02-Year FINAL REPORT

UH/NPS Unit

Cooperative National Park Resources Studies Unit

Completed 10 November, 1975

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INTRODUCTION

This is the final report of work accomplished by the University of Hawaii Cooperative National Park Resources Studies Unit during the 02-year, July 1, 1974 through June 30, 1975.

5-year Program Plan Submitted

A 5-year UH/CPSU program plan has been submitted to the Western Regional Office for review. This plan sets forth the kinds of research activities the Unit feels should be pursued to provide park management personnel a basis upon which to make rational resource management decisions. It is the result of extensive discussions between Unit researchers and the Haleakala, Volcanoes and City of Refuge Park Superintendents as well as the State Director. At present there is little adequate knowledge of the natural resources being managed in the Hawaii Parks beyond the more spectacular.

The Unit plans to expand the depth and scope of research activities during the 03-year. Consensus has been reached between the Unit Director and the State Director on which research program areas listed should be pursued (refer to 03-year work plan for outlines of these projects). Detailed research program planning and budgeting is currently underway to prepare proposals in these areas which will be submitted to the Western Regional Office.

Haleakala National Park Resources Basic Inventory

A resources basic inventory program was initiated this summer in Haleakala National Park under the supervision of Dr. Clifford Smith, Associate Professor of Botany; Dr. Jack Beardsley, Professor of

Entomology; and Dr. Andrew Berger, Professor of Zoology. Such a basic inventory in this relatively biologically unknown area is essential to establish baselines for the contemporary fauna and flora. Drs. Smith, Beardsley and Berger and their associates have completed the collection work in the Park and are now identifying and analyzing the specimens collected. It is the intention of the Unit to continue this work until the organisms and their ecology can be understood and evaluated for park management purposes.

Puukohola Heiau National Historic Site Research Completed

A plant survey at Puukohola Heiau Historical Site and a basic inventory of the marine biota of the six acres of ocean area included within this Historic Site's boundaries have been completed in preliminary fashion. The Unit presently intends to assist in continuing these and other research projects which are essential for management decision-making. Dr. Leighton Taylor, Director of the Honolulu Aquarium, has completed the second phase of his research on the fish populations in Honaunau Bay.

Other work

Other work completed during the 02-year but not reported on in the midyear progress report includes a study of the possible predation on NENE by owls in Haleakala National Park conducted by H. Eddie Smith. The texts of the report is included as an appendix to the report. Status reports of the Halape Coastal Marine Inventory presently underway; a collection of fern and flowering plants from Volcanoes National Park; and the Kalapana Extension Survey are included also. Dr. Gerald Carr,

Dr. Hampton Carson, Dr. Gordon Macdonald and others largely from former IBP projects, have begun or continued studies toward obtaining knowledge of the Parks as well as RBI information.

Facilities

At this stage in the development of the Unit's research activities, it seems to be of little practical value for the Unit to expend funds to maintain base accommodation facilities for researchers. The proposed projects are too small, too few and too short to justify such expense. Also, park management has need of such facilities for researchers and technicians from other institutions and organizations, e.g., the Fish and Wildlife Service and the U.S.G.S. The Unit Director and the Park Superintendents are therefore exploring the feasibility of the Parks maintaining such facilities and allocating priority use of them to Unit researchers. Any funds saved by eliminating these direct costs to the Unit could be applied directly to the Park research projects.

The work reported on here has been accomplished by the various people credited. The contribution made by Unit Staff members should not go unrecognized, especially that of Ms. Carole Packard, administrative assistant, who has just departed with her husband for American Samoa. She will be sorely missed. The services of Messrs. H. Eddie Smith, site manager at Haleakala National Park, and Terry Parman, site manager at Hawaii Volcanoes National Park have contributed significantly to the development of the Unit's research work. Mr. Barry H. Hill, on temporary loan to the Unit, and who in the absence of the Unit Director contributed much to the planning and organization of these research efforts including the submission of the manuscript for this report deserves much credit for a job "well done".

Of course without the help and cooperation of Park Superintendents Harry, Huntzinger and Shimoda and State Director Barrel, none of this would have been possible.

REPORT

A. RESEARCH FACILITIES DEVELOPMENT AND MANAGEMENT

1. Haleakala National Park

Superintendent Hugo Huntzinger is currently in the process of reconstructing the Second World War Army Barracks near Hosmer's Grove Park Headquarters into a first-class base for research and as an accommodation facility for researchers and, possibly, other groups. Due for completion in late August or September, this facility will greatly facilitate the conduct of Unit research in the Park.

Yet this facility is many miles of arduous hiking or travel via horse or mule from the interior and slopes of Haleakala Crater, where future research must be accomplished.

During this summer's RBI program, a large Army surplus hospital tent was erected near Paliku cabin to serve as a bunking and storehouse facility for the field researchers. This tent proved unsatisfactory as high winds almost immediately destroyed it. Accommodations in the crater and dry space for specimen storage must therefore be found if the pending RBI program is to be continued. Additional horses may also be necessary for researcher transportation and supply.

The necessity for having a full-time on-site Unit manager is currently under investigation. Superintendent Huntzinger has suggested that Park staff may be able to provide the support functions necessary for the planned research.

2. Hawaii Volcanoes National Park

Site manager Terry Parman has been in residence in Hawaii Volcanoes National Park since last Spring. His facilities status report follows.

a. Living quarters and laboratory facilities.

Maintenance, upgrading of living quarters and laboratory facilities at the Park Research Center have continued.

Minor improvements completed include the partial panelling and painting of the interior hallways within the living quarters. Dormitory space has been increased and is presently capable of accommodating approximately twenty visiting research participants. Further improvements are still pending and this work will continue.

Approximately 40 to 50 manhours per week are spent completing the following tasks:

(i) 10-15 hours in mopping, cleaning and sweeping the living and laboratory facilities.

(ii) 10-15 hours in allocating dormitory space for sleeping, collecting linens, cleaning, straightening and arranging sleeping facilities.

(iii) approximately 10-20 hours in repair of motor vehicles and transporting people to and from the airport.

(iv) approximately 5-7 hours in collecting rental fees, writing receipts and general bookkeeping involved with daily rental of dormitory facilities.

(v) approximately 10 hours in monitoring and repairing the four climatic stations.

b. Monitoring of climates.

Three of the stations are located on the Mauna Loa Trail at elevations of 4200 feet in Kipuka Ki and at 5400 feet and the other at the end of the paved portion of the Mauna Loa Truck Trail at 6700 feet. The fourth station is within the Kilauea Forest Reserve at an elevation of 5400 feet. At the 5400-foot stations, the following instruments are located:

(i) One, Gottingen Recording Hygrothermograph

(ii) One, Bendix Event-Recording Rain Gauge

(iii) One, American Standard U.S.W.B. Rain Gauge

(iv) Eleven, "Tru-Check" Rain Gauges

The stations located inside the Park at 4200 feet and 6700 feet are both equipped with the following instruments:

(i) One, Gottingen Recording Hygrothermograph

(ii) One, American Standard U.S.W.B. Rain Gauge

c. Use of facilities.

The most frequent visitors at the Hawaii Volcanoes National Park Research Center have been the twenty or so research participants of the Hawaii International Biological Program. On any given week from one to twelve researchers have been in residence. During March, the Center was visited by Mr. Clive Bulmer of the Royal Botanic Gardens, Kew, Surrey, England. Mr. Bulmer was sent to Hawaii in an effort to collect plant specimens for the new greenhouse and arboretum which Kew has recently constructed for the conservation and preservation of Hawaiian plants. During May, Mr. Kirk Wampler, an undergraduate at the University of California at Berkeley,

was in residence at the center. He was here in connection with the Resources Management Internship Program of UCB's Department of Forestry. Mr. Tom Casadevall and Mr. Mike Ryan of Pennsylvania State University and the Hawaii Volcanoes Observatory have been conducting geological research within the Park this summer and have been in residence at the Center since mid-July.

3. City of Refuge National Historical Park

Due to the limited nature of the research program in this park during the 03-year and the concentration of Unit effort at Puukohola Heiau Historical Site with nearby Waimea/Kamuela which can serve as a support base, there is no need for accommodation facilities at this time.

B. RESOURCES BASIC INVENTORY

1. Haleakala National Park Resources Basic Inventory

At present Drs. Clifford Smith, Jack Beardsley and Andrew Berger and their associates are sorting and identifying their insect, bird and plant collections in preparation for data synthesis and analysis. Their full report will be some months in preparation. Submitted here is an excerpt from an initial analysis of the biological problems identified in the Park by Dr. Smith.

Scientific

The Haleakala Crater and surrounding outside slope above 2,000 meters have been poorly investigated from a biological point of view. The interest of the National Park Service in promoting research there is of immense importance. Their overt cooperation will be advantageous to biologists as we can contribute to their program while carrying out our own more esoteric research.

Haleakala National Park has some enormous problems. Pigs are a serious threat which must be controlled now before too much of the natural vegetation is converted to exotic grassland. Goats browsing on the vegetation and disturbing the soil by trampling are another major problem. The current method of shooting goats without always burying the carcass has resulted in an epidemic of flies. They in turn could initiate a health problem.

Weeds present a different danger. Many are associated with the trails, e.g., Oenothera sp. Others are not and their eradication or control may be impossible by now. Rubus penetrans has started to invade the Paliku meadows and unless kept under rigid control the camping grounds could become a nightmare.

Future research possibilities

Prospects for pure research programs are legion. For example, the only groups that appear to have been collected or studied with any vigor are the angiosperms, birds, insects and mosses. Thus many groups particularly in the animal and fungal kingdoms, have been ignored. No serious comprehensive work can proceed without a thorough knowledge of many of these groups. Yet, there is much to be carried

out on many of the endemic species before they become endangered by the nearly inevitable intrusion of exotics. For example, the life cycle of the flightless and day-flying moths would be of considerable interest from an evolutionary viewpoint, among others. The trophodynamics of the Haleakala ecosystem needs to be studied now.

Then there is Kipahulu Valley, an apparent plum to almost all terrestrial biologists. Currently off-limits to even bona fide biologists, this wilderness area will have to be inventoried to provide a management base and judge management's success in maintaining its pristine condition. The current policy is correct in that it allows for a detailed study of the crater without the distraction of the valley. Also, the less disturbed the valley, the less the occasion for abuse.

Future program

The continued operation of the inventory program is recommended. Its potential for significant research is enormous. The personnel are available also. However, the future will need careful planning coordination and a greater financial outlay to support the people in the field. The process of preparing a plan for a coordinated research program is underway.

The narrative report to the 1975 study will be issued as a technical report later this year.

2. Puukohola Heiau National Historic Site Plant Survey

Mr. James D. Macneil, Jr., and Ms. Lisa Croft, students at the University of Hawaii at Hilo, completed a checklist of plants at this site under the direction of Dr. Donald Hemmes, Associate Professor of

Botany. The Unit intends to support a second plant survey during the rainy season to collect the more ephemeral species present in the area and to make an analysis of the ecosystems present.

A complete herbarium collection of all plants identified and collected has been forwarded to Superintendent Jerry Shimoda. A modified text of the report which accompanied the collection follows.

Introduction

This initial survey provides a checklist of the dry season flora of the Puukohola Heiau Historic Site. Field collection and identification of the representative species took place during the month of May, 1975. Five days were allotted for field collection to guarantee complete coverage of the seventy-seven acre site. After drying, mounting and preliminary identifications by Macneil and Croft, all specimens were forwarded to Dr. Derral Herbst, the plant taxonomist at the Lyon Arboretum, University of Hawaii at Manoa, Oahu for final verification.

Geographical location and climate

The Puukohola Heiau Historical Site is located in the arid coastal zone of the island of Hawaii on the leeward side of the Kohala Mountains, approximately one mile south of Kawaihae. The total annual precipitation averages only 7.45 inches.

The site is bordered to the west by the Pacific Ocean and the Kawaihae Sand Quarry and to the south by Samuel Spencer County Park which gives way to undeveloped savannah. The north and east sides are likewise undeveloped grassland that run in a northwesterly direction to the northern boundary on the mauka side of Hawaii State Route No. 26.

The site was divided (See Fig. 1) into four sections. Sections I and IV are unique. A brackish pond transects them. This no doubt accounts for the greater variety of collected species in these two sections as compared to sections II and III, which are arid savannah (Table I).

The existing roadways are depicted on the map and may be seen to act as an appreciable watershed for the establishment of varying species.

The results and discussion of this portion will be combined with the wet season report and issued as a technical report.

