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PACIFIC ISLAND ECOSYSTEM WORKSHOP

SEPTEMBER 24-30, 1980 / HONOLULU, HAWAII

ABSTRACTS

RAYMOND S. TABATA, EDITOR

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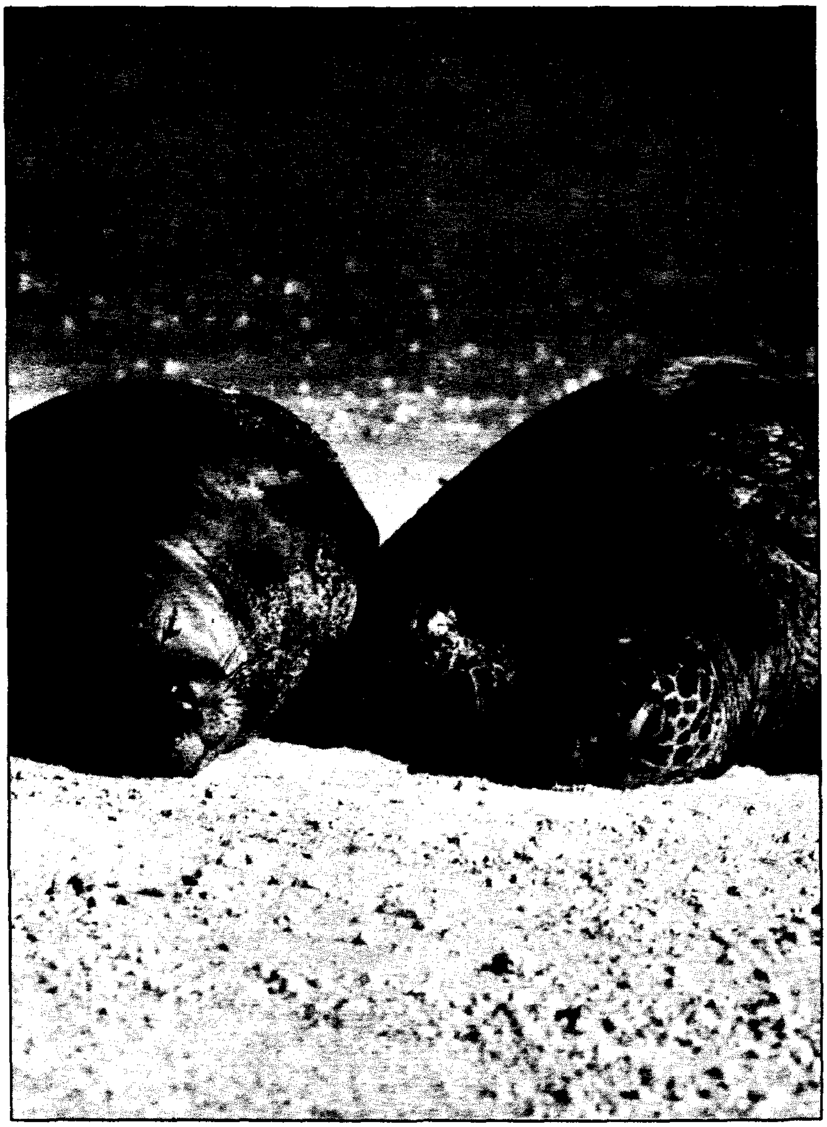

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PACIFIC ISLAND ECOSYSTEMS WORKSHOP ABSTRACTS

Raymond S. Tabata, Editor

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SEA GRANT COLLEGE PROGRAM

University of Hawaii
Honolulu, Hawaii

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Cover photo: Green turtle and Hawaiian monk seal basking on the beach at Whale-Skate Island, French Frigate Shoals in the Northwestern Hawaiian Islands. Photo courtesy of George H. Balazs.

PREFACE

Partly due to the sensitivity of island ecosystems to various types of disturbances, Hawaii and other Pacific islands are among the most intensely studied areas in terms of their terrestrial and aquatic ecosystems. This sensitivity is evidenced by the relatively large number of native plants and animals that are now considered threatened or endangered—especially in the Hawaiian Archipelago where many endemic taxa have evolved. Because Hawaii and other Pacific islands have unique environments, many researchers and resource managers are working to protect critical habitats and important ecosystems.

The Pacific Island Ecosystems Workshop, held September 29-30, 1980, disseminated current information to resource managers, scientists, environmental planners and consultants, and interested citizens. The workshop also introduced participants to information sources regarding island ecosystems and resource people in the community. In the five major topic areas—endangered species, terrestrial environments, reef environments, island streams, and wetlands—participants heard from specialists in these areas. There was also an opportunity to ask questions and discuss specific concerns. There was considerable interest in future workshops focusing on specific topic areas. Indeed, each of the major workshop sections could have been expanded into one or two-day workshops. Participants were also interested in having similar "overview" workshops periodically (e.g., every two years) to provide an opportunity for interested persons to share information and review the current state of island ecosystems management in Hawaii and Pacific islands.

Abstracts of presentations are included in the sequence presented at the workshop and in the form provided by the individual speakers. No effort was made to edit the abstracts except for typographical and grammatical inconsistencies. The appendix contains the workshop program and a directory of speakers for readers who may wish to pursue a particular presentation. Also, a list of registered participants is included. Finally, the appendix includes an illustration of information available in a shoreline inventory of Oahu.

Raymond S. Tabata, Editor

ACKNOWLEDGMENTS

On behalf of the sponsors, we thank all the speakers and moderators who contributed to the overall success of the Pacific Island Ecosystems Workshop. We also appreciate the interest and participation of the nearly 200 persons who attended the workshop.

We also thank Dr. John E. Byrne, Office of Biological Services, U.S. Fish and Wildlife Service, for his assistance and cooperation in organizing the workshop. Financial support from the U.S. Fish and Wildlife Service for workshop costs is gratefully acknowledged.

For the sponsors,

Peter Rappa
Ray Tabata
Bill Thomas

Sea Grant College Marine Advisory Program
University of Hawaii at Manoa
Honolulu, Hawaii

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ABSTRACTS

PACIFIC ISLAND ECOSYSTEMS PROJECT

PIE – A NATURAL RESOURCE DATA BASE ON PACIFIC ISLAND ECOSYSTEMS
John E. Byrne

This paper describes the Pacific Island Ecosystems work and the data base developed by the U.S. Fish and Wildlife Service to aid in research and management activities. The data base is primarily oriented to the inshore and terrestrial natural resource literature of the Pacific Area under U.S. jurisdiction. History of the project and potential applications of the data base are discussed along with a description of its availability.

U.S. Fish and Wildlife Service
500 NE Multnomah Street, Suite 1650
Portland, Oregon 97232

PACIFIC ISLANDS INFORMATION RESOURCES
Barbara K. Bird

In the search for information, scientists are no longer dependent on traditional resources; computers have been incorporated into many facets of research, and libraries are no exception. To supplement the millions of pages of printed material available in books and journals in Hawaii's libraries, computerized literature searches now facilitate speedy access to millions of citations.

In the field of environmental sciences, there are several machine-readable data bases which store thousands of citations on botany, zoology, marine science, pollution, management of ocean resources, etc. Our difficulty in Hawaii has been to identify and retrieve from those large files the materials most appropriate to our island needs.

This presentation examines the Pacific Island Ecosystem (PIE) data base in light of its specific design and also in relation to other data files which it may overlap or supplement.

College of Tropical Agriculture
University of Hawaii at Manoa

STATUS OF ENDANGERED SPECIES

STATUS OF ENDANGERED HAWAIIAN PLANTS
Derral Herbst

Five taxa of Hawaiian plants have been listed as endangered: *Vicia menziesii, Haplostachys haplostachya* var. *angustifolia, Stenogyne angustifolia* var. *angustifolia, Lipochaeta venosa,* and *Kokia cookei.* Four additional species are presently being reviewed by the Washington, D.C. office as candidate endangered species: *Euphorbia skottsbergii* var. *kalaeloana, Hibiscadelphus distans, Panicum carteri,* and *Remya mauiensis.* The *Euphorbia* reproposal has been published in the Federal Register and comments are being solicited. It probably will be our most controversial endangered plant because of its potential impact on the Barbers Point harbor. Listing packages are presently being compiled for two Diamond Head species: *Bidens cuneata* and *Schiedea adamantis,* to be followed this fiscal year by

Marsilea villosa and *Abutilon sandwicense*. A contract has been awarded to the Research Corporation, University of Hawaii, to develop listing packages for ten additional plants this coming year: *Abutilon menziesii, Achyranthes splendens* var. *rotundata, Argyroxiphum sandwicense* var. *sandwicense, Cyanea superba, Gardenia brighamii, Gouania hillebrandii, Kokia drynarioides, Mezoneuron kavaiense, Santalum freycinetianum* var. *lanaiense, Scaevola coriacea*. The 1975 Notice of Review has been updated and revised and tentatively is to be published in November, 1980.

