COOPERATIVE NATIONAL PARKS RESOURCES STUDIES UNIT

DEPARTMENT OF BOTANY

UNIVERSITY OF HAWAII AT MANOA

HONOLULU, HAWAII 96822

(808) 948-8218

TECHNICAL REPORT #10

HALAPĒ MARINE SURVEY

NATIONAL PARK SERVICE

CONTRACT #CX8000 6 0031

Contribution #: (This work carried out under CPSU Year 02.)

Clifford W. Smith, Unit Director

The National Park Service and the University of Hawaii signed the memorandum of agreement establishing this Cooperative National Park Resources Studies Unit on March 16, 1973. The unit provides a multidisciplinary approach to studies on the biological resources in the National Parks in Hawaii, that is, Hawaii Volcanoes National Park, Haleakala National Park, City of Refuge National Historical Park and Puukohola National Historic Site. Through the Unit Director, projects are undertaken in areas identified by park management. These studies provide information that will facilitate the development and implementation of resource management programs. The involvement of University faculty and students in the resource management of the National Parks in Hawaii lends to a greater awareness of the problems and needs of the Service. At the same time research not directly or immediately applicable to management is also encouraged through the Unit.

A SURVEY OF THE MARINE ORGANISMS AT HALAPĒ, HAWAII VOLCANOES NATIONAL PARK

FREDERICK W. BALL
DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
3190 MAILE WAY
HONOLULU, HI 96822

TABLE OF CONTENTS

PREFACE

This report of the survey of the marine resources at Halapē was conducted July 17-23, 1975. Since that time the area has been severely disturbed by natural phenomena. The November 29, 1975 earthquake, (Richter Scale magnitude 8.4), generated a small tsunami which claimed the lives of two people and also severely disturbed the marine flora and fauna at Halapē. Many animals and some plant material were either crushed or left stranded on land. However, this destruction was minor com with the gross change in the habitat brought about by the land subsidence during the earthquake and in the following weeks. The land in the Halapē region has sunk approximately eleven feet. The benthic environment in the area will not recover for some years as the newly submerged land surface is colonized and the previously submerged regions adapt and change in response to their greater depth. Figures 1 and 2 illustrate the conditions at Halapē before and after the earthquake. There was no volcanic activity in the Halapē area.

Though this report presents information about an area whose features have been radically altered by nature, the results contained herein are still of considerable significance for resource management purposes. The report is the first comprehensive qualitative inventory of marine organisms along the coastline of Hawaii Volcanoes National Park. As such it will form the basis for future resource inventory studies in the area and all consequent ecological studies that may be necessary for resource management. Some work on the colonization of the newly submerged coastline is already being sponsored by the CPSU UH.

Fig. 1. An aerial photograph of the Halapē coastline Hawaii Volcanoes National Park prior to the November 29, 1975 earthquake. Keaoi Island is in the left foreground. (Photo by R. Holcomb, USGS # 1-16-75/Frame 12).

Fig. 2. An aerial photograph of the Halapē coastline Hawaii Volcanoes National Park after the November 29th, 1975 earthquake. Keaoi Island is just to the bottom left hand corner; only a small portion is left exposed (not shown in this photograph). Note the position of the coastline with respect to the Halapē Coconut Grove and the small pali hehind. (Official photograph of USGS taken by Boone Morrison).

Introduction

The Hawaii Volcanoes National Park coastal boundaries extend eastward from La'ahana, near the Great Crack, to Kupapau Point, which is located about 3.5 miles West of Kalapana (Fig. 3). The region surveyed covered an area approximately 0.5 mile East of Keaoi Island to 1.75 mi. West of it (Fig. 4).

A base camp was established at Halapē (Lat. N. 19° 16' 24", Long. W. 155° 15' 37"), a very attractive site amidst very bleak surroundings. Although its coastline is located leeward of the prevailing trade winds, refraction of the westward setting waves is sufficient to create moderately exposed conditions. The waves have gnawed away at and eroded the lava-formed coastline, fashioning it into myriad forms that take the shape of arches, jagged spires, subterranean caves, pot holes and the like.

Primarily due to its remoteness and somewhat harsh physical and topographical conditions, the marine environment along the approximately 30-mile stretch of Hawaii Volcanoes National Park coastline has received little attention. Studies of potential value, beneficial not only to the National Park Service but also to the scientific community as well, consist of (1) faunal and floral succession studies on recent lava flows, and (2) an assessment of the degree of human impact on coastal organisms, such as mollusks, opihi in particular, and fish.

Fig. 3. Location of Hawaii Volcanoes National Park in the Hawaiian Islands.

