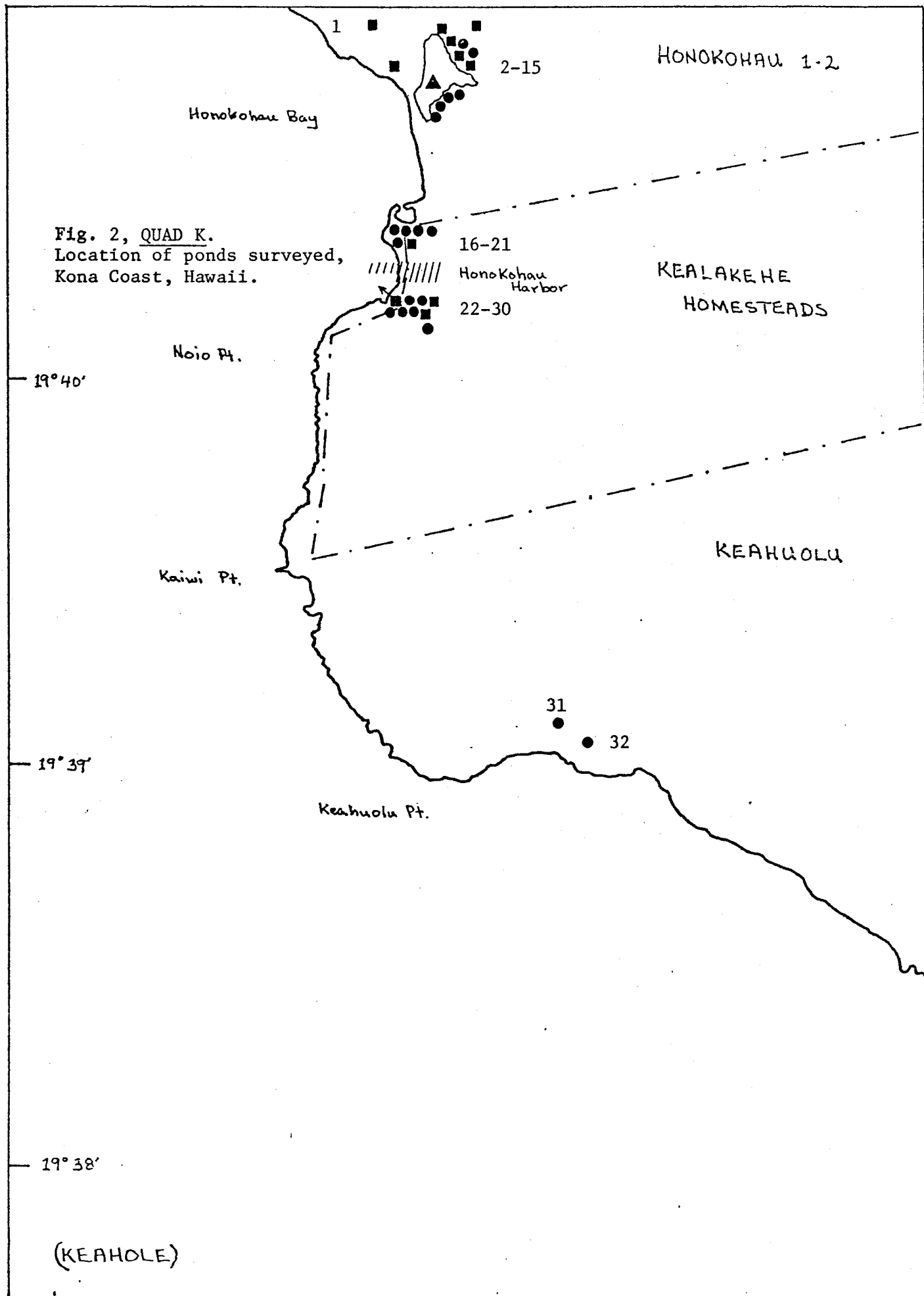


Fig. 2, QUAD I.
Location of ponds surveyed,
Kona Coast, Hawaii.





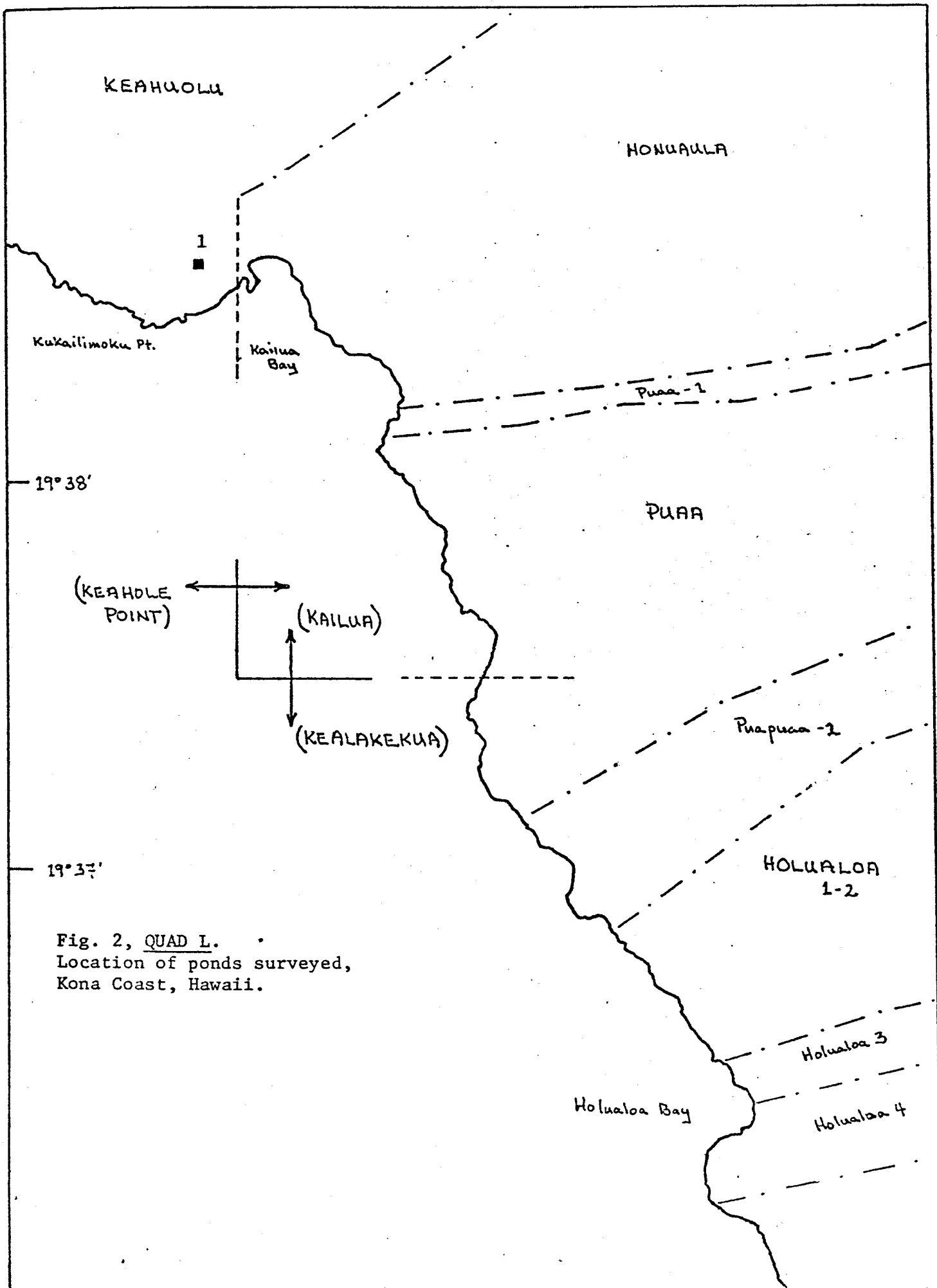


Fig. 2, QUAD L.
Location of ponds surveyed,
Kona Coast, Hawaii.

Fig. 2, QUAD M.
Location of ponds surveyed,
Kona Coast, Hawaii.