U.S. Fish and Wildlife Service
Office of Endangered Species
Honolulu, Hawaii

STATUS OF ENDANGERED SPECIES: INSECTS AND OTHER TERRESTRIAL INVERTEBRATES

Wayne C. Gagne

Progress on the official recognition of terrestrial invertebrates as endangered or threatened species in Pacific Basin nations is reviewed. Hawaii lags in this respect for no terrestrial invertebrate has yet been officially declared as endangered, although two species of troglobites, a lycosid spider (*Adelycosa anops*) and a beachhopper (*Spelaeorchestria koloana*), as well as all species of the Oahu tree snail genus *Achatinella*, have been proposed to be added to the Federal endangered and threatened lists. The importance of terrestrial invertebrates in ecosystem functioning are indicated. Factors contributing to the endangerment of these species, especially in Hawaii, are reviewed. Studies on the status of these ca 8,000 species of organisms are only now being initiated. The author is the principal investigator of a 2-year contract from the Federal Office of Endangered Species to investigate this aspect for native Hawaiian arthropods to eventually produce a list of species that could be considered endangered or threatened. We are presently "truthing" pilot species groupings by selecting larger genera in each of the following ecological functional groups: aquatic or semiaquatic, anthophagous, phytophagous, predaceous, parasitic, and detritivorous. We are developing an "Index of Rarity" for each species and are computerizing the accompanying data base. We will proceed similarly with all the native arthropods. The possible "weighting" of the factors contributing to endangerment are discussed.

Department of Entomology
Bishop Museum
Honolulu, Hawaii

HAWAII'S ENDANGERED TERRESTRIAL BIRDS

J. Michael Scott

Hawaii has 21 species and subspecies of endangered land birds. They are found on the islands of Hawaii (7), Maui (5), Molokai (2), Oahu (2), and Kauai (6). The status of each of these species varies from extremely rare to common within a restricted and diminished range. With the recent surge of interest in and research on endangered birds by private, state, and federal agencies, we have available large amounts of information about the distribution, abundance, diseases, parasites, habitat preferences, and feeding ecology of these species. Using this information, interagency groups have put together recovery plans for most species.

The threats to the continued survival of Hawaii's endangered forest birds vary, but habitat elimination and degradation is an important factor for every species. Many of the forest birds are found in the same areas. In fact, they frequently co-occur with many other endangered plants, invertebrates, and Hawaii's only native land mammal. As an example of this, in the upper montane koa forest of Hawaii no fewer than five of seven endangered forest birds found on that island as well as the endangered Hoary bat and at least one of the endangered plants (*Vicia menziesii*) are all found in that single vegetation type. Given the large number of different endangered species which may occupy a single area, it is obvious that management strategies aimed at increasing the numbers of one species may well reduce the survival chances of another, equally endangered, species. Thus the soundest policy is for management for the long-term survival of naturally evolving forest communities. This requires that we think in terms of systems rather than single species. Island-wide programs need to be started in which the status of each major vegetational community is assessed. This type of analysis will allow early identification of threats and objective prioritization of our research and management efforts.

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THE ENDANGERED HAWAIIAN WATERBIRD RECOVERY EFFORT
Ronald L. Walker

The threats to the survival of the Hawaiian stilt, coot, and gallinule were brought to our attention in 1946 by Charles and Elizabeth Schwartz. They urged that habitat protection, marsh manipulation, and law enforcement be brought to bear on the problems facing the native Hawaiian waterbirds. Thirty years later the Hawaiian Waterbirds Recovery Plan (approved in June, 1978) recommended (1) habitat acquisition, development, and management, (2) reduction of inimical factors such as predation, poaching, and disturbance, (3) prevention or mitigation of the effects of new predators, diseases, and pollutants, (4) regular censusing and monitoring, (5) public information programs, and (6) possible captive rearing.

Progress to date in implementing these recommendations has been slow, but significant. The U.S. Fish and Wildlife Service now has five National Wildlife Refuges on Kauai, Oahu, and Molokai purchased (or leased), developed, and managed primarily for waterbirds. The state manages the Kanaha Wildlife Sanctuary on Maui, the Paiko Lagoon Wildlife Sanctuary on Oahu, and the Paradise Pacifica ponds on Kauai for endangered waterbirds. Cooperative agreements between the federal, state, and military levels of government account for waterbird refuges at the Kaneohe Marine Corps Air Station, Bellows Air Force Base, and Lualualei Naval Ammunition Station on Oahu. Designation of new waterbird sanctuaries or refuges at Mana (Kauai), Salt Lake (Oahu), Kealia (Maui), and Opaeula (Hawaii) are pending.

Intensified management on existing waterbird areas including water control structures, moating, artificial nesting islands, fencing, and predator control have increased water productivity significantly. Cooperative (federal, state, and private) censuses of over 265 waterbird habitats statewide, in the summer and winter monitor population fluctuations. Studies of the breeding biology, food habits, nesting success, habitat requirements, and movements of waterbirds have either been completed or are in progress.

Public awareness of the plight of Hawaiian waterbirds has increased with the provision of printed materials, illustrated talks by team members and other biologists, and the availability of the plan itself. Recently, the Honolulu Zoo in cooperation with the U.S. Fish and Wildlife Service and State Division of Forestry and Wildlife has successfully reared Hawaiian stilts in captivity and now has as endangered waterbird exhibit in place. Although these efforts have not yet resulted in removing any of the waterbirds from the endangered status, their situation at present is at least no worse than it was 30 years ago and there is optimism about their future if these programs continue.

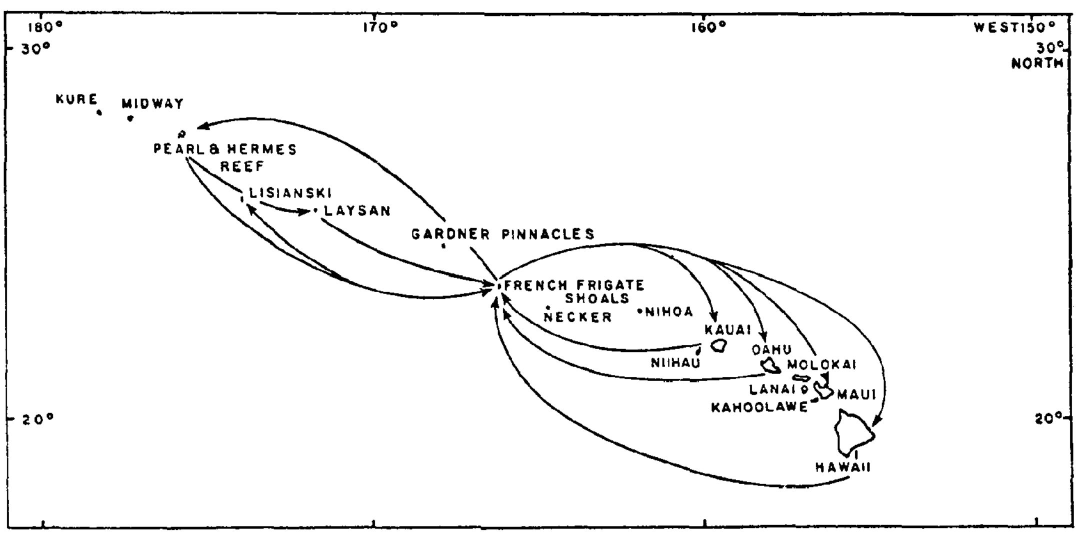
Department of Land and Natural
Resources
Division of Forestry and Wildlife
Honolulu, Hawaii

STATUS OF SEA TURTLES IN THE HAWAIIAN ISLANDS

George H. Balazs

A research program focused on the Hawaiian population of green turtles (*Chelonia mydas*) since 1973 has provided considerable insight on migrations, growth rates, food sources, predation, terrestrial basking, and reproductive ecology. A basic component of this work is the use of corrosion-resistant Inconel 625 alloy tags for the individual identification of adults at the breeding site of French Frigate Shoals and immature turtles captured at foraging pastures throughout the 2,450 km long Hawaiian Archipelago.

Both the range and size of the Hawaiian green turtle population have declined within historical times. As in other areas of Polynesia (as well as Micronesia and Melanesia), declines in sea turtles and other easily exploitable marine resources can be attributed to a breakdown in traditional conservation systems brought about by the introduction of cash economies, a decline of traditional authority, and the imposition of new laws and practices by colonial powers.



Reproductive migrations undertaken by green turtles (*Chelonia mydas*) in the Hawaiian Archipelago. Arrows represent 52 tag recoveries.

The hawksbill turtle (*Eretmochelys imbricata*) also occurs in coastal Hawaiian waters, but only in small numbers exclusively around islands at the southeastern end of the Archipelago. The leatherback (*Dermochelys coriacea*) is regularly recorded in offshore areas, but nesting is not known to take place within the Hawaiian chain.

