year recorded 127 stilt in the ponds. No counts since that time have surpassed these early observations. HDF&G/USF&WS and HAS counts of stilt over the years are marked with unexplained radical fluctuations, suggesting a pattern of movement between this and other habitats. Counts as low as nine birds were recorded, but the species has never been absent. An average population based on HAS count records for nearly thirty years is less than 45 birds, whereas HDF&G/USF&WS count records indicate an average closer to 50 birds.

In recent studies by HDF&G biologists at KMCAS, two major nesting areas have been identified on pickleweed mudflats north of Nuupia 'Ekolu and east of Pa'akai. Stilt prefer to build their nests on bare areas of the mudflats or in openings within the pickleweed ground cover on ridges left by tracks of military vehicles. In 1976, 11 of 13 nests containing eggs that HDF&G biologists found in the nesting areas were destroyed by predators before hatching. Observed hatching success during the 1977 season was similarly low (523). Abnormal rainfall patterns in 1977 also resulted in heavy losses due to nest flooding. Most stilt at KMCAS nest between April and June, but some birds may still be laying eggs in late June. Stilt range widely within the shallow waters of nearly all ponds to feed, but they are seen in greatest numbers close to the primary nesting areas. The mangrove shorelines of Nuupia 'Elua and Nuupia 'Ekahi attract some stilt to feed but there is very little suitable nesting habitat in these areas.

Both Hawaiian Coot and Hawaiian Gallinule appear on early count records at the KMCAS ponds, but neither have been recorded since 1957. HAS data show gallinule in the ponds on only two early counts. However, coots were apparently quite common at the ponds during early HAS Christmas counts. The species was not missed on ten counts between 1947-1956. An average of 44.5 birds was recorded on these trips. Then, without any obvious downward trend in numbers, the species disappeared from counts and has not been observed in KMCAS ponds since. It is probably significant that observations of migratory Pintail ducks changed radically almost simultaneously with coots. Although 1,064 Pintails were counted in 1947, the average number of pintails recorded on HAS Christmas counts between 1948-1955 was 125 birds. Then the species was missing from count records for several years, and has appeared only intermittently, and in very low numbers (1-16) ever since. Both Pintails and coots frequent freshwater habitats more frequently than saline waters, suggesting that a major change in habitat (possibly salinity) may have occurred at KMCAS around 1956-57. We are unaware of any further explanation for this mysterious change in avifauna.

On two trips to KMCAS during this study, we recorded, respectively, eight and twenty Black-crowned Night Herons. Virtually all waters, from puddles on the pickleweed flats to pond waters as deep as ten inches, provide suitable feeding habitat for herons at KMCAS. These birds often congregate around the culverts between ponds and the outlets under the H-3 highway. Shallow water within the mangrove areas is also preferred habitat. Herons nest within the kiawe forest south of Nuupia 'Ekolu and within the kiawe forest west of the sewage plant indicated on the photograph. In recent years, the Principal Investigator has found small numbers of herons nesting within the Cattle Egret rookery in this area. Observed numbers of herons have varied considerably over the 30 years that HDF&G/USF&WS and HAS counts have been made at the ponds, in part because of the difficulty in visiting the kiawe forest roosting sites and the more inconspicuous feeding areas in the west ponds. Between 1947-1968, only one HAS heron count has exceeded ten birds, but the average since then has been nearly thirty birds. The recent

HDF&G/USF&WS counts have averaged closer to 15 birds. It is not certain what has caused the apparent increase in herons at the site. There appears to be no shortage of undisturbed nesting areas. Presumably availability of food is the primary limiting factor. Herons have been suspect in predation of stilt nests but there is no documentation of this activity. In three years of documentating predation by herons on small tern chicks on Manana Island, the Principal Investigator in this study never once found any evidence of egg predation by this species. For this reason alone, we suspect that only chicks, rather than eggs, are threatened by this species. It would be advisable to collect regurgitated pellets from heron roosts or nests in the KMCAS area during the stilt nesting season to determine if chick predation is occuring.

Until recently, the first and only report of Koloa at KMCAS ponds was on a HAS Christmas Count in 1948, when five birds were counted. Munro (382) reported that Koloa nested on Mokulua Islands in the early 1940's, and some of these birds were reported in Kawainui Swamp and Kaelepulu Canal. In an attempt to restore Koloa populations on Oahu, the HDF&G has released color-marked birds at KMCAS, Kawainui and Waimea Falls beginning in 1969. The releases at Kawainui Marsh appear to have been relatively successful, as some of the birds are counted on virtually every trip to the site, and breeding by released birds has been confirmed in the area. Several recent surveys at KMCAS have missed the species altogether. We are unaware of any data from earlier studies of this species that suggest that Koloa would adapt readily to this brackish environment, and for that reason alone, the releases at KMCAS were probably destined to fail. However, a good possibility is that some birds have dispersed successfully to more suitable sites. Tim Ohashi reported that a pair of Koloa hatched a brood of seven young at the sewage treatment plant in 1977 (522). He also indicated that an earlier brood of young was probably eliminated by predators at the site. One adult and one young bird observed at this pond were the only Koloa we recorded on survey at KMCAS.

The unexplained radical decline in Pintails observed at KMCAS ponds was discussed earlier (page 267). Both Pintails and Shovelers appear intermittently on recent count records, but it is clear that the ponds now provide only marginal habitat for these species. Several areas in the State that are a small fraction as large as this site attract far greater numbers of both species. However, continued interest in bird populations at the site has increased the chance that unusual or rare migratory waterfowl are seen. In addition to Pintails and Shovelers, the list of migratory waterfowl recorded in the past at KMCAS ponds includes Lesser Scaup, Bufflehead, Black Brant, Canada Goose and Hooded Merganser.