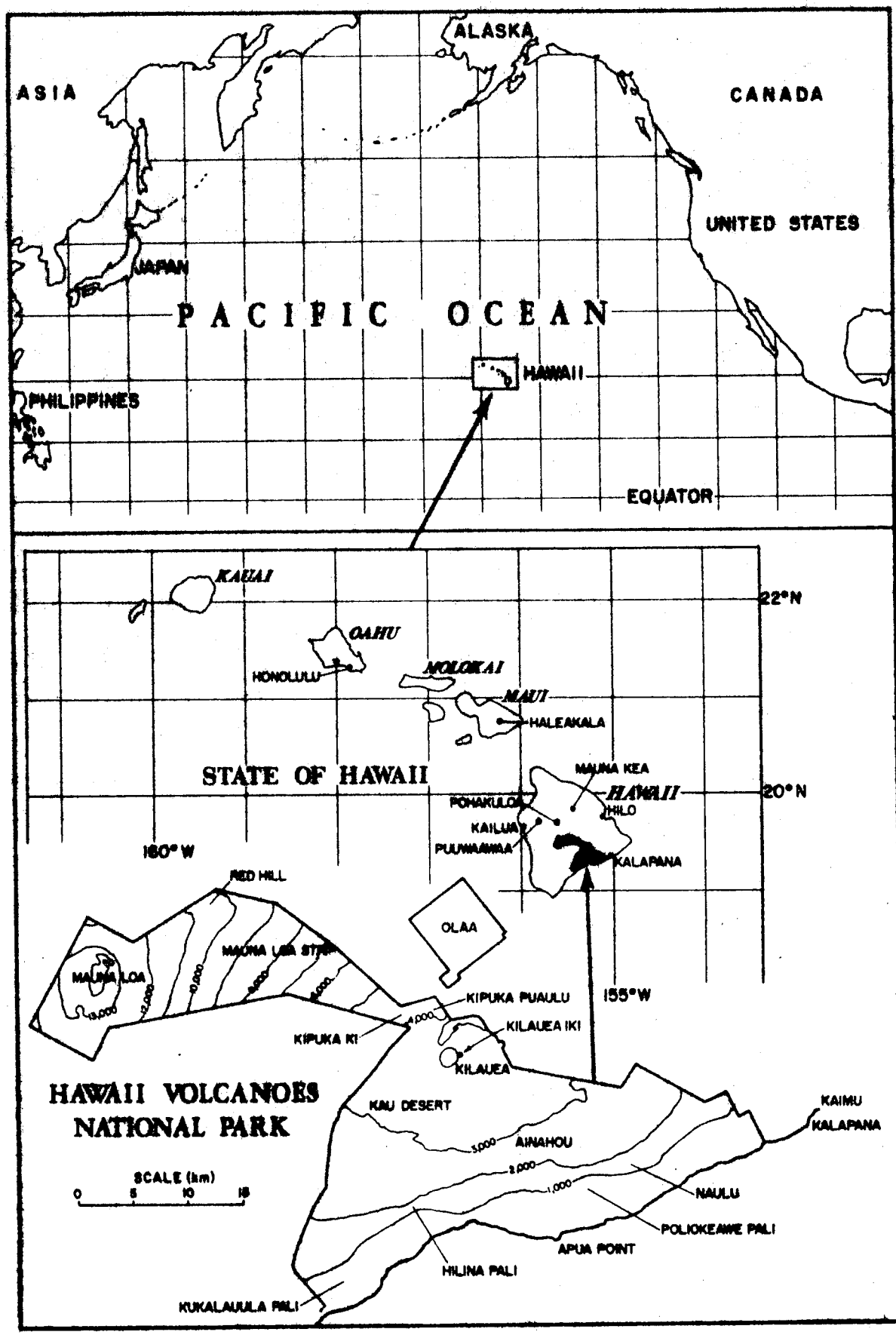
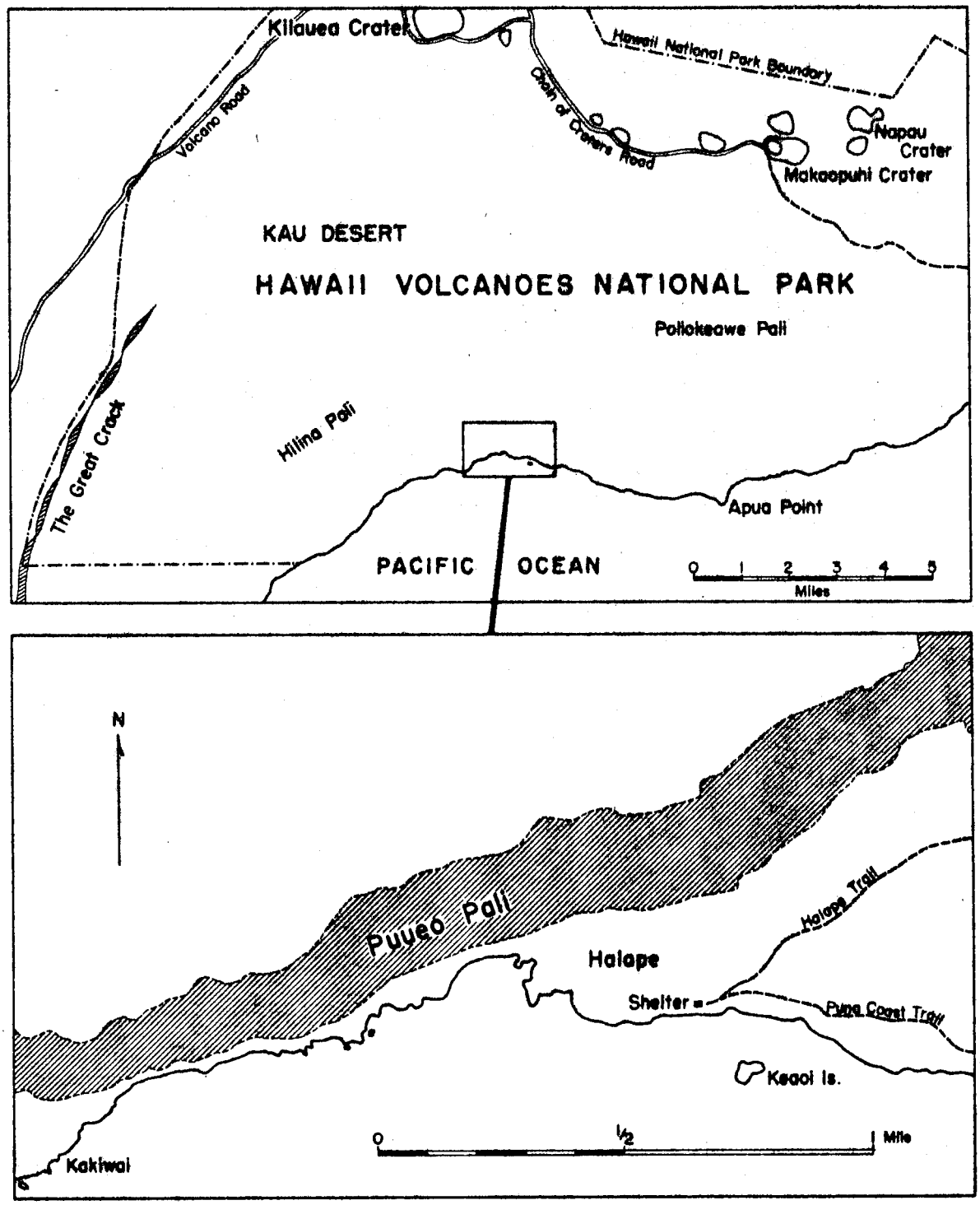

ALASKA
ASIA
CANADA
UNITED STATES
JAPAN
PACIFIC OCEAN
HAWAII
PHILIPPINES
EQUATOR
KAUAI
OAHU
HONOLULU
MOLOKAI
MAUI
HALEAKALA
STATE OF HAWAII
MAUNA KEA
HAWAII
HILO
POHAKULOA
KAILUA
PUUWAAWAA
KALAPANA
22°N
20°N
160° W
155°W
RED HILL
OLAA
MAUNA LOA
MAUNA LOA STRIP
KIPUKA PUAULU
KIPUKA KI
KILAUEA IKI
KILAUEA
HAWAII VOLCANOES
NATIONAL PARK
KAU DESERT
AINAHOU
KAIMU
KALAPANA
NAULU
POLIOKEAWE PALI
APUA POINT
HILINA PALI
KUKALAUULA PALI
SCALE (km)
0 5 10 15

Fig. 4. Location of the Halapē Study Area in Hawaii Volcanoes National Park.