All three species of Hawaii sea turtles receive legal protection under regulations of the Department of Land and Natural Resources, State of Hawaii, and the U.S. Endangered Species Act. A world conservation strategy recently developed for sea turtles offers potential for restoring populations to their former levels of abundance.

Southwest Fisheries Center Honolulu
Laboratory
National Marine Fisheries Service, and
Hawaii Institute of Marine Biology
University of Hawaii at Manoa

THE HAWAIIAN MONK SEAL, *MONACHUS SCHAUINSLANDI*

William G. Gilmartin

The Hawaiian monk seal, *Monachus schauinslandi*, population has experienced a significant decline in the past 20 years with present seal counts approximately one half of those of the late 1950's. Major reduction in seals at the west end of the Northwestern Hawaiian Islands (Kure, Midway, and Pearl and Hermes Reef) have occurred while the population at French Frigate Shoals has increased. Decreases have been attributed to human disturbance, shark predation, ciguatera, and parasites.

Monk seals have been observed breeding in the nearshore waters; they give birth from late December through mid-August (peaking between March and May) and remain with and nurse their pups for about 5 weeks. Seals are away from the islands for varying lengths of time depending on the season and age/sex class of the animal. They feed on fish and invertebrates associated with the inner reef and outer reef slopes and have been found to dive to 120 to 170 m.

Because of the endangered species of the Hawaiian monk seal, critical habitat has been proposed and a Hawaiian Monk Seal Recovery Team has been formed to develop a recovery plan for the species.

Southwest Fisheries Center Honolulu
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National Marine Fisheries Service,
NOAA

TERRESTRIAL ENVIRONMENTS

ISLAND ECOSYSTEMS: SOME ECOLOGICAL CHARACTERISTICS

Dieter Mueller-Dombois

During the International Biological Program (IBP), from 1971-76, a multidisciplinary research team from the University of Hawaii and Bishop Museum worked to discover some of the intrinsic biological organization aspects of island ecosystems. Emphasis was placed on the interaction of native and non-native species. Some 77 technical reports and an equal number of journal articles were published during this period. Late last year, a synthesis book on terrestrial island ecosystems was submitted from this group for review. It was accepted by an outside IBP review panel and will be published soon by Dowden, Hutchinson, & Ross (*Island Ecosystems: Biological Organization in Selected Hawaiian Communities.* IBP Synthesis Series, vol. 15. In press). Rather than summarize the findings described in this book, which would be hard to do in ten minutes, I will concentrate on a few points only:

a) A brief eco-geographic overview of island ecosystems,
b) Some distributional characteristics of island biota,
c) Ecosystem structure and function: the role of dominant endemics, and
d) Island ecosystem stability: impact of exotic species.

Department of Botany
University of Hawaii at Manoa

HISTORICAL CHANGES IN THE HAWAIIAN ENVIRONMENT
Harold St. John

Original vegetation. Forest and Upland Zones descended to lower levels. Salt Lake Crater, Diamond Head, Manoa, Maunawili, Hillebrand's Glen, Wahiawa Saddle.

Settlement by Hawaiians. Their impact on the vegetation.

Haole or foreign settlement, and their large impact. Urbanization, agriculture, forest fires, animals.

Bishop Museum
Honolulu, Hawaii

IMPACTS OF INTRODUCED ORGANISMS ON NATIVE HAWAIIAN ECOSYSTEMS
Frederick R. Warshauer

Ecosystems which have evolved on isolated oceanic islands tend to be very susceptible to changes in their environments, as natural traumas to which they have been exposed occur very infrequently over their evolutionary history. Whenever man has arrived on oceanic islands the scale of physical change and, more important, the rate of plant and animal introductions have increased enormously. In the Hawaiian Islands the recent rate of species introductions has increased to hundreds of thousands times the natural rate, providing an accumulation of traumas far in excess of most native ecosystems' abilities to absorb them.

Many of the organisms introduced into Hawaii by man are totally foreign to the types of ecosystems which have evolved in these islands. Ungulates, small mammalian predators, and ants are examples of animals which have brought enormous changes to Hawaiian ecosystems. As foreign organisms are generally introduced without their natural restraints of predation, parasitism, and disease, many have been able to quickly accrue enormous populations and to create impacts in Hawaii far greater than they would in their native environments.

Interactions among certain introduced organisms have created far more damage to the Hawaiian environment than they could have produced independently. Disturbance to native forests by ungulates provides habitats in which many introduced weed species can establish.

Many of these weeds are preadapted to withstanding browsing and trampling, and thus may now have a competitive advantage over unadapted native plant species. Diseases brought in by introduced birds were able to spread to vulnerable native birds after the introduction and establishment of the mosquito vector and the widespread creation of mosquito breeding sites by man and feral pigs.

Directly or indirectly the decline and disappearance of Hawaii's terrestrial biota is due primarily to the cumulative presences of introduced plants and animals. Any schemes for reversing or reducing current trends of degradation of native ecosystems need to incorporate some basic restraints on the imports and impacts of introduced species.

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THE MANAGEMENT OF INTRODUCED PLANTS AND ANIMALS IN NATIVE HAWAIIAN ECOSYSTEMS

James D. Jacobi

Introduced species of plants and animals pose a serious threat to the stability and long-term maintenance of the remaining native Hawaiian ecosystems and their endemic components.

To date, a majority of the noxious species control work in Hawaii has been directed toward threats to economic crops or pasturelands. Some of these control programs have had excellent success with species such as pa-nini cactus (*Opuntia megacantha*), Klamath weed (*Hypericum perforatum*), and Hamakua pa-makani (*Ageratina riparia*). It is equally important to strive for control of plant species such as banana poka (*Passiflora mollissima*), Koster's curse (*Clidemia hirta*), Himalayan raspberry (*Rubus ellipticus*), Fountain grass (*Pennisetum setaceum*), and even the guava species (*Psidium guajava* and *P. cattleianum*) which are seriously altering the structure and composition of certain native habitats. Similar efforts must also be directed towards controlling or preferably eliminating populations of feral animals, particularly pigs, goats, cattle, sheep, and Axis deer (*Axis axis*) from native habitats which are still relatively intact.

A serious management program with a statewide overview needs to be developed to reduce, and in some cases, eliminate the effects which introduced species have on the native biota. This program should parallel the current noxious species control program which is directed primarily towards economic crops. However it should include an expansion of the present restrictions on importation of certain potentially noxious taxa or life-forms into Hawaii, the current list of noxious species in Hawaii, and control efforts, so they include a realistic consideration for threats to the native ecosystems.

Unless such a management program is developed soon and implemented, the outlook for the preservation of what remains of Hawaii's unique and evolutionary important biota is not optimistic.

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AVIAN DISEASES

Charles Van Riper III
(presented by Dr. Clifford Smith, Department of Botany, University of Hawaii at Manoa)

Only *Plasmodium relictum* is found in Hawaii Volcanoes National Park and adjacent areas. Unexposed Hawaiian birds (for example, Laysan Finch) are more susceptible to malaria than our species that have been previously exposed to the parasite. The 'i'iwi has less resistance to malaria than does the 'apapane. The 'amakihi and 'oma'o are the most resistant endemic species. Introduced birds are also very resistant to the parasite. Yearly patterns of mosquito abundance and avian malaria were closely related. *Culex quinquefasciatus* is the primary vector of avian malaria in Hawaii. Steps need to be taken by resource managers to eliminate potential mosquito breeding sites.

Cooperative National Parks Resources
Studies Unit
University of California at Davis

REEF ENVIRONMENTS

THE CORAL REEF INVENTORIES – AN APPROACH TO INFORMATION DISSEMINATION

Eric B. Guinther

AECOS, under contracts to the U.S. Army Corps of Engineers (USACE), has been involved in the development and production of coastal zone information compilations concerned primarily with coral reefs and coral bottom assemblages. Presently completed or in progress are texts and accompanying atlases for the coasts of Oahu, Maui, and the islands of American Samoa (the latter sponsored by the American Samoa Coastal Zone Program). The coral reef inventory (CRI) approach encompasses the following:

1. Literature review and annotation;
2. Supplemental field surveys;
3. Descriptive text covering physical and biological aspects, water quality, historical and archaeological sites, and ocean related activities and uses; and
4. An atlas of maps on a scale of 1" = 500 feet illustrating the geographical relationships of the above.

Like other information storage and retrieval systems, the CRI text is stored on a magnetic medium (8" flexible disks) and can be accessed by computer. Unlike most other systems, the end product is a printed text. The text can be widely disseminated to prospective users lacking ready access to a computer, yet the information can be updated as required.