Migratory shorebirds visit the pickleweed mudflats near the KMCAS ponds in greater numbers than at most other wetlands in the State. As many as 361 Golden Plovers have been observed on one HAS count at the ponds, but the HAS count average is approximately 70 per visit. The average for recent HDF&G/USF&G counts is nearly the same. Unlike most of the other shorebirds at the site, Golden Plovers also frequent lawns and golf courses, so actual numbers at the Base may run much higher than count records indicate. Ruddy Turnstones are also common at KMCAS, often feeding in mixed flocks with plovers and other shorebirds. Sanderlings and Wandering Tattlers are considerably less common but are present in small numbers on nearly all winter counts. The list of rare migratory shorebirds that have been reported at KMCAS ponds includes Greater Yellowlegs, Long-billed Dowitcher, Wilson's Snipe, and Willet.

The largest Cattle Egret rookery in the State is found on KMCAS grounds, in a kiawe forest west of the sewage treatment plant. The species was first introduced to the islands in 1959. By 1960, a small rookery had established in the kiawe forest within KMCAS (351). The colony has been estimated at various times at 300-1,000 birds, but no accurate counts within the rookery have been made. A count of 1,002 birds was recorded on the 1971 HAS Christmas Count. Other counts since that date have been so variable that one can assume that count coverage has been very different from year to year. We have visited the egret rookery since 1970 and have watched the area containing nests expand each year towards the north and west. Most of the birds that nest and roost in KMCAS grounds leave the Base in the daytime to feed in Waimanalo and in Kawainui Marsh. It now appears that a major portion of the population at KMCAS is sustained by food obtained at the Kapaa Landfill, above Kawainui Marsh.

The KMCAS ponds are one of few wetlands that regularly provide food for resident seabirds. Great Frigatebirds and Black Noddies are recorded at the site on nearly every HDF&G/USF&WS or HAS count. Both species roost or nest on Moku Manu Island, off Ulupau Head. Frigatebirds feed most often within Nuupia 'Ekolu, but they never land. Noddies feed in the shallow waters of Nuupia 'Ekolu and Pa'akai, and less frequently in other ponds. The noddies will frequently roost on small piles of dirt, but only feed while hovering over the water surface. As many as fifty frigatebirds and twenty to thirty noddies may be at the ponds at one time. The KMCAS ponds also attract a few straggler seabirds. Least Terns appear in small numbers nearly every year, whereas Ring-billed Gulls, Laughing Gulls and other unidentified gulls have been sighted less commonly.

One additional straggler species deserves mention because it has been sighted at KMCAS ponds on at least three separate years. The first published Osprey record for KMCAS was in 1971. We observed a single bird during the present survey (30 May), as it dove for fish within Nuupia 'Ekolu. Ralph Penner reported seeing an Osprey at least six times over the same pond between January and May, 1977 (524).

HABITAT EVALUATION: Although the KMCAS ponds are considered "primary" waterbird habitat in the draft HWRP (346), there is good reason to believe that the greatest value of this habitat lies in its potential. Refuge designation attracted attention to the plight of the Hawaiian Stilt and focused interest and eventually field research into an important waterbird area. However, available population data do not show a pattern of increasing productivity of stilt in the wetland since active management began. Recent research data suggests that despite ambitious trapping effort to eliminate mongoose and dogs from the nesting area predation is still a major source of mortality during nesting. Further, the amount of nesting habitat available does not appear to be limiting the stilt population at the ponds, as evidenced by wide variations in density of nesting birds, as well as large areas of similar habitat that have not been colonized by nesting birds. It appears that a sincere effort to increase stilt production at the ponds will require a far more significant commitment of money, land and research effort than has been evident to date.

There are several natural and man-related variables that affect the success of Hawaiian Stilt and other waterbirds in the ponds. In the absence of mechanisms for efficient control of water level, the amount and condition of nesting and feeding habitat varies dramatically. The argument that this is a natural phenomenon to which the birds have adjusted does not alter the fact that many nests are

flooded and other nests are predated when water levels change. Nor does it rule out the probability that mortality could be reduced, and production of young increased, by tempering the effects of this natural phenomenon. Effective water level control also would permit increase in the availability of feeding and nesting habitat at will.

Although the mangrove growth in the western ponds does increase the availability of limited feeding habitat, the long-range impact on habitat for stilt will probably be adverse. Periodic clearing of this encroaching vegetation should be encouraged.

Human disturbance in the nesting and feeding areas should be rigorously controlled. It is questionable whether or not the continued use of pickleweed mudflats as a vehicle training area is advisable. We observed some areas where vehicles had narrowly missed stilt nests despite the current seasonal restrictions on training and HDF&G nest marking flags. Recent HDF&G data suggests that barren mudflats are preferred for nesting and that the shallow channels created by vehicle tracks are totally inadequate to prevent predator access to nests. The amount of pickleweed cover seems to directly affect the suitability of a particular area for nesting, rather than the amount of relief or distribution of shallow water. It is possible that these vehicles could be used to manipulate the condition of the habitat in a productive way. Kridler (519) indicates that much of the habitat was totally choked with pickleweed only a decade ago and that training vehicles helped to open up portions of this habitat. It is clear that an experimental program using various means of habitat manipulation would be desirable.