3. Puukohola Heiau National Historic Site Marine Survey.

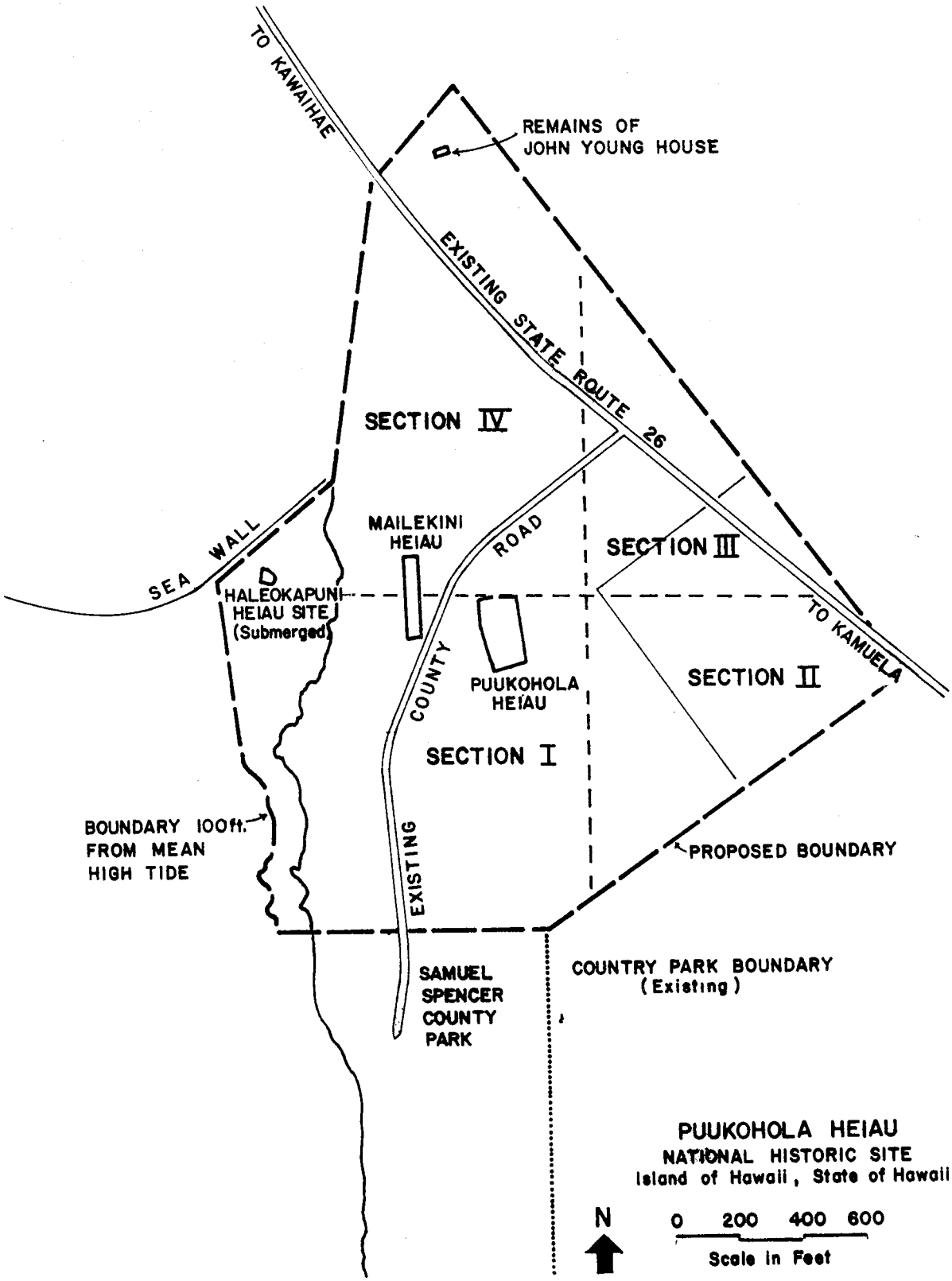
This pilot project has only recently been completed. The report will be submitted later.

4. Survey of the Reef Fish Communities of Honaunau Bay, Hawaii: Second Sampling Visit. City of Refuge National Historical Park.

Dr. Leighton Taylor, Assistant Leader of the Hawaii Cooperative Fishery Unit, conducted a second sampling series of fish transects at Honaunau Bay, June 10 - 14, 1975. The purpose of these studies is to provide City of Refuge National Historical Park management personnel with baseline data on fish populations within the Bay so that any changes in species abundance or diversity over time can be measured and recorded. These data will be of great importance by increasing our understanding of how the natural history of the bay relates to the story of the historic and ethnic uses of the site. The text of Dr. Taylor's report and sample interpretive reports are attached as Appendices A and B respectively.

Table I. Number of flowering plant species present in each section of Puukohola Heiau Historic Site.

Section number	Number of species present
I	23
II	14
III	18
IV	24


TO KAWAIHAE
REMAINS OF
JOHN YOUNG HOUSE
EXISTING STATE ROUTE 26
SECTION IV
SEA WALL
MAILEKINI
HEIAU
ROAD
SECTION III
HALEOKAPUNI
HEIAU SITE
(Submerged)
TO KAMUELA
COUNTY
PUUKOHOLA
HEIAU
SECTION II
SECTION I
BOUNDARY 100ft.
FROM MEAN
HIGH TIDE
EXISTING
PROPOSED BOUNDARY
SAMUEL
SPENCER
COUNTY
PARK
COUNTRY PARK BOUNDARY
(Existing)
PUUKOHOLA HEIAU
NATIONAL HISTORIC SITE
Island of Hawaii, State of Hawaii
N
0 200 400 600
Scale in Feet

5. The Halape Coastal Marine Inventory (Hawaii Volcanoes National Park)

A basic ecological inventory and survey of approximately two miles of coastline near the Halape Shelter is currently being conducted by Mr. Fred Ball, formerly with the University of Hawaii Botany Department and the Cooperative Unit. The study is intended to gather general ecological information of the various coastal marine ecosystems in the area. It is anticipated that collections of seaweed as well as vertebrate and invertebrate organisms will be made. Also, a comparative study of the salinity gradients within both brackish and seawater tidal pool areas will be done. A complete report of this work should be completed within the next three months. Some information on the marine worms has already been forwarded to Mr. Bryan Harry, Superintendent, H.V.N.P. This report will be included in the main report and not here to minimize fragmentation of the information.

6. Collection of ferns and flowering plants (Hawaii Volcanoes National Park)

The 1974 RBI study of Hawaii Volcanoes National Park conducted by Mr. T. Herat has been completed. The results will be issued as a technical report after herbarium information from the Bishop Museum has been incorporated with Mr. Herat's study. In addition, a provisional checklist of the ferns in Hawaii Volcanoes National Park is in draft form and will be submitted to the Hawaiian Botanical Society Newsletter for publication. The narrative report of the study follows.

Narrative Report. In the summer of 1974, the University of Hawaii Cooperative National Park Resources Studies Unit under the guidance of Dr. William L. Theobald, Department of Botany, University of Hawaii, Honolulu,

Hawaii carried out a Resources Basic Inventory of the flowering plants in Hawaii Volcanoes National Park. At the same time, the herbarium in the Park was updated and reorganized to facilitate future research. It was evident that such a project would give a better understanding of the distributional patterns of plant species, a record of the endemic plants and their abundance within the park and also a record of new and potential weedy introductions to the park. Even though the time period available for this project was very short (June 12 to August 3, 1974), over 500 plant specimens were collected from various localities within the park and some of its neighboring regions increasing the total park collection by over 33 percent. These collections included many native plants and new records of species occurring in the park. Since there were no collections of mosses in the Park herbarium these were collected also. About 75 specimens of mosses were collected and a set of these will be deposited at the Park herbarium when they have been identified. In the field many color photographs of plants were taken that could later be of value for teaching and demonstration purposes. Roughly two weeks (Aug. 3-15, 1974) were spent at the Bishop Museum Herbarium, Honolulu, determining correct names of the plants collected and also incorporating new names and new name changes according to St. John (1973). Original plant specimens collected have been deposited at the Park herbarium and duplicates of these specimens have been deposited in other leading herbaria such as the Bishop Museum, Berlin, and University of Hawaii.

At the present time the Hawaii Volcanoes National Park Herbarium contains approximately 1550 specimens most of which are from various parts of the park area. The others are from outside the park on the Big Island or from one of the other major islands. These specimens include about 192 ferns and fern allies, 5 gymnosperms, 303 monocots and 1050 dicots. The families are arranged alphabetically within the major groups. Except for a few recent collections made by C. H. Lamoureux mainly in the Kipuka Puaulu area in the 1960's most of the collections date from the 1930's and 1940's. The latter were made by such workers as G. E. Olson, H. Morley, G. O. Fagerlund and A. L. Mitchell. Most of these collections are cited by F. R. Fosberg (1966). A survey of these collections revealed the need for extensive new collections for possible recent introductions, new species and varieties, range extensions and an understanding of distributional patterns in general. Also, recent lava flows and animal disturbance have probably changed various aspects of the flora.

In order to facilitate the preparation of these systematic collections and avoid repetition of what already had been collected by earlier workers it was decided to plot known localities on 1:2400 topographic maps of the park. As suspected these revealed that many of the collections had been made in just a few isolated and convenient areas of study. These included Kipuka Puaulu, (Bird Park) Kipuka Ki, Kipuka Nene, Hilina Pali and the park residential area (Fig. 2). As such it was decided that a general plant collection should be made covering as many other areas of the park as possible before attempting to augment checklists of plant species with the few more recent collections that have been made since 1966.

Almost daily collecting field trips were conducted in various parts of the park where no records of plants are available at the herbarium and also a three-day field trip was made along the Puna Coast Trail in order to cover the coastal area of the park (Fig. 2). On one occasion the very valuable service of a helicopter was made available by the Park Superintendent Mr. B. Harry and Ranger D. Reeser for a trip to the Puu Keone area. Whenever time permitted, especially during weekends, collections were also made in areas adjacent to the park such as Kilauea forest, Olaa forest and in other parts of the island such as forests along the Saddle Road in order to gain a better understanding of the distribution of various species within and outside the park and also enable workers to make comparative studies.

When not in the field time was spent at the herbarium processing the plants collected and reorganizing the herbarium. As mentioned earlier the specimens at the Park herbarium are arranged within groups such as fern allies, ferns, gymnosperms, monocots and dicots in alphabetical order of their families. At the present time no attempt was made to rearrange them into any system of classification. For the ferns, however, it was thought best to follow Wagner's unpublished system of classification of the Hawaiian Pteridophytes rather than to leave them as they are with a great number of taxa under one major family, the Polypodiaceae. New family folders for these taxa and new family insertion name cards for all the other families were made in order to improve the retrieval of specimens. Work was also started on an inventory of fern and fern allies available in the herbarium. The data and information on the specimen sheets were transferred to 5" x 8" catalogue cards. Using this information and information from the

collections just made, a checklist of fern and fern allies found within the park was compiled. This information together with data from the Bishop Museum will be published in a technical report. From this list it has been established that there are 42 endemic, 28 indigenous and 6 exotic fern and fern allies species and varieties found within the park. The status of the various fern species was estimated and notes and recommendations made for the rarer species. In order to keep track of specimens collected an inventory of all plants collected within the park was also made.

At the beginning many problems had to be overcome due to the lack of equipment such as cardboards, presses, straps and a dryer that were needed for the proper care of the plants collected while at the Hawaii Volcanoes National Park. However these problems were taken care of when Dr. William L. Theobald sent on loan the necessary equipment. Due to the lack of adequate plant drying facilities and the high humidity at that elevation (i.e. Park Headquarters) the plants collected soon started to get moldy and deteriorate. It was decided to have a dryer made by the Park Service carpentry work shop, to the specifications needed. With such essential equipment in hand it was possible to carry out the work smoothly and efficiently.

In order to update the herbarium and to have a complete reference of the plants found within and outside the park more collecting expeditions are needed. With the control of the goat population the number and types of plants in the Park will increase and should be inventoried on a continuing basis. Also an inventory of the plant specimens available in the herbarium should be maintained. It is also felt that a reference library in the herbarium should be maintained in order to facilitate scientific research.

Literature Cited

Fosberg, F. R. 1966. Vascular Plants in Doty, M. S. and Mueller-Dombois, D. Atlas for Bioecology Studies in Hawaii Volcanoes National Park pp. 153-238. Hawaii Agricultural Experiment Station Miscellaneous Publication 89.

St. John, H. 1973. List and Summary of the Flowering Plants in the Hawaiian Islands, in Pacific Tropical Botanical Garden Memoir. Number 1. 519 pp.