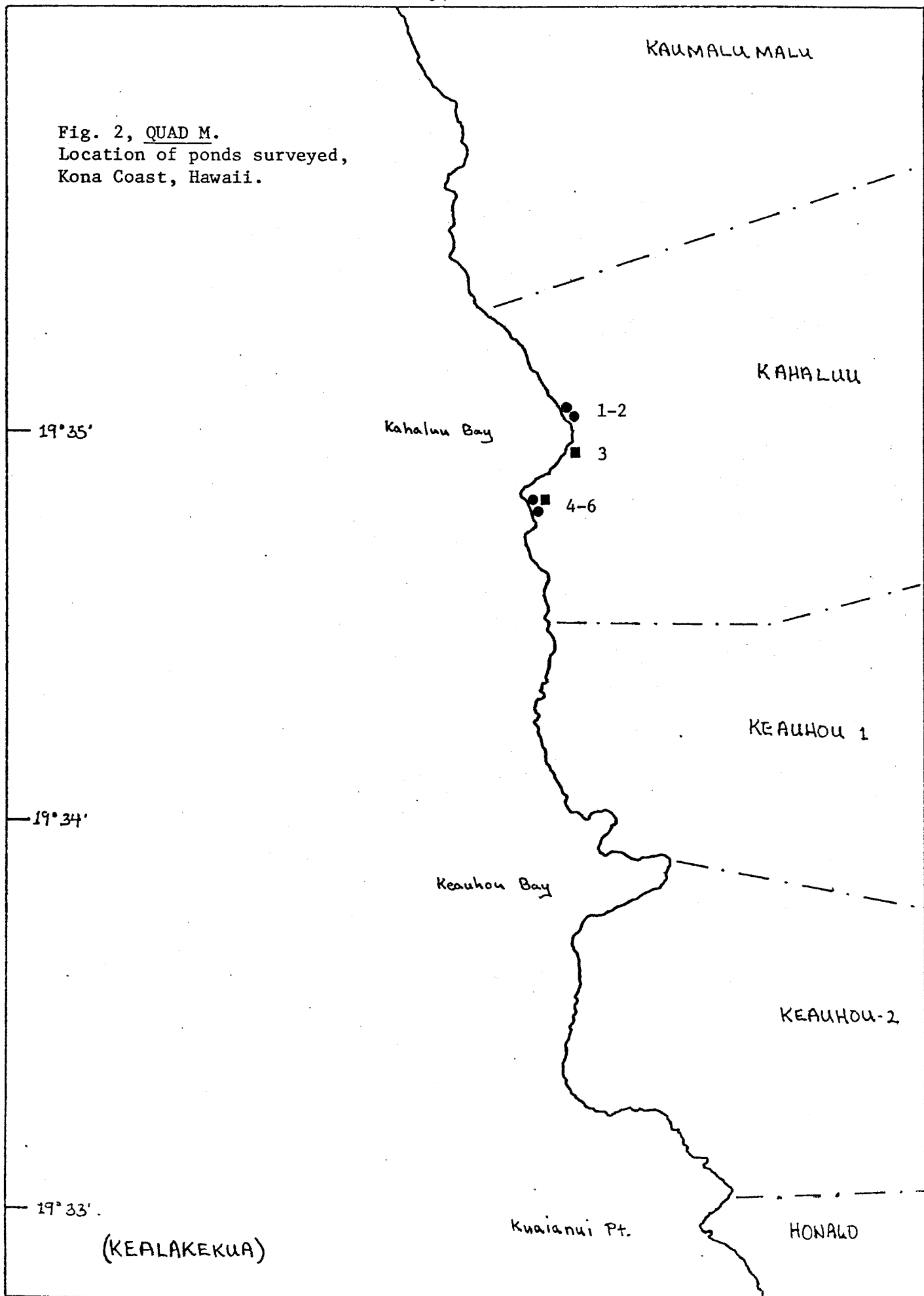
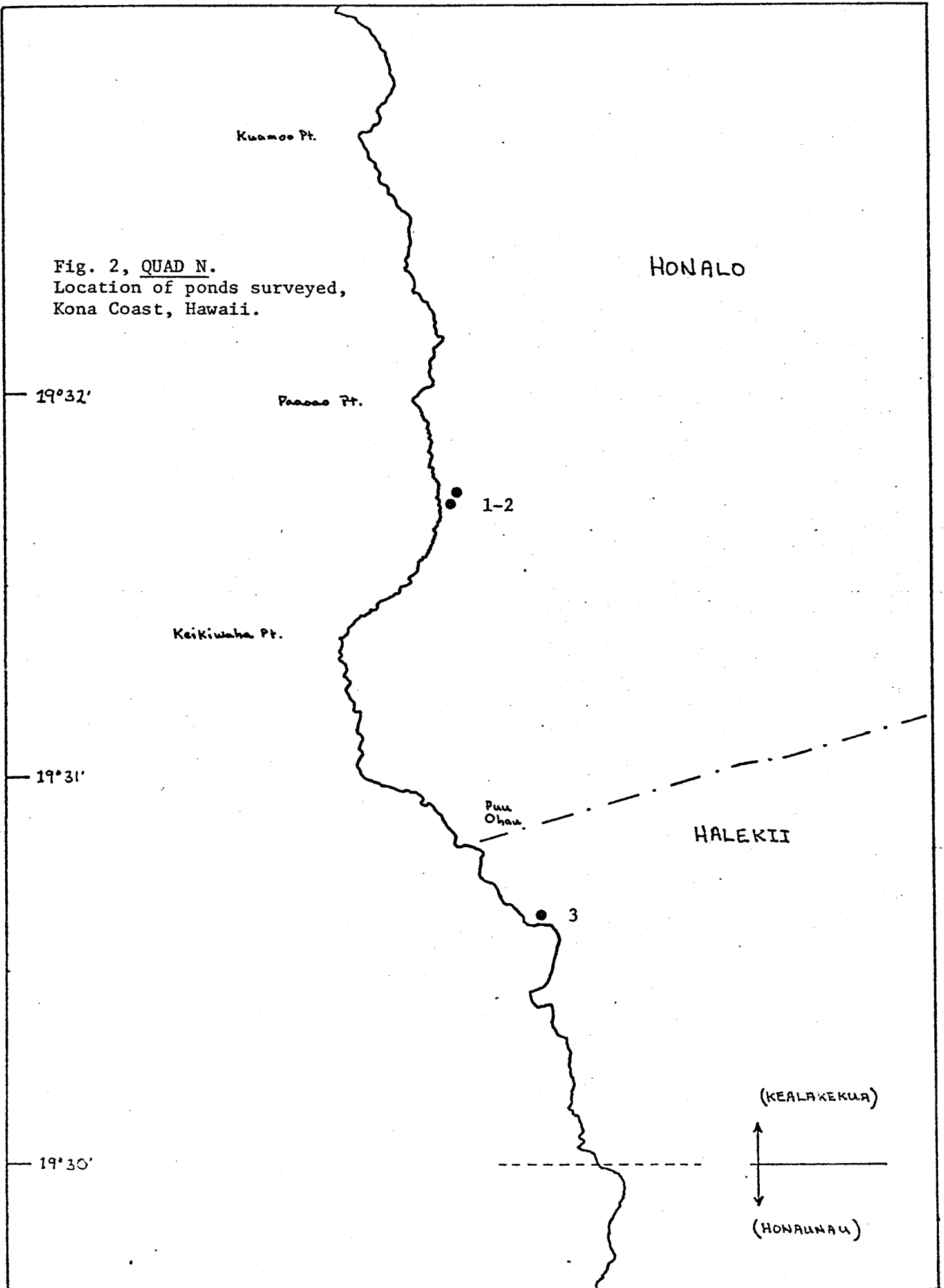
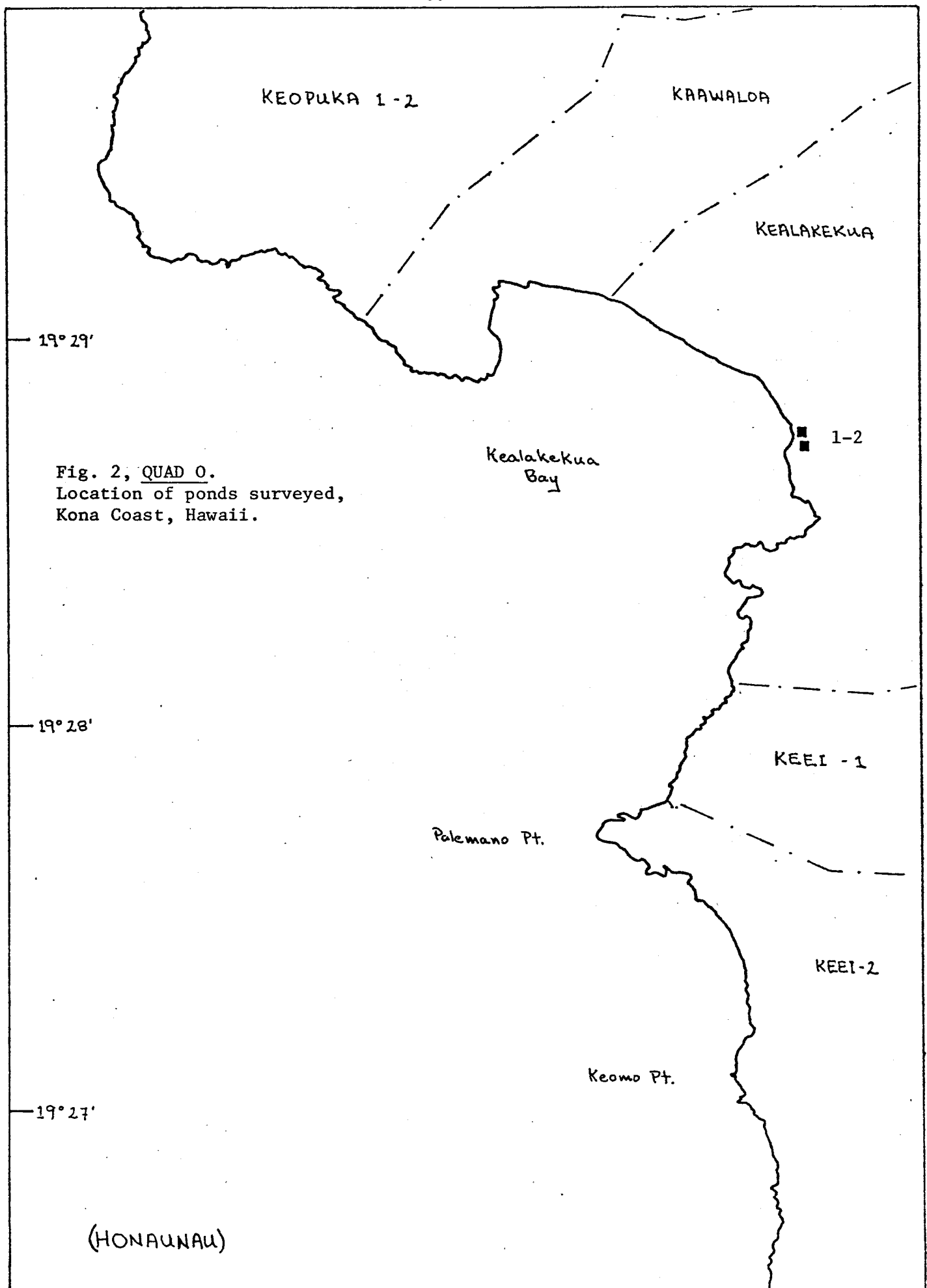
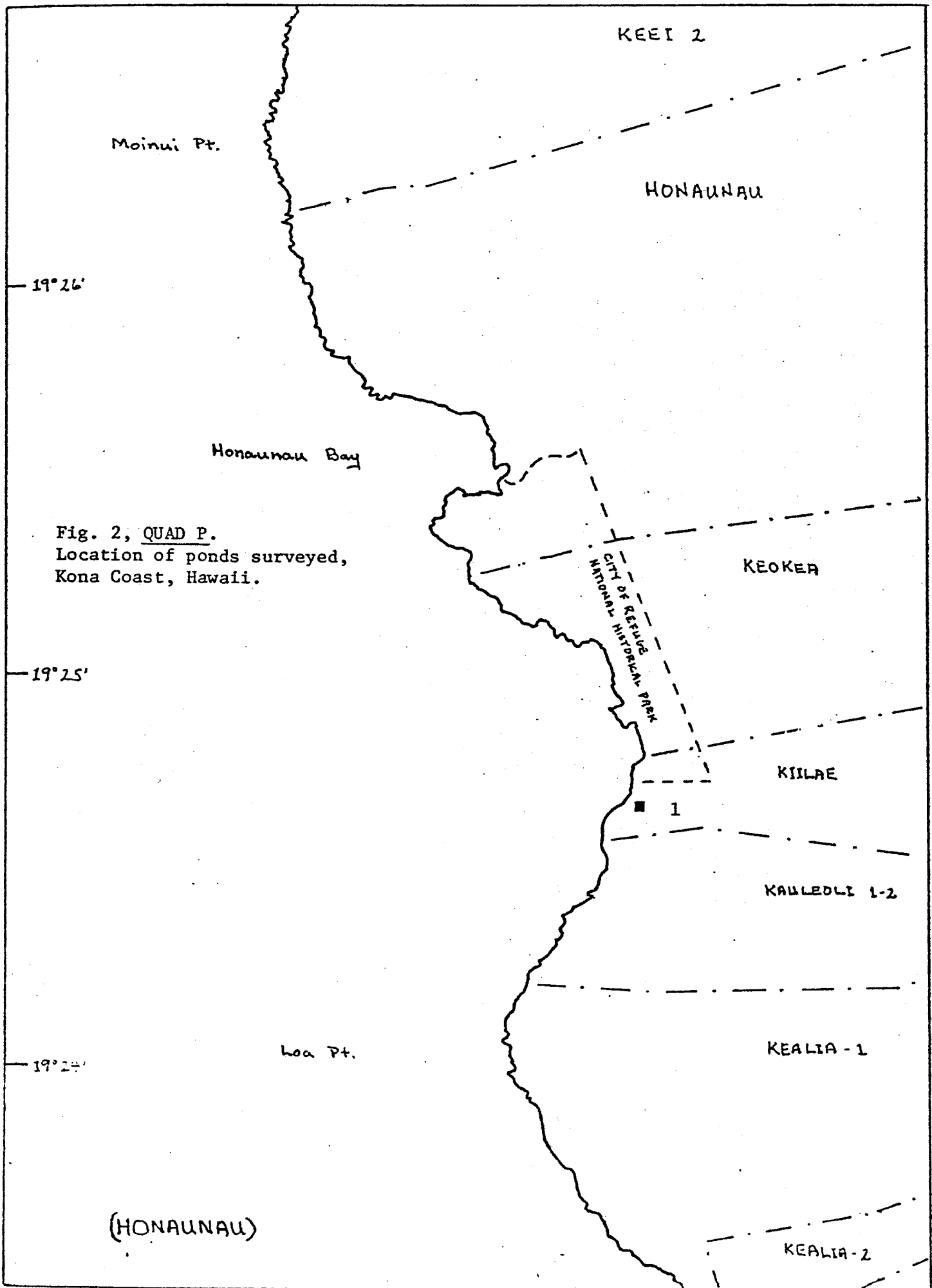


Fig. 2, QUAD N.
Location of ponds surveyed,
Kona Coast, Hawaii.