In light of the ambitious effort of base personnel, it is unfortunate that predator control in the nesting colonies to date has been inadequate to prevent serious egg loss. A single mongoose can conceivably eliminate the nesting efforts of several pairs of stilt in an afternoon, unless access to the colony is prevented. It appears that a large moat constructed around the inland edge of the two major nesting areas may be the only viable, long-term solution to the problem of nest predation. Fencing of the ponds, associated wetlands and forested lands would further help to control predation by large mammals and the continuing problem of human disturbance.

POTENTIAL EFFECTS OF DREDGE/FILL ACTIVITIES: There are several aspects of a habitat improvement program in the KMCAS ponds that would require dredging and filling. Nesting islets that were created in Nuupia 'Ekahi pond near the H-3 highway have not been used extensively by birds but this does not rule out the possibility that artificial islets placed closer to prime feeding areas would be used in the future. Placement of islets along the north shoreline of Nuupia 'Ekolu pond has the advantage in that colonization of the islets by stilt would involve an expansion of the existing nesting colony rather than initiation of an entirely separate one. Although the birds are territorial in their colonies, the social stimulation provided by the presence of other birds may be an important influential factor. One result of highway construction across the west end of the ponds was the creation of culverts that can eventually be manipulated to control water levels. The connection between Pa'akai and the ocean would have to be improved and controlled if any future attempt to manipulate water levels in the entire pond complex was to be successful. This would require some channelization and damming, but the long-term effect on waterbird habitat would be positive if designed as part of a total water control system. A moat around the nesting areas would require extensive

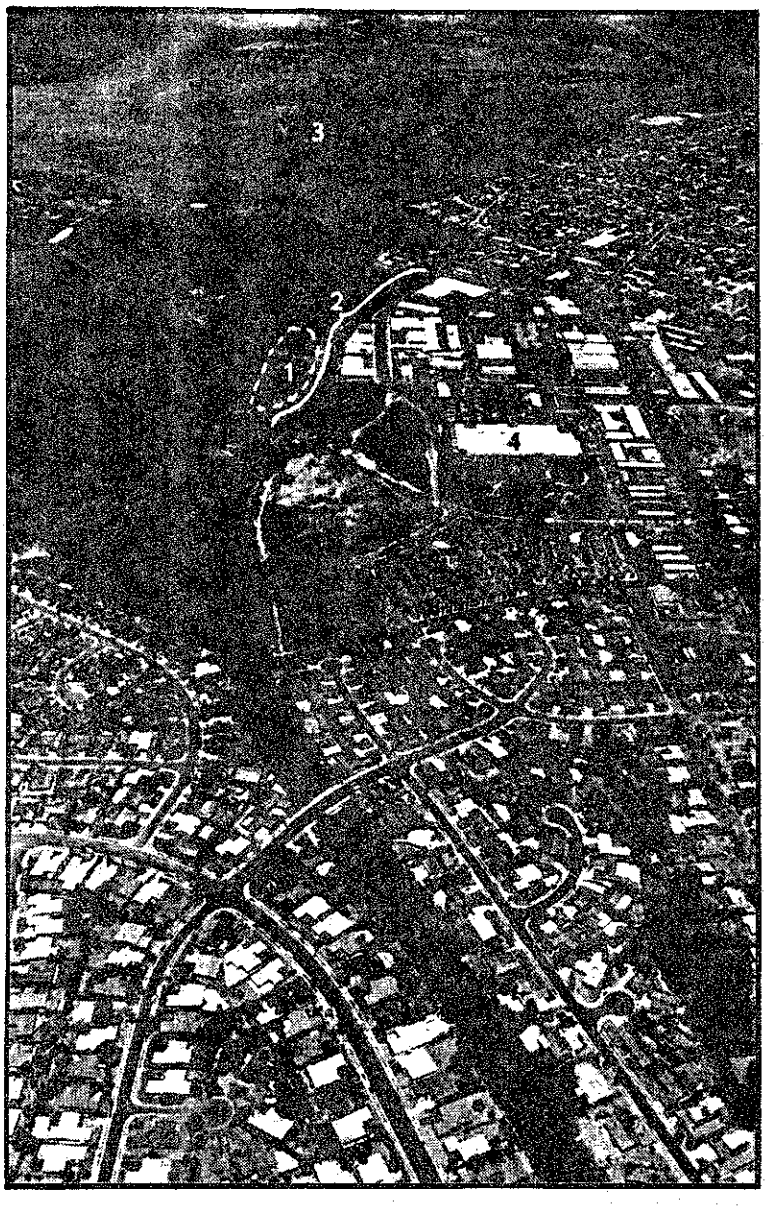
dredging and removal of material. Some of this could be used as fill for construction of nesting islands. All of this habitat alteration should be preceded by a more thorough investigation of patterns of water level fluctuation and circulation in the ponds. Major dredging operations within the feeding or nesting areas should be scheduled to avoid peak nesting seasons, and staggered by area to minimize impact. Any additional construction activities near the pond should be evaluated for their potential impact on wildlife due to runoff of pollutants, excessive siltation in feeding habitat, elimination of ground cover and other disturbance.