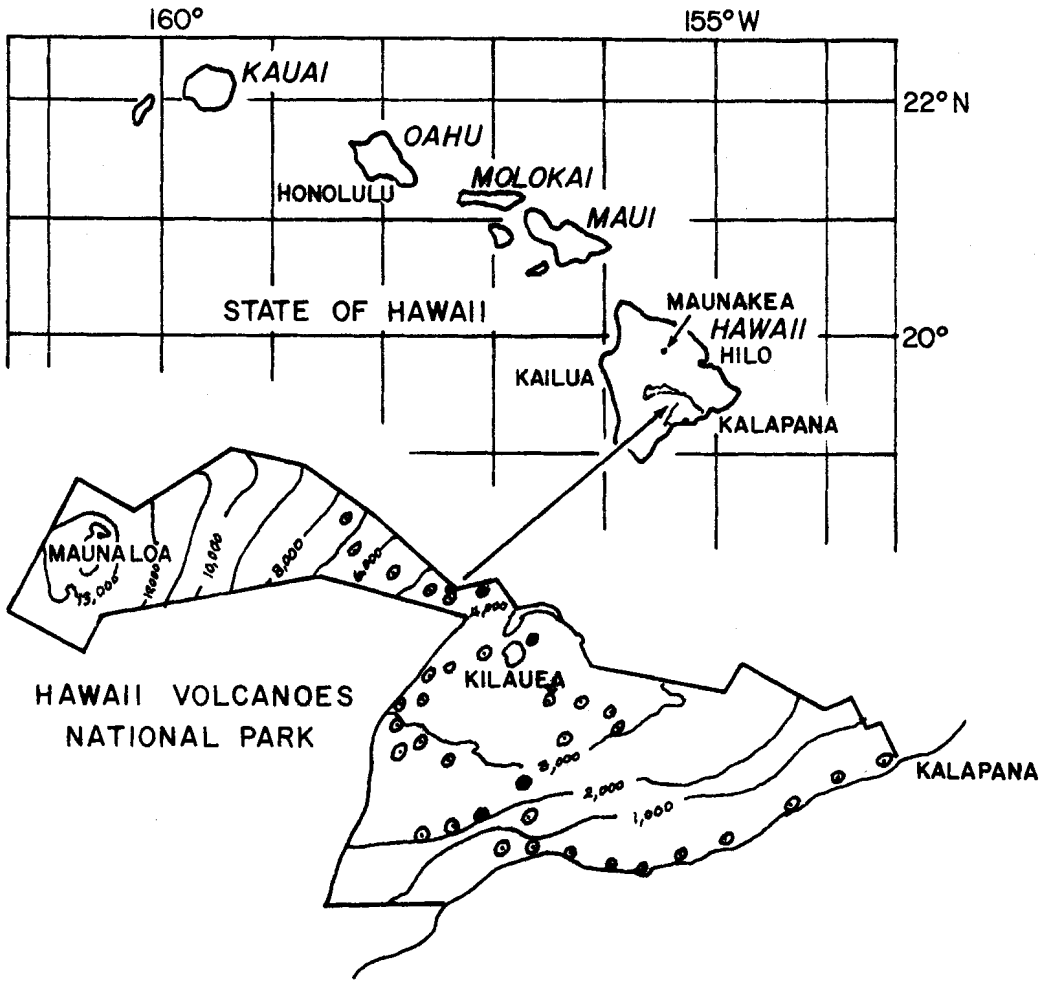


Figure 2. Approximate localities of many plant collections made by earlier workers and collections made during summer 1974.

Details: ● Some of the localities of plant collections made by earlier workers.

◉ Some of the localities of plant collections made during summer 1974.

C. ECOLOGY

The Kalapana Extension Survey (Hawaii Volcanoes National Park)

The final phase of this general ecological-vegetation study of the Kalapana Extension of the Park is now being prepared for final revision. The last segment to be examined, the Northeast corner, has not been surveyed and mapped as yet by Mr. Rick Warshauer. A comprehensive list of the plant species occurring within the Kalapana Extension will be provided with the final segment of the report, which is expected to be completed by the end of this calendar year.

D. MANAGEMENT-RELATED METHODS DEVELOPMENT

1. Possible predation on NENE by owls in Haleakala National Park

From March to May, 1975, Mr. H. Eddie Smith, UH/CPSU Site Manager at Haleakala National Park, conducted a study to determine if owls were a possible predator on NENE (Branta sandvicensis). His report is attached (Appendix C).

E. RESOURCE MANAGEMENT CERTIFICATE PROGRAM

The University of Hawaii Botany Department Curriculum Committee has issued a preliminary statement of approval of the Resource Management Certificate Program to the UH/CPSU Director (see copy of the Committee's letter in Appendix).

The Botany Department Curriculum Committee has reviewed the proposal and their reponse follows. The University Administration has added their initial approval and support for the creation of the program.

Recognizing that there are serious management problems in the Parks requiring immediate attention it is unrealistic to expect to begin the program in all its aspects this Fall. However it is apparent that the University higher administration would like to see some degree of action.

Therefore, the Unit Director recommends that a program coordinator be hired on a part-time basis beginning in January 1976 to continue the development of a program plan and syllabus and to teach one of the courses (e.g., "Resource Management in the Wildlands") on an experimental basis. Following this plan, the program could be gradually developed as funds become available.

University of Hawaii at Manoa

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May 16, 1975

MEMORANDUM TO: Dr. M. S. Doty, Botany Department

FROM: Curriculum Committee

SUBJECT: Wildlife Resource Management Proposal

This committee has reviewed your proposal for the Wildlife Resource Management Certificate and is very much in favor. We will support your submission of the proposal to the department for their approval and subsequent submission to the College.

There is a very real need for this type of program. The increasing pressure by hikers, etc. in National and State Parks, and other natural areas will require a compromise between those who want these areas maintained in their pristine condition and those who want access. Someone is going to have to make decisions and a person trained in the biological sciences and management would be the most logical candidate. We are particularly pleased that this program would be offered here in the subtropics because the graduates would be adaptable having been trained in tropical and temperate ecosystems. We foresee an increasing demand for this type of program.

We have a few suggestions that you should consider before submitting the final proposal.

1. We would like to see some formal coursework in management and planning. There are various means of doing this. For example, you could make use of PUSSPP or the College of Tropical Agriculture programs. On the other hand you may wish to initiate your own course.

2. The course proposals are only in outline form at present. They must be presented in greater detail.

3. We would like to see some projections of the numbers of participants expected.

4. We would prefer to see this as a complete program rather than have it attached to an already existing degree program. However, this is a problem that involves University politics, and is beyond our bellywick.

5. We would like to see the responsibilities of the Program Coordinator spelled out in detail. We assume that this person will be affiliated with the Botany Department faculty. If this is so the department must be appraised of its responsibilities and commitment as soon as possible. Under the current fiscal restraints in the University there are no funds available to initiate this proposal. However, the department is willing to contribute academic and administrative support. We welcome the possibility that the National Park Service may be able to provide such financial support.

APPENDIX A

CITY OF REFUGE NATIONAL HISTORICAL PARK

Survey of the Reef Fish Communities of Honaunau Bay, Hawaii

Second Sampling Visit

Dr. Leighton Taylor
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ABSTRACT

Fish censuses were made in three well-defined habitat types in Honaunau Bay and adjoining Alahaka Bay, Hawaii, from June 10-14, 1975, during 20 hours of SCUBA assisted observations. A standardized transecting method was employed utilizing 50 m segmented lines along which a diver swam recording on underwater paper all species seen and the number of individuals of each species. Five replicates were accomplished in the coral-rich and drop-off habitats; four in the boulder habitat.

Preliminary, qualitative comparisons with three previous studies suggest changes in relative abundance of certain species over time. These include Ctenochaetus strigosus, Acanthurus nigrofuscus, Zebrasoma flavescens, Chromis agilis, C. hanui, C. vanderbilti, and Paracirrhites arcatus. Although it is possible that these apparent differences are due to sampling error, this is judged unlikely in the case of some species and further study is recommended.

A brief example of interpretive material about aboriginal Hawaiian fishing practices at Honaunau is included in the appendix, p. 48.

INTRODUCTION

The fish fauna of Honaunau Bay is rich and diverse. A number of varied habitat types are represented within a relatively small area. The accessibility and protected waters of Honaunau Bay and neighboring Alahaka Bay to the south provide an excellent opportunity for the study of changes in the structure of reef fish communities. In

addition, the area is subject to increasing stress from a variety of potential sources including influences of the adjacent City of Refuge National Historical Park and increasing fishing pressure by divers and from the nearby boat launching ramp.

Monitoring of the fish populations to detect natural or man-induced changes has been proposed to the Park Unit (Taylor, 1974a). This report is a result of the second sampling visit supported by Park Unit funds. The initial visit in November, 1974 (Taylor, 1974b), was mainly devoted to selection of sites and to collaboration with Dr. E. S. Hobson, whose recent study of Kona Coast fish communities (Hobson, 1974) contains much data taken in Honaunau Bay in 1969-1970.

Comparative data are also available from other sources. The Hawaii State Division of Fish and Game has been conducting transects in Honaunau since 1965 (Doty, 1969). However, differences in methodology preclude the use of these data in quantitative comparisons with the counts reported herein.

More useful for this purpose are the results of the Marine Parks Study Team (MPST) which conducted an assessment of the potential of Honaunau Bay as a marine conservation district in August 1974. A summary of these data will appear in a University of Hawaii Sea Grant Technical Report now in preparation (Kimmerer, 1975). Detailed data resulting from fish transects will not appear in that report but have been made available to me through Mr. Kimmerer. Fig. 2 illustrates the location of transects conducted by the MPST and Table 4 is a sample data print-out from HCZDB.

The major purpose of this report is to present reliable census information for three distinctive habitat types. These data can be compared with future counts made in the same way and in the same area so that any changes in fish community structure can be detected. Preliminary comparisons are also made with data collected in June, 1975, and data resulting from studies made in August 1974, November 1974, and pooled data for various months in 1969.

MATERIALS AND METHODS

Transect Technique

Fishes were censused using a refinement of the transect method suggested by Brock (1954). The problems of obtaining reliable quantitative data using this technique are discussed by Taylor and Nolan (1975); the modifications which they suggest for improved data collection were utilized in this study.

A 50 m 3/16" polypropylene line, marked with waterproof tape at 5 m intervals, was installed in the pre-selected habitat zone (Hobson, 1974; Taylor, 1974b) by tying both ends to coral protuberances and tucking intermittent points of the line beneath rocks and coral branches so that it lay flat. These lines remained in place for the duration of the study and two stations were left in place for use in future censuses.

At the beginning of each sampling run, the observer (using SCUBA) attached cork floats to each 5 m point along the line using stainless steel halibut snaps and a 1 m length of line. This resulted in the 50 m line being divided into ten segments each 5 m long (Fig. 3). The diver then waited at the beginning of the line for five minutes, then

began to census fish (Fig. 4). The activity of the diver installing the floats had no lasting observable effect on fishes in the vicinity of the line.

Fishes within 5 m of the line were recorded with No. 2 pencils on pre-printed data sheets of underwater Ascot Paper (Voit, Inc.). In addition to providing reference points for the estimation of the 5 m distance to the side, the cork floats divide the line into twenty 5 m^2 quadrats (Fig. 3). Numbers of individuals of all species are recorded by quadrat. Full details of this method are given in Taylor and Nolan (1975).

Sampling Sites

Fifty-meter transect lines were established in three habitat zones:

1. Boulder zone, located in 2-4 m depth along the inner shoreline of Alahaka Bay (Fig. 1); characterized by large basalt boulders dotted with various algae and corals (mainly Pocillopora meandrina);
2. Drop-off zone, located off Puuhonua Pt. about 100 m offshore where the bottom drops abruptly from 15 m to greater depths, generally overgrown with Porites compressa and P. lobata interspersed with sand patches and basaltic pavement and boulders;
3. Coral-rich zone, located about 50-100 m off the south shore of Honaunau Bay in 5-10 m depth; characterized by dominant bottom coverage (80-100%) of various sized heads of Porites lobata with some fingerlike P. compressa interspersed.

These habitat zones are further described in Hobson (1974); see also Figs. 1 and 2.

These areas were selected for their distinctiveness and because their fish faunas have been well-delineated thus facilitating the intended monitoring of changes in fish abundances and community structure. Transects conducted in June 1975 were located approximately where the November 1974 samples (Taylor, 1974) and Hobson's 1969-1970 samples were taken (Hobson, 1974). Two transect lines installed in the coral-rich area in November 1974 were still in place in June; a steel rod marking the north end of the boulder zone transect was relocated in June; remnants of the drop-off transect and recognizable topography allowed the placement of the June transect in the same area sampled in November 1974.

Because the November lines were located with a high degree of confidence in June and because the November lines were installed with the collaboration of E. S. Hobson, I feel relatively certain that the areas sampled in June are the same as those sampled in November 1974 and by Hobson in 1969-70.

RESULTS

Tables 1-3 record numbers of individuals of selected species for the three habitat types. Five replicates each were taken at the coral rich and drop-off sites; four were made at the boulder site. Samples were taken by two observers (denoted in the tables by LT for Leighton Taylor and FS for Frank Sutherland). Species listed are those which occurred at least twice in a list of the ten most abundant species for

each sample. The balance of the species are not recorded in Tables 1-3 but are available from the Hawaii Coastal Zone Data Bank (Department of Oceanography, University of Hawaii). A complete species list is not included here but may be found in Hobson (1974). One new species record may be added here; an unidentified pomacentrid, provisionally identified as Chromis acares Randall and Swerdloff was photographed and the resulting color slide sent to Dr. Randall for confirmation. If this is Chromis acares, it is the first record from Hawaii; if it is not, it is probably an unnamed species.