Kilauea Crater
Hawaii National Park Boundary
Volcano Road
Crater Rim Drive
Napau Crater
Makaopuhi Crater
KAU DESERT
HAWAII VOLCANOES NATIONAL PARK
Pollokeawe Pali
Hilina Pali
The Great Crack
Apua Point
PACIFIC OCEAN
0 1 2 3 4 5
Miles
N
Puueo Pali
Halape
Halape Trail
Shelter
Puna Coast Trail
Keaoi Is.
0 1/2 Mile
Kakiwai

By determining the diversity and density of the marine fauna and flora the management of the resources in the area will be improved. In addition, the National Park Service is interested in expanding its jurisdiction to 0.25 miles offshore. Hence, the concern to survey the coastline in terms of its marine organisms. At present, the National Park Service exercises control over those lands within its boundaries extending down to the mean high tide mark. Beyond this point the State has jurisdiction out to the 3 mile limit.

The human impact within the National Park's jurisdiction of the coastline is well known. There are historical records that the Hawaiians made extensive use of certain parts of the coastline between Puna and Ka'u. The physical remains of several hundred sites of ancient villages, heiaus, petroglyphs, shelter caves and other displays of ancient native habitation are present in the area. Major archaeological sites have been located mostly towards the Kalapana end of the National Park's boundaries at such locations as Pu'u Loa, Kamoamoa, Ka'ili'ili and Wahaula. In general, perhaps because of the ruggedness of the coastline between Puna and Ka'u, the population of ancient Polynesians was rather sparse west of the Kalapana Extension.[1] For the most part, the majority of the population of this rugged region was only transient.[2]

During historic times, there has been a steady decline in the population of this area. In the mid 1800's Keauhou Landing was a landing place for tourists visiting Kilauea

Volcano. During this period Keauhou consisted of a fairly large village and steamship port until it was destroyed in 1868 by a tsunami (tidal wave). This port was also used by the pulu (a fern product) factory located on the trail between Makaopuhi and Napau Craters.[1] The loss of the landing place at Keauhou was the beginning of the end. The area reverted to a status of basic subsistance and the population dwindled.

Previous collections in the area

Hartman (1966) compiled a list of polychaete annelids found in the Hawaiian Islands, including collections from Halapē made by Hiatt and Brock. Of the total number of polychaete species collected by Hiatt and Brock, 36 were identified as being found in the Halapē area. Seven of these species, Phyllodoce madeirensis, Platynereis dumerilii, Eunice afra, Mesochaetopterus sagittarius, Polyopthalmus pictus, Lygdamis nesiotes and Nicolea gracilibranchis, were collected during the present study; the remaining 15 species are new records for Halapē. The discrepancy in the species found can be accounted for by differences in collecting techniques and the time of year when sampled.

Doty (1966) conducted a preliminary survey of the seaweeds at Kalapana and vicinity and identified about 40 species of micro- and macro- types of algae. By comparison, of the 40 species of macrobenthic algae collected at Halapē, only 9 were of the same species. The difference in species

composition between the two areas is probably the result of habitat difference; the Kalapana Coast is an area of rugged cliffs exposed to the full force of the waves whereas at Halapē there are many sheltered areas.

In April of 1973, Major made some brief observations on the various kinds of reef fish located between Keaoi Island and the beach. The results of his observations were filed with the Hawaii Volcanoes National Park Library in an unpublished report and are summarized in this report in Appendix A.

Undoubtedly, there are other such "preliminary" surveys that have been conducted by various individuals on the marine biota of this region, the results of which are probably left uncovered deep in some file.

To date, the information compiled in this report is the most comprehensive study conducted thus far regarding the marine environment at, and adjacent to, Halapē.

Materials and Methods

Daily weather conditions were recorded as follows. Wind velocities were read from a hand-held anemometer, while its direction was determined with use of a compass. A continuous recording hygrothermograph was used to measure temperature and humidity, and was checked for accuracy periodically against a Bendix psychrometer model #566.

Sample sea water salinities were obtained using a Yellow Springs Instrument Company salinometer model #33.

A tightly capped 2-liter sample of sea water was sent to the Hawaiian Institute of Marine Biology, Coconut Island, for a more accurate analysis of salinity, the result of which was used to calibrate field readings.

Water temperature was measured with a glass thermometer calibrated in degrees Celsius.

For wind and sea condition evaluation, reference was made to the Beaufort scale.