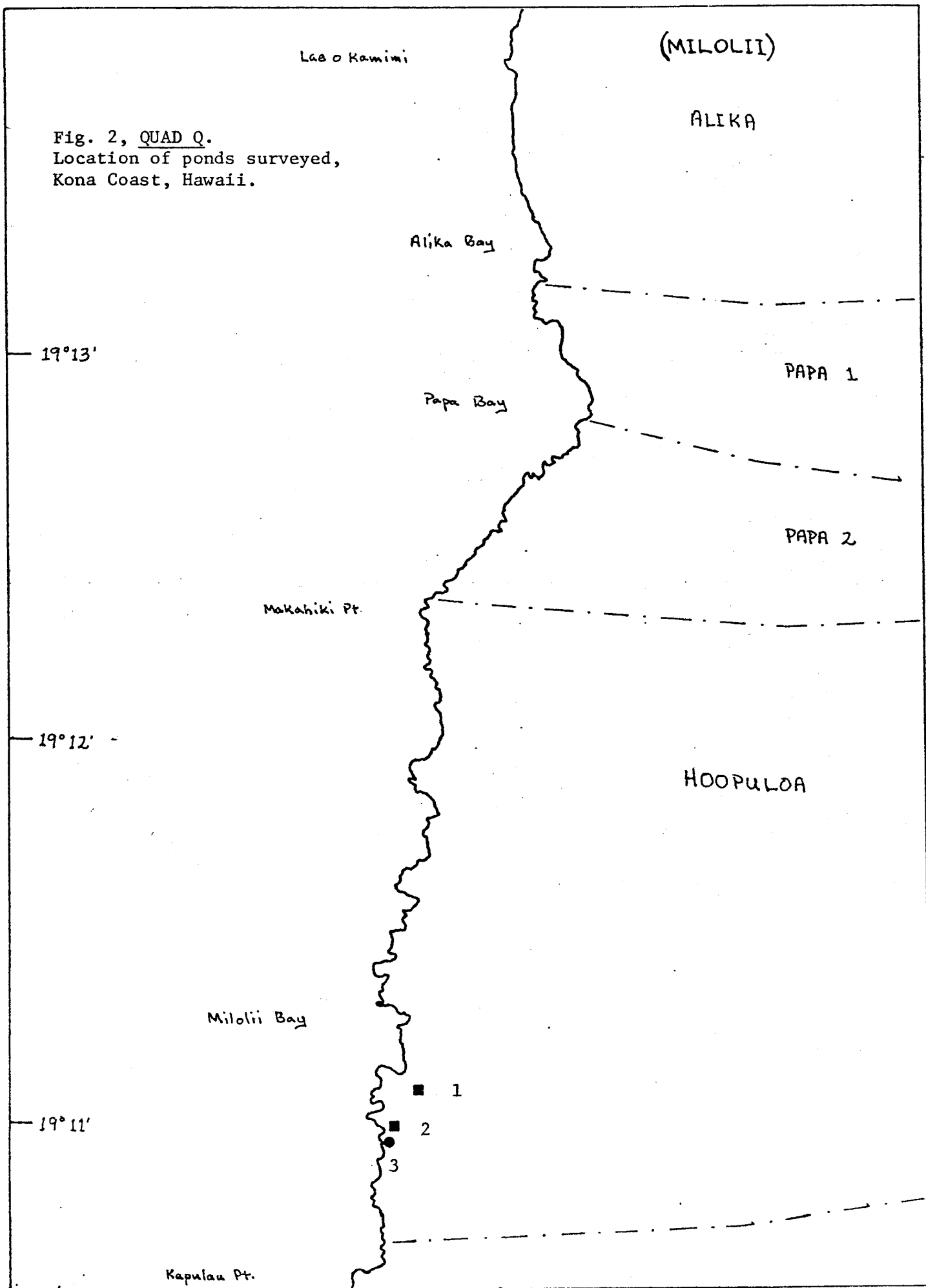
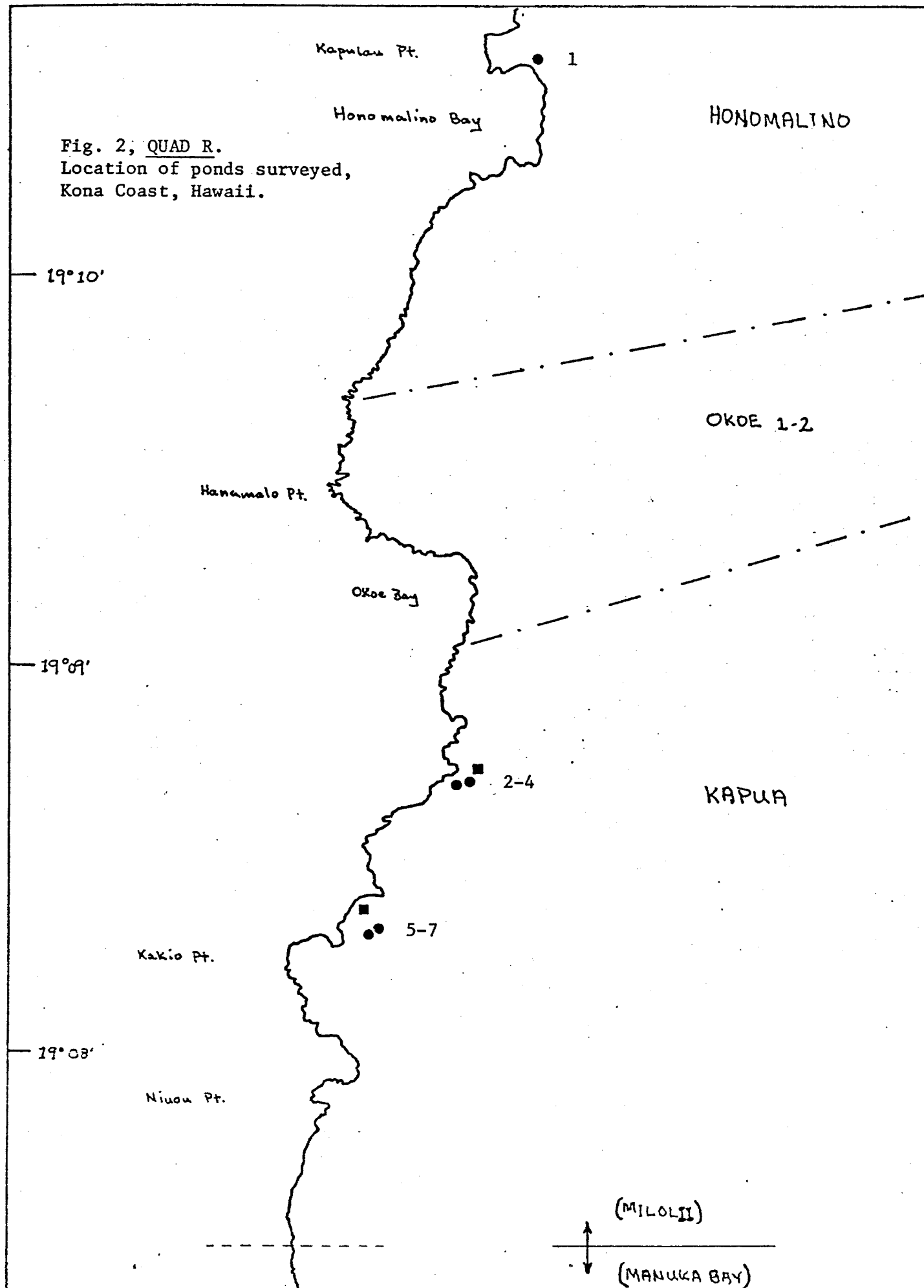
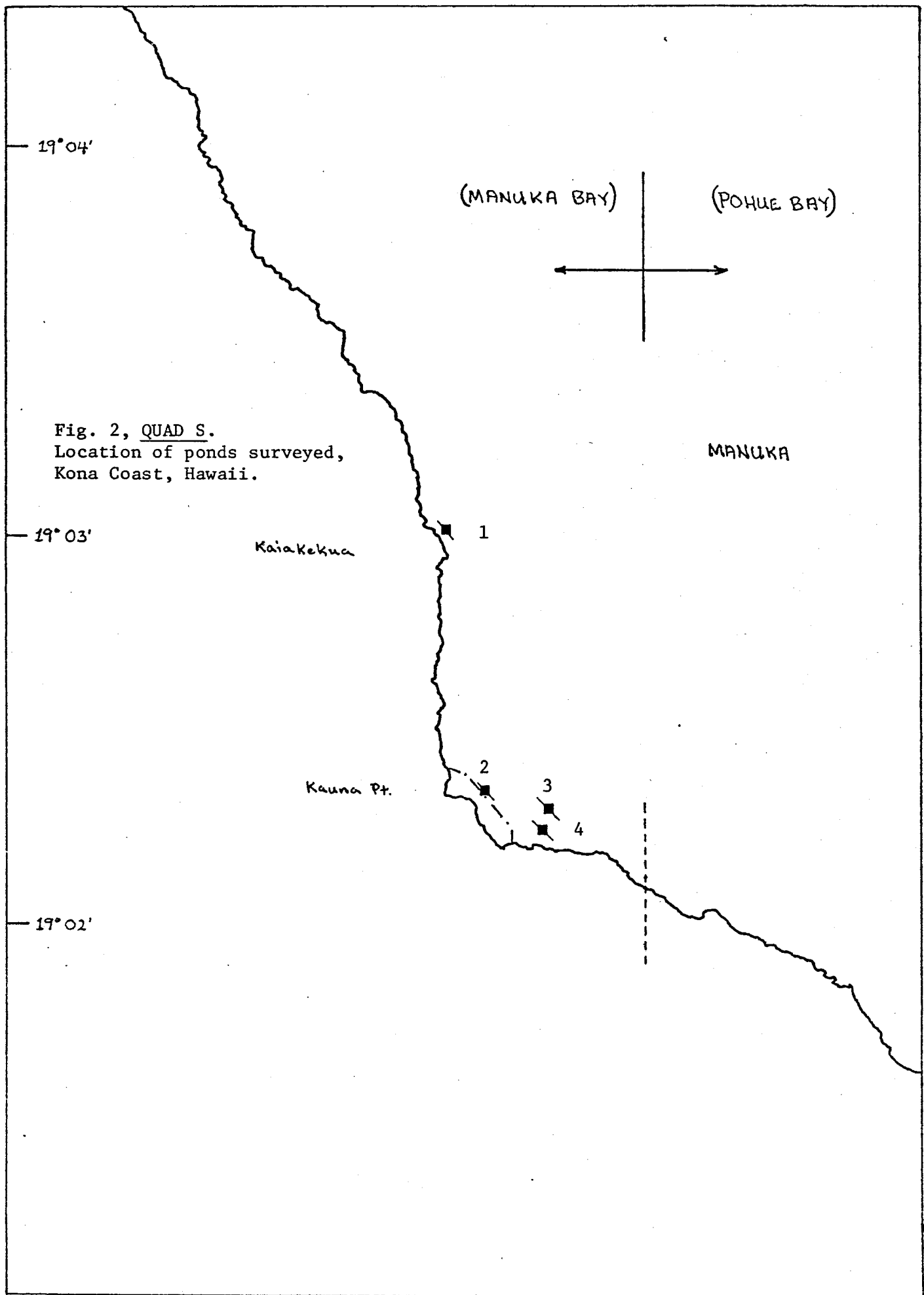


Fig. 2; QUAD R.
Location of ponds surveyed,
Kona Coast, Hawaii.





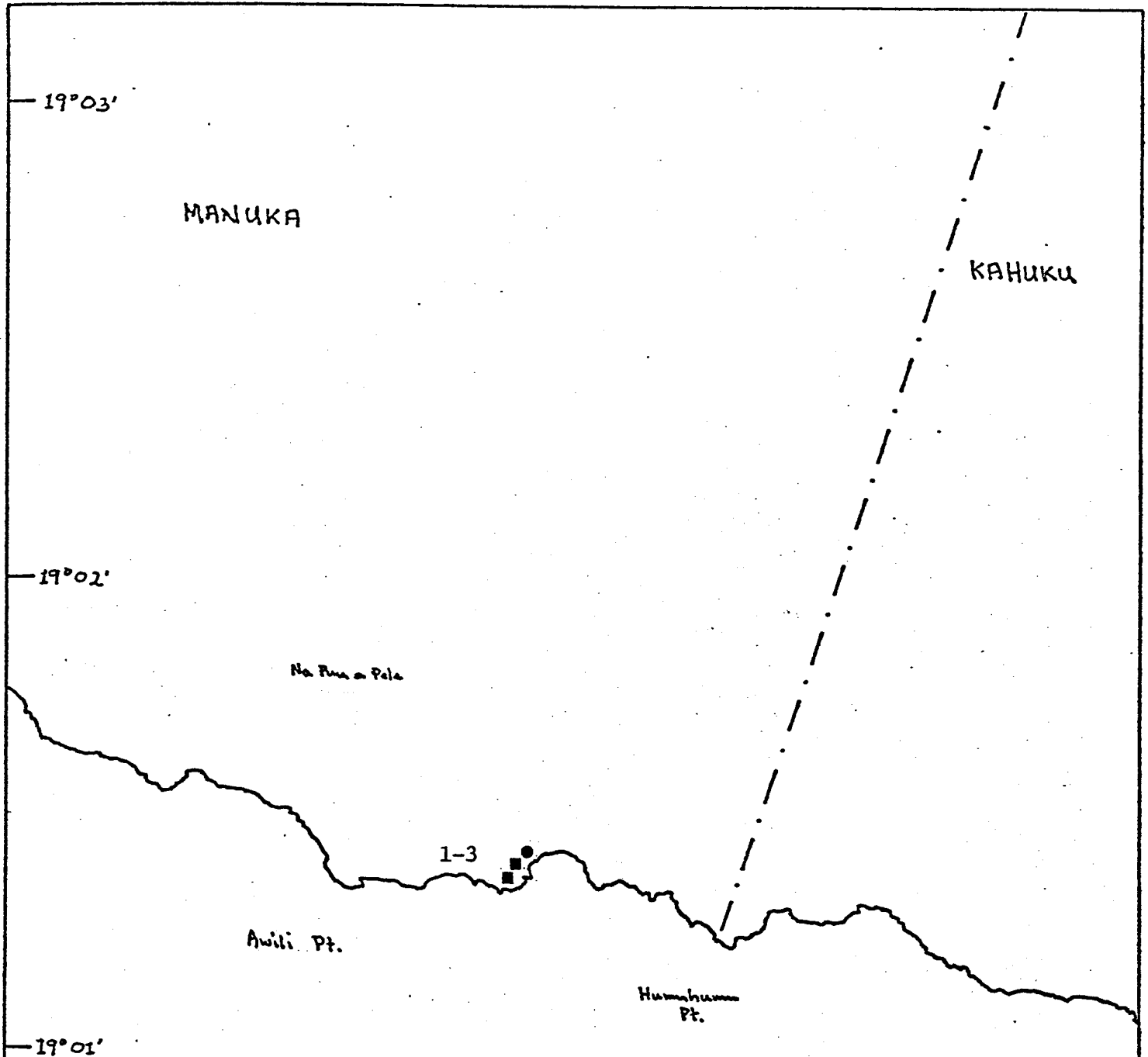
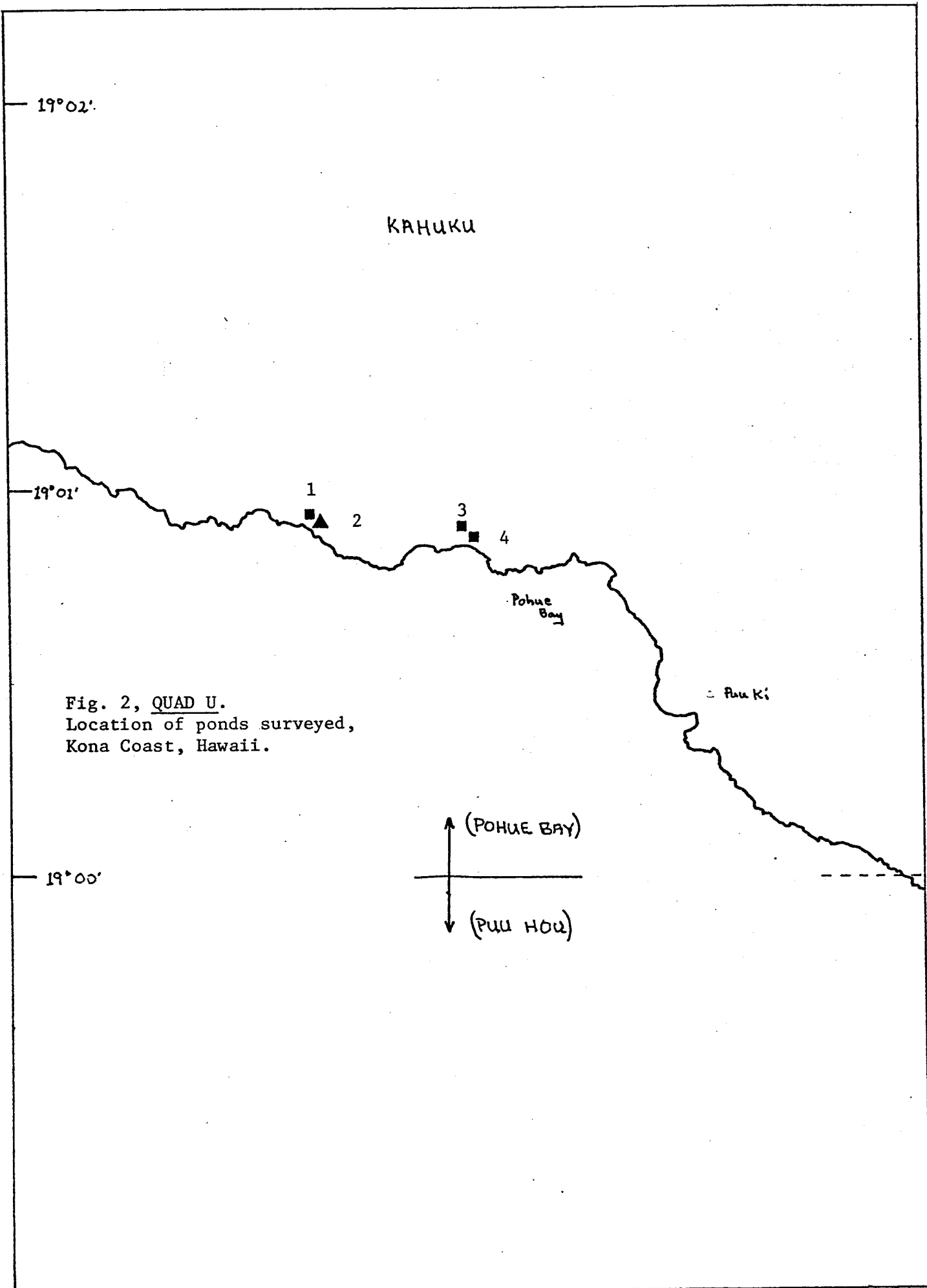