The abundance index (AI) for each species is the number of individuals of that species in the sample expressed as a percentage of the total of all individuals of all species observed in the sample (Hobson, 1974). Although there are a number of disadvantages to this index (Taylor and Nolan, 1975), it does allow comparison between samples of varying sizes and from varying transect lengths. Also entered in the Table are mean AI from previous studies; Kimmerer (1975) presents no transect data for the drop-off or boulder habitat types, but the mean AI entered for the coral-rich transect is calculated from the counts from the nine transects shown in Fig. 2.

DISCUSSION

The comparison of reef-fish community structure in two or more areas or within the same area at two or more times is of major interest. However, reliable quantitative techniques are still being formulated. Ideally, the data to be compared are derived from replicate samples from the same transect location taken with the same methods by experienced observers. Variables such as time of day, tide, and visibility should

also be considered.

The parameters to be compared are also major considerations; included are the mean number of individuals of a species per transect, the abundance rank of a species along the transect, and the abundance index for a species.

Only a preliminary comparison is now possible for Honaunau data because of differences in the data sets available. For example, Hobson's 1969 data (Hobson 1974) were taken over a one-year period along 100 m unsegmented lines; Taylor's 1974 data, while collected with the same technique described herein, were based on only two replicates; Kimmerer's data were collected on 100 m X 5 m unsegmented transects at a number of sites within the same habitat type but witout replicates.

Although these differences are slight enough to allow preliminary qualitative comparisons which may suggest trends, they are great enough to preclude rigorous quantitative comparisons. Future censuses made with the same techniques with which June data were collected will allow such treatment.

Coral-Rich Habitat

Abundance Indices from four studies (Table 1) suggest some differences. For example, Ctenochaetus strigosus appears to be relatively more abundant in June and August than in November. The relative abundance of Pomacentrus jenkinsi was higher in Hobson's study than in any of the three others, perhaps due to one or two periods of seasonal abundance in Hobson's pooled sample. I have requested the data for each transect from Dr. Hobson in order to assess this apparent

difference. A similar situation is found in Chaetodon multicinctus.

The differences in relative abundance in Chromis vanderbilti might be due to vagaries in sampling: this small species aggregates above coral cover while feeding and is highly visible; at other times (for various reasons), individuals seek cover within coral interstices and are not seen.

Outer Drop-Off Habitat

Apparently, greater differences exist in the relative abundance of three species in this habitat in the 1969, 1974, and 1975 censuses. Two of these fishes, Ctenochaetus strigosus and Acanthurus nigrofuscus, are wandering herbivores which may account for differences in counts. Although the large differences in Chromis agilis and C. vanderbilti may be due to their aggregating habits and consequent counting error, it is equally possible that there are ecological explanations. It has been observed that these two species tend to be mutually exclusive (see also Table 1). It appears that the balance has shifted from November 1974 when C. agilis was more abundant to June 1975 when C. vanderbilti occurred in greater numbers. C. hanui is usually associated with C. agilis, or at least occurs with that species concurrently although in lesser numbers. Counts for C. hanui are also lower in June compared to November. Further observations are needed to confirm this apparent inverse relationship and to ascertain the cause.

Boulder Habitat

The same three species of herbivorous acanthurids which show differences in the drop-off habitat also appear to be more abundant in the June 1975 counts than in the November 1974 counts and in Hobson's 1969 pooled counts although the changes are not as marked as in the drop-off habitat.

A more striking difference is shown by Paracirrhites arcatus, the eyebrow hawkfish. This fish had abundance indices less than 1.0 in past counts but shows a value of 6.78 in June counts when it was the fourth most commonly encountered fish. This difference is difficult to ascribe to sampling error because the fish is sedentary and non-secretive. It is very tolerant of diver activity and is easily seen. Further investigation is also recommended for this species.

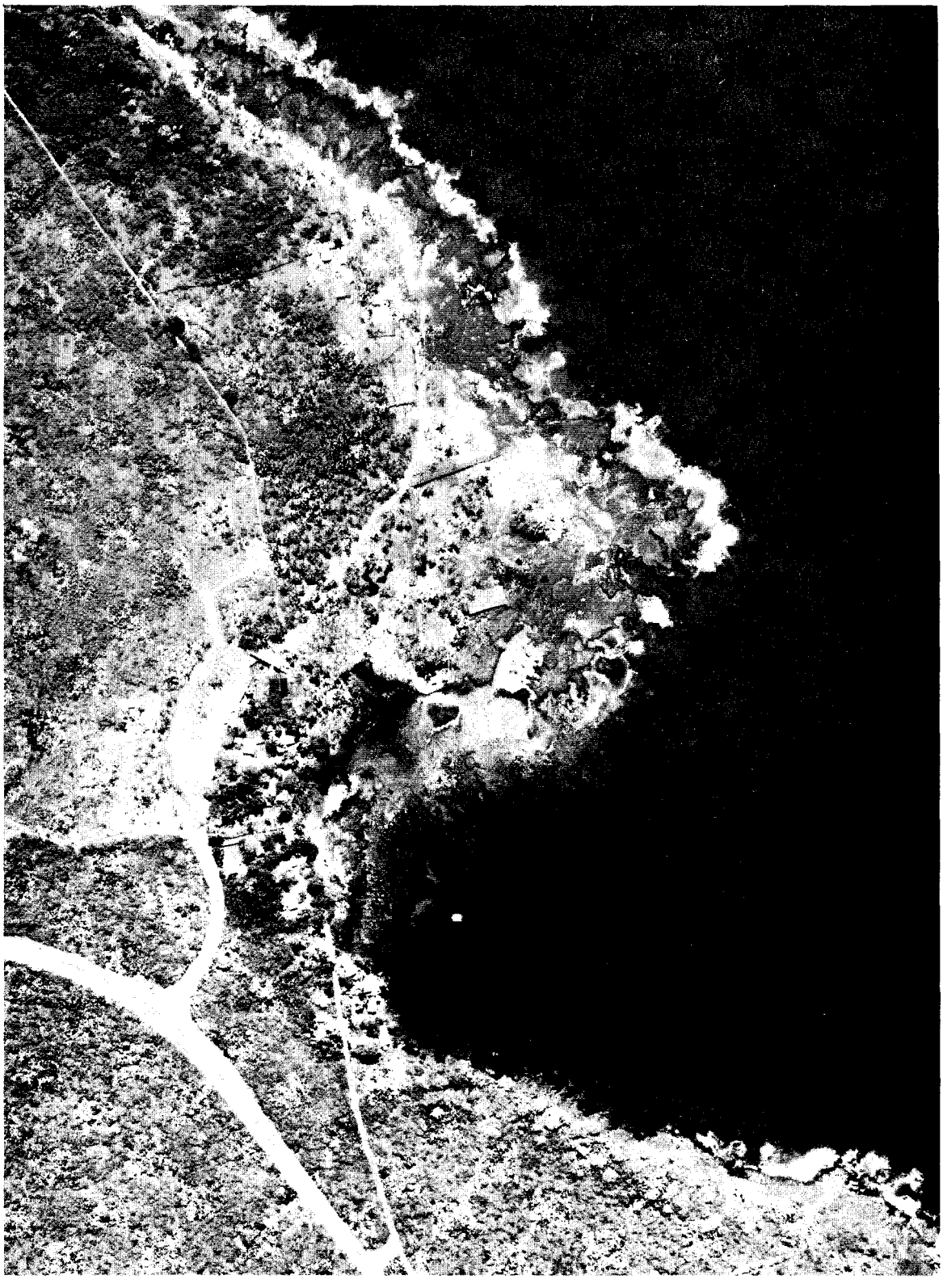

Fig. 1. Aerial view of Honaunau Bay (courtesy R. M. Towill Corp., Honolulu; 1" = 500' approximately). Compare Fig. 2 for location of transects.

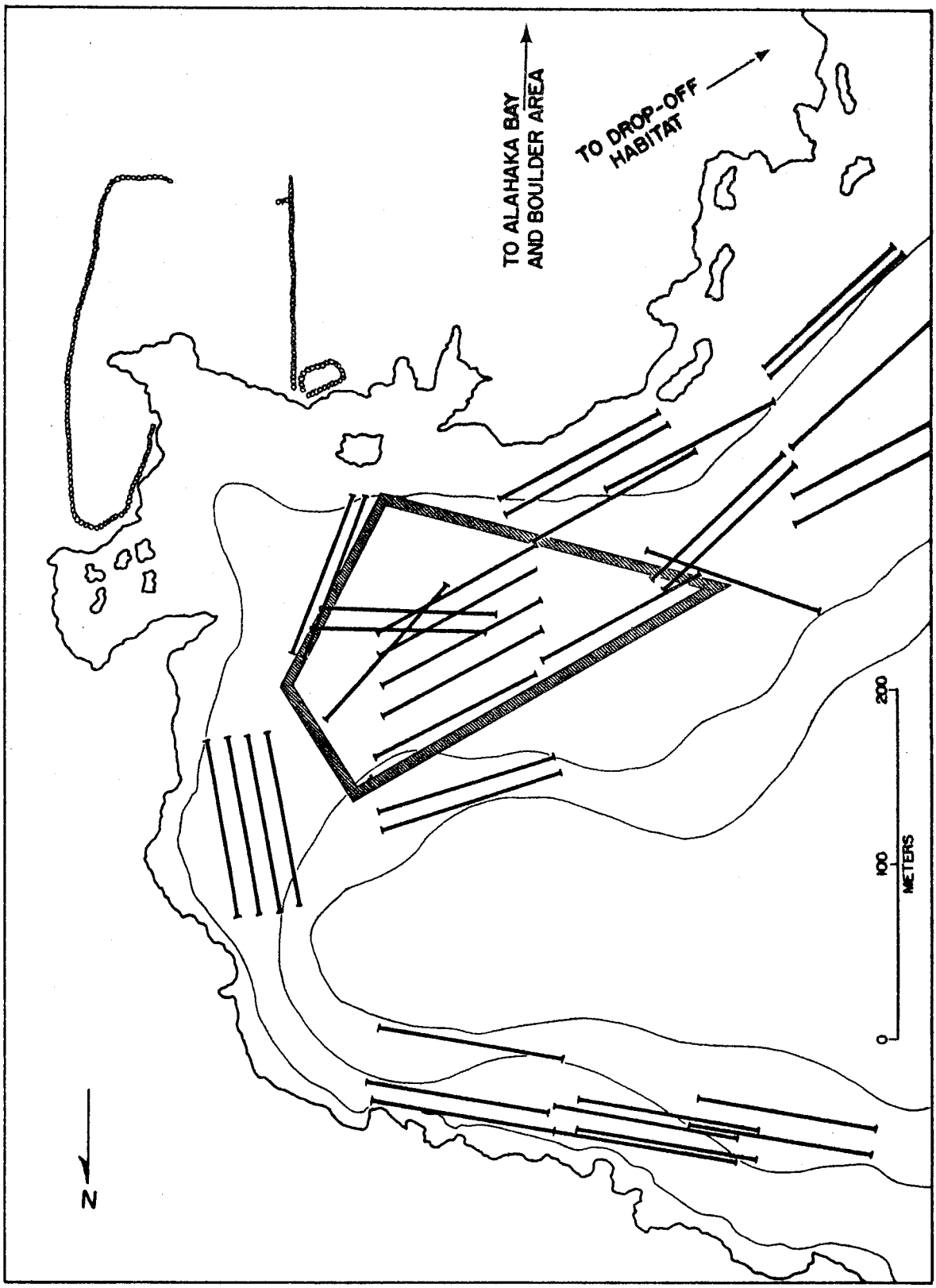

Fig. 2. Map of Honaunau Bay showing transect locations studied by the Marine Park Survey Team (Kimmerer, 1975). Comparative data used in this report were taken from transects enclosed in the box; these fall within the coral-rich zone.