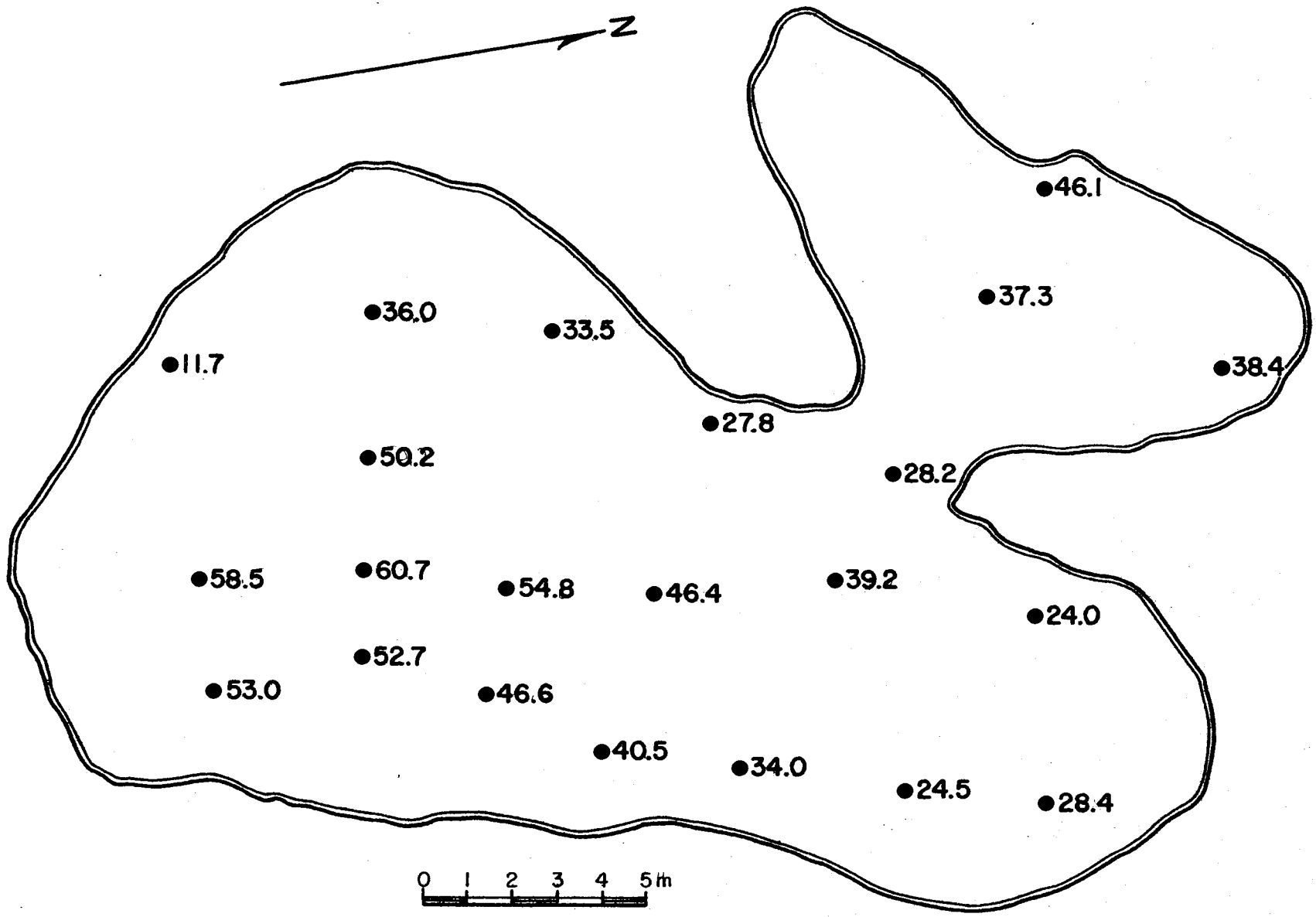
A current tide table was consulted to determine the approximate time of high and low tide on any given day, using the nearest tidal reference station, Honu'apo, Hawaii, located about 25 miles Southwest of Halapē.

Plankton tows were made using a 30 cm diameter net (mesh size unknown). The planktonic collections were preserved in Leugol's solution in order to preserve the identity of any armored dinoflagellate specimens obtained.

Invertebrate and vertebrate collections were preserved in stock solutions of either 5% formaldehyde or 70% ethyl alcohol.

Mapping of one of the tidal pools (Fig. 5) was accomplished with the use of a plane table, an open sight alidade, a rangefinder, a Brunton compass, a tripod, an architect's triangular scale, and a range pole. The map was supplemented by aerial photos taken at a later time. Aerial photos were also taken from an altitude of about 200' to depict the general character of that part of the coastline

Fig. 5. Depths (cm) of largest tidepool, one half mile west of the Halapē shelter, which was sampled intensively during this study.


N
46.1
37.3
36.0
33.5
38.4
11.7
27.8
50.2
28.2
58.5
60.7
54.8
46.4
39.2
24.0
52.7
53.0
46.6
40.5
34.0
24.5
28.4
0 1 2 3 4 5m

under study, in addition to close-up photographs of the area in general.

A reference collection of all specimens collected has been deposited at the Hawaii Volcanoes National Park Headquarters. An almost complete set has also been deposited in the Bishop Museum.

Results

Since time was a limiting factor during the course of the survey, the results obtained should only be considered as a partial representation of the marine organisms located in the Halapē vicinity. Continued studies at a future time will be necessary for a more complete inventory.

With respect to the weather, from the period 17-23 July typical tradewind conditions prevailed. The highest temperature and humidity recorded for this period was 29°C and 24% RH, refer to Table I for a summary of temperature and relative humidity results. About 95 percent of the time the winds were NE to ENE, averaging 12-18 kts., with peak gusts to 35+ kts. Precipitation was negligible.

Since most of the tidal pools sampled were substantially large and deep enough, and in sufficient contact with the open sea, little fluctuation in water temperature or salinity was observed. The average sea water temperature measured was 24°C, and the mean salinity 31.3‰. A salinity check was also conducted on one of several accessible, supposedly "brackish" water pools formed along a large rift zone located

Table I. Summary of daily air temperatures and percent relative humidity (R.H.) recorded at Halapē campsite during the period 17-23 July, 1975.

DATE

	17		18		19		20		21		22		23	
Hr.	°C	R.H.	°C	R.H.	°C	R.H.	°C	R.H.	°C	R.H.	°C	R.H.	°C	R.H.
00			23	52	22	50	22	39	24	41	23	41	22	47
02			23	53	23	40	22	46	24	42	22	41	22	45
04			23	54	21	42	22	42	23	41	22	50	22	44
06			23	56	21	38	22	44	23	40	21	40	21	47
08			23	50	27	30	28	34	27	32	28	26	27	30
10			25	46	27	30	27	40	30	28	29	34		
12			25	52	29	29	27	44	27	44	27	38		
14	28	24	27	40	28	30	27	42	*	*	28	28		
16	28	38	26	41	26	44	26	50	26	40	26	40		
18	25	48	25	44	25	40	25	50	25	42	24	47		
20	24	52	22	56	22	42	24	45	23	38	23	49		
22	23	54	21	52	21	55	23	50	23	38	23	44		

*No data for this period due to temporary interruption of chart recorder.

inland about 250 m. Since lava is very porous, it was assumed that seawater filters though the rock and mixes with the input of fresh water gained from runoff and percolation. The influence of the ocean water is evidenced by the fact that the water level of the pools fluctuates in concert with each corresponding high and low tide. What appeared to be inconsistent, however, was the fact that salinity readings made during both high and low tide conditions only ranged from 3.5-3.9‰. The variability is probably not significant and is due to instrument error. Thus the inland water pools are essentially fresh water but the level within the pools is subject to the influence of the tides. The water temperature was 28°C.

Lists of the faunal and floral collections made can be found in the attached appendices. Table II summarizes the number of individual species collected and identified. A small portion of the collection, involving species of crustose algae, phytoplankton, and certain forms of invertebrates, have not been identified in time for this report, but will be reported on later.