Fig. 2, QUAD T.
Location of ponds surveyed,
Kona Coast, Hawaii.

(POHUE BAY)



(Puu Hou)

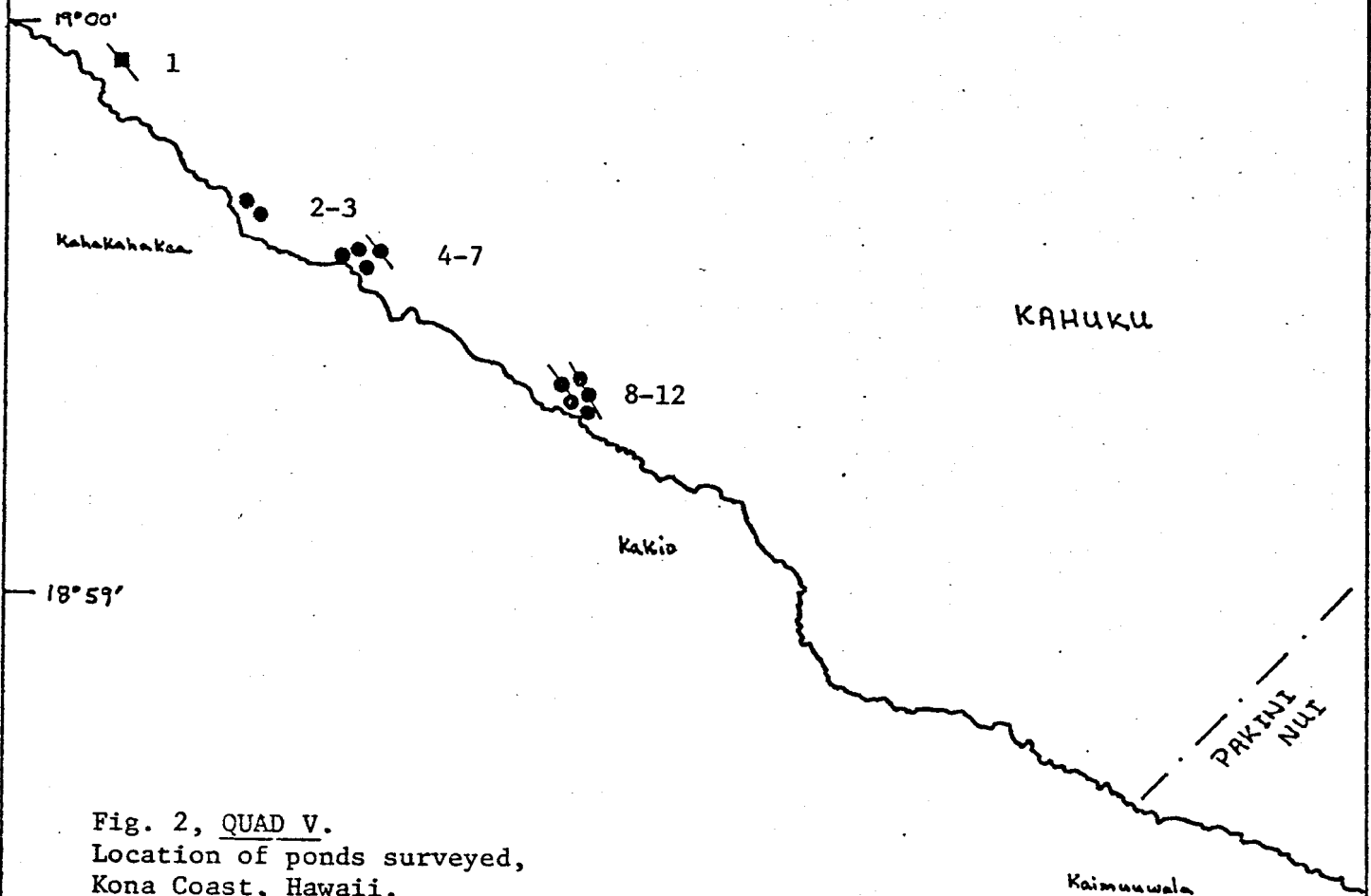
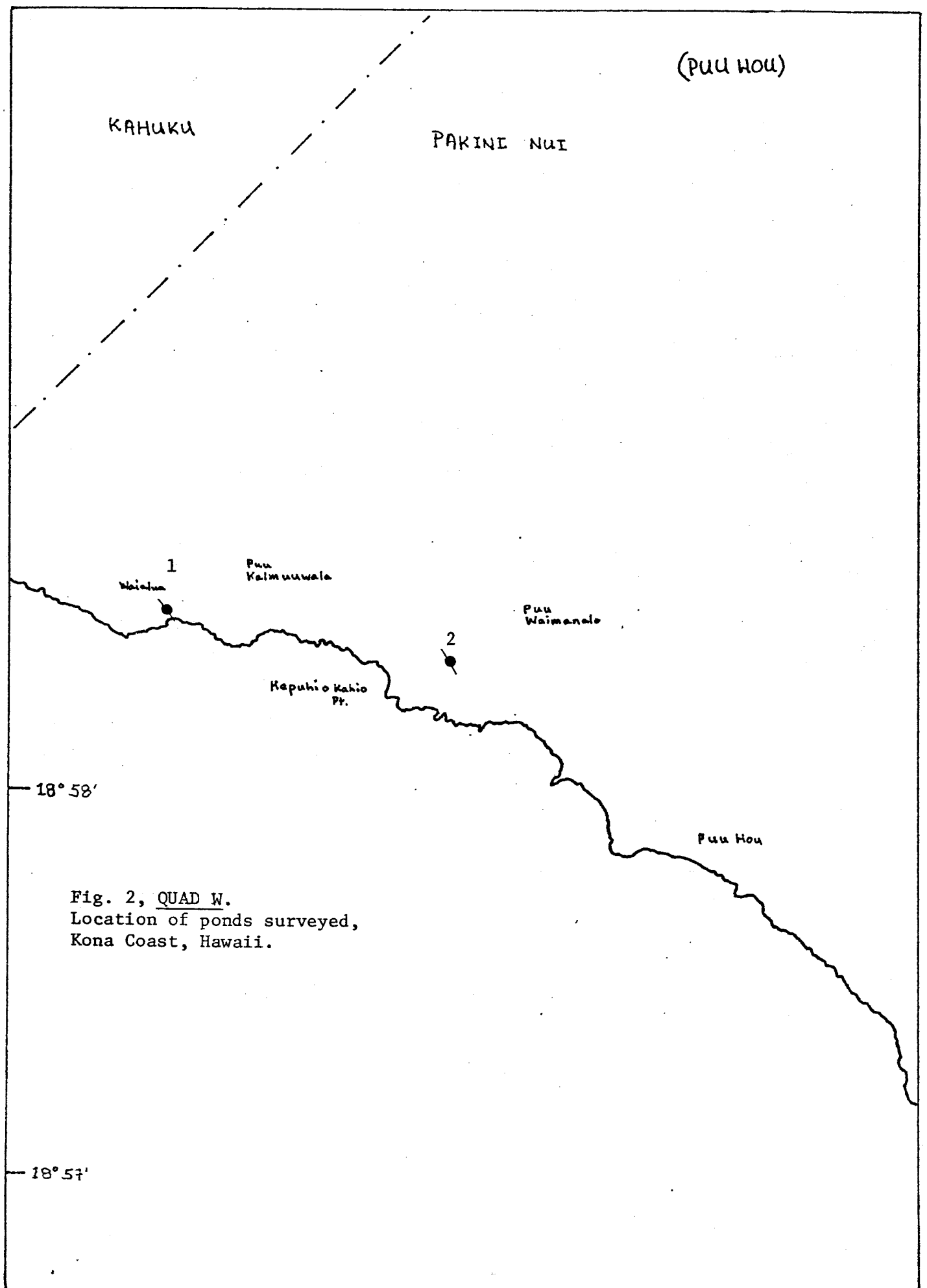
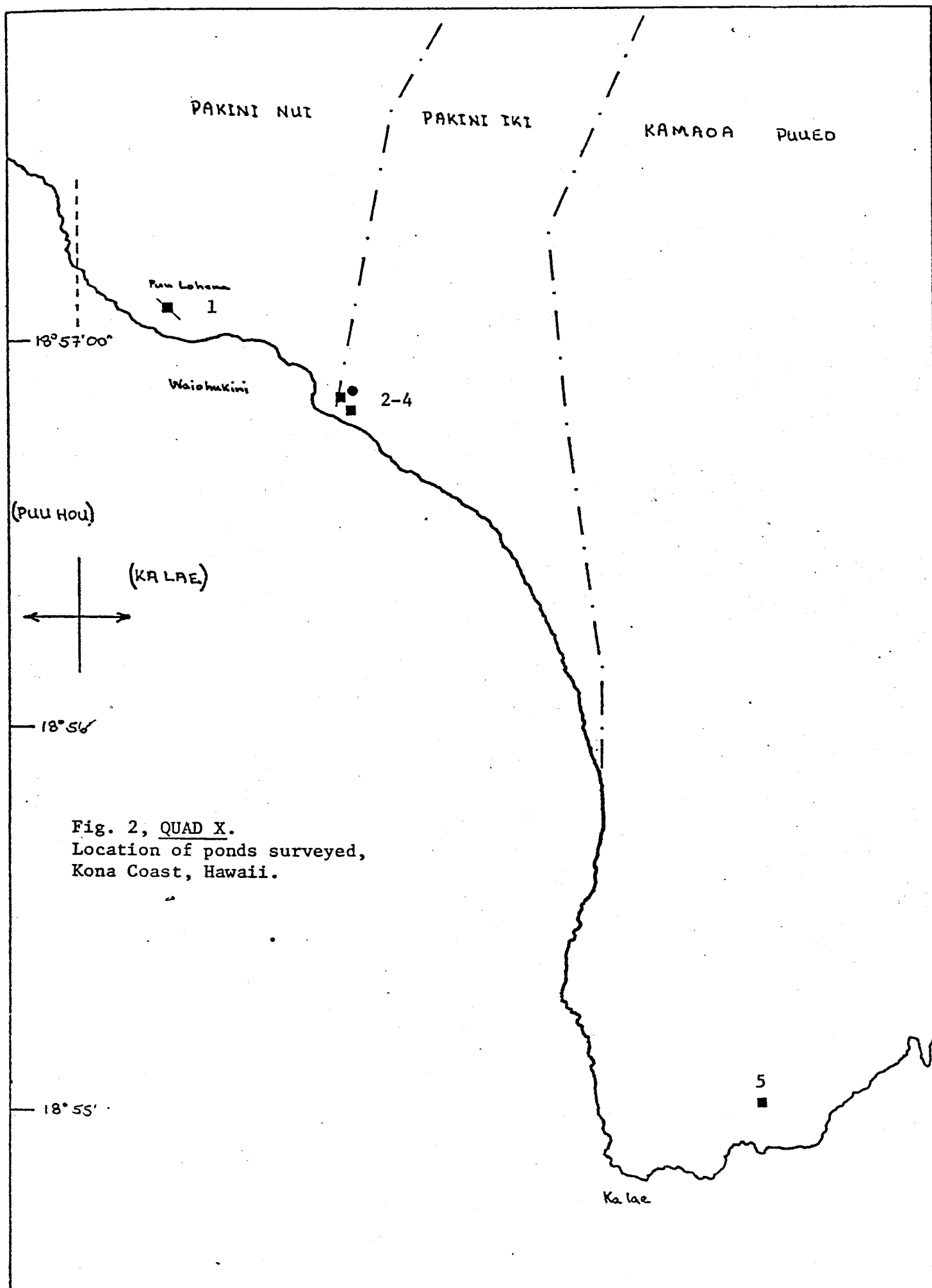