SITE NAME: Ka-wai Nui Marsh

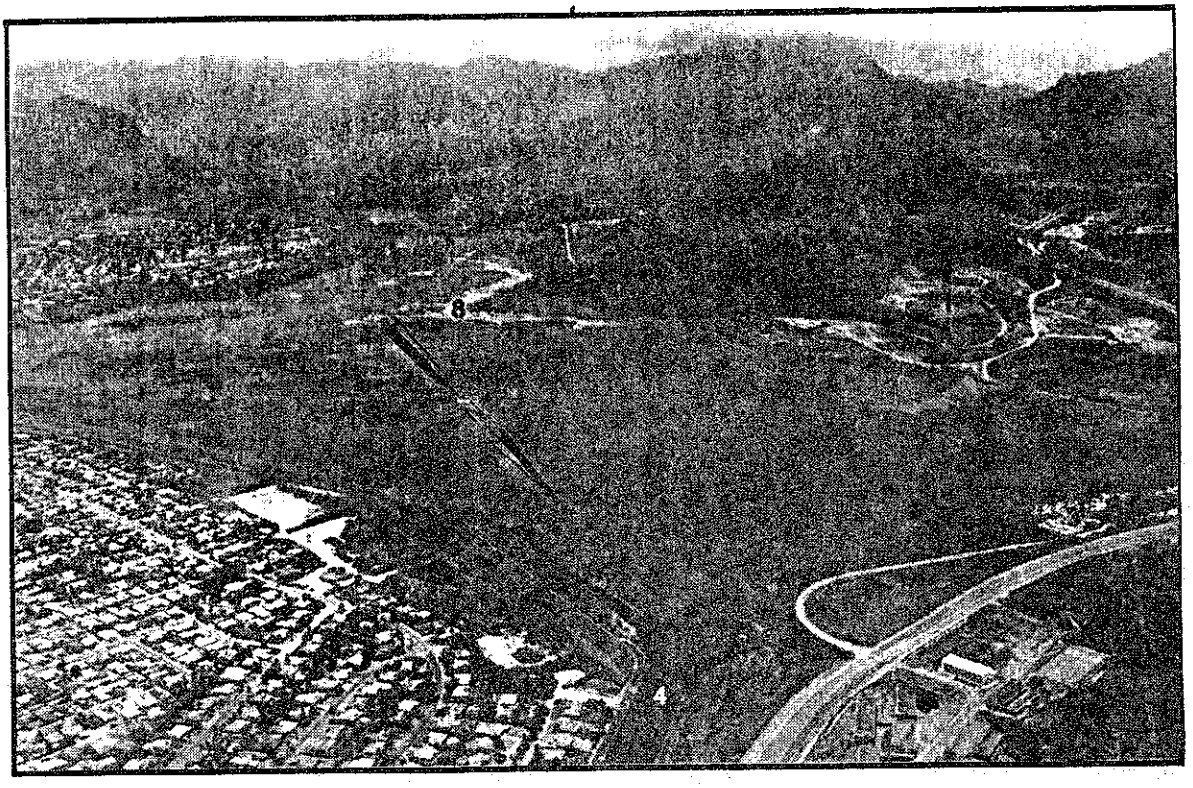
LOCATION: Ko'olau Poko District, O'ahu

TOPOGRAPHIC MAP: Mō-kapu

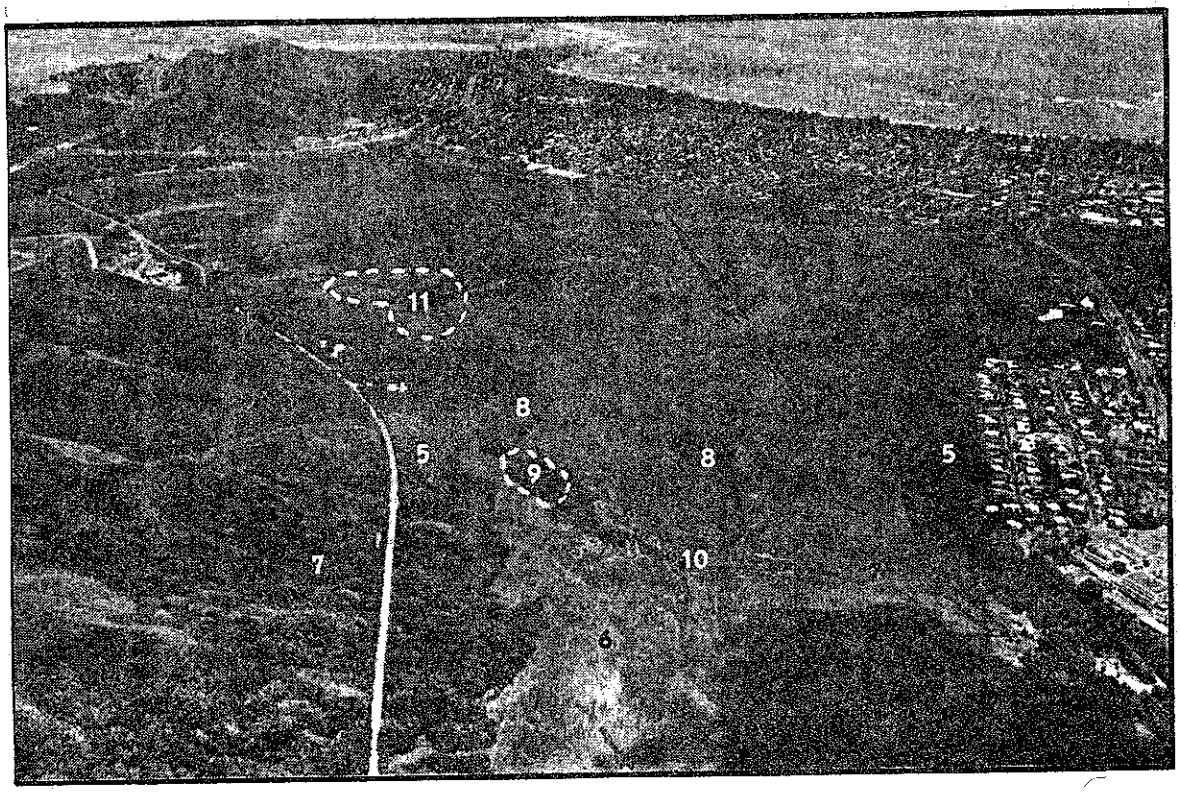
DATES OF SURVEY: 1 May, 20 May, 23 May, 28 May, 15 August, 1977