The CRI text does not supplant existing bibliographic storage/retrieval systems, but draws from and supplements them. Basically, the CRI text reduces into short statements the results of environmental studies and surveys, use oriented material and surveys, and information not easily handled by bibliographic systems (e.g., personal communications, file notes). From this material, essential (basically descriptive) information is extracted, properly credited, and integrated with information from other sources into a readable text. Storage and retrieval are based on geographical location and information type (see item 3. above).

For many users, the text may answer most or all questions regarding environmental concerns about a given area. For others, an extensive bibliography keyed to specific areas along the coastline will provide an efficient means of determining and locating existing source material. (See Appendix D for example of text.)

An example of a map section description taken from Part B (text) of the Oahu Coral Reef Inventory (OCRI) accompanies this abstract. Inquiries concerning this project should be directed to Dr. James Maragos at the Corps of Engineers (Honolulu District) or Eric Guinther at AECOS (46-132 B Kahuhipa Street, Kaneohe, Hawaii. Phone: 235-6494).

AECOS, Inc.
Kaneohe, Hawaii

CORAL REEF CONDITIONS IN THE PACIFIC

James E. Maragos

Major impacts to Pacific reefs under U.S. control have resulted from dredging, filling, sedimentation, sewage and thermal discharges, military activity, oil spills, overfishing, and fishing with poisons and dynamite. The patterns of impact differ considerably for each major island group, depending upon physiography, population growth and distribution, economic development, and degree of government aid and regulation.

Because of the complexity of economic development in Hawaii, major stresses to reefs have been quite varied, particularly on Oahu. Sources of reef impact have included municipal waste discharges, especially in confined lagoons or embayments, thermal discharges on shallow reef, high levels of freshwater runoff and sedimentation where land clearing and high rainfall are prevalent, dredging and filling for air and sea transportation facilities and residential development, and generally heavy fishing pressure on reef resources.

In American Samoa, land ownership patterns, and recent development of air and sea transportation facilities have concentrated major reef impacts in the Pago Pago Bay and Pala lagoon areas of Tutuila. Pago Pago is also subject to sedimentation, sewage discharge, dredging, filling, and occasional oil spills. Elsewhere road construction on steep hillsides has caused landsliding and resultant sediment stress to reef areas.

The Mariana Islands, especially Guam, have been subject to extensive military and harbor construction which has impacted reefs. Thermal and sewage stresses to Guamanian reefs have also been documented. Exposure to frequent typhoon damage has also aggravated human derived impacts.

Limited economic development and government aid in the Caroline Islands (Palau, Yap, Truk, Ponape, Kosrae) have caused different stresses to reefs. The high cost and limited availability of building materials for roads, airports, and buildings have led to preferential use of accessible, "free" reef materials which has resulted in serious impacts from dredging and filling. Rapid growth and the drift of population to urban centers have also intensified stresses to adjacent reefs, particularly port development, sewage discharge, and landfilling for residences, churches, etc. Fishing with dynamite has also been reported from the region.

The scarcity of land on the atolls of the Marshall Islands and other U.S. possessions (Palmyra, Wake, Midway, Johnston) has also spurred dredging and filling for residential areas, ports, runways, roadways, and building materials. Significant military activity and weapons testing since World War II have also caused considerable impact to reefs (e.g., Enewetak, Bikini, Kwajalein). Lagoon discharge of municipal sewage may also be a problem on certain atolls with high populations (e.g., Kwajalein and Majuro).

Haphazard economic development and government control, coupled with inadequate study and planning for reef resource use will tend to encourage further destruction of reef ecosystems in many parts of Micronesia. Burgeoning population growth and the islanders' dependence on reef resources for subsistence further underline the need for reef conservation. More organized government assistance and control, greater scientific study of reef impacts and resource inventories, and manpower training and development appear to be several of the major actions required to reverse existing trends.

U.S. Army Corps of Engineers
Pacific Ocean Division
Honolulu, Hawaii

REEF ENVIRONMENTS – EFFECTS OF SILTATION AND RUNOFF

Paul Bartram

Freshwater and sediment discharged from the land into reef environments are naturally-occuring "effluents" reaching the ocean from widely-distributed sources and in varying quantities related to rainfall patterns. Marine environments are not equally susceptible to the effects of land runoff. Two broad classes of marine environments can be recognized: (1) rough waters of open coasts where wave action and currents carry away the smaller, lighter particles of sediment and freshwater runoff is rapidly diluted and mixed; and (2) quiet waters of sheltered bays and other settings where waves and currents are too weak to rapidly dilute freshwater and small grains of sediment are deposited.

Sheltered reef environments receiving runoff from one or more perennial streams are generally inhabited by marine species which are adapted to large, natural fluctuations in water conditions. Persistent effects of non-storm or low flow is often detectable only near stream mouths. Detrimental effects to reef areas away from stream mouths are limited to extreme floods of infrequent occurrence, although such storms can be catastrophic (e.g., the damage to shallow marine life which occurred in Kaneohe Bay in May 1965).

Low-salinity water entering sheltered reef environments during flooding will tend to remain close to the surface, so that damage is usually limited to shallow reef organisms. However, reef flats are especially vulnerable to damage at low tide, when bottom dwelling organisms are closest to the water surface.

Extreme floods also have the potential for causing siltation of outer reef flats, where reef-building organisms (principally corals and coralline algae) are concentrated. Deposition of large volumes of flood-borne sediment may cover hard bottoms, altering them to soft bottoms for some period of time. Sediments provide no firm anchoring sites for reef organisms which attach to solid bottoms, nor do they provide cover sought by small fishes. Sediment loads insufficient to completely bury hard bottoms may nonetheless kill attached or encrusting organisms which are unable to survive more than a few millimeters of cover by silt. Bacteria quickly use up the supply of oxygen below the surface of mud deposits and oxygen-free (anaerobic) conditions develop. Death of reef organisms results from oxygen depletion.

Extensive removal of vegetation and erosion of watershed areas, coupled with installation of man-made drainage systems to speed runoff downslope and downstream, can result in more frequent repetition of flood damage by magnifying the effect of smaller storms.

AECOS, Inc.
Kaneohe, Hawaii

DESTRUCTIVE FISHING METHODS

Richard E. Brock

Coral reef fishes are a renewable resource that may be successfully exploited and with appropriate management, this pursuit may have little negative impact on the other components of the reef systems. Techniques of coral reef fisheries management are, however, in their infancy and much remains to be done. Man in his exploitation of the fishery resources of reefs has not only frequently overfished and depleted these resources but has developed a number of capture techniques that may affect the entire coral reef community. The two most deleterious of these destructive methods are the use of poisons and dynamite. Other techniques harmful to fish only, include the application of certain intoxicants specific to fish, use of small mesh monofilament nets and the loss of portable traps which continue to fish for years.

Hawaii Institute of Marine Biology
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IMPACT OF SEWAGE ON CORAL REEFS

Stephen V. Smith

The effect of sewage on ecosystems can be either nutritional or toxic (or both). The major input of sewage on most Pacific coral reefs is domestic, probably with relatively low levels of toxins, so the primary environmental effect is therefore likely to be nutritional. Thus, sewage input to reef ecosystems favors organisms, particularly plankton, with rapid nutrient uptake characteristics. The rate of net biomass production and either washout or sedimentation will approximate the rate of loading by the most limiting nutrient (usually nitrogen). Productivity will be sustained well above the loading rate by rapid internal nutrient cycling.

Growth of the plankton lowers water clarity and delivers nutrients to the reef benthos community largely by the sedimentation of particulate organic materials. Both decreased light and increased particulate fallout in response to sewage loading favor the buildup of a detritivore and filter-feeding epifaunal community which erodes reef rock. The conversion of hard substratum to unconsolidated materials can eventually limit the accumulation of infauna, epifauna, and reef fishes which depend on hard substrata for shelter. Some rapidly growing benthic algae may also flourish locally, apparently responding to both dissolved nutrients in the water and to elevated nutrient regeneration by the macro and microheterotrophs. However, the net shift of the reef benthos community seems to be generally towards heterotrophy.

Available evidence suggests that reef biomass is relatively rapidly responsive to sewage diversion. Responses of biological composition may be slower than biomass responses if the nutrient subsidy, cumulative heterotrophic biomass buildup, and consequent bioerosion have altered the substratum excessively.

Hawaii Institute of Marine Biology
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DREDGING IN CORAL REEF AREAS

John S. Ravina

Background: Reef areas in Hawaii and Pacific islands consist mainly of unconsolidated coral limestone debris to hard coral limestone or cemented limestone fragments. In our areas of jurisdiction various methods and equipment have been used to dredge reef areas.

Discussion: Review of cutterhead dredges, clamshell, dragline, spudding, explosives, and spiders.

U.S. Army Corps of Engineers
FM&S Branch
Honolulu, Hawaii

THE ENVIRONMENTAL EFFECTS OF DREDGING AND QUARRYING ON PACIFIC ISLANDS

George S. Losey Jr.