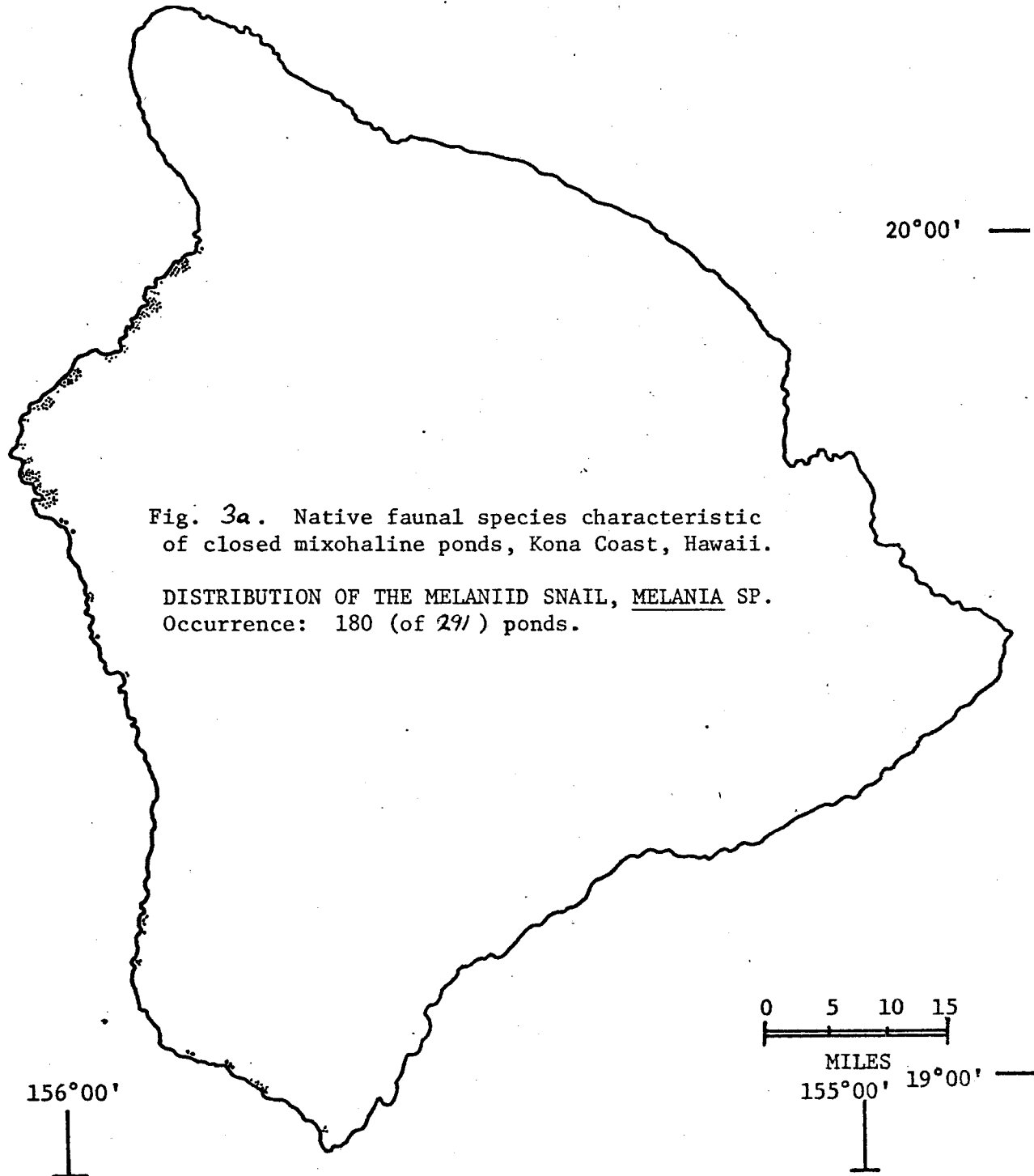
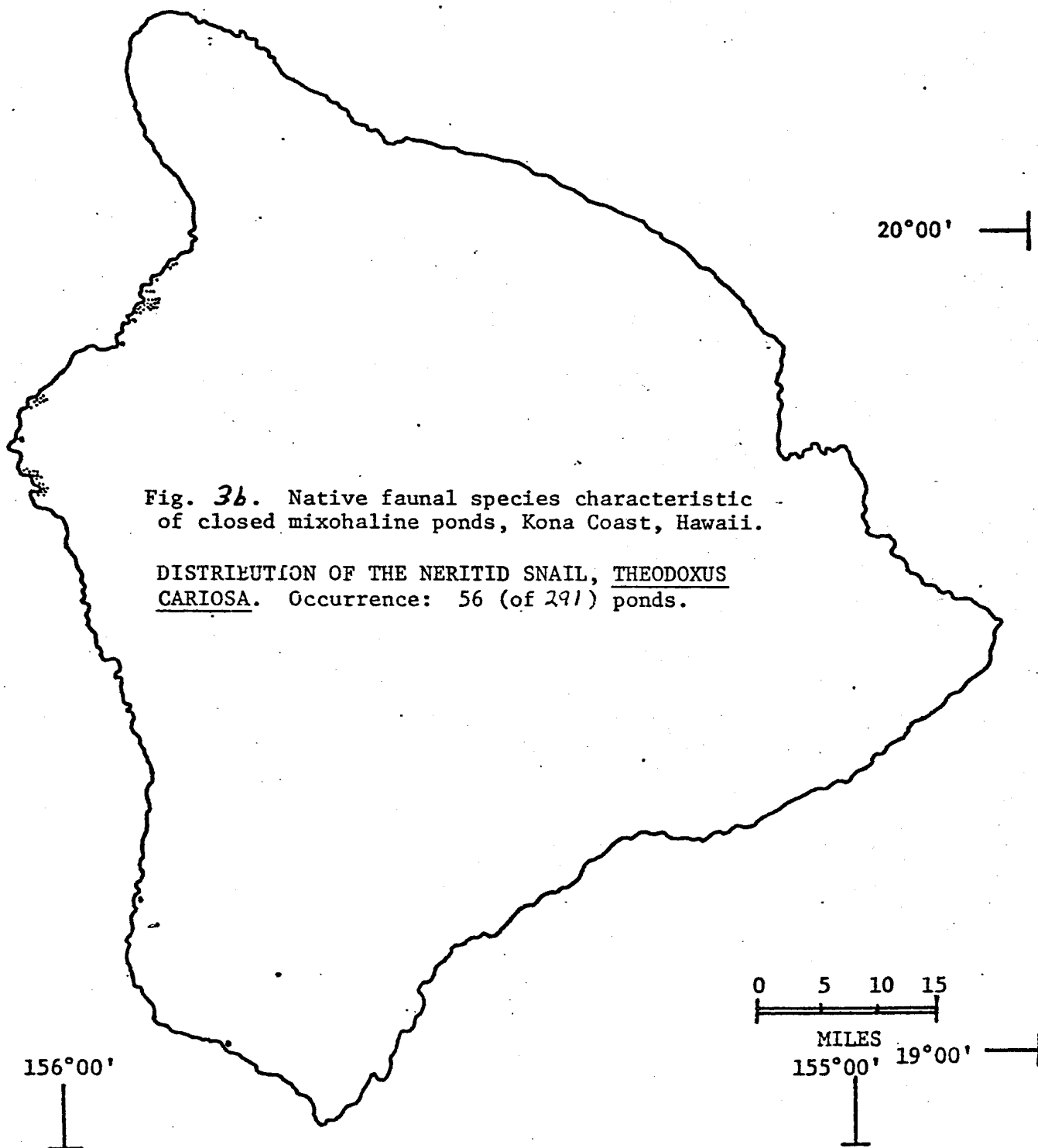


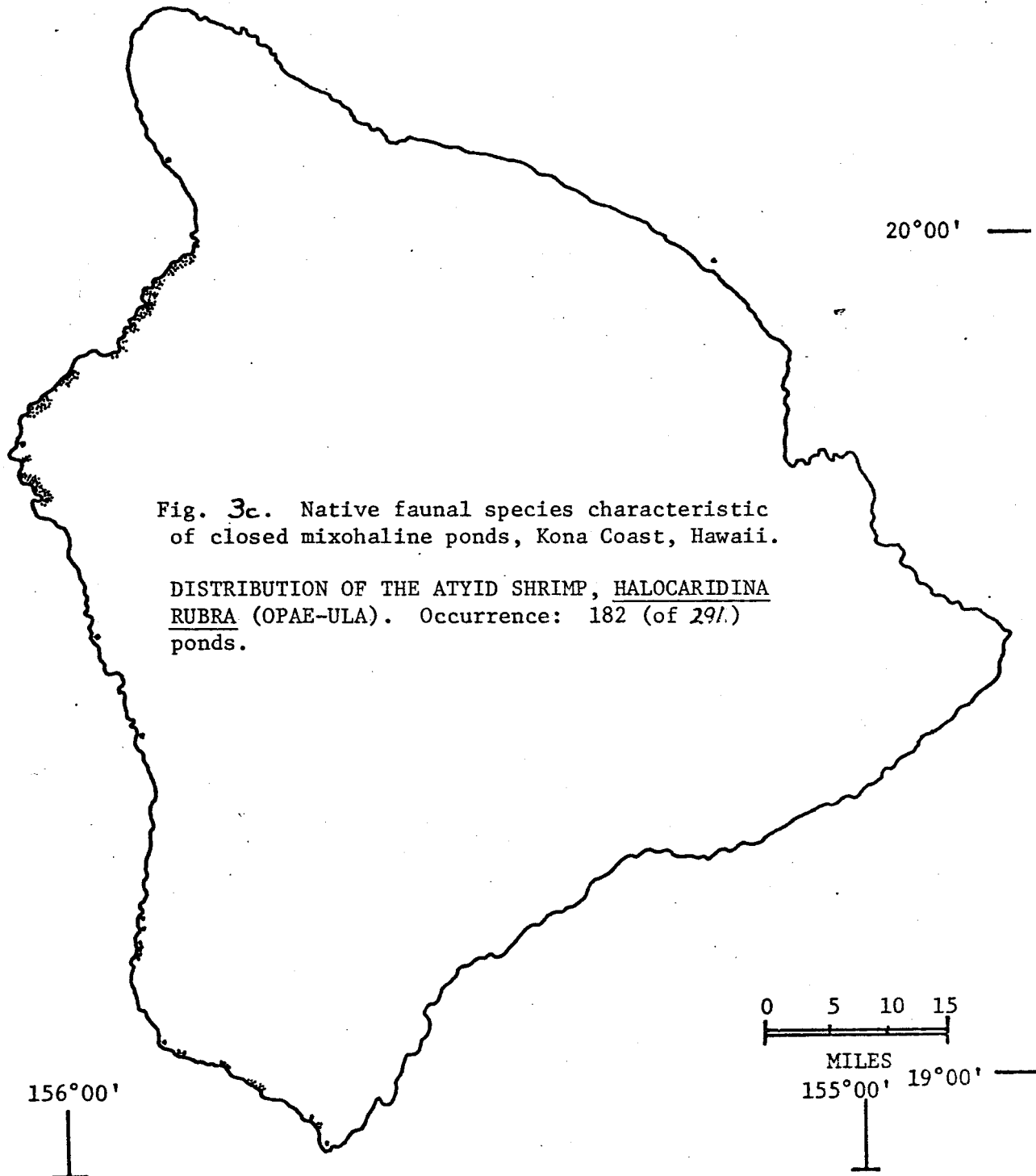
Fig. 2, QUAD V.
Location of ponds surveyed,
Kona Coast, Hawaii.