1. primary stilt & koloa habitat along canal
2. primary gallinule range in canal
3. Kawainui Marsh
4. Kailua Holiday Mart



Kawainui Marsh:
1. operating landfill
2. former landfill
3. auto wrecking yard
4. Kawainui Canal (to ocean)
5. proposed housing development
6. Kahanaiki Stream
7. Maunawili Stream
8. open water
9. stilt nesting area (1977)
10. koloa release site
11. primary gallinule habitat



WETLAND DESCRIPTION: Historically, Kawainui Marsh was a 450 acre fishpond, kept clear of encroaching vegetation by the communal efforts of residents of Windward Oahu. The original pond drainage was a canal at the southeast corner of the pond, that fed directly into Kaelepulu canal and out to the ocean. Some of the drainage from Kawainui was diverted to feed taro patches. Milkfish, mullet, aholehole and o'opu were taken from the Kawainui pond and drainage. When the repetive clearing of vegetation ceased, the natural process of ecological succession continued uncontrolled. Since that time, the original pond has shrunk to a fraction of its former size through sedimentation and encroachment of vegetation.

The largest natural water source into Kawainui Marsh is Maunawili Stream. A smaller drainage, Kahanaiki Stream, feeds the marsh less than 1/6 of the water that passes through Maunawili Stream. Another small intermittent stream enters the marsh near the present location of the rock quarry. The original drainage into Kaelepulu Stream has been blocked by construction of a long dike along the northeast edge of the marsh, but the canal to Kaelepulu Stream still remains. A wide channelized drainage (Kawainui Canal) was constructed in the north corner of the marsh. The upper streams and remnant ponds in the marsh are fresh water, while the salinity of water within Kawainui Canal is affected by tidal influence. Patterns of water flow and circulation within the marsh are poorly understood. The amount of open water left in the marsh varies considerably with patterns of rainfall runoff. A large central pond, ranging in depth from three feet to more than ten feet in places, has remained open and free of floating vegetation in recent years. Heavy rainfall in early May, 1977 produced extensive flooding in the upper marsh, resulting in a substantial (more than 100%) increase in the amount of open water by clearing of vegetation. Other small ponds in the marsh are now covered with a dense mat of water hyacinth, but part of this pond cover is opened during periods of heavy rainfall or high winds.

The dominant marsh plants are California grass, bulrush and sedge. Cattails line portions of the large pond as well. The distribution and condition of emergent plant growth around the ponds changes considerably with changes in water level. The sloping lands that border the marsh support a dense forest dominated by koa haole, hau, monkeypod, banyan, ironwood, mango, pandanus and several other trees. Berger (88) provides a list of the most common plant species in the forested lands and within the marsh.

In our surveys at Kawainui Marsh we also visited several sites along the canal. (here called Hamakua Drive Canal) leading to the Kaelepulu Canal and to the sea. The only remaining undeveloped habitat in this area is pastureland bordering the southwest edge of the canal as it passes through Kailua. This pastureland is grazed heavily, but supports some grasses, small patches of bulrush and scattered clumps of pluchea and other shrubs.

Kawainui Marsh and associated wetland areas have undergone considerable change in recent years that relate to the condition of wildlife habitat. An auto wrecking yard, a rock quarry, and an operating landfill all border on the edge of the marsh. Treated sewage now enters the marsh at two locations near the input streams and at two additional sites along the southeast border of the marsh. An interceptor sewer line has recently been proposed to transfer all sewage to the soon to be completed deep water outfall in Kailua Bay. The interceptor line, as proposed, would cross under Maunawili Stream, and follow along the southeast edge of the marshland.

The 750 acres of land owned by the City and County of Honolulu include the major portion of the wetlands. The City proposed development of a large recreational park complex for the site over 15 years ago. These original plans included a wildlife sanctuary within the proposed park. The City has withdrawn its original plan, but a coalition of community groups has worked with the City to develop a comprehensive plan for a "nature park" that would include the marsh and surrounding forest lands. A large shopping center complex was proposed by the private landowner for the flat land in the upper marsh where the two input streams converge. The proposal was withdrawn after considerable public protest, but more recently, the forested lands east and west of the upper marsh have been proposed for housing development. Although the marshland is presently zoned for conservation use, these forested lands are zoned for urban development. The State, the City and a coalition of community groups has requested to the State Land Use Commission that the land in question be rezoned to conservation designation. The decision by the commission has not yet been made.