Dredging and quarrying operations must destroy or drastically alter existing habitats. Past dredging operations on tropical Pacific islands offer examples of everything from widespread and long lasting destruction to the creation of new productive habitats that are of use to man.

Meck I. (Kwajalein Atoll) is typical of destructive subtidal dredging in an open lagoon site. Impact probably resulted both from the methods and the scale of the operation. From 1964 to 1969, suction dredge and causeway dragline operations removed nearly all of the lagoon terrace. In 1972, the remaining slope was primarily flat pavement with precipitous drops to a sandy rubble bottom. Reefs downstream of the dredging operation were heavily impacted for about 3/4 mile.

Pou Bay (Moen I., Truk) illustrates destructive dredging of an area with poor circulation. Continuous dredging of a sheltered inlet has resulted in a large silt covered basin up to 8 m deep. Recolonization by marine life over a 5 to 20 year period was restricted to algae and a few fish.

Harbor dredging at Illeginni I. (Kwajalein Atoll) shows far less destruction of habitat. Siltation damage to the reef was limited to a 10 to 20 m band on either side of the dredge site. Good planning and water circulation probably prevented massive damage.

Reef flat quarries can add valuable habitat that is useful for subsistence fishing. Shallow quarries that include much cover and consolidated material such as at Enewetak Atoll are quickly recolonized. Deeper quarries with a largely sand and silt bottom appear to discourage recolonization and form little more than a sheltered swimming pool.

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ISLAND STREAMS

ECOLOGY OF PACIFIC ISLAND STREAMS

Robert A. Kinzie III

There are two underlying concepts around which we must construct our ideas of the Pacific island streams. The first is that introduced by the limnologist H.B.N. Hynes; the study of a stream cannot be considered apart from the valley in which the stream lies. That is, streams and their drainage areas are really a single entity and must be viewed as such. The second concept relates to the body of thought stemming from the recent interest in island biogeography. Certain sorts of habitats or systems, e.g., caves, mountain tops, lakes, and streams are thought to be analogous to true islands in that they are separate spatially and may represent replicates in the long term experiments carried out by the adaptive process.

With these foundations laid we may begin to construct our framework of Pacific island stream ecology. The first concept, the stream in its valley, can be broadened to include, in many cases, the entire island geologic history and the surrounding oceanic and meteorological processes. Pacific island streams are strongly influenced by the processes that form, shape, and ultimately consume the islands where they flow. The streams in turn are primary forces shaping the islands. From the viewpoint of island biogeography, Pacific island streams can be thought of as "islands on islands."

Turning to more concrete aspects of the ecology of island streams, the first striking thing is that the macrofauna of Pacific island streams is not particularly rich except for the predictably striking insect component. Primary division freshwater fishes are of course lacking and, except near the margins of the Pacific Plate, the fishes are characteristically derived from close marine ancestors. Much the same can be said for the molluscan and crustacean component of Pacific island streams. While there is a fairly diverse fauna of relatively inconspicuous amphipods and isopods and several groups of small snails, the larger invertebrates like the fishes are distinctly marine in their affinities. In fact, in Hawaii, where Dr. J. Maciolek has pioneered limnological studies, it has been shown that all the native stream fishes, the large neritid snail and both large native crustaceans are diadromous. That is, all require that their larvae spend a period of their lives as members of the marine planktonic community. After this larval period in the sea, the length of which is still a mystery, the juveniles return to a stream and make their way back up to the higher stream reaches where they mature and renew the cycle. The evolutionary link with the sea is thus renewed in each individual as part of an ecological chain.

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ENVIRONMENTAL CONDITIONS OF PACIFIC STREAMS
John I. Ford

Pacific island streams are perhaps the least well known ecosystems within Oceania. Recent field studies conducted by the Fish and Wildlife Service and the Army Corps of Engineers have characterized the physiochemistry and biology of principal watersheds in Hawaii, Guam, and American Samoa. These investigations have given particular attention to the effects of land and water uses and watershed development upon the indigenous fauna of these areas.

The most common types of cultural modifications to stream courses throughout the Pacific are surface catchments and culverts under roads. Channel alterations and dewaterment have seriously affected Hawaiian stream ecosystems; roughly 15% of the 365+ perennial streams in Hawaii have suffered some form of habitat destruction (over 85% of Oahu's streams have been so impacted). Large-scale dewaterment seriously threatens remaining streams and endemic stream fauna on Oahu and Maui islands, in particular. Increasing urban development and population growth in Southern Guam is creating similar pressures for water supply and flood control. The relatively tiny streams (less than 1 sq mile watershed area) of American Samoa support the highest diversity of aquatic life of all Pacific streams which have been investigated in detail. The existing level of development in American Samoa has not led to significant degradation of streams and loss of indigenous fauna. However, recent road construction has destroyed some stream habitat through excessive soil erosion.

Future research efforts on Pacific island streams should include the high islands within the Trust Territories, and the Northern Mariana Islands. Wise management of these unique aquatic resources can be effected through adoption and enforcement of instream flow and water quality standards, and sound land use policies.

U.S. Army Corps of Engineers
Pacific Ocean Division
Honolulu, Hawaii

EFFECT OF STREAM HABITAT ALTERATION ON FISHES AND DECAPOD CRUSTACEANS
Amadeo S. Timbol

Tropical, insular streams such as those in Hawaii are especially vulnerable to modern cultural inroads. Native stream fishes and crustaceans are diadromous. These animals need suitable pathways from the stream to the ocean and back to the stream.

Four major types of channel alteration have been recognized in Hawaii: lined channel, vegetation removed-channel realigned, revetment, and culverts. Altered streams were found to harbor more species than unaltered streams. A high percentage of species in altered streams are introduced, while a high percentage of native species characterized unaltered streams. The most pernicious of these channel modifications is the lined channel, a structure whereby concrete cement replaces both natural banks and stream bed. In such structures, water attains temperatures up to 36°C. Laboratory studies showed that lethal temperatures in which there is a 50% mortality (LD_{50}) in native fishes and crustaceans are between 34° and 36°C. Introduced species such as poeciliids and tilapia begin to die at higher temperatures (LD_{50} at 41° and 43°C, respectively).

Habitat alterations favor introduced species (mostly trash fishes) over native species. Several of the native species have both economic and intrinsic values (e.g., nakea goby, *Awaous stamineus*).

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HAWAIIAN STREAMS: AN ASSESSMENT OF USE RELATIVE TO DIVERSION OF STREAMFLOW

L. Stephen Lau

1. Beneficial Uses of Hawaiian Streams

There are four major beneficial uses of Hawaiian streams whose reaches are beyond ocean tidal influence: (1) supply water for irrigation, and domestic and public consumption; (2) transport storm-water runoff; (3) supply energy generation for hydroelectric plants and water for cooling purposes for thermal electric plants; and (4) provide the environment of aquatic life, recreational activities, and aesthetic enjoyment.

The use classifications (2), (3), and (4) are in-stream (while the first use classification is stream) use. Classifications are not always clear cut, such as thermal electric plant which diverts water from the stream for use and returns the water to stream after use.

2. Historical development and trend of streamflow diversion

- Streamflow diversion has been historically practiced by Hawaiians for crop irrigation. Low, stone dams were built in streambeds to raise the level of water which could then flow into auwais (1894 Thrum's Hawaiian Annual).

- The development of large-scale, sugarcane cultivation required a more extensive system and source of water for irrigation that led to streamflow diversion and transport. An example is the Hamakua Ditch, which was completed in 1878 and which flows about 2 miles inland from and parallel to the northern coastline of Central Maui. This ditch is 17 miles long and has a 60-million gallons per day (mgd) capacity.

- Prior to the first drilling of an artesian well on 22 September 1879, water from streams was one of the principal consumption sources for domestic and public. Today, public and private water purveyors prefer groundwater sources, rather than streamwater, for a potable water supply because of the superior water quality. Although this dependence on groundwater sources will continue, stream water is again regarded as an important alternative water source for areas where groundwater sources are nearing full exploitation, such as the Pearl Harbor aquifer. Thus, diversion of streamflow can be expected to continue and to even increase. (The State Water Commission has identified streams in windward Oahu, especially Kahana and Punaluu, for possible surface water development for domestic and public drinking water—with the provision that such development will be consistent with environmental considerations.)

3. Statistics of Hawaiian streamflow diversion

- Two inventories of statewide streamflow diversion were published in 1975: the Nakahara inventory reported by the U.S. Geological Survey and the Hawaii State Division of Water and Land Development, and the report of the Hawaii Water Resources Regional Study (HWRRS). Although the two sets of data are not always consistent, they are fairly close except for the Oahu data.