Since time did not allow for a study of resident populations in terms of relative abundance and distribution, those organisms collected from the tidal pool diagrammed in Fig. 4 are denoted in the list for reference purposes in the event future studies are conducted.

Table II. A summary of the number of species collected from the various phyla of animals and plants.

Phylum	Common name	Number of species
Porifera	Sponges	7
Cnidaria	Sea anemones	3
	Corals	5
Platyhelminthes	Flatworms	1
Nemertinea	Ribbon worms	1
Sipunculida	Peanut worms	1
Echiuroida	Echiuroids	1
Annelida	Segmented worms	22
Arthropoda	Joint-footed animals	21
Mollusca	Mollusks	37
Echinodermata	Echinoderms	19
Hemichordata	Acorn worms	1
Chordata	Animals with backbones	26
Chlorophyta	Green algae	11
Phaeophyta	Brown algae	11
Rhodophyta	Red algae	18
Chrysophyta	Diatoms	42
		227

Wave exposure and general observations on the distribution of organisms are mentioned in the following section on discussion.

Discussion

At present, there exist an assortment of coastal habitat types, such as exposed areas, i.e., those areas receiving the brunt of wave attack, versus sheltered inlets; tidal pools formed on flat benches or created remote from the sea's edge as a result of a natural barrier restricting the water's return during low tide; calcareous sand beach areas, of which there were few, versus predominately rocky shores; and subterranean caves. Reports of brackish water pools in the vicinity were unfounded, although they no doubt do exist in certain areas along the Hawaii Volcanoes National Park coast.

Zonation of the flora and fauna at the shoreline is not obvious. In general zonation is not as well expressed in Hawaii as it is in other parts of the world where rocky shores prevail, such as along the coasts of New Zealand, New England, England and parts of Africa.[4] However, some zonation is obvious and can be observed, e.g., in areas of exposure vs. sheltered conditions. In exposed areas, where wetted surfaces reach up higher and extend further, there exist expanded belts of seaweeds, littorinids, barnacles, and sea urchins; in sheltered regions, these same species are compressed in distribution.

Certain species of seaweeds, e.g. Sargassum, appeared stunted in exposed areas, but of normal size in sheltered areas. This phenomenon is not uncommon, however, especially among certain fucoid species found in other parts of the World; it is apparently associated with the degree of wave pressure exerted on the plant relative to the extent of the algal surface presented. An alga with a broad surface area sujected to heavy wave conditions is more likely to be torn loose from the substratum than one much smaller in size.[3]

In general, among the benthic algal populations of exposed shores, brown algae appeared to be present in the largest biomass, followed by red algae and then green algae; on the other hand, the red algae had a greater diversity of species present. Additional observations and collections, however, will be necessary in order to establish more accurately the degree of quantitative relationships.

Although the remoteness and rugged conditions of the Hawaii Volcanoes National Park coastline provide a certain amount of natural protection from human impact, there still remain some regions, such as around Halapē and vicinity, that are visited by opihi collectors, in particular. Since there are no known records documenting the actual status of opihi populations from previous years, it is difficult to assess the extent of human impact with any degree of accuracy. On several occassions the author has personally

observed individuals carry large gunney sacks filled with opihi collected from the vicinity of Halapē.

The need for a fact-finding study to determine the current status of opihi populations and the effects of human intervention should be considered by the Hawaii Volcanoes National Park Resource Managers.

Ideally, extension of the Park's jurisdiction from above mean high tide to a predetermined point offshore would allow full protection for any marine organism found within these confines. If it is determined that opihi, for instance, along the Hawaii Volcanoes National Park coast is endangered, then the Park administration undoubtedly would be able to afford them protection.

Dr. A. Kay, University of Hawaii at Manoa is currently studying the status of the opihi in the Hawaiian Islands for the State Legislature. The CPSU UH is encouraging her to include the Halapē area in her investigation.

A large part of the Hawaii Volcanoes National Park coastline remains to be investigated and inventoried. There exist unique opportunities to study pioneer colonies of benthic organisms on recent lava flows. The effects of human impact along the coastal regions of Hawaii Volcanoes National Park are of major importance and should be investigated at some point in the near future. Once armed with sufficient data, Hawaii Volcanoes National Park officials will have a better understanding of the coastal margin and how it should be managed.

References

1. Master Plan. Hawaii Volcanoes National Park, Hawaii.

2. Personal communication with Russel Apple, historian for the Hawaii National Park Service.

3. Lewis, J. R. 1964. The Ecology of Rocky Shores. London: The English Universities Press, Ltd.

4. Stephenson, Anne. 1949. "The Universal Features of Zonation Between Tide Marks on Rocky Coasts". J. Eco. 37: 289-305.

APPENDIX A

THE COMMON AND SCIENTIFIC NAMES OF FISH SEEN AT HALAPĒ, HAWAII

by

Peter F. Major

1973

FAMILY	LOCAL NAME	COMMON	SPECIES
Acanthuridae			
	manini	convict tang	Acanthurus sandvicensis
	paku'iku'i	achilles tang	A. achilles
	maikoiko		A. leucopareius
	maiko		A. nigroris
			A. nigrofuscus
	na'ena'e	orange spot tang	A. olivaceus
	palani		A. dussumieri
	kole		Ctenochaetus strigosus
	lau'i-pala	yellow tang	Zebrasoma flavescens
	kala	unicorn fish	Naso lituratus
			N. brevirostris ?
Apogonidae			
	upapalu	cardinal fish	Apogon species (2)
Aulostomidae			
	nunu	trumpet fish	Aulostomus chinensis
Balistidae			
	humuhumu-nukunuku-a-pua'a	triggerfish	Rhinecanthus aculeatus
	humuhumu-'ele'ele		Melichthys buniva

Blenniidae			
		blennies	*Runula ewaensis*
			Entomacrodus marmoratus
			Cirripectus obscurus
			C. variolosus
Canthigasteridae			
		sharpbacked puffers	*Canthigaster jactator*
Chaetodontidae			
		butterfly fish	*Chaetodon miliaris*
			C. quadrimaculatus
			C. multicinctus ?
			C. lineolatus ?
			C. lunula
			C. unimaculatus
			C. auriga
	lau-wiliwili-nukunuku-'oi'oi	long-snouted butterfly fish	*Forcipiger flavissimus*

FAMILY	LOCAL NAME	COMMON	SPECIES
Cirrhitidae			
	piliko'a	hawkfish	Paracirrhites arcatus
	hilu piliko'a		P. forsteri
	piliko'a		P. cinctus
Diodontidae			
	'o'opu-kawa	spiny puffers	Diodon hystrix
Holocentridae			
	ala-'ihi	squirrel fish	Holocentrus lacteoguttatus?
	u'u, menpachi		Myripristis argyromus
Kuhliidae			
	aholehole	flagtails	Kuhlia sandvicensis
Kyphosidae			
	nenue	rudderfish	Kyphosus cinerascens
Labridae			
		wrasses	Labroides phthirophagus
	'aki-lolo, hinalea 'i'iwi		Gomphosus varius
	hinalea luahine		Thalassoma ballieui
	hinalea lauwili		T. duperreyi
			Coris sp.