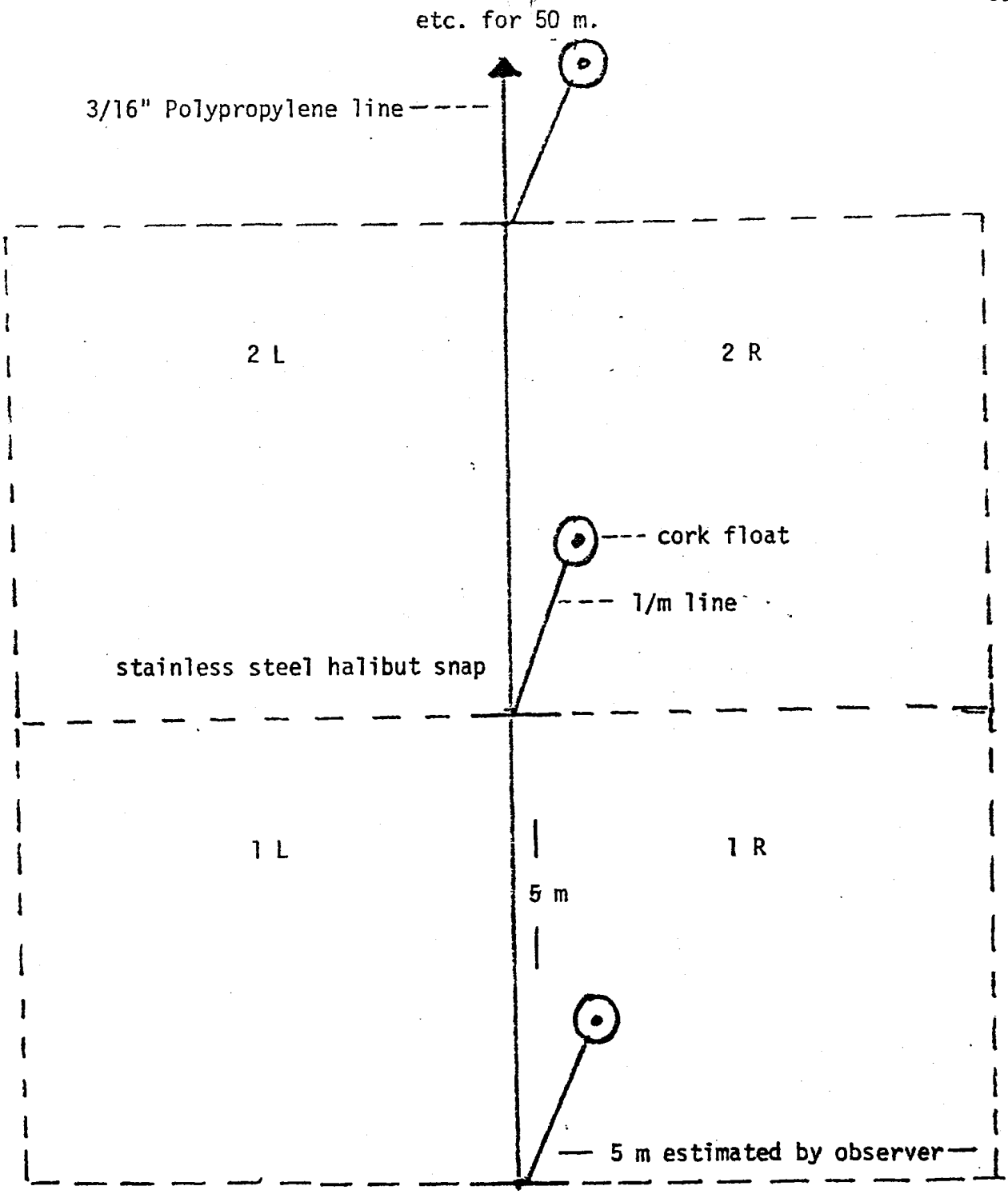

Fig. 3. Schematic plan view of segmented transect line used in fish survey.

Fig. 4. A University of Hawaii graduate student records the species and numbers of fishes seen along a 50 m transect in the "coral-rich zone". This area of Honaunau Bay exemplifies some of the richest coral and fish communities found in Hawaii.

Replicate No.	LT-1		LT-2		LT-3		FS-1		FS-2							
	No. of Indivs.	A.I.[1]	No.	AI	No.	AI	No.	AI	No.	AI	$\bar{X}$, No. Indivs.	Rank of X	$\bar{X}$, AI	$\bar{X}$, AI Hobson (74)* (n = 5)	$\bar{X}$, AI Taylor (74) (n = 1)	$\bar{X}$, AI Kimmerer (75) (n = 9)
Ctenochaetus strigosus	61	17.48	71	18.35	71	16.06	78	23.49	80	20.36	72.2	1	19.15	15.45	9.9	25.24
Chromis agilis	51	14.61	67	17.31	88	19.90	59	17.77	82	20.87	69.4	2	18.09	[3]	16.7	14.84
Zebrasoma flavescens	57	16.33	55	14.21	84	19.00	49	14.76	65	16.54	62.0	3	16.17	10.58	12.8	17.30
Chaetodon multicinctus	25	7.16	47	12.14	33	7.47	38	11.45	43	10.94	37.2	4	9.83	4.41	9.3	7.68
Thalassoma duperreyi	35	10.03	21	5.43	42	9.50	10	3.01	13	3.31	24.2	5	6.26	5.71	2.6	3.15
Chromis hanui	16	4.58	24	6.20	13	2.94	16	4.82	16	4.07	17.0	6	4.52	[3]	2.6	2.54
Centropyge potteri	9	2.58	19	4.91	14	3.17	12	3.61	15	3.82	13.8	7	3.62	2.49	2.2	2.37
Plectro. john.[2]	17	4.87	11	2.84	13	2.94	8	2.41	9	2.29	11.6	8	3.07	3.07	2.9	2.83
Chaetodon ornatissimus	8	2.29	10	2.58	10	2.26	9	2.71	13	3.31	10.0	9	2.63	1.80	4.5	1.45
Chromis vanderbilti	10	2.87	10	2.58	8	1.81	9	2.71	nc	--	9.3	10	2.49	0.15	0.6	3.61
Pomacentrus jenkensi	6	1.72	5	1.29	6	1.36	5	1.51	8	2.04	6.0	11	1.58	6.71	1.0	2.51
Time of day (at start)	1030		1345		0920		0930		0930		--	--	--	--	AM	various
Total species	31		31		38		36		34		34	--	--	<82	54	40
Total Individuals	349		387		442		332		393		380.6	--	--	522	312	646
Date	6/10		6/11		6/12		6/12		6/13		--	--	--	1969	11/20/74	8/74

[1]A.I. = Abundance Index, see text.

[2]Plectroglyphidodon johnstonianus.

[3]Taxonomic revision since Hobson's study precludes the records of this species. Hobson records both species under the name Chromis leucurus; see Randall and Swerdloff, 1974.

[4]These data are pooled from two Honaunau sites and two Kealakekua sites taken during 1969

Table 1. Coral Rich Transect - Honaunau, Hawaii. June 10-13, 1975.

Replicate No.	LT-1		LT-2		LT-3		FS-1		FS-2						
	No. of Indivs.	A.I.[1]	No.	AI	No.	AI	No.	AI	No.	AI	X, No. Indivs.	Rank of X	X, AI	X, AI Hobson (74)[3] (n = 4)	X, AI Taylor (74) (n = 2)
Ctenochaetus strigosus	124	29.95	108	20.57	120	24.96	137	25.84	118	23.37	121.4	1	24.88	3.87	8.1
Chromis vanderbilti	25	6.04	86	16.38	85	17.49	134	25.28	122	24.16	90.4	2	17.87	0.84	1.7
Acanthurus nigrofuscus	48	11.59	71	13.52	47	9.67	55	10.38	55	10.39	55.2	3	11.21	1.62	0.5
Zebrasoma flavescens	27	6.52	46	8.76	51	10.49	60	11.32	48	9.50	46.4	4	9.32	4.76	12.1
Chromis agilis	27	6.52	49	9.33	33	6.79	18	3.40	42	8.32	33.8	5	6.87	--	2.39
Thalassoma duperreyi	20	4.83	19	3.62	24	4.94	10	1.89	15	2.97	17.6	6	3.65	5.71	3.4
Chaetodon multicinctus	18	4.35	15	2.86	18	3.70	14	2.64	15	2.97	16.0	7	3.30	3.76	3.2
Chromis hanui	7	1.69	13	2.48	8	1.65	11	2.08	15	2.97	10.8	8.5	2.17	--	6.8
Centropyge potteri	11	2.66	15	2.86	9	1.85	11	2.08	8	1.58	10.8	8.5	2.21	3.45	2.5
Halichores ornatissimus	19	4.59	11	2.10	19	3.91	9	1.70	5	0.99	12.6	10	2.66	1.15	0.3
Plectro. john.[2]	5	1.21	2	0.38	2	0.41	1	0.19			2.5	11	0.44	1.25	0.8
Time of day (at start)	1320		1045		1115		1100		0930		--	--	--	--	
Total species	39		36		38		28		30		34	--	--	<78	50
Total individuals	414		525		486		530		505		492	--	--	478	729
Date	6/10		6/11		6/12		6/12		6/13		--	--	--	1969	19/11/74

[1]A.I. = Abundance Index, see text

[2]Plectroglyphidodon johnstonianus

[3]Pooled from two Honaunau and two Palemano Pt. sites.

Table 2. Outer Drop-off Transect-Honaunau, Hawaii. June 10-13, 1975.

Replicate No.	LT-1		LT-2		FS-1		FS-2						
	No. of Indivs.	A.I.[1]	No.	AI	No.	AI	No.	AI	X, No. Indivs.	Rank of X	X, AI	X, AI Hobson (74)[3] (n = 4)	X, AI Taylor (74) (n =)
Ctenochaetus strigosus	209	36.03	219	32.25	167	28.55	162	27.46	189.3	1	31.07	10.77	23.9
Acanthurus nigrofuscus	133	22.93	140	20.62	136	23.25	155	26.27	141.0	2	23.27	13.74	19.6
Zebrasoma flavescens	69	11.90	53	7.81	57	9.74	67	11.36	61.5	3	10.20	9.61	11.4
Paracirrhites arcatus	20	3.45	37	5.45	58	9.91	49	8.31	41.0	4	6.78	0.74	2.2
Thalassoma duperreyi	30	5.17	53	7.81	28	4.79	37	6.27	37.0	5	6.01	6.44	4.1
Pomacentrus jenkensi	20	3.45	30	4.42	18	3.08	21	3.56	22.3	6	3.63	5.25	6.0
Chaetodon multicinctus	15	2.59	22	3.24	16	2.74	9	1.53	15.5	7	2.53	1.08	2.7
Acanthurus leucopareius	1	0.17	33	4.86	8	1.37	10	1.69	13.0	8	2.02	4.73	4.1
A. achilles	5	0.86	14	2.06	9	1.54	9	1.53	9.3	9	1.50	8.00	7.8
Plectro. john.[2]	6	1.03	9	1.33	10	1.71	7	1.19	8.0	10	1.32	0.07	0.2
Forcipiger flavissimus	8	1.38	6	0.88	8	1.37	2	0.34	6.0	11	0.99	1.01	0.8
Time of day (at start)	1545		1410		1415		1100		--	--	--	--	--
Total species	35		34		33		36		35	--	--	<77	38
Total individuals	580		679		585		590		608.5	--	--	672	552
Date	6/10		6/12		6/12		6/14		--	--	--	1969	11/19/74

[1]A.I. = Abundance Index, see text

[2]Plectroglyphidodon johnstonianus

[3]Pooled from two Honaunau and two Palemano Pt. sites.

Table 3. Alahaka Bay Transect, Hawaii. June 10-14, 1975.