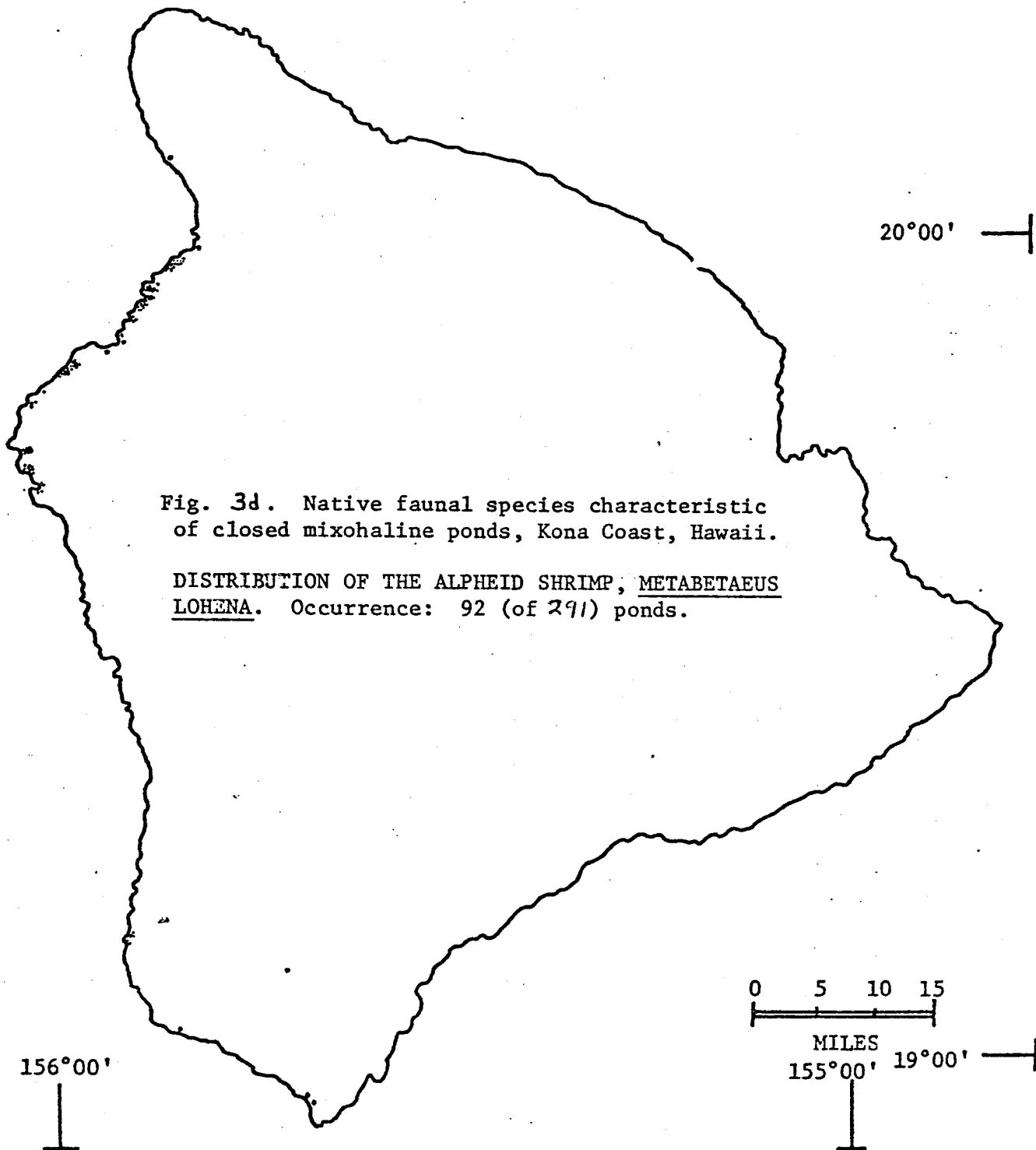


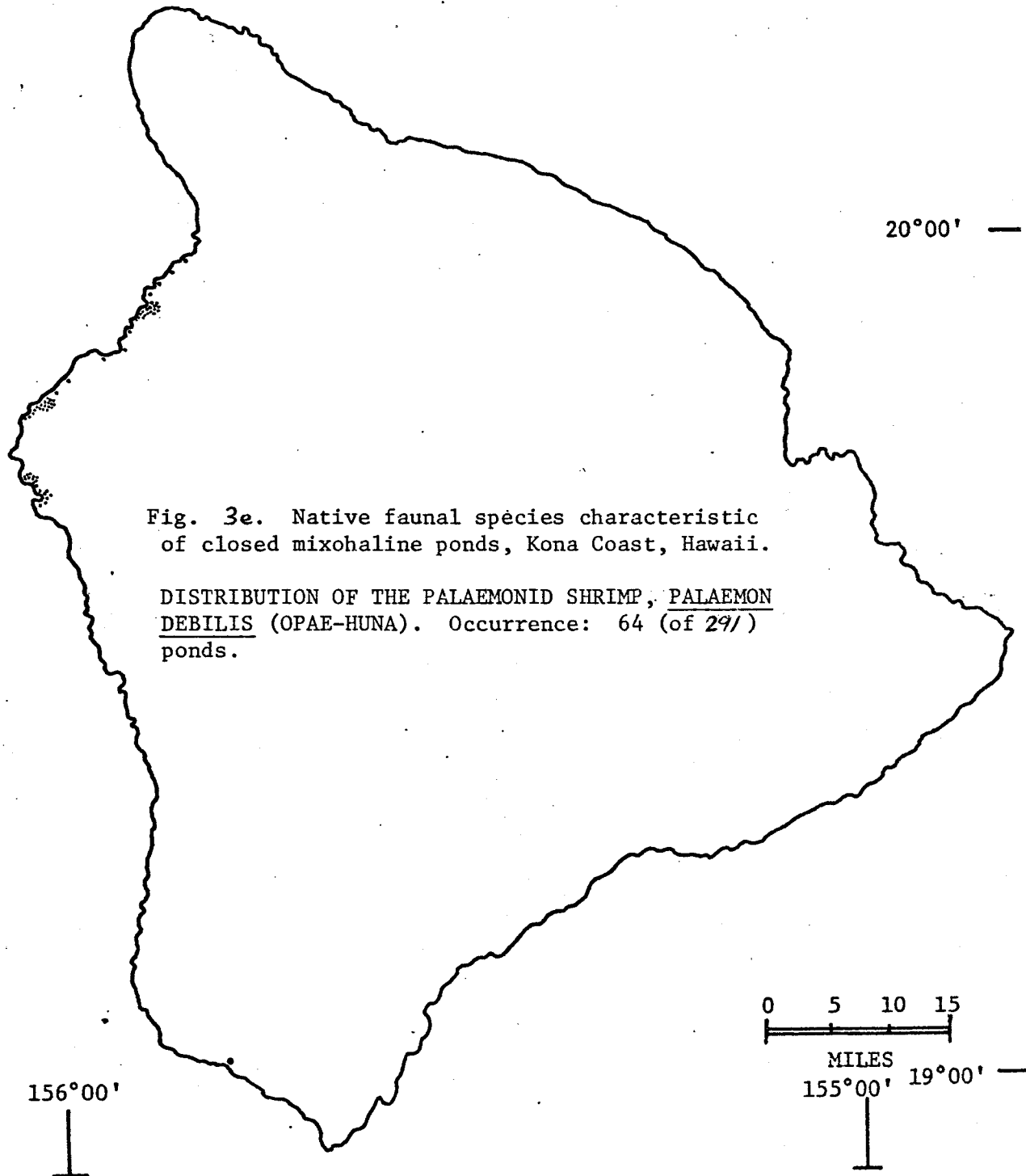


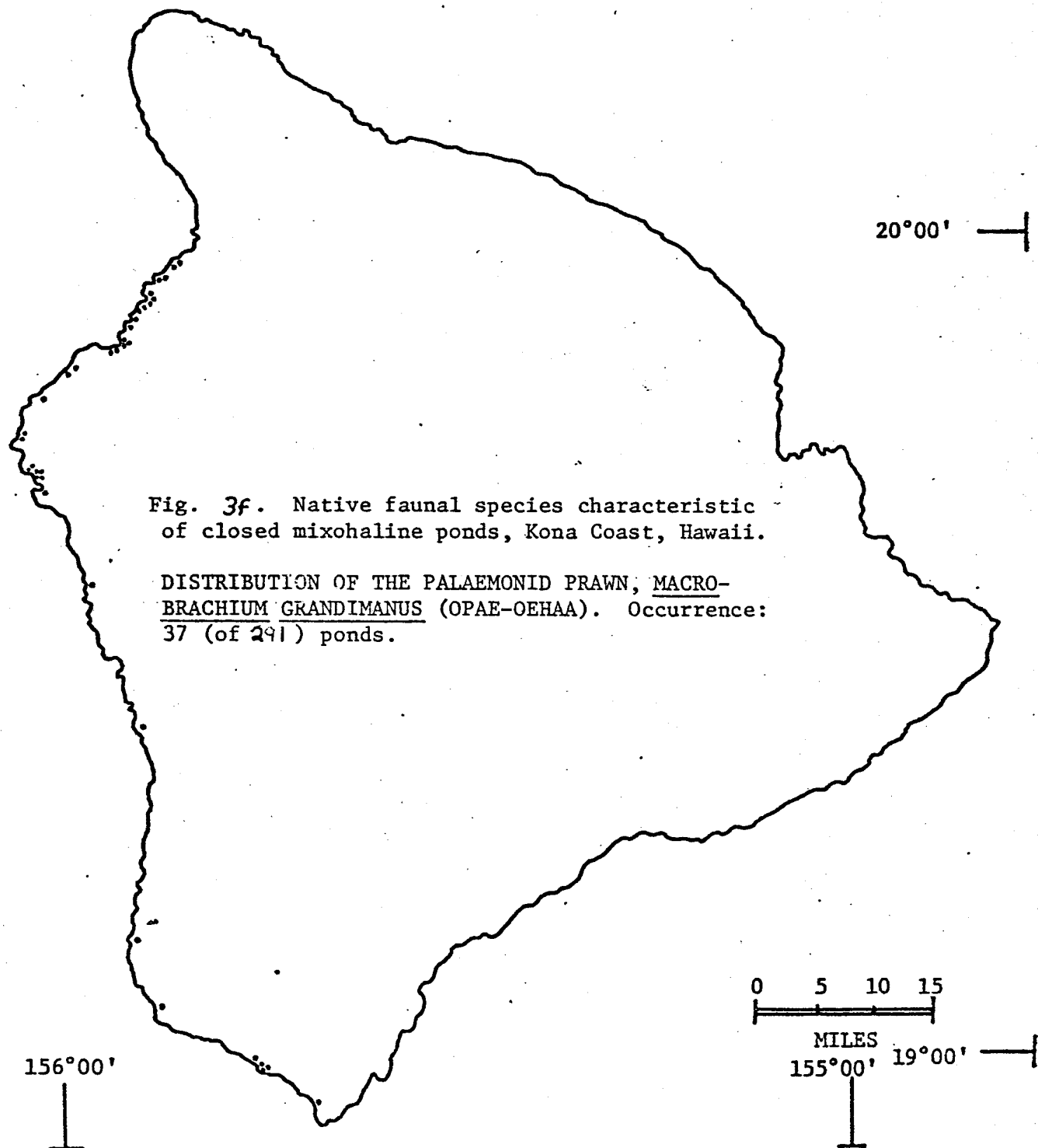


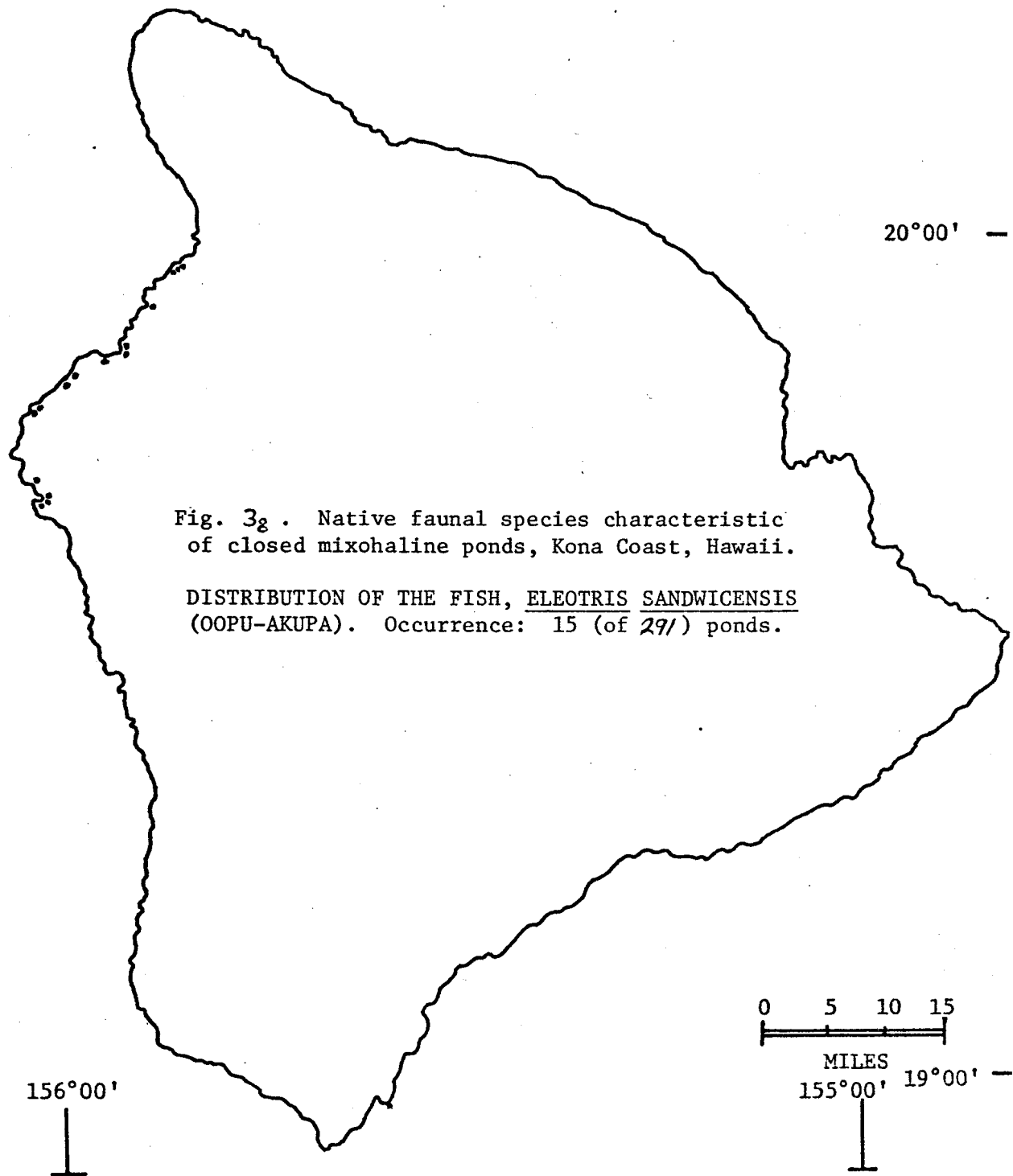












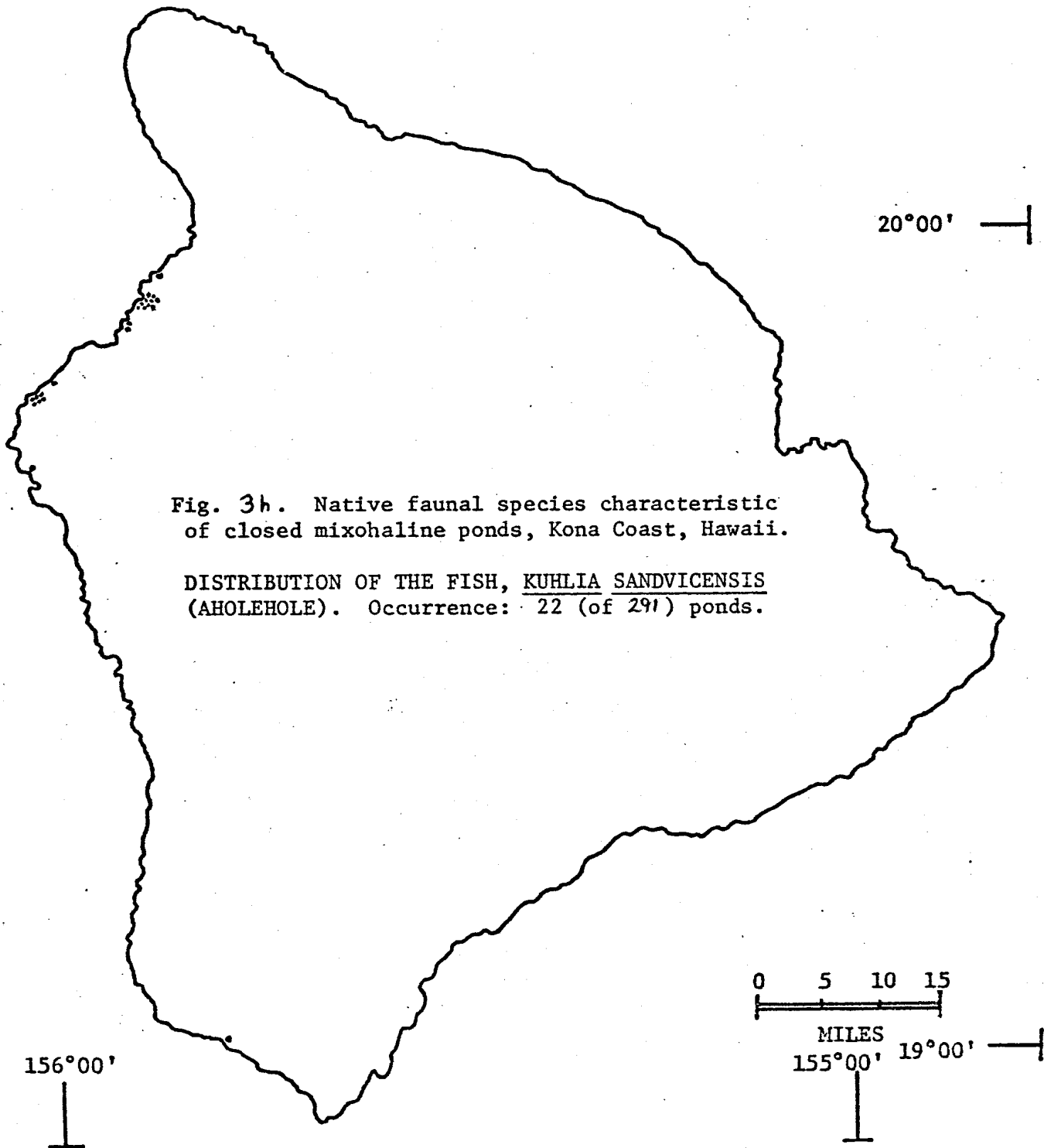
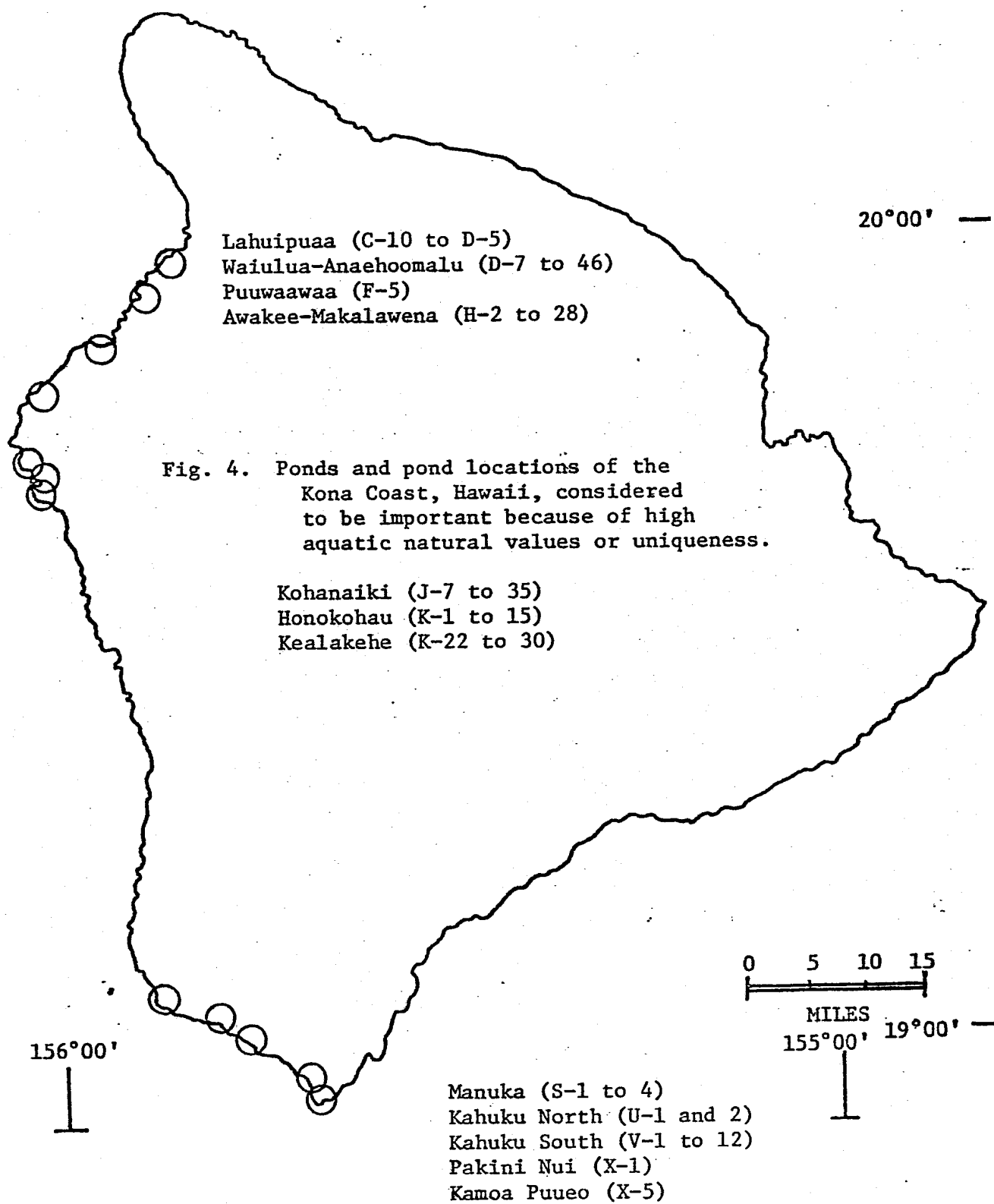