NON-AVIAN WILDLIFE: The stream, pond and estuarine canal at Kawainui Marsh provide a diversity of conditions for aquatic species. The only fish species we have observed in all three areas is tilapia. This species is in the greatest density within the Hamakua Canal, where some individuals grow to more than eight to ten inches. Other fish in the stream and pond include mosquito fish, mollies, smallmouth bass and carp. The estuarine portion of the marsh supports mullet, milkfish, barracuda, aholehole and o'opu. Freshwater turtles are common in the marsh area, particularly in the Hamakua Drive Canal. The largest invertebrate in the stream and pond is the crayfish, but native 'opae shrimp are also present. A large variety of aquatic insects are found within the duckweed and emergent cattails in the central pond.

Cattle are grazed in the upper flat grassland between the two inlet streams, and less commonly on the forested slopes on the west side of the marsh. Cattle may graze into the marshy area where the streams converge, creating problems for the Koloa that share this habitat. Mongoose find access to all but the deepest ponds, by wading or even swimming through shallow water and by crossing the dense ground cover of California grass. The ranch manager that runs cattle within the marsh has trapped some mongoose near his ranch in cooperation with HDF&G biologists. Dogs and feral cats are virtually unrestricted in their access to and through much of the marsh. Dog tracks in the upstream end of the enlarged open water indicate that both stilt and Koloa that inhabit this area are vulnerable to predation.

NON-WATERBIRD AVIFAUNA: Earlier data on non-wetland birds for the Kawainui Marsh area is available from a report of bird studies by Berger (88) and from unpublished notes of the Principal Investigator in this survey. Berger (88) recorded 13 species of non-wetland birds during his fieldwork in the marsh and in surrounding forests. These included Rock Dove, Spotted Dove, Barred Dove, Melodious Laughing-thrush, Red-vented Bulbul, Shama, Japanese White-eye, Common Myna, House Finch, Spotted Munia, House Sparrow, Northern Cardinal and Red-crested Cardinal. He also mentioned reports of Japanese Bush-warbler from surrounding lands. Kridler (519) reports having regularly observed Red-billed Leiothrix ten years ago, but this species is now rare on Oahu and has not been recorded in lowlands for several years. We recorded all of the species seen by Berger with the exception of the Japanese Bush-warbler. We have heard bush-warblers in surrounding forest lands only during winter and spring, as it typical for this species in Hawaii. The least common bird at the site during our survey was the Melodious Laughing-thrush.

Bulbuls have become increasingly common in recent years along the Quarry Road and in surrounding housing areas. The only "non-wetland" species that were recorded actually in the marsh itself were Common Myna, Spotted Dove and Spotted Munia. Barred Doves were very common in the ranch area near Maunawili Stream. The most common non-wetland birds along Hamakua Drive canal during our survey were Common Mynas and Barred Doves.

WATERBIRDS OBSERVED: Historical data on waterbirds within Kawainui Marsh comes from annual and semiannual waterbird counts by HDF&G and USF&WS biologists, Christmas Count data by HAS members, recent studies by Berger (88) and unpublished notes from prior field work by the Principal Investigator in this study. Unfortunately, much of the historical data was derived from surveys that did not adequately cover the marsh, and for some species, represent an underestimate of actual populations. A combination of survey from several different vantage points and an investigation by boat and foot within the marsh is necessary for an accurate evaluation of waterbird population. Historical data for the Hamakua Drive Canal is far less complete than for the marsh itself.

The Hawaiian Duck or Koloa is a species that has been a recent focus of attention at Kawainui Marsh. Munro (382) reports that Koloa nested on Mokulua Island in the early 1940's and traveled with their young into the Kaelepulu Canal and into Kawainui Marsh. However, none were seen within the marsh since this early report. Since 1969, HDF&G has released more than 165 cage-reared Koloa at Kawainui. The first of these appeared on HAS Christmas Count reports in the same year (1969), but have only been observed on one Christmas Count since. However, we have found that a thorough survey through flooded grassland in the upstream portions of the marsh will invariably turn up at least six birds. We have recorded as many as 16 birds in one trip, but the highest count during this survey was 13. Berger (88) recorded 11 on August 4, 1976. The vegetative cover is dense and the birds are often reluctant to take flight, so an estimate actual population within the marsh should probably run as high as twice the number counted on a thorough survey. When flushed from the grass cover, Koloa will sometimes fly to the small ponds containing a water hyacinth cover. We found this to be particularly true since flooding in May, 1977 eliminated some of the surface vegetation.

We did not find any nests or young birds in our trips to Kawainui, but Tim Ohashi (523) did observe a Koloa brood in the marsh during early summer, 1977. The Principal Investigator observed at least three unbanded Koloa in the vicinity of a koloa release cage in the marsh on November 16, 1977. We observed a pair of Koloa with a single large chick in the Hamakua Drive Canal on January 24, 1977. Residents near the canal informed us that this brood originally contained six chicks, but they were probably lost to predators. They also indicated that this adult pair (or perhaps another pair) had hatched a brood of five chicks several weeks earlier but they were only seen once. A large wet area on the pasture land by Hamakua Drive Canal is the probably nesting site for this pair(s). Since the January observation, we have observed as many as five Koloa in this pastureland or canal. These data and an earlier report of a Koloa brood from Black Point are the first records of Koloa nesting on Oahu since the observations on Mokulua Island in the 1940's.