Monocanthidae	'o'ili uwiwi	filefish	Pervagor spilosoma
Mugilidae	ama'ama	mullet	Mugil cephalus ?
Ostraciontidae	moa, mamoa waa	boxfish	Ostracion lentiginosus
Pomacentridae	maomao	damselfish	Abudefduf imparipennis A. abdominalis Pomacentrus jenkinsi Chromis leucurus
Scaridae	uhu	parrotfish	Scarus species (2-3)
Tetraodontidae	'o'opu-hue, Makimaki, keke	puffers	Arothron hispidus
Zanclidae	kihikihi	moorish idols	Zanclus canescens

FAMILY	LOCAL NAME	COMMON	SPECIES
Muraenidae			
	puhi	moray eels	*Gymnothorax* sp.
Mullidae			
	weke	goatfish	*Mulloidichthys samoensis*
	kumu		*Parupeneus porphyreus*

APPENDIX B

A LISTING BY PHYLUM OF ALL SPECIES COLLECTED IN THE HALAPĒ AREA BY F. W. BALL IN JULY 1975

ANIMAL KINGDOM

Phylum	Class (Subclass)	Family	Species
*Porifera (Sponges)	Demospongia	Tedaniidae	+Tedania ignis
		Spongiidae	Spongia spp.
		Adociidae	+Petrosia puna
		Tethyidae	+Tethya diploderma
		Spirastrellidae	Spirastrella keaukaha (coccinea ?)
		Halichondriadae	Rhaphisia myha
	Calcarea	Leucascidae	Leucetta solida
Cnidaria (Sea anemones and corals)	Anthozoa	Actiniidae	Cladactella ? manni
		Zoanthidae	Isaurus elongatus
			Palythoa tuberculosa
		Pocilloporidae	+Pocillopora meandrina

*Sponges identified by Dr. Sidney Townsley

+ Indicates those species collected from the tidal pool represented in fig. 2.

Phylum	Class (Subclass)	Family	Species
Cnidaria (Sea anemones and corals)	Anthozoa	Faviidae	+Leptastrea purpurea
			+L. bottae
		Poritidae	+Porites lobata
		Acroporidae	+Montipora flabellata
Playtyhelminthes (Flatworms)	Turbellaria		+(?) Paraplanocera spp.
Nemertinea (Ribbon worms)	Nemertea		Taeniosomma cingulatum
Sipunculida (Peanut worms)			Phascolosoma spp.
Echiurida (Echiuroids)			Anelassorhynchus inanensis

+ Indicates those species collected from the tidal pool represented in fig. 2.

Phylum	Class (Subclass)	Family	Species
*Annelida (Segmented worms)	Polychaeta	Phyllodocidae	**Phyllodoce madeirensis
		Syllidae	Typosyllis variegata
			T. magnopalpa
		Neriedae	**Platynereis dumerilii
			Nereis sp. ? waikikiensis
		Glyceridae	Glycera tesselata
		Eunicidae	**Eunice afra
			E. antennata
		Dorvilleidae	Dorvillea moniloceras
		Chaetopteridae	**Mesochaetopterus sagittarius
			Chaetopterus spp.
		Opheliidae	**Polyophthalmus pictus
		Sabellariidae	**Lygdamis nesiotes

* Annelid identification provided by Dr. Julie H. Bailey-Brock.

** Previously recorded from Halapē.

Phylum	Class (Subclass)	Family	Species
*Annelida (Segmented worms)	Polychaeta	Terebellidae	**Nicolea gracilibranchis
			Loimia crassifilis
		Sabellidae	Sabellastarte sp.
		Serpulidae	Hydroides norvegica
			Vermiliopsis torquata
			Protula atypha ? (empty tubes only)
			? Janua nipponica
			J. pagenstecheri
			Pileolaria koehleri
Arthropoda (Joint-footed animals)	Crustacea (Cirripedia)	Balanidae	Balanus a. amphitrite
	(Malacostraca)	Ligiidae	Ligia kauaiensis
		Peratanaidae	+Leptochelia dubia

* Annelid identification provided by Dr. Julie H. Bailey-Brock.

** Previously recorded from Halapē.

Phylum	Class (Subclass)	Family	Species
Arthropoda (Joint-footed animals)	Crustacea (Eurcarida)	*Alpheidae	+Alpheus latipes
			+A. clypeata
			A. pacificus
			A. brevipes
			Alpheopsis equalis
			Metalpheus paragracilis
			M. rostratipes
		Hippolytidae	+Saron marmoratus
		Xanthidae	+Trapezia maculata
		Stenpodidae	+Stenopus hispidus ('Ōpae kai)
		Ocypodidae	Ocypode ceratopthalma

* Alpheids identified by Mrs. Dora Banner.

+Indicates those species collected from the tidal pool represented in fig. 2.

Phylum	Class (Subclass)	Family	Species
Arthropoda (Joint-footed animals)	Crustacea (Eurcarida)	Grapsidae	Cyclograpsus granulatus
			Grapsus tenuicrustatus
			Percnon planissimum
		Scyllaridae	+Parribacus antarticus (Ulapapapa)
		Diogenidae	Calcinus latens
			C. laevimanus
			Clibanarius zebra
*Mollusca	Amphineura	Acanthochitonidae	Acanthochiton viridis
		Ischnochitonidae	Ischochiton petaloides
	Gastropoda	Pacellidae	Cellana exarata
		Trochidae	Trochus histrio
		Turbinidae	Turbo sandwicensis/ Leptothyra rubricincta

+Indicates those species collected from the tidal pool represented in fig. 2.

*Mollusk identification provided by Dr. Alison Kay.