Fig. 3h. Native faunal species characteristic of closed mixohaline ponds, Kona Coast, Hawaii.

DISTRIBUTION OF THE FISH, KUHLIA SANDVICENSIS (AHOLEHOLE). Occurrence: 22 (of 291) ponds.



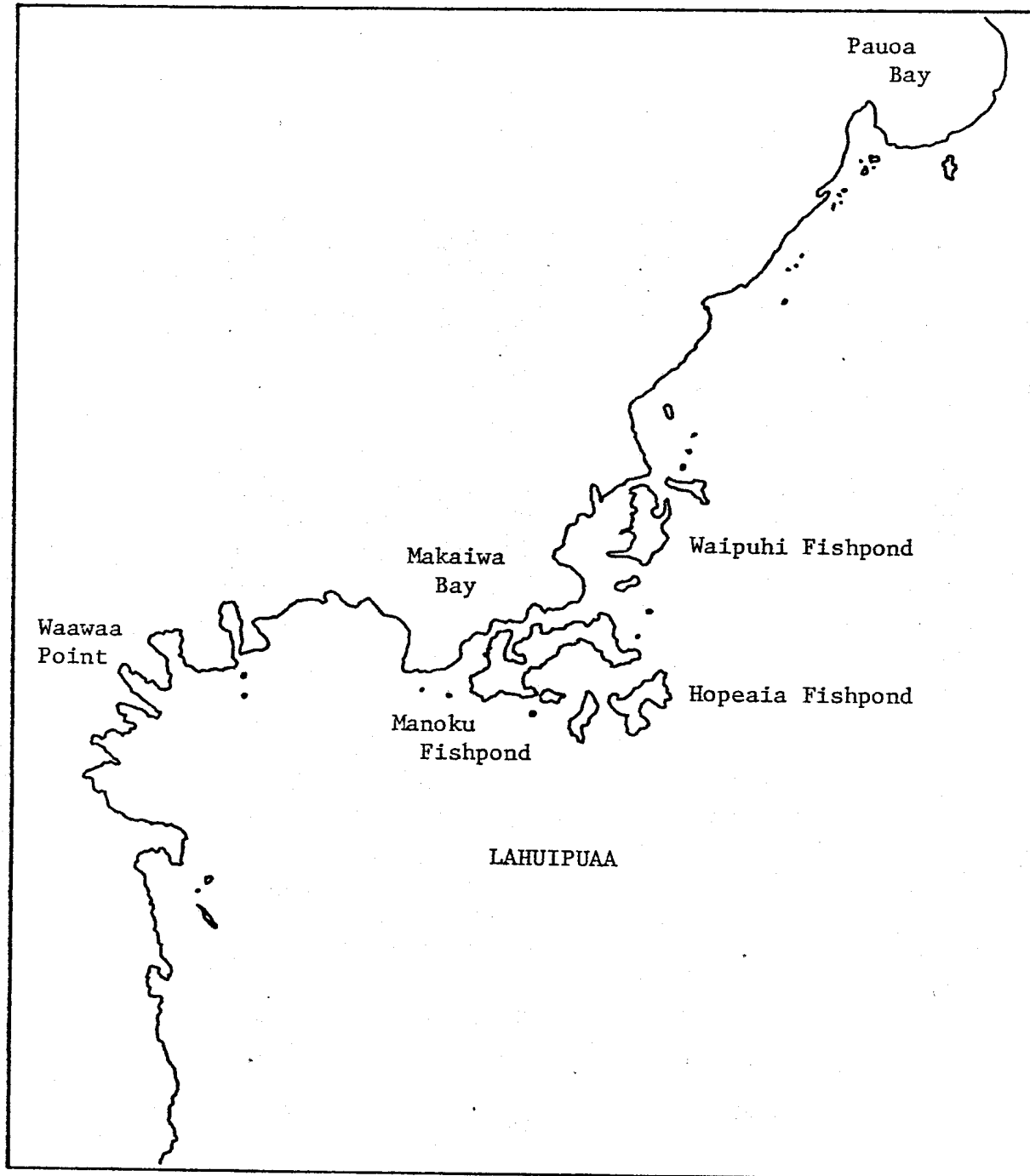


Fig. 5. Important pond areas of the Kona Coast, Hawaii.