- The total streamflow diversion (in mgd) are large for three neighbor islands, Kauai (330), Maui (290), Hawaii (140); and small by comparison for Oahu (40 to 60) and Molokai (3 to 0). It should be noted that insofar as total quantity for each island is concerned, streamflow remains plentiful after diversion. The gross diverted amount does not exceed 35% of the total flow for Maui, which practices the greatest diversion; 25%, Kauai; 20%, Oahu; 7%, Hawaii; and 17%, statewide. Overall statistics like these are rather meaningless because ecological flow requirements must be dealt with on a stream-by-stream basis.

- Improvement of the data base is necessary for the diversion quantity and the streamflow quantity for specific streams of concern.

4. Hydrology of Hawaiian streams for diversion and in-stream uses

- Streamflow hydrology has been analyzed for the highest and lowest values of discharge over a given period of time, depending on the purpose of the study. An extreme high, which is the highest discharge at an instant during a year, has been the basis of flood peak-frequency analysis. An extreme low is the lowest instantaneous discharge during a year or during a certain designated portion of a year. From an ecological viewpoint, the latter is important because fish and most aquatic animals cannot survive without water for even a few moments. For water resources management purposes, instantaneous, non-zero lowest discharge can be obtained by probabilistic analysis based on and projected beyond the historical records. Because analysis of this kind has not but should be made, research is warranted to develop the appropriate methodology for such an analysis.

- Tantamount to the relevance of the hydrologic analysis of available streamflow is the determination of the biological requirements for instream flow to sustain and propagate aquatic life. These requirements can be hydraulic parameters, such as discharge, velocity, turbulence, and water depth for the species to be protected. Research to obtain such data for base flow requirements was only recently initiated, and only on a minor scale, by the University of Hawaii Water Resources Research Center. These studies should go beyond hydrologic characteristics, such as substrate composition, exposure to sun, and vegetative canopy over the stream.

5. Hawaiian stream-water quality for diversion and in-stream uses

- Hawaiian stream-water quality as a whole is inadequately characterized for both the water and the sediment. The data base is quite narrow: records date from approximately the early 1970s and only for a few streams—almost all on Oahu.

- The Hawaii streams studies show generally (1) considerably high dissolved oxygen concentration, and satisfactory pH values relative to water-quality standards; (2) the problem water-quality factors of suspended solids, turbidity, nitrogen and phosphorus, and bacterial indicators; and (3) the protected, undeveloped forest reserves generating substantial concentration of the above problem water-quality factors which exceed those from sugarcane fields and are causal factors for frequent exceedance of water-quality standards during wet weather.

- For ecological in-stream flow purposes, hydrological, water quality, and biological studies should be conducted as essential components of a comprehensive project. This approach is seldom done and is urgently needed.

6. Problem-solving strategies including research needs: in-stream uses and values of water

There are many economically, socially, and environmentally beneficial uses of water which entail the diversion of either groundwater or surface water from streams. The most significant of these include domestic, agricultural, and industrial uses. There are also, however, many beneficial in-stream uses of water, including fauna and flora habitat, recreation and aesthetic enjoyment, and maintenance of stream water quality.

Hawaii's laws do not specifically provide for the protection or preservation of water for in-stream uses. Therefore, under conditions of increasing stress on water supplies, the need to leave sufficient water for in-stream use is often given inadequate consideration. Greatly contributing to the problem of in-stream water use is lack of information on minimum flow and quality requirements that are necessary to maintain stream ecosystems and recreation and aesthetic values.

Thus, to treat the overall problem of in-stream uses and the values of water, several strategies are suggested. These include (1) identifying the competing in-stream and out-of-stream uses, (2) inventorying these uses for all such streams within the state, (3) establishing minimum flow and/or quality requirements for the various in-stream uses, and (4) establishing a system of balancing the values of diverted streamflows against the values of flows left undiverted for the maintenance of in-stream uses. The following detailed outline presents steps in the analysis to accomplish these strategies.

A. Identify and Inventory In-Stream and Out-of-Stream Uses
   1. Identify streams and reaches of streams to be included
   2. Develop criteria for inclusion of particular uses for each stream course
   3. Inventory out-of-stream uses for each stream course (ground-water and surface water diversion)
   4. Inventory in-stream uses for each stream course (ecological, aesthetic and recreational, hydroelectrical, groundwater recharge, maintenance of water quality)

B. Out-of-Stream Uses
   1. Determine value for out-of-stream uses for each stream course

C. Ecological Criteria
   1. Identify critical or indicator species in each stream course
   2. Evaluate flow and/or quality requirements for each indicator species
   3. Establish relationship between indicator species and other desirable species in stream
   4. Investigate the methodology for establishing the value of indicator species and/or other significant species

D. Recreation and Aesthetic Values Criteria
   1. Evaluate flow and/or quality requirements
   2. Investigate the methodology of establishing the value of various recreational and aesthetic uses

3. Investigate alternative sources of recreation and aesthetic experience
   a. Watershed reserves (recreation vs. closed conservation)
   b. Flow augmentation by reclaimed waste effluent

E. Other In-Stream Use Criteria
   1. Hydroelectric development
   2. Flow augmentation by reclaimed effluent including thermal waters
   3. Groundwater recharge through stream channel
   4. In-stream agriculture (taro, watercress)

F. Legal and Management Considerations
   1. Define legal status of various in-stream uses
   2. Define legal rights of access for recreational and aesthetic uses
   3. Determine management and enforcement agencies for various in-stream uses
   4. Clarify public vs. private ownership

Water Resources Research Center
University of Hawaii at Manoa

WETLANDS

WETLANDS — WATER AND NUTRIENT BUDGET

David Creer

One important function of wetland communities is to act as a buffer at the land/water interface. This buffering activity is manifested in removal of suspended solids and nutrients washing out of upland watersheds and can be illustrated by calculating water, suspended solids, and nutrient budgets for major influents and effluents to the community. Using Kawainui Marsh as an example it can be shown that sewage effluents are the major inputs of phosphorus and nitrogen (95% and 88%, respectively). Kawainui Marsh retains 72% of influent phosphorus but only 12% of influent nitrogen. (Wetlands, such as Kawainui, have some potential for nutrient scrubbing of sewage effluents.) Unfortunately, the capacity for nutrient removal of Kawainui Marsh is insufficient to prevent most of the nitrogen of sewage origin from entering Kailua Bay. This excess nitrogen passing through the marsh has substantial potential for fertilizing Kailua Bay inasmuch as nitrogen is the limiting nutrient in nearshore marine environments. In the future, water quality problems experienced in Kailua Bay will probably be widely attributed to the Mokapu outfall. However, the nutrient budget of Kawainui Marsh suggests that Kawainui Canal is a more likely source for unwanted fertilization of Kailua Bay.

AECOS, Inc.
Kaneohe, Hawaii

WETLAND VEGETATION AND THE NATURAL HISTORY OF HAWAII'S WETLANDS

Margaret E. Elliott

The Hawaiian Islands host relatively few areas of wetland and few native coastal wetland plant species compared with other major Pacific islands. This is due in part to physical geographic characteristics and Hawaii's unique isolation from other land masses. Inland, porous soils, steep topography, and a high rate of organic matter decomposition prevent the accumulation of watersaturated mineral or organic soils and corresponding water-tolerant flora except in areas of high rainfall, cool temperatures, high water table, and/or impeded drainage. Along the coasts, high wave energy, porous substrate, and narrow intertidal zones restrict coastal wetland development to older, more protected island shores. Despite these limiting factors, wetlands can and do occur in Hawaii, regrettably less so today than in the past. Their occurrence and vegetative formations provide interesting clues to the natural history of these isolated Pacific island ecosystems. In the upland bogs, for example, rare and unusual plant assemblages have evolved in a harsh, wet, cloudy, cool environment. Native plant and animal species may still be found in these areas despite significant damage wrought by exotic plant and animal introductions. Low-elevation inland and coastal wetlands, on the other hand, bear a history of disturbance and alteration since earliest human occupation of the Hawaiian Islands. Their plant assemblages have developed from originally few natives adapted to coastal wetland conditions, followed by early use of wetlands for agriculture and aquaculture; rapid niche occupation by introduced species; and subsequent deterioration or destruction of many areas through weedy infestation, sedimentation, drainage alteration, and filling.

Vegetation, as a physical expression of wetland conditions, is useful today in determining the significance of wetlands as wildlife habitat, organic producer, water purifier, aesthetic component, or laboratory for scientific observation. There is great potential for enhancement of wetlands through careful manipulation of vegetation. While they may do little to recover lost areas, it offers hope that Hawaii's wetlands will continue to be a natural legacy for generations to come.