HONAUNAU BAY.SOUTH KONA.HAWAII.FISH TRANSECTS.1974.MARINE PARKS.DURW74B

TRANSECT NO. 6 HONAF 0607087410 HONAUNAU BAY.FISH TRANSECTS. AM DURW74B 14211 500

•	ID	SPECIES NAME	NUM	LENGTH	NUM/AREA	WEIGHT	WT/AREA
1	8555690202	CTENOCHAETUS HAWAIIENSIS RANDALL	1	20	2	.218	.436
2	8555690103	ACANTHURUS ACHILLES SHAW	23	13	46	1.120	2.240
3	8555690105	ACANTHURUS LEUCOPAREIUS (JENKINS)	1	15	2	.072	.144
4	8555690106	ACANTHURUS NIGROFUSCUS (FORSSKAL)	64	8	128	.743	1.487
5	8555690107	ACANTHURUS NIGRORIS CUVIER & VALENCIENNES	23	8	46	.191	.382
6	8555690201	CTENOCHAETUS STRIGOSUS (BENNETT)	189	8	378	2.173	4.347
7	8555690301	ZEBRASOMA FLAVESCENS (BENNETT)	154	8	308	2.411	4.823
8	8555690401	NASO LITURATUS (BLOCH & SCHNEIDER)	12	20	24	2.561	5.123
9	8555690404	NASO UNICORNIS (FORSSKAL)	2	25	4	.770	1.540
10	8549060101	AULOSTOMUS CHINENSIS (L.)	1	23	2	.019	.039
11	8558020401	MELICHTHYS NIGER (BLOCH)	10	20	20	2.018	4.037
12	8558020501	SUFFLAMEN BURSA (BLOCH & SCHEIDER)	3	15	6	.261	.522
13	8555340203	CIRRIPECTUS VARIOLOSUS (CUVIER & VALENCIENNES)	1	8	2	.006	.012
14	8555340101	EXALLIAS BREVIS (KNER)	1	13	2	.029	.058
15	8558005103	CANTHIGASTER AMBOINENSIS (BLEEKER)	1	10	2	.028	.056
16	8554570401	FORCIPIGER FLAVISSIMUS JORDAN & MCGREGOR	1	10	2		
17	8554570402	FORCIPIGER LONGIROSTRIS (BROUSSONET)	1	10	2	.013	.027
18	8554570708	CHAETODON LUNULA (LACEPEDE) JORDAN & EVERMANN	1	15	2	.121	.242
19	8554570711	CHAETODON ORNATISSIMUS SOLANDER	3	13	6	.198	.397
20	8554570712	CHAETODON QUADRIMACULATUS GRAY	3	10	6	.082	.165
21	8554570713	CHAETODON MULTICINCTUS GARRETT	48	8	96	.610	1.221
22	8554660101	PARACIRRHITES ARCATUS (C. & V.)	7	8	14	.062	.125
23	8554560102	PARACIRRHITES FORSTERI (BLOCH & SCHNEIDER)	1	15	2	.068	.137
24	8554660401	CIRRHITOPS FASCIATUS BENNETT	1	8	2	.009	.018
25	8546180403	MYRIPRISTIS MURDJAN (FORSSKAL)	4	15	8	.321	.642
26	8555070401	LABROIDES PHTHIROPHAGUS RANDALL	2	5	4	.002	.005
27	8555070802	PSEUDOCHEILINUS OCTOTAENIA JENKINS	1	8	2	.006	.013
28	8555070803	PSEUDOCHEILINUS TETRATAENIA SCHULTZ	1	5	2		
29	8555070801	PSEUDOCHEILINUS EVANIDUS J. & V. "SCARLET WRAS	4	5	8	.007	.014
30	8555071405	THALASSOMA DUPERREYI (QUOY & GAIMARD)	29	10	58	.496	.992
31	8555071501	GOMPHOSUS VARIUS LACEPEDE	1	8	2	.003	.007
32	8555071604	CORIS GAIMARDI (QUOY & GAIMARD)	1	13	2	.024	.049
33	8555071801	STETHOJULIS BALTEATA (QUOY & GAIMARD)	8	8	16	.052	.105
34	8555072201	HALICHOERES ORNATISSIMUS (GARRETT)	16	8	32	.099	.199
35	8558025302	CATHEPHINES SANDWICHIENSIS (Q. & G.)	1	8	2	.008	.016
36	8554470306	PARUPENEUS BIFASCIATUS (LACEPEDE)	1	15	2	.048	.097
37	8554575303	CENTROPYGE POTTERI JORDAN & METZ "RUSSET ANGELFI	37	8	74	.502	1.005
38	8554640301	PLECTROGLYPHIDODON JOHNSTONIANUS FOWLER & BALL	17	8	34	.137	.274
39	8554640401	POMACENTRUS JENKINSI JORDAN & EVERMANN	36	8	72	.444	.889
40	8554640501	CHROMIS VANDERBILTI (FOWLER)	105	3	210	.030	.061
41	8554640511	CHROMIS AGILIS	84	5	168		
42	8554640504	CHROMIS VERATER JORDAN & METZ	49	13	98	2.692	5.384
43	8554640509	CHROMIS HANUI RANDALL & SWERDLOFF	17	5	34	.072	.145
44	8555090304	SCARUS SORDIDUS FORSSKAL	2	13	4	.133	.267
45	8554450101	MONOTAXIS GRANDOCULIS (FORSSKAL)	1	25	2	.253	.507
46	8555695101	ZANCLUS CANESCENS (L.)	3	13	6	.173	.346
47	8555070800	PSEUDOCHEILINUS SP.A	2	8	4		

NUMBER OF SPECIES = 47 NUMBER OF FISH = 1948

TOTAL WEIGHT = 38.619
CALCULATED ON 43 SPECIES

Table 4. Sample print-out from the Hawaii Coastal Zone Data Bank of transect data from the Marine Park Survey Team (Kimmerer 1975).

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APPENDIX B

CITY OF REFUGE NATIONAL HISTORICAL PARK

Sample Interpretive Material Relating to the Marine Fauna of Honaunau Bay, Hawaii

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The marine life communities seen in Honaunau Bay today have been altered but little and so are undoubtedly very similar to those utilized by the pre-contact Hawaiian inhabitants of the Honaunau area. The use of marine resources by the Hawaiians and their legends about the marine animals in the Bay are documented in some detail in Emory et al. (1957) and Titcomb (1952).

Visitors to the City of Refuge National Historical Park would presumably welcome information about the Bay's marine life and the Hawaiians' use of it. Many visitors will observe the coral communities of the Bay during snorkeling trips either in the Bay or in adjacent areas. Knowledge of the Hawaiian's regard for the same species he is observing will add meaningful dimensions to the visitor's experience and increase his knowledge and responsibility for the marine resources of Hawaiian waters.

Non-snorkeling visitors to the Park would also benefit from interpretive information about Hawaiian marine life expressed in graphic exhibits, lectures, and printed material. The following paragraphs are provided as ample subjects for interpretive use by the Park Service for augmenting visitor experience.

1) The long-nosed butterflyfish. Two very similar species of long-nosed butterflyfishes (both with the same Hawaiian name, Lauwiliwilinukunuku'oi'oi) are found in Honaunau Bay. The rarer species of the two, Forcipiger longirostris, is found in only a few locations in Hawaii, but is abundant in the Bay. It can be distinguished from the more common species, F. flavissimus,

by the its smaller mouth, longer snout, and the black flecks on its chest. Forcipiger longirostris was the first Hawaiian fish to receive a Linnaean, or scientific name. A specimen collected by a naturalist on Captain Cook's visit to nearby Kealakekua Bay was sent back to Europe and described in 1789 by P. M. A. Broussonet, whose type specimen is preserved in the British Museum (Natural History) in London.

The Hawaiians' name for these two Lauwiliwilinukunuku'oi'oi, literally translated, means "sharp-backed wiliwili leaf", referring to the leaf of the native tree whose wood was used for net floats and surfboards. Although there is little meat on these fish, the Hawaiians occasionally ate them broiled (Titcomb 1960). Individuals of both species are usually seen traveling in pairs, swimming over the coral rich areas of the reef, using their long snouts to pluck small invertebrate animals from crevices in the reef. While both species are found in the yellow color pattern, rarely individuals of F. longirostris are found in an all black form. Scientists are still puzzled over the reasons for this unusual color variation.

Today, these two species still have economic importance in Hawaii. Over 7,500/year are collected alive for sale in the aquarium trade within the state and on the mainland. The annual wholesale value is about $30,000 for these two species at present.

2) Shark fishing and lore. Sharks featured prominently in Hawaiian folklore and sportfishing and some were believed to be the patron demigods of certain fishermen.

Stokes (in Emory et al. 1957) relates the alii's sport of fishing for niuhi ("maneater", probably the tiger shark, Galeocerdo cuvier or rarely the great white, Carcharodon carcharias) in waters off Honaunau Bay. Chumming bait was prepared by placing a large dead pig or human remains

on a rock shelf at the City of Refuge for several days. The decayed flesh was then wrapped in ti leaves and suspended from the connecting booms of a large double canoe at the fishing site. The bundle was poked with sticks to release juices of the decomposed flesh which dispersed in the water and attracted the shark.

As the shark swam to the bait, nooses were slipped over the head and tail. The sporting chiefs then jumped overboard and proceeded to wrestle the shark and kill it with wooden daggers. The shark flesh was kapu for women to eat but was consumed by the victorious fishermen.

Stokes also relates the Hawaiian belief that underwater caves in the area were the home of a shark god, the cave being called Lua mano. Although the location of this cave is not specified in detail, it is possible that the extensive undercuts and deep caves under the pahoehoe west of the restored heiau may be the legendary site. Calm weather during the June visit allowed preliminary exploration of this network. Caution and the lack of diving lights precluded entry into one cave that appeared to be at least 10 m deep. The reef white-tip shark, Triaenodon obesus is commonly found in such large holes and this may be related to the belief that the caves housed a shark god.

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_____. 1960. Native use of Hawaiian Fish. B. P. Bishop Museum Press.

APPENDIX C

HALEAKALA NATIONAL PARK

Possible predation on *Branta sandvicensis* (NENE) by owls in Haleakala National Park

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ABSTRACT

This paper is the result of field work conducted at Haleakala National Park from March 13 to May 7, 1975. It was not possible during this short time period to investigate all aspects of the proposal that was submitted before the field work began. All the evidence that was obtained suggested that the Barn Owl (Tyto alba) is an uncommon species within the boundaries of the Park. I was therefore unable to find either roosts or nests of this species and could not be certain that the pellets found belonged to this species or to the PUEO.[1] A large number of pellets

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[1]Hawaiian vernacular names are printed in upper case letters throughout.

(about 60) from areas within the crater where there appeared to be overlap in the feeding areas of the Barn Owl and the PUEO (Asio flammeus) were eliminated from my analysis.

Although the Barn Owl and the PUEO are both large enough to prey upon recently hatched NENE (Branta sandvicensis), no evidence was found that they do so. This report is in no sense conclusive because the roost of the Barn Owl that was heard near Paliku Cabin was not found, and owl pellets from this area would be the critical ones for determining the food habits of owls in the NENE release area.

Introduction

Walker (1974) reports that mainland Short-Eared Owls are gregarious and colony ground-nesting birds that prefer the tall grasses in and around marshy areas. However, Walker also reports that, on the island of Oormlashka of Alaska, Short-Eared Owls have altered their typical nesting habits and build their nests in burrows. Very little has been published on the breeding habits of the PUEO; all nests reported thus far have been built on the ground. There is no evidence that the PUEO is colonial or gregarious.

That owls cast pellets in their hunting territory was described by Craighead and Craighead (1969) who stated: "Frequently the Short-Eared Owl casts a pellet in the late afternoon or evening before leaving the roost...indicating that the birds often cast in later afternoon and that each owl would eject no more than one pellet at the roost per day and might not cast until after it had left the roost." Guerin (in Craighead and Craighead, 1969) found that there were at least two daily ejections of pellets by the Barn Owl---one in the hunting area, and one at the roost.

Pellet analysis has been found to be an accurate method of determining the food habits of owls. This is best expressed by Craighead and Craighead (1969) who state: "where small rodents are the major food of hawks and owls, there generally is sufficient osseous evidence in the pellets to reveal accurately the number of individuals represented. Because a greater amount of bone is found in owl than in hawk pellets, the number of individual prey items per owl pellet more closely represents the actual number of individuals consumed to form the pellet than is the case with hawks... We found that for each individual prey item, 722 Short-Eared Owl pellets averaged 2.24 grams, while 450 Marsh Hawk pellets averaged .92 grams. This difference is largely indicative of the great difference in osseous remains found in the two types of pellets. We also determined that approximately 90 percent of the rodents fed to a captive Marsh Hawk was evident in the pellets, whereas practically 100 percent was found in the Short-Eared Owl pellets."

Methods and Study Areas

From six different regions in and adjacent to Haleakala National Park, I collected 87 owl pellets from the PUEO. Each of these areas was designated as a hunting territory of the PUEO, based on visual observations of PUEO hunting in the daylight hours.

The six designated areas of collection and observation in this study (with the exception of the crater floor, which exhibited vast areas of sparsely vegetated regions) were all similar in plant types and habitat but were widely separated by elevation. (Fig. 1).

Upon collection the pellets were labeled and each separately placed in plastic containers and returned to the laboratory for analysis. The

pellets were classified according to the form and apparent state of weathering as old or fresh and whole or broken. Each pellet was weighed to the nearest tenth of a gram on an Ohaus triple beam balance, sized by length and width with calipers and then teased apart and scanned under a Bausch and Lomb dissecting microscope for content.

Animal remains were initally sorted into four groups: rat, mouse, bird and insect. Then, when possible, identification to genus and species was made. Each pellet examined was placed in a container, marked and shipped to the B. P. Bishop Museum for confirmation of identification of mammals and insects; Dr. Berger identified all bird remains when possible. (Figs. 2 - 5).

Care was taken to collect pellets only in areas thought to be utilized by only one of the two species of owls, thus minimizing the chance of pellet misidentification. Uncertainty on this point in respect to some study areas is the reason that the data collected on the Barn Owl, and as many as 60 pellets thought to be PUEO, are not included in this report.

Several methods of recording pellet content data are in general use. Pellet contents may be expressed as the number of times remains of prey animals are represented or as percentages of individual prey items found in the pellets. In this study, both methods have been used whenever possible, but major reliance is placed on percentage of prey species rather than frequency of representation.

Observations were made in six separate PUEO feeding areas. In five of these, only a single owl was observed; a pair of birds was seen in one area.

Area 1 stretches along the horse trail used as a service road by the National Park Service leading from Hosmer Grove, (6,500 ft.) to the

crater rim near the beginning of Halemauu Trail, (8,000 ft.). The habitat in this area is characterized by scrub Vaccinium, silver geranium, OHELO, scrub MAMANE, and scattered patches of tussock grass. Sixteen pellets were collected in this area. Owls were seen on seven field trips here.