5a. Hawaiian fishponds and other water exposures on the Lahuipuaa land division.

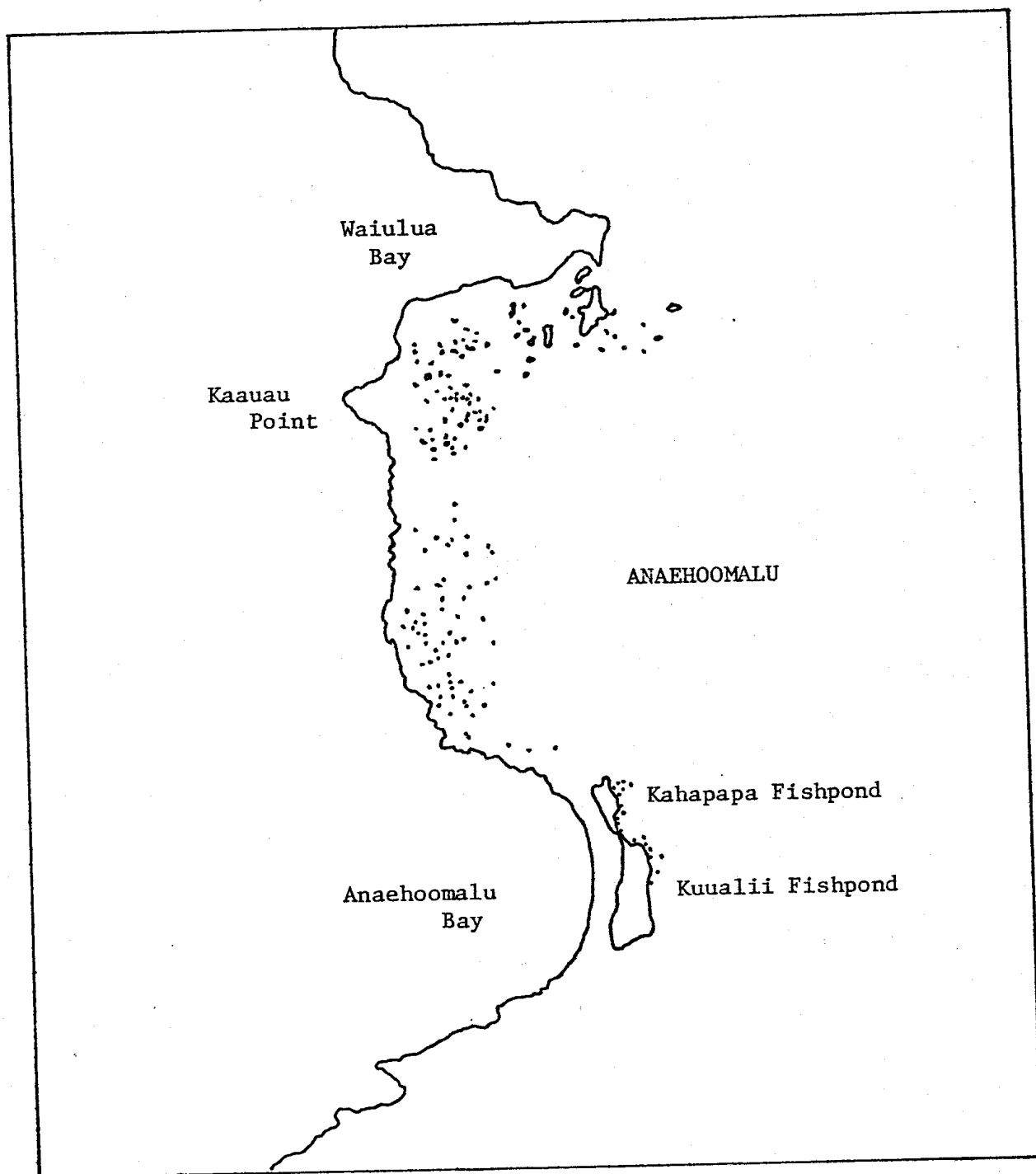


Fig. 5. Important pond areas of the Kona Coast, Hawaii.

5b. Distributional pattern of the large number of ponds on Anaehoomalu land division south of Waiulua Bay.

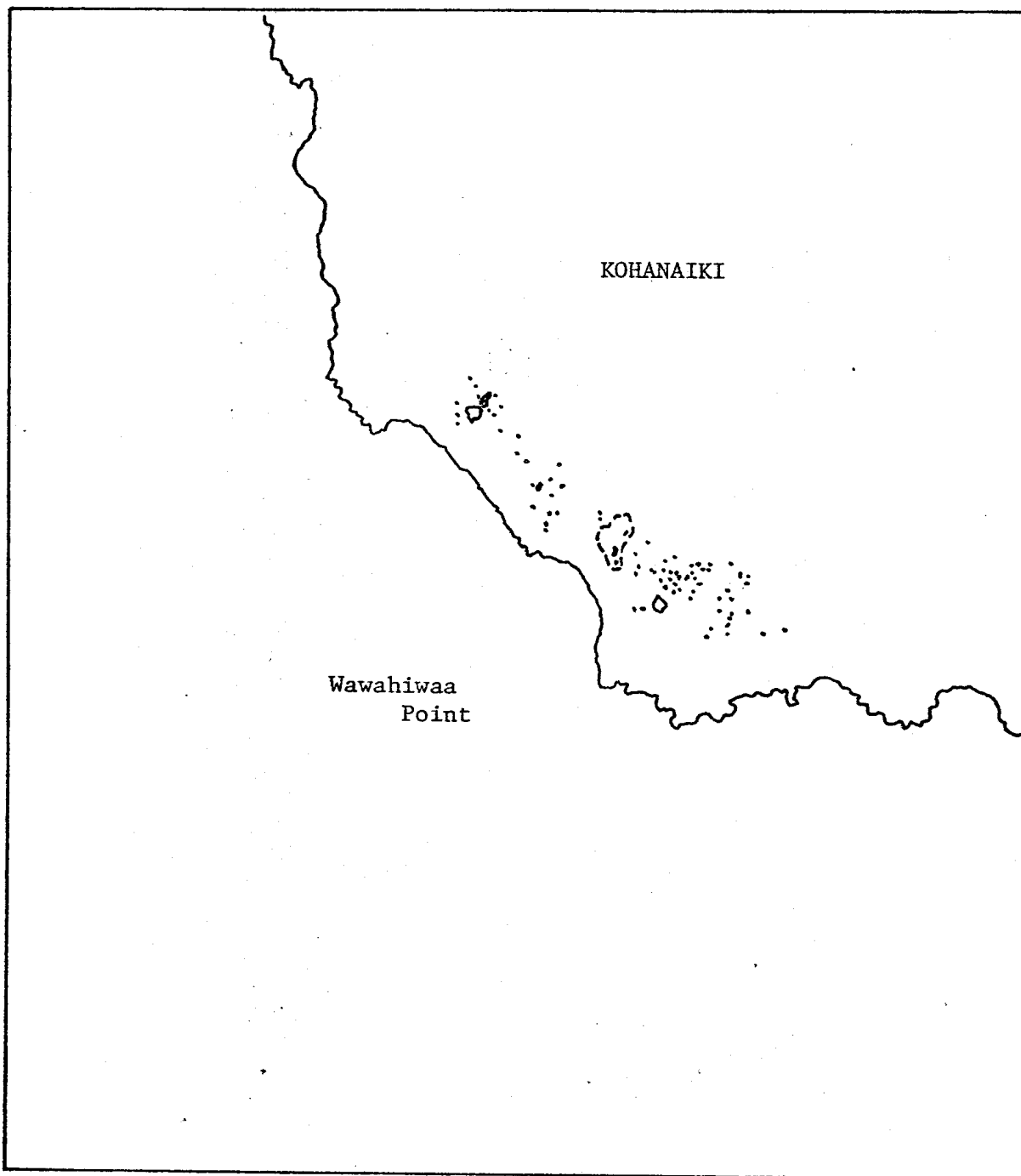


Fig. 5. Important pond areas of the Kona Coast, Hawaii.

- 5c. Distribution of ponds in older pahoe-hoe of Kohanaiki land division near Wawahiwaa ("Pine Tree") Point. Area enclosed by dashed line is stand of large mangrove trees.



Fig. 6a. Part of the summer crew surveying one of the numerous ponds in a recent aa lava at Awakee-Makalawena (H-2 to H-22 series). Crew consisted of University of Hawaii (Manoa) staff assisted by UofH Sea Grant Marine Options Program students from Hilo College.



Fig. 6b. Sunlight reflecting from water exposures in dark lava at Waiulua Bay shows several of larger ponds in this aerial view of the north end of Anaehoomalu area (D-7 to D-13 series). Largest pond near center of photo, notable for its marine fishes, is shown from ground view in Fig. 7. Recent bulldozer track entering from upper right transects pond area.

Fig. 7. Mixohaline ponds of the Kona Coast, Hawaii, having high natural qualities or representative of pond areas with exceptional natural value.

Top, left: Water exposure in cave-like setting--one of the many diverse pond types at Lahuipuaa (C-10 to C-32 series).

Top, right: Largest open pond adjoining Waiulua Bay, Anaehoomalu area (D-8)--contains several marine fish species (cf., Fig. 6b).

Second row, left: Largest pond north of "Pine Trees" (in background), Kohanaiki area (J-10).

Second row, right: One of many smaller ponds south of "Pine Trees", Kohanaiki area (J-20 to J-35 series). Dark green growth in water is the pondweed, Ruppia maritima.

Third row, left: Aimakapaa--largest pond surveyed and prime waterbird habitat, Honokohau area (K-10).

Third row, right: Deep, but unusually clear water of pond (U-1) at Kahuku North shows extensive algal deposits of whitish marl. Pluchea indica, a common shrub, borders most of landward shore.

Bottom, left: One of several fissures extending below the sea watertable in Kahuku South area (V-8 to V-12 series). Surface areas and depths of such "ponds" are difficult to estimate.

Bottom right: The most unusual fauna was collected in deeper waters of this complex depression located in Kamaoa Puueo area (X-5). Phytoplankton produces noticeable turbidity. Structurally, pond appears to be a collapse point in a deep-lying lava tube.



Fig. 8. Common native fauna of mixohaline coastal ponds.
All specimens are approximately life-size.

- a. Gastropod mollusks, dorsal and ventral views. Top left--the brown wi, Theodoxus vespertina; top right--Melania sp.; both species frequently have severely eroded shells. Middle row--Theodoxus cariosa showing extremes of "wing" development (lateral expansion of shell). Bottom row, miscellaneous gastropods--left, Melampus parvulus; center, the ubiquitous Assiminia sp.; right, unidentified (probably new species).
- b. Shrimps. Four larger specimens are Palaemon debilis (opae-huna), the smaller of which are short-rostrum ecotypes from Opaaula Pond (H-23); two specimens of Halocaridina rubra (opae-ula) at lower right.
- c. Opae-oehaa, Macrobrachium grandimanus--female with eggs above and male below. In streams, this prawn is typically more robust, especially in the single large chela of the male.
- d. Small red shrimps. Metabetaeus lohena (top), and Halocaridina rubra (below)--two specimens of each.
- e. Aholehole. Two juvenile specimens of Kuhlia sandwicensis. Largest individuals found in ponds exceed 1 foot in total length. Silvery in life--preservation causes darkening.
- f. Oopu-akupa. Male specimen of Eleotris sandwicensis. Exceptionally large specimens of this predator may approach a foot in length.