Kawainui Marsh has long been known as an important habitat for Hawaiian Gallinule. Prior to 1965, several early HDF&G/USF&WS counts recorded as many as 11 gallinule. The average number of gallinule observed on HAS Christmas Counts since

1961 and on recent HDF&G/USF&WS counts is less than three birds per trip. Berger (88) recorded a maximum of five birds on his surveys, but admitted that the "numbers of birds inhabiting the swamp must be several times that figure". Our maximum count on this trip was seven birds, but we have counted as many as twelve within the last three years. We have found gallinule nests in both bulrush and cattails in the marsh. No nests were found on a brief survey on 1 May 1977, and floodwaters in early May destroyed the bulrush area where we have regularly observed gallinule in the greatest numbers. If birds were nesting at the time of the heavy runoff it is certain that nests were destroyed. We found no nests later in the summer 1977, but the flood waters had opened up a large amount of potential nesting habitat that will probably be used in future years.

Gallinule have also inhabited the Hamakua Drive Canal in greater numbers recently than records for earlier years indicate, although this area was not surveyed so thoroughly in the past (519). We counted a maximum of seven adult and five young birds in several trips to this site since early January. At least three broods of young were produced this spring and summer within the canal, but in no cases did we observe an adult with more than two chicks older than four to five weeks. Again, it appears that predation (probably dogs and mongoose) is limiting production of young in this habitat.

Hawaiian Stilt were not listed among the regular inhabitants of Kawainui Marsh until this year. In the past, a small number of stilt were counted occasionally in small potholes near the auto wrecking yards and along the Kawainui Canal, but they were not seen in the main body of the marsh. The storm runoff in early May 1977 carried several tons of new sediment into the marsh, and at the same time, cleared much of the California grass that was choking the water path. As the water flow diminished, several acres of partially exposed mudflats were left behind. We visited the site within ten days of the heavy rains and observed two adult stilt feeding in the shallow water pouring over the mudflats. Puddles with dense concentrations of young tilapia and other fishes provide the most likely food source. The stilt appeared to be paired and they circled us several times and engaged in a distraction display characteristic of nesting stilt. Although no nest was found at the time, we felt certain that these birds were nesting in the area. In visits over the next three months, we documented the successful nesting of at least two stilt pairs. These observations were confirmed during field work by HDF&G biologists (523).

For several years, groups of stilt have been seen on the pasture land along Hamakua Drive Canal after rainfall or high water in the canal has left water on the mudflats. We counted as many as 16 stilt at this site on one visit during this survey. At this time, small puddles teeming with juvenile tilapia were covering the mudflat. It is uncertain whether or not stilt have attempted to nest on this mudflat during this year, but it is likely that they would if a more permanent food supply was available.

Hawaiian Coots have been recorded at Kawainui Marsh on nearly all HDF&G/USF&WS and HAS counts. As many as 75 birds (501) have been reported, but the average runs fewer than 15 per count. Wide variation in numbers reflects both movement in and out of the marsh and differences in the methods of survey. In earlier studies, the Principal Investigator has discovered that many birds are often found within emergent vegetation that are missed while surveying the marsh from a

distance. We counted as many as 19 birds on this survey. It is not likely that the marsh supports more than 20-30 coots on a regular basis. We have found both active and abandoned coot nests within the marsh in past years, but found no evidence of nesting during the survey this year. Presumably flooding in May destroyed some nests and disturbed the birds sufficiently to inhibit later nesting. Coots were also observed less frequently in the Hamakua Drive Canal, but no nesting was recorded.

Black-crowned Night Herons are resident within Kawainui Marsh year around. Herons roost in trees on the forested slopes bordering the marsh. Although no nests of this species have been discovered at the marsh, juvenile birds are observed with regularity. Herons often roost in trees which have such dense foliage that small numbers of nesting birds could be concealed from view. It is probably safe to assume that herons do nest in the neighboring forest, but it will take more prolonged survey in spring and summer months to verify this. Most of the birds which feed in the marsh stalk fish at the edge of the central pond. In past surveys, the Principal Investigator has counted as many as twelve birds around the perimeter of this pond. Since the flood runoff in early May of this year, large numbers of herons have been gathering regularly on the exposed mudflats, where they take advantage of the shallow water and abundant fish and crayfish. Our counts at this location ranged as high as 24 birds this summer, with a maximum total count for the marsh at 32 birds. The average on most HAS and HDF&G/USF&WS counts over the last several years has been less than ten birds, but a count of 65 birds in January, 1973 raises some interesting questions. Herons are less common on the pastureland along Hamakua Drive Canal, but small numbers do visit the area when fish are trapped on the mudflat when flood waters recede.

Although Cattle Egrets were first introduced to Oahu in 1959, they did not appear on HAS Christmas Count records at Kawainui Marsh until 1967, when 34 birds were counted. The first report of nesting at Kaneohe Marine Corps Air Station was in 1970 (351). They have appeared on every HAS and HDF&G/USF&WS count at Kawainui since 1967, in numbers that have exceeded 350. Considerable variation in numbers reported at the marsh reflects variation in count coverage and time of day. Egrets follow a regular pattern of early morning arrival at Kawainui and evening departure. Most of the birds in the Kawainui area are found at the Kapaa Landfill and with herds of cattle in the upper marsh area. We counted more than 135 birds roosting in a monkeypod tree at the edge of the marsh on August 15, 1977. Smaller flocks were observed within pockets in the cattails near the central pond on nearly every trip.