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WATERBIRDS AND HABITAT CONDITIONS IN HAWAII

Richard A. Coleman

A major shift in wetland habitat management is underway in the 1980's. The earlier policy of land acquisition and custodial maintenance of these wetland areas is evolving into an active habitat management effort. Federal, state, and county governments are coordinating efforts to determine optimum habitat requirements of the endangered Hawaiian waterbirds and to effect habitat modifications to reflect these findings. Current key management efforts by the State Department of Land and Natural Resources at Kanaha Pond on Maui and by the U.S. Fish and Wildlife Service at Pearl Harbor and James Campbell National Wildlife Refuges on Oahu, reflect this commitment to improve the productivity and achieve the optimum use of these vital wetlands. Research efforts to better clarify habitat management objectives include a major study of Hawaiian stilts and Hawaiian coots, a behavioral ecology study of the Hawaiian gallinule, a controlled Koloa/mallard hybridization study, and a Hawaiian stilt captive rearing study. Improvement to waterbird census techniques are being implemented to better evaluate productivity. Additional studies are needed to answer current management questions, including predation of young waterbirds by black-crowned night heron, waterbird predation in aquaculture and wetland agriculture areas, and field assessments of the Koloa hybridization threat by feral mallards.

U.S. Fish and Wildlife Service
Honolulu, Hawaii

WATERBIRDS AND HABITAT CONDITIONS IN THE PACIFIC

Robert J. Shallenberger

This paper is somewhat arbitrarily restricted to a consideration of waterbirds and habitat on islands of the Pacific, excluding Hawaii, which are under some form of United States jurisdiction. Principal species involved include resident and/or migratory birds of the families Ardeidae (herons, egrets), Anatidae (ducks/geese), Rallidae (rails, coots, gallinules), Charadriidae (plovers), and Scolopacidae (sandpipers, snipes). Wetlands are scarce on low, coralline islands and on high islands are confined largely to coastal areas where a long history of human habitation has left little habitat unaltered by agriculture or other activities. Effective conservation of waterbirds and dwindling habitat on Pacific islands is hindered by the lack of adequate baseline data, limited regulatory authority, diverse socio-cultural conditions, limited funding resources, and the uncertain political status of territories. These constraints necessitate a somewhat innovative, shotgun approach to management of wetlands and waterbirds which will include baseline research, local/federal regulatory control, environmental education, habitat acquisition, project mitigation, landowner assistance, and captive propagation. Examples are drawn from ongoing programs in American Samoa, Guam, and the Northern Marianas.

U.S. Fish and Wildlife Service
Honolulu, Hawaii

APPENDICES

Appendix A. Workshop Program

Program

MONDAY, SEPTEMBER 29, 1980

8:00 REGISTRATION

8:30 INTRODUCTION AND WELCOME: J. Davidson, Director, UH Sea Grant College Program

PACIFIC ISLAND ECOSYSTEMS PROJECT

8:40 Project background: J. Byrne, USFWS
National Coastal Ecosystems Team Activities: R. Stewart, USFWS

9:00 Overview of Status Papers: J. Hirota, HIMB

9:30 Pacific Islands Information Resources: B. Bird, UH Hamilton Library

9:45 P.I.E. Data Base Retrieval Demonstration: B. Bird

10:15 MORNING BREAK

10:30 STATUS OF ENDANGERED SPECIES
- Moderator: S. Conant, UH General Science
- Endangered Flora: D. Herbst, USFWS
- Insects and Land Snails: W. Gagne, Bishop Museum
- Terrestrial Birds: M. Scott, USFWS
- Waterbirds: R. Walker, State DLNR
- Marine Turtles: G. Balazs, HIMB/NMFS
- Marine Mammals: W. Gilmartin, NMFS

12:00 LUNCH
- Luncheon Speaker: D. Coggeshall, Pacific Islands Administrator, USFWS, "Future Fish and Wildlife Service Activities in the Pacific"

1:00 TERRESTRIAL ENVIRONMENTS
- Moderator: C. Lamoureux, UH Botany
- Island Ecosystems—Some Ecological Characteristics: D. Mueller-Dombois, UH Botany
- Historical Changes in the Hawaiian Environment: H. St. John, Bishop Museum
- Impact of Feral Animals and Introduced Plants: R. Warshauer and J. Jacobi, USFWS
- Avian Diseases: C. Van Riper, Cooperative National Parks Resources Studies Unit, UC/Davis (presented by C. Smith, UH Botany and CNPRSU)

2:45 AFTERNOON BREAK

3:00 REEF ENVIRONMENTS
- Moderator: E. Reese, UH Zoology
- Reef Resource Inventories: E. Guinther, AECOS
- Reef Conditions in the Pacific: J. Maragos, US Army Corps of Engineers
- Effects of Siltation and Runoff: P. Bartram, AECOS
- Destructive Fishing Methods: D. Brock, HIMB
- Sewage Impacts: S. Smith, HIMB
- Dredging Technology: J. Ravina, US Army Corps of Engineers
- Dredging Impacts: G. Losey, HIMB

5:00 NO-HOST COCKTAILS

TUESDAY, SEPTEMBER 30, 1980

8:30 ISLAND STREAMS
- Moderator: D. Cox, UH Environmental Center
- General Ecology: R. Kinzie, UH Zoology
- Conditions of Pacific Streams: J. Ford, US Army Corps of Engineers
- Effects of Habitat Alteration: A. Timbol, Cooperative Fisheries Unit
- Water Diversion: L.S. Lau, UH Water Resources Research Center

10:00 MORNING BREAK

10:15 WETLANDS
- Moderator: L. Stemmermann, UH Botany
- Hydrologic and Nutrient Budget: D. Crear, AECOS
- Wetland Vegetation: M. Elliott, UH Geography
- Waterbirds and Habitat Conditions in Hawaii: R. Coleman, USFWS
- Waterbirds and Habitat Conditions in the Pacific: R. Shallenberger, USFWS

12:00 LUNCH
- Luncheon Speaker: A. Ziegler, Bishop Museum, "Prehistoric Birds of Hawaii"

1:00 NATIONAL WETLANDS INVENTORY
- History, Status, and Future of NWI: D. Peters, USFWS

1:30 WETLAND CLASSIFICATION SYSTEM
- Part I: Introduction to Hierarchy of the System: D. Peters

2:30 AFTERNOON BREAK

3:00 Part II: NWI Mapping Procedures: D. Peters

4:45 CLOSING REMARKS FOR WORKSHOP: J. Byrne

5:00 ADJOURNMENT

Appendix B. Directory of Speakers and Moderators

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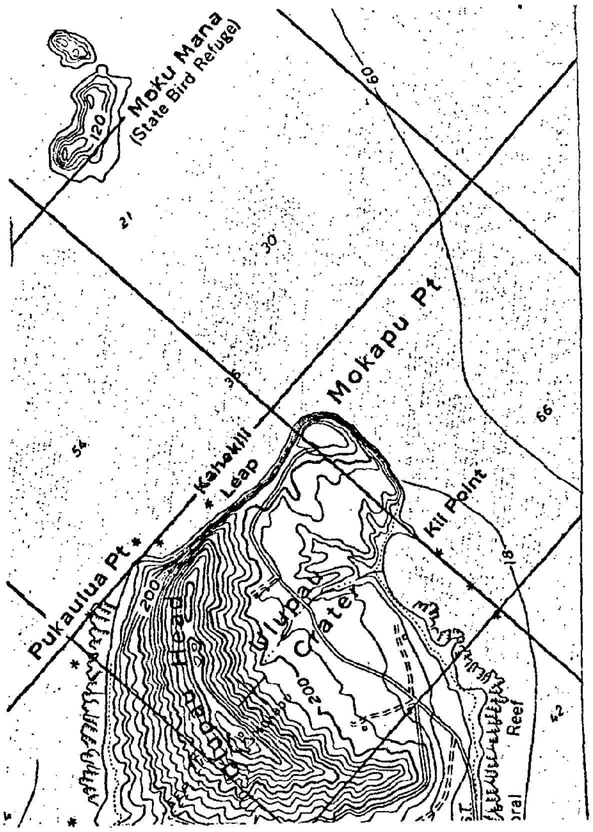

MAP 11 ULUPAU

(ULUPAU HEAD, MOKAPU POINT, PUKAULUA POINT, MOKU MANU)

- Mokapu Quadrangle
- POD, 1:6000 BW, 2:

PHYSIOGRAPHY

ULUPAU HEAD

Ulupau Head is a large tuff cone with a complex geological history. The eastern rim of the cone has been eroded away, whereas the western rim reaches elevations of over 600 feet (180 m). The north face of Ulupau Head is a spectacular sea cliff: the shear face of Kahekili Leap alone is over 200 feet (60 m) high. A solution bench, cut into an upraised limestone reef, borders the western shore and much of the southeastern shore up to Ki'i Point. At Ki'i Point the solution bench gives way to a water-leveled bench in Ulupau tuff. The bench on the western shore is particularly interesting from a geological standpoint owing to the inclusion of tuff talus blocks in the limestone, forming a massive breccia (246). Near the point, tuff inclusions constitute a greater proportion of the breccia than does limestone (180). Large tuff blocks litter the shore and nearshore waters off Pukaulua Point. A cove cut into the floor of the crater west of Ki'i Point is floored by a platform of tuff rising to a shoreline of sand and cobbles, backed by a cliff (180). The coast is subject to tsunami and storm wave flooding (88).