Area 2. This area included the entire crater floor, and a large area where it is believed there are only two PUEO hunting territories. The habitat of the crater floor ranges from large stretches of barren lava and cinders to PUU's densely covered by MAMANE and Vaccinium, and to the lush and diverse vegetation from Paliku to the entrance of Kaupo Gap.

Of some 73 pellets collected in this area, only thirteen were analyzed and used in this report because of two possible territorial overlaps by the Barn Owl and PUEO. The possibility of pellet misidentification in these areas proved too great to include these data in this report.

Area 3. This is Kalapawili Ridge at an elevation of about 8,000 feet. It overlooks the crater floor. This area is chiefly Deschampsia grassland with scrub Vaccinium predominating in the periphery of the area. PUEO were observed on three field trips. Twelve pellets were collected along the ridge.

Area 4. This is the habitat along Haleakala Highway, from Hosmer Grove at 6,800 ft. to the summit at 10,000 feet. The cover ranges from Vaccinium, MAMANE and Raillardia in the scattered meadows from 6,800 to 9,000 ft., to the relatively barren landscape of the summit. Numerous sightings of the PUEO hunting along the highway were recorded up to 8,000 feet. Twenty pellets were collected and analyzed from this area.

Area 5. This is a private cattle grazing pasture just outside the park boundary. It offered the most information on owl behavior of any of the other study areas. Over 30 visual observations were made of a

single PUEO, with daily recordings being made of its activity at various times between sunrise and sunset. A pair of PUEO was observed only once at dusk. The vegetation in this area was predominantly grassland with occasional stands of eucalyptus and four gulches which ran the length of the area. Twenty-five pellets were collected and analyzed from this habitat. The remains of one or more pheasants and one petrel were found but the cause of death of these birds could not be determined.

Area 6. This is Ukulele Trail which leads down-slope from Hosmer Grove predominantly through introduced evergreen trees. Only five old pellets were found along this jeep road.

Results

Of the 87 PUEO pellets examined, it was found (Tables 1 - 8) that rats constituted 35.63%, mice 57.47%, birds 48.27%, and insects 22.98%.

On April 29, 1975, I observed a PUEO hover and land in the Area 5 study plot. When I approached the area in which the bird was last seen, the owl flushed at a distance of not more than 15 yards. Clutched in its talons was a decapitated skylark.

Although no feral dogs or cats were collected for confirmation of their food habits by stomach analysis, two cats and seven dogs were observed numerous times within the crater by me, members of the park staff, and by employees of the State Division of Fish and Game. On one occasion, five dogs were seen to hold five feral goats at bay and apparently were closing in to kill. Hunters, who were witnessing this spectacle, shot and killed two of the goats but missed in their attempt to shoot the dogs.

On April 3, 1975, the mutilated carcass of one adult NENE was found. The color bands which remained on the leg of this bird bore numerous tooth

marks such as could have resulted from having been gnawed by either a dog or large cat. Further evidence was found in collecting what appeared to be the scat of a dog containing the feathers and bones of a large bird.

On April 3, 1975, Mr. Joseph Medeiros of the State Division of Fish and Game and I discovered the nest of a NENE with three eggs that had been abandoned. Signs of dogs having been in the vicinity (e.g., dog tracks and scat) were found during a later visit.

Although actual predation by dogs upon the NENE has not been reported, sufficient circumstantial evidence has been observed in this study to warrant a strong suspicion that dogs are instrumental in the declining state of the NENE.

Discussion

Little is known about the feeding behavior or breeding biology of Hawaii's native Short-Eared Owl. The study on the food habits of Hawaii's raptorial birds produced by Tomich (1971) was informative, but was restricted to the island of Hawaii. Tomich did not find any bird remains in the pellets that he examined, whereas in this study bird remains were found in 48.27 percent of the 87 pellets examined.

Although positive identification of all the species of prey items has not yet been completed, sufficient remains of 44 birds did allow for a breakdown into two categories: 1) medium-sized birds (e.g., young pheasants, skylarks and plovers) and 2) small birds (e.g., honeycreepers, white-eyes and linnets). Of these 44 bird remains, 28 were found to be those of small birds (one of which was positively identified as that of an APAPANE, Himatione sanguinea, by Dr. Berger) and 16 were classified as medium-sized birds. One was identified as possibly a juvenile pheasant.

Seven remains were found to have yellow feathers, 4 with red feathers, and 2 with green feathers. This evidence, coupled with the positive identification of one APAPANE ingested, lends credence to my theory that the PUEO could be instrumental in the control of endemic bird populations. It was further suggested, by the osseous remains of the sixteen medium-sized birds which in some instances exhibited intact digits of young pheasants, that the PUEO is capable of preying on NENE goslings.

I believe that there are no more than two pairs of barn owls and possibly only one pair within Haleakala Crater. Until the nests or roosts of these birds are found, so that pellets can be collected, we will not be able to discover the food habits of these owls in greater detail.

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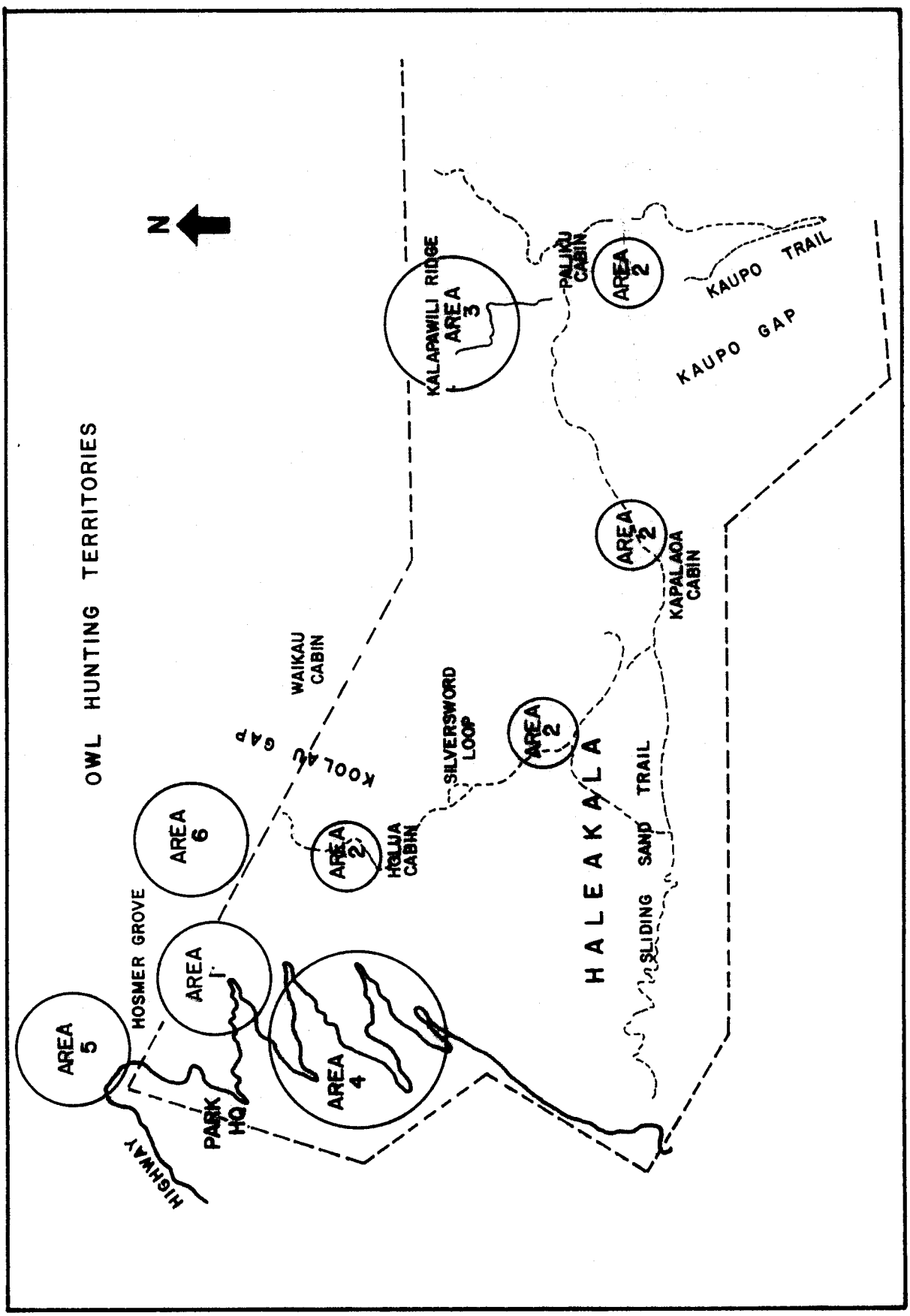
Acknowledgements

I express my appreciation to the Superintendent and personnel of Haleakala National Park for their cooperation in enabling me to conduct this study and to Andrew J. Berger under whose direction this study was made. The project was financed by the funds from a contract between the U.S. National Park Service and the University of Hawaii.


OWL HUNTING TERRITORIES
N
AREA 5
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AREA 6
AREA 1
AREA 4
PARK HQ
HIGHWAY
AREA 2
HOLUA CABIN
KOOLAU GAP
WAIKAU CABIN
SILVERSWORD LOOP
AREA 1,2
HALEAKALA
SLIDING SAND TRAIL
KALAPAWILI RIDGE
AREA 3
PALIKU CABIN
AREA 2
KAUPO TRAIL
KAUPO GAP
AREA 1,2
KAPALAOA CABIN

Table 1. Summary of PUEO (Asio flammeus) fecal pellet contents.

Food Source	Number of occurrences	Percentage occurrence
Birds	42	48
Mice	50	57
Rats	31	36
Insects	20	23

Average weight per pellet was 2.37 g.

Fig. 2. Fecal pellets of PUEO (Asio flammeus) photographed in situ in Area 5.

Fig. 3. Typical PUEO (Asio flammeus) pellets collected from Haleakala National Park, Hawaii.

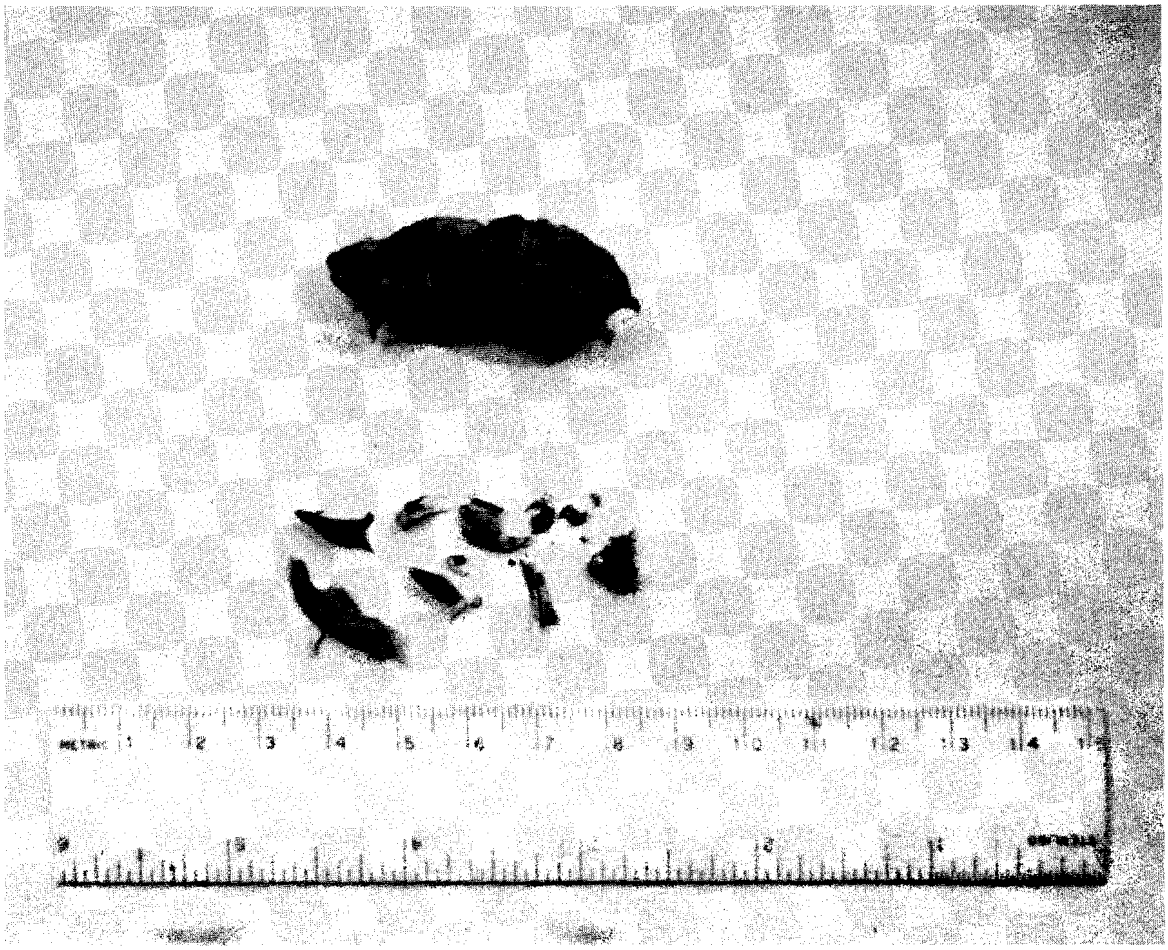

Fig. 4. PUEO (Asio flammeus) fecal pellets and osseus remains of a rat from part of the pellet.