Phylum	Class (Subclass)	Family	Species
*Mollusca	Gastropoda	Neritidae	Nerita picea
		Littorinidae	Littorina pintado
		Rissoidae	Rissoina miltozona
		Cerithiidae	Cerithium atromarginatum
			C. nesioticum
			C. placidum
			C. interstriatum
		Vermetidae	Serpulorbis variabilis
		Eulimidae	Balcis spp.
		Architectonicidae	Heliacus variegatus
		Cypraeidae	Cypraea mauritiana
			C. caputserpentis
			C. isabella

*Mollusk identification provided by Dr. Alison Kay.

Phylum	Class (Subclass)	Family	Species
*Mollusca	Gastropoda	Conidae	Conus abbreviatus
			C. hebraeus
			C. rattus
			C. lividus
		Mitridae	Mitra litteratus
		Muricidae	Thais harpa
			T. intermedia
			Drupa ricina
			Purpura aperta
			Maculotriton bracteatus
		Buccinidae	Pisania gracilis
		Umbraculidae	Umbraculum sinicum
		Atyidae	Atys semistriata
		Aplysiidae	Aplysia spp.
		Onchidiidae	Onchidium verraculatum

* Mollusk identification provided by Dr. Alison Kay.

Phylum	Class (Subclass)	Family	Species
*Mollusca	Pelecypoda	Arcidae	Acar plicata
		Isognomonidae	Isognomon costellatum
		Chamidae	Chama iostoma
Echinodermata (spiny-skinned animals)	Asteroidea (Starfish)	Asteropidae	+Asterope carinifera
	Ophiuroidea (Brittle stars)	Ophicomidae	Ophiocoma pica
			O. brevipes
			O. erinaceus
			O. insularia var. variegata?
		Amphuridae	Ophiactis savignyi
	Echinoidea (Sea urchins)	Echinometridae	+Heterocentrotus mammillatus ('ina'ula)
			Echinometra mathaei
			Colobocentrotus atrata (hā'uke'uke)

* Mollusk identification provided by Dr. Alison Kay.

+ Indicates those species collected from the tidal pool represented in fig. 2.

Phylum	Class (Subclass)	Family	Species
Echinodermata (spiny-skinned animals)	Echinoidea (Sea urchins)	Diadematidae	Diadema paucispinum (Wana)
		Cidaridae	+Eucidaris metularia
		Echinidae	Tripneutes gratilla (Ina)
			Lythechinus verruculatus
	Holothuroidea (Sea cucumbers)	Synaptidae	+Opheodesoma godeffroyi
		Holothuridae (Loli, Namako)	Actinopyga obesa
			A. mauritiana
			+Holothuria pervicax
			+H. cinerascens
		Stichopodidae	Stichopus chloronotus
Hemichordata (acorn worms)	Enteropneusta		Ptychodera flava
Chordata	Ascidiaceae	Didemnidae	Didemnum sp.

+ Indicates those species collected from the tidal pool represented in fig. 2.

Phylum	Class (Subclass)	Family	Species
Chordata	Osteichthyes (Bony fish)	Pomacentridae (Damselfishes)	Abudefduf abdominalis (Maomao, Mamo)
			A. imparipennis
			A. sinodus
			Pomacentrus jenkinsi
			Chromis vanderbilti
		Holocentridae (Squirrel fishes, Uukanipo)	Holocentrus sammara (Aliahi)
			+H. tiere
		Centhigasteridae (Sharpbacked Puffers)	Canthigaster amboinensis
		Antennaridae (Frogfishes)	Anthennarius moluccensis
		Labridae (Wrasses, Ea, Hinalea)	Thalassoma umbrostigma
			Labroides phthirophagus

+Indicates those species collected from the tidal pool represented in Fig. 2.

Phylum	Class (Subclass)	Family	Species
Chordata	Osteichthyes (Bony fish)	Cirrhitidae (Hawkfishes)	Cirrhitidae alternatus
		Soleidae (Flatfishes)	Aseraggodes kobensis
		Acanthuridae (Surgeonfishes, Maiii)	+Acanthurus sandvicensis (Manini)
		Mugilidae (Gray mullets)	+Neomyhus chaptalii (Uouoa)
		Blenniidae (Blennies, Pao'o)	Entomacrodus marmoratus
			Istiblennius zebra
			I. spp.
		Gobiidae (Gobies, 'o'opu)	? Ctenogobuius tongarevae
			Kellogella oligolepis

+Indicates those speices collected from the tidal pool represented in Fig. 2.

Phylum	Class (Subclass)	Family	Species
Chordata	Osteichthyes	Muraenidae (Moray eels, Puhis)	Gymnothorax flavimarginatus
			G. gracilicaudus
			G. hilonis
			Uropterygius knighti
		Chaetodontidae (Butterfly fishes)	Chaetodon miliaris

+ Indicates those species collected from the tidal pool represented in Fig. 2.

PLANT KINGDOM

Division	Order	Family	Species
*Chrysophyta	Coscinodiscales	Coscinodiscaceae	Actinocyclus subtilis
			Coscinodiscus granii
			C. nitidus
			Hemidiscus cuneiformis
			Podosira montagnei
	Aulacodiscales	Eupodiscaceae	Aulocodiscus orientalis
	Biddulphiales	Biddulphiaceae	Biddulphia aurita
			B. pulchella
			B. titiana
			Climacodium frauenfeldianum
			Triceratium favus
			T. formosum
			T. shadboltianum
	Diatomales	Fragilariaceae	Asterionella notata
			Climacosphenia moniligera
			Dimerogramma minor

* Diatoms identified by Dr. Gerald Prowse.

Division	Order	Family	Species
*Chrysophyta	Diatomales	Fragilariaceae	Licmophora communis
			L. ehrenbergii
			L. remulus
			Plagiogramma staurophorum
			Rhabdonema arcuatum
			Striatella unipunctata
			Synedra formosa
			S. fulgens var meditarranea
			S. hennedyana
			S. laevigata
			S. undulata
	Achnanthales	Achnanthaceae	Achnanthes brevipes
			A. longipes
			Cocconeis heteroidea
			C. scutellum
	Naviculales	Naviculaceae	Amphora binodis
			A. exigua
			A. pusio

* Diatoms identified by Dr. Gerald Prowse.

Division	Order	Family	Species
*Chrysophyta	Naviculales	Naviculaceae	Diploneis crabro
			Mastogloia fimbriata
			M. tenuis
			Navicula abruptoides
			N. cancellata
			N. oscitans
			Pleurosigma normanii
			P. strigosum
			Trachyneis aspera
			Tropidoneis lepidoptera var samoensis
		Auriculaceae	Auricula complexa
			A. intermedia
		Epithemiaceae	Rhopalodia gibberula
		Bacillariaceae	Nitzschia longissima
			N. panduriformis

* Diatoms identified by Dr. Gerald Prowse.