OFFSHORE BOTTOM

No coral reefs occur offshore. The bottom is predominantly consolidated limestone grading to sand and rubble at depths of 100 feet (30 m) (172).

MOKU MANU

Moku Manu is a remnant of an eroded volcanic cone consisting of tuff, basalt, and cinder. The two parts of the island are connected by a shallow shelf partially exposed during periods of low swell. Cliffs drop directly into the sea around more than half of the island, and a wave-cut bench extends along the western shore (167). Surrounding the island is a bottom of massive and loose volcanic tuff breccia cemented by calcareous rock. Sand and rubble has accumulated between the boulders (OCRI-11B1).

FLORA AND FAUNA

OFF ULUPAU HEAD AND MOKAPU POINT

Off the eastern side of Ulupau, coral cover at depths of 40 to 60 feet (12 to 18 m) is 35 to 45 percent, with Porites lobata dominant and Pocillopora meandrina abundant. At the 100-foot depth (30 m) cover decreases to 23%, with the same species predominating. At 120 feet (37 m), coral cover is only 6% (mostly Poc. meandrina). Seaweeds are most abundant at the 100-foot depth, where Codium sp. dominates, followed by Amansia sp. and Halimeda sp. The urchin, Echinothrix calamaris, is present (172).

Directly offshore of Mokapu Point, coral cover is 30% at depths of 20 to 60 feet (6 to 18 m), increasing to about 50% at depths of 100 to 120 feet (30 to 37 m). At 20 feet, Pocillopora meandrina dominates, followed by Porites lobata. At 40 feet, the same two species are equally abundant. At 60 to 100 feet, P. lobata dominates, but yields again to Poc. meandrina at 120 feet. Porites compressa and Montipora patula make significant contributions to total cover at the 100-foot depth. Frondose algae are sparse at all depths off the Point. Several species of sea urchins are present (Echinothrix calamaris, E. diadema, Echinometra mathaei, Tripneustes gratilla), along with sea cucumbers (Holothuria spp.) and soft corals (Palythoa spp.) (172). Green sea-turtles (Chelonia mydas) are frequently sighted off Ulupau Head.

The fish fauna off Ulupau Head has been well surveyed in recent years. At least 22 species, dominated by Thalassoma duperreyi and Pervagor spilosoma, occur at a depth of 20 feet (6 m) directly off Mokapu Point. Fewer species occur at a depth of 40 feet (12 m), but P. spilosoma remains most abundant. At 60 feet (18 m) some 22 species are found with Chaetodon miliaris dominant, and Thalassoma duperreyi and T. ballieui abundant (172). In waters near shore fishes are abundant and the fauna diverse, dominated by Acanthurus triostegus, Chromis vanderbilti, Acanthurus leucopareius, Thalassoma duperreyi, and Mulloidichthys vanicolensis. Fewer fish species and fewer individuals occur at 40 to 50 foot depths (12 to 15 m). Anthias thompsoni, Paracirrhites forsteri, P. arcatus, and Thalassoma duperreyi, are most common. At 60 feet (18 m) there occurs a moderately diverse fauna of high abundance. This distinct assemblage includes Anthias thompsoni, Chromis leucurus, C. vanderbilti, Chaetodon kleini, Centropyge potteri, and Adioryx xantherythrus (31;172).

OFF MOKU MANU

Coral cover off Moku Manu is about 10% of the bottom, nearly all accounted for by Porites lobata. A variety of other macroinvertebrates are present, including five species of sea urchins (Diadema paucispinum, Echinometra mathaei, Tripneustes gratilla, Echinothrix diadema, Echinostrephus aciculatus), bryozoans, soft coral (Palythoa tuberculosa), and an orange sponge. Very little benthic algal cover is present (OCRI-11B1). Fishes are abundant in areas of high bottom relief. A total of 67 species are recorded, of which 20 rated common, including: Abudefduf abdominalis, Sufflamen bursa, Thalassoma duperreyi, Forcipiger flavissimus, Chaetodon miliaris, C. fremblii, Ctenochaetus strigosus, Naso lituratus, Chromis verator, and Macropharyngodon geofferyi (OCRI-11F1). The uncommon soft coral, Sinularia abrupta, occurs at depths between 55 and 120 feet (17 to 37 m)(319).

MOKAPU POINT, ULUPAU HEAD, AND ULUPAU CRATER

Trees on the inner slopes of the northern portion of Ulupau Crater are a breeding site for the Red-footed Booby (Sula sula rubripes) (17;235).

A recent survey of vegetation on the west slope of Ulupau found one possibly endangered species (Euphorbia degeneri), three other rare or uncommon species (Plectranthus australis, Boerhavia pubescens, Cocculus ferrandianus), and an introduced pest species (Bidens alba)(69).

MOKU MANU

Fourteen species of sea birds are known to inhabit Moku Manu and at least eleven species breed there (17;167).

WATER QUALITY

NEARSHORE WATERS

Nearshore waters are classified "A" by the Department of Health (189). An ocean outfall sewage disposal system is located off Mokapu Point. The diffuser portion is at a depth of 100 feet (30 m), located approximately one-half mile from shore. The outfall handles effluents from Kailua and Kane'ohe STP's (since December 1977), and KMCAS STP (since May 1978). Eventually, the effluents from four small STP's serving the Maunawili and Pohakupu areas, and the Ahuimanu STP (MAP 22) will be diverted through force-mains to the ocean outfall.

Monthly monitoring of water chemistry and planktonic organisms in the general vicinity of the outfall has been undertaken since 1976 (63). The biostimulatory impact of the nutrient influx is minimized by the turbulent mixing of these waters which provides rapid dilution. Offshore net transport directions are southeasterly to southwesterly from August through April (39).

USES

MOKAPU POINT AND ULUPAU CRATER

Ulupau Head is a wildlife refuge administered by the U.S. Marine Corps (88). A buffer zone extending 500 yards from the shore of Mokapu Peninsula is off limits to the general public. Fishing activity along the precipitous cliffs of Ulupau Crater is extremely limited due to controlled access by the U.S. Marine Corps. A part of the area is used as a firing range for field artillery and armored vehicles. Some pole fishing is permitted from time to time at the beach south of Mokapu Point. The pounding waves make entry and exit for offshore water activities very treacherous. Strong currents occur offshore.

MOKU MANU

Moku Manu is a State Bird Sanctuary (88), offering excellent birdwatching for scientists and natural history students. Public access is prohibited without a permit, which is issued for scientific or educational purposes only. The abundance of breeding seabirds on the two rocks is attributed to the fact that Moku Manu is the least accessible of the offshore islands around O'ahu (167).

OFFSHORE WATERS

The waters around Moku Manu offer some of the best diving off O'ahu. Underwater visibility was 80 feet (25 m) during the OCRI survey, but is reported to exceed 200 feet (60 m) at times (236). Opportunities for underwater photography are thus excellent. Shell collecting is notably productive (375). Commercial dive shops run charters to these waters, most often during periods of Kona weather. Strong currents occur in the channel between Ulupau Head and Moku Mana. These waters are particularly dangerous during heavy trade wind swell owing to confused seas arising from wave reflection off the cliffs around Mokapu Point.

STUDIES AND SURVEYS

16 - Bathen (1978): p. 86-89, figs. 9, 10, 21, 22; Compilation and analysis of offshore water circulation data. Additional references.

31 - Char, et al. (1972): Stations A1, A2, A3, B1, B2, and B3 of six transects enumerating fishes off Ulupau Head.

63 - ECI (1977): Sta. MZ and DC of three off Ulupau Head. Zooplankton and larval fish enumerated from monthly tows with 1-meter and 0.5-meter nets at three stations in the vicinity of the Mokapu Ocean Outfall. ((330))

167 - Richardson and Fisher (1950): Study of birds on Moku Manu with description of Island and its ecology.

172 - Russo, Dollar, and Kay (1977): Stations A and B of five between Alala Point and Mokapu Point. Substratum types, fish, plankton, algae, corals, macroinvertebrates, and micromolluscs. ((364))

180 - de Silva (1966): Shoreline geology.

325 - Laws (1977): Sta. MZ and DC of three in vicinity of Mokapu Ocean Outfall at which primary productivity, chlorophyll a, and water quality parameters were measured monthly between March 1976 and February 1977.

330 - AECOS (1979): Sta. MZ and DC of three off Ulupau Head. Continuation (year 02) of zooplankton and larval fish surveys in vicinity of Mokapu Ocean Outfall.

364 - Russo, Dollar, and Kay (1979): Stations A & B of five in Kailua Bay between Alala Point and Mokapu Point. Results of second year benthic survey conducted for Mokapu Ocean Outfall.

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