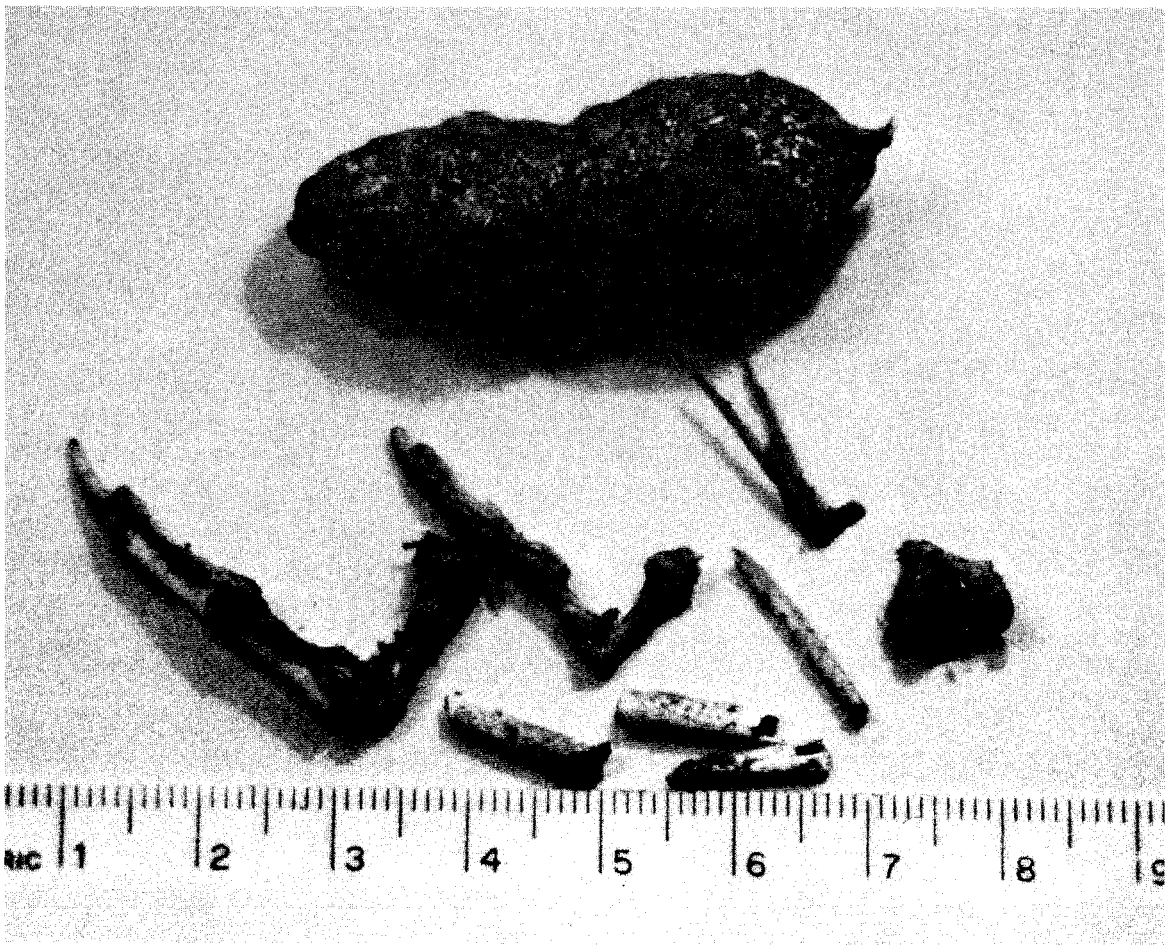

Fig. 5. Third and Fourth Phalanges of a juvenile pheasant feased out of a PUEO (Asio flammeus) fecal pellet collected in Haleakala National Park.

Table 2. The contents of Asio flammeus fecal pellets from Area 1.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
50	2.00	1	-	1 (Orthoptera)	-	Old
51	1.81	-	1	-	-	Old
52	2.65	-	1	-	-	Old
53	1.82	-	1	1 (Coleoptera)	1 (medium)	Old
54	2.13	1	-	1 (Orthoptera)	-	Old
55	2.42	-	1	-	-	Old
56	1.81	-	1	-	1 (small)	Fresh
57	5.58	-	1	-	1 (small)	Old
58	4.26	-	1	-	-	Old
59	1.78	-	1	-	-	Old
75	5.72	1	-	-	1 (small)	Old
76	5.04	1	-	2 (Orthoptera)	-	Old
77	6.49	1	-	-	-	Old
78	7.81	-	-	3 (Orthoptera & Coleoptera)	2 (small)	Fresh
79	6.91	-	-	-	2 (small)	Fresh
80	6.75	-	-	1 (Orthoptera)	1 (small)	Fresh

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
5	8	9	9

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
4	0	3	1	1	1	2	1	3

AVERAGE WEIGHT PER PELLET = 4.06

Table 3. The contents of Asio flammeus fecal pellets from Area 2.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
9	3.82	-	1	-	1 (small)	Old
11	1.85	-	1	-	1 (small)	Fresh
36	4.88	-	1	-	-	Old
37	4.66	-	1	1 (Orthoptera)	-	Old
38	3.69	-	1	1 (Orthoptera)	-	Old
41	3.46	1	-	-	-	Old
45	2.90	-	1	-	-	Old
60	2.00	-	1	-	-	Old
61	2.45	-	1	1 (Orthoptera)	1 (med.)	Old
62	2.52	1	1	-	-	Old
63	2.00	-	1	-	-	Old
64	2.10	1	-	-	-	Old
67	2.47	-	1	-	1 (med.)	Fresh

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
4	11	4	3

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
4	1	4	3	0	0	0	2	0

AVERAGE WEIGHT PER PELLET = 2.99

Table 4. The contents of Asio flammeus fecal pellets from Area 3.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
1	2.61	-	1	-	1 (small)	Old
2	2.40	-	1	-	1 (small)	Old
3	2.61	-	2	-	-	Old
4	2.90	-	1	-	-	Old
5	2.79	-	1	-	-	Old
6	2.50	-	1	-	-	Old
50	2.62	-	1	-	-	Fresh
51	1.82	-	1	1 (Mantidae)	-	Old
52	2.91	1	-	-	1 (small)	Old
53	3.49	1	-	-	1 (med.)	Old
54	2.20	-	1	-	1 (small)	Old
74	5.60	1	-	-	1 (small)	Fresh

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
3	10	6	1

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
5	0	3	1	0	3	0	0	0

AVERAGE WEIGHT PER PELLET = 2.87

Table 5. The contents of Asio flammeus fecal pellets from Area 4.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
15	2.68	-	1	-	-	Fresh
16	2.43	-	1	-	-	Old
17	2.40	-	1	-	1 (small)	Old
18	3.45	-	1	-	1 (medium)	Old
19	2.21	-	2	-	-	Old
20	2.00	-	1	-	-	Old
21	2.09	-	1	-	1 (small)	Old
22	2.50	-	1	-	-	Old
23	1.81	-	1	2 (Orthoptera)	-	Old
24	2.01	-	1	1 (?)	1 (small)	Old
25	2.41	-	1	1 (Orthoptera)	-	Old
26	1.82	-	1	-	1 (medium)	Old
27	1.89	-	2	-	-	Old
28	2.19	-	1	-	-	Old
29	3.49	-	1	-	1 (medium)	Old
30	3.50	-	1	-	-	Old
31	4.20	-	1	-	1 (medium)	Fresh
32	2.51	-	1	-	-	Fresh
33	2.49	-	1	1 (Orthoptera)	-	Fresh
34	1.48	-	1	-	1 (medium)	Old

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
0	22	8	5

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
9	0	8	4	0	0	0	0	0

AVERAGE WEIGHT PER PELLET = 2.48

Table 6. The contents of Asio flammeus fecal pellets from Area 5.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
96	4.72	1	-	-	1 (medium)	Old
97	3.90	1	-	1 (Coleoptera)	1 (medium)	Old
98	5.30	2	-	-	-	Old
99	4.08	1	-	-	-	Old
100	2.70	1	-	2 (Orthoptera)	-	Old
101	2.43	1	-	-	-	Fresh
102	3.34	-	-	1 (Hymenoptera)	1 (medium)	Old
103	5.62	1	-	-	-	Old
104	5.01	1	-	3-4 (Orthoptera)	1	Old

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
9	0	4	8

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
0	0	0	0	1	1	1	4	1

AVERAGE WEIGHT PER PELLET = 4.12

Table 7. The contents of Asio flammeus fecal pellets from Area 5A.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
82	5.32	-	-	1 (Coleoptera)	1 (small)	Old
83	6.80	-	-	-	1 (med.)	Old
84	2.72	2	-	-	-	Old
85	3.57	1	-	-	1 (small)	Fresh
86	3.70	1	-	-	1 (small)	Old
87	4.61	1	-	-	1 (small)	Old
88	2.20	-	-	-	1 (small)	Old
89	2.10	-	-	-	1 (med.)	Old
90	3.67	1	-	-	-	Old
91	2.80	1	-	1 (Coleoptera)	-	Fresh
92	4.00	1	-	-	1 (small)	Old
93	3.79	2	-	-	-	Old
94	1.74	1	-	-	-	Fresh

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
11	0	8	2

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
0	0	0	0	3	4	1	4	1

AVERAGE WEIGHT PER PELLET = 3.92

Table 8. The contents of Asio flammeus fecal pellets from Area 6.

Pellet No.	Weight (Grams)	Rat Remains	Mouse	Insect	Bird	Age of Pellet
69	3.85	-	1	-	1 (med.)	Old
70	3.80	1	-	-	1 (small)	Old
71	4.00	1	-	1 (Orthoptera)	1 (small)	Old
72	3.12	-	1	-	1 (small	Old
73	---	1	-	-	1 (small)	Old

TOTAL PREY SPECIES

Rat	Mouse	Bird	Insect
3	2	5	1

PREY SPECIES PER PELLET

Mouse Only	Mouse & Rat	Mouse & Bird	Mouse & Insect	Bird Only	Bird & Rat	Bird & Insect	Rat Only	Rat & Insect
0	0	2	0	0	3	0	0	0

AVERAGE WEIGHT PER PELLET = 3.69

APPENDIX D

Personnel involved in the University of Hawaii National Parks Cooperative Studies Unit in 02 year.

Unit Support and General Activities

Dr. Maxwell S. Doty	Dept. of Botany	Director
Mr. Barry Hill	"	Admin. Asst.
Ms. Carole Packard	"	Admin. Asst.
Ms. Joan Kirtley	"	Secretary
Mr. Ismael Trono	"	Illustrator
Mr. H. Eddie Smith	UHCPSU	On site Manager at HALE
Mr. Terry Parman	UHCPSU	On site Manager at HAVO

Research Projects

HALE RBI

Dr. Clifford W. Smith	Dept. of Botany	Project Leader, Lichens
Dr. Jack Beardsley	Dept. of Entomology	Insects
Dr. Andrew Berger	Dept. of Zoology	Birds
Mr. H. Eddie Smith	UHCPSU	Birds
Mr. Paul Higashino	Dept. of Botany	Flowering Plants
Mr. William Hoe	Dept. of Botany	Mosses
Mr. Robert Burkhart	Dept. of Entomology	Insects

HALE - Owl Predation on NENE Study

Mr. H. Eddie Smith	UHCPSU	Principal Investigator

HAVO RBI

Mr. Tissa Herat	Dept. of Botany	Principal Investigator
Ms. Ruki Herat	Dept. of Botany	Field Assistant
Mr. Paul Higashino	"	Field Assistant

HAVO - Halape Coast RBI

Mr. Fred Ball	UHCPSU	Principal Investigator

HAVO - Kalapana Extension Plant Ecology Survey

Mr. Rick Warshauer	Dept. of Botany	Principal Investigator

PUHE Plant Survey		
Dr. Don Hemmes	Biology Dept., Hilo College	Principal Investigator
Ms. Lisa Croft	" "	Field Assistant
Mr. James MacNeill	" "	Field Assistant
PUHE Marine Survey		
Mr. Del Dykes	Biology Dept., Hilo College	Principal Investigator
Mr. James Murphy	" "	Field Assistant
CIRE Fish Survey		
Dr. Leighton Taylor	Dept. of Zoology	Principal Investigator