Division	Order	Family	Species
*Chryosphyta	Naviculales	Surirellaceae	Campylodiscus oceanicus
			C. sp.

* Diatoms identified by Dr. Gerald Prowse.

Macroscopic Benthic Marine Algae (Limu)

Phylum	Order	Family	Species
Chlorophyta (Green Algae)	Ulvales	Ulvaceae	*Ulva fasciata* (Pala, (Lipalahalaha, Lipalahaloha, Pakaiea, Pahapaha, Haloha)
	Cladophorales	Cladophoraceae	*Cladophora* spp.
		Anadyomenaceae	*Microdictyon japonicum*
			M. japonicum var. *laxum*
	Siponocladales	Valoniaceae	*Valonia aegagropila*
			Dictyosphaeria versluysii
		Boodleaceae	*Boodlea composita*
	Siphonales	Caulerpaceae	*Caulerpa taxifolia*
			C. racemosa
		Codiaceae	*Codium edule*
	Dasycladales	Dasycladaceae	*Acetabularia clavata*

Phylum	Order	Family	Species
Rhodophyta	Nemalionales	Helminthocladiaceae	Nemalion pulvinatum
(Red Algae)		Bonnemaisoniaceae	Asparagopsis taxiformis
		Chaetangiaceae	Galaxaura fasciculata
			G. rudis
		Corallinaceae	Amphiroa fragilissima
			Jania ? mexicana
			J. ungulata
			Porolithon onkodes
		Namaliaceae	Yamadaella cenomyce
	Cryptonemiales	Rhizophyllidaceae	Chondrococcus hornemanni
	Gigartinales	Phyllophoraceae	Ahnfeltia concinna
			(Akiaki, Koeleele, Ekaha-kaha)
	Ceramiales	Ceramiaceae	Griffithsia spp.
			Spyridia filamentosa
		Delesseriaceae	Martensia fragilis
		Dasyaceae	Dasya villosa

Phylum	Order	Family	Species
Rhodophyta (Red Algae)	Ceramiales	Rhodomelaceae	Amansia glomerata (Lipepeiao)
			Laurencia spp. (Lipuupuu, Lipalu, Lipeepee, Palewawae)
			Alsidium spp.

Phylum	Order	Family	Species
Phaeophyta	Ectocarpales	Ectocarpaceae	Giffordia breviarticulatus
(Brown Algae)	Dictyotales	Dictyotaceae	Dictyota friabilis
			Padina japonica
	Dictyosiphonales	Scytosiphonaceae	Colpomenia sinuosa
			Rosenvingea orientalis
	Ectocarpales	Ralfsiaceae	Lobophora variegata
		Chnoosporaceae	Chnoospora minima
			C. implexa
	Fucales	Sargassaceae	Sargassum echinocarpum
			(Kala, Kalalaunuinui)
			S. polyphyllum
			(Kala)
			Turbinaria oranta

BIBLIOGRAPHY*

Clark, Austin H. 1949. Ophiuroidea of the Hawaii Islands. Bernice P. Bishop Museum, Bull. 195, 133 pp.

Doty, Maxwell S. & Dieter Mueller-Dombois, 1966. Atlas for bioecology studies in Hawaii Volcanoes National Park. Hawaii Botanical Sci. Paper #2, University of Hawaii, Honolulu, Hawaii, 507 pp.

Edmonson, Charles H. 1946. Reef & shore fauna of Hawaii. Bernice P. Bishop Museum, Special Pub. #22, Bishop Museum, Honolulu.

Ely, Charles A. 1942. Shallow-water Asteroidea and Ophuiroidea of Hawaii. Bernice P. Bishop Museum, Bull. 176: 1-63.

Gosline, William A. & Vernon E. Brock. 1965. Handbook of Hawaiian fishes. University of Hawaii Press, Honolulu, 372 pp.

Hartman, Olga. 1966. Polychaetous Annelids of the Hawaiian Islands. Bernice P. Bishop Museum, Occas. Papers, 23(11): 163-252.

Hiatt, Robert W. 1954. Hawaiian marine invertebrates, a guide to their identification. University of Hawaii Press, Honolulu.

Hobson, Edmund and Edith H. Chave. 1972. Hawaiian reef animals. University of Hawaii Press, Honolulu, 135 pp.

Major, Peter R. "Brief summary of observations made at Halapē, Hawaii." Unpublished report, 1973.

Morris, Percy A. 1966. A field guide to shells of the Pacific Coast and Hawaii. Riverside Press, Cambridge. 330 pp.

Poulter, Jean L. 1963. The taxonomy and anatomy of some of the common polyclad flatworms of Oahu with notes on their biology. M.S. Thesis, University of Hawaii, 279 pp.

Tinker, Spencer W. 1965 Pacific crustacea. Charles E. Tuttle Co., Rutland, Vermont & Tokyo, Japan. 134 pp.

_____. 1967. Pacific sea shells. Charles E. Tuttle, Co., Rutland, Vermont & Tokyo, Japan. 230 pp.

* References used by the author to identify the organisms collected.

ACKNOWLEDGEMENTS

The author is particularly indebted to Glen Kaye of the National Park Service for his cooperation and assistance, and to the 147th Army Aviation Co. for the services that they provided.

The author is also grateful for the assistance provided by the following individuals: Drs. Julie Brock, Alison Kay, Sidney Townsley, Gerald Prowse and Arthur Reed, members of the U.H. faculty at Manoa, Mrs. Dora Banner, H.I.M.B. Staff, and U.H. graduate students William Magruder, Dennis Russell, and Jeff Hunt for their assistance in identifying portions of the marine collection; Drs. Robert Tilling and Donald Peterson, and Robin Holcum, of the USGS Volcanoes Observatory, for their cooperation, use of surveying equipment and the photographs of Halapē; Janice Dean, Diane Ohama and Dora Tsuha clerical assistance; Tamotsu Nakata for the figures; and Dr. Clifford Smith, who reviewed this report and offered helpful criticisms.

Finally, special thanks to personnel of the HIMB laboratory for determining the salinity of one of the sea water samples, and to the students and staff members of the Hawaii Youth Conservation Corps, who aided in the author's field work.