Migratory waterfowl inhabit the central pond and smaller potholes within Kawainui Marsh during winter months. As many as 175 ducks (mostly Pintails and Shovelers) have been counted on past HAS Christmas Counts. The tendency of these birds to crowd into small ponds surrounded by tall emergent vegetation makes some of the earlier count data suspect. We have found that hand-clearing of water hyacinth from portions of a choked pothole will allow surprisingly large numbers of waterfowl to inhabit areas of the marsh that might not otherwise be available. The list of rare or uncommon migratory waterfowl recorded at Kawainui Marsh includes Canada Goose, Emperor Goose, Ring-necked Duck, Lesser Scaup, Green-winged Teal, American Wigeon and Redhead. There appear to be a number of feral Mallards that are resident in the marsh. Some have been seen in company with Koloa, raising the likelihood that interbreeding may occur. The fact that Mallards are present in the marsh has raised some concern among HDF&G biologists about the advisability of further Koloa releases.

Migratory shorebirds find little suitable habitat in the central portion of the marsh, but do visit the drainage ditches and ephemerally flooded pastureland along Hamakua Drainage Canal. Probably the exposed mudflats created by early summer rains will result in greater numbers and variety of shorebirds near the confluence of the two input streams. As is the case in most wetland habitat, Golden Plovers are invariably counted at Kawainui in greater numbers than other species. Ruddy Turnstones are common visitors to the flooded mudflats along Hamakua Drive Canal as well. Other less common shorebirds recorded at Kawainui in past years include Sanderlings and Wandering Tattlers. Common Snipe and Long-billed Dowitcher have been recorded on one occasion each.

The only seabird that is observed with regularity within Kawainui Marsh is the Great Frigatebird. The Principal Investigator has watched individual birds and groups of as many as nine birds at a time while they drank and attempted to catch fish from the surface of the central pond. We saw no more than three on any survey day in this study.

One final bird species recorded at Kawainui Marsh during 1977 is worthy of mention. Together with other observers, the Principal Investigator observed a single Peregrine Falcon over the central pond during April, 1977. Another falcon, presumably the same bird, had been reported at three locations on Oahu during the previous December and January. This is a rare straggler in Hawaii and it is unlikely that it is of any significance to the ecology of this marsh.

HABITAT EVALUATION: In its present state, Kawainui Marsh serves several important functions in addition to its value as waterbird habitat. It serves as a flood basin, protecting the urbanized lands of Kailua from the effects of excessive runoff. At the same time, it serves as a settling basin for the silt and other particulate matter carried in storm waters through the streams that enter the marsh. The scenic value of this open space in the midst of urban development is difficult to define but nevertheless of real importance. As a natural marsh, it provides a resource for environmental education, scientific study and recreation. Currently it serves as a receptacle and filter for more than 210 million gallons of treated sewage every year. In the past, it has served as a site for sanitary landfill.

For wildlife, the long-term values of Kawainui Marsh are only partially understood. Potentially the estuarine portion is of importance in the life cycle of marine fishes, some of which are of commercial importance. Although the populations of endemic waterbirds that inhabit the marsh are not large, the diversity is impressive. The greatest value of Kawainui Marsh to waterbirds lies not in its present condition, but in its potential for habitat improvement. The greatest reasons for concern lie in the accelerating demand for potentially conflicting use of the marsh and neighboring lands.

The natural process of plant succession will lead to further loss of open water through the encroachment of vegetation. The positive effect of flood waters that have increased the size of the central pond will be temporary, because the extensive deposition of silt has raised the level of the substrate in areas that were formerly underwater. In the few months since heavy rains, California grass and honohono grass have already taken over a significant portion of the exposed mudflat. The stilt habitat created by flooding is only temporary, but the natural process does indicate how adaptable the species is and the methods of water control that

could be used to create and maintain suitable habitat for this and other species. Additional clearing of vegetation will involve two separate processes: the dredging and removal of silt that is covered with grasses and the mechanical removal of floating vegetation (water hyacinth) that has rendered some of the smaller potholes and ponds nearly worthless as waterbird habitat. The latter process may be more easily accomplished and will have more rapid, positive effect on patterns of waterbird use.

The contemplated uses of neighboring lands should be evaluated on the basis of their potential impact on marsh ecology and upon the opportunity of people to take advantage of the marsh's educational and recreational potential. We do know that four species of endangered waterbird now nest and feed within the marsh. This in itself makes the marsh unique in comparison to other wetland habitat in the State. We also have every reason to believe that conditions for all species could be improved through manipulation of habitat. What we do not fully understand is the immediate and long-term effects of different patterns of land use within and around the marsh. A thorough interdisciplinary study of marsh ecology has been proposed for the marsh and should be completed prior to initiating any development of neighboring lands or any habitat improvement program of significant proportions.

The Hamakua Drive Canal area is somewhat unique in its current and potential role as waterbird habitat. All four endangered species inhabit the canal and pastureland, and at least two of these nest in the area. The proximity of this site to a densely urbanized neighborhood and a large population center is both dangerous and desirable. There is no other wetland habitat in the State where the public can observe all four endangered waterbirds from close range. The present condition of this habitat is threatened by the ongoing pollution of the canal, herbicide spraying of the shoreline cover vegetation, grazing of cattle on the flatlands bordering the canal, and the unlimited access of predators (and people) to the feeding and nesting areas. At the same time, the adaptability of the waterbirds to marginal conditions suggests that manipulation of the habitat and control of the inimical factors would yield very positive results. The main deterrent preventing year-round occupation of the pastureland by stilt is the ephemeral nature of the food supply. A series of water impoundments, or more simply a means to route canal water into the mudflats, would improve the quality and permanence of the habitat quickly. A moat and/or a fence around the pastureland, together with a localized mongoose trapping program, would improve the nesting and fledging success of birds that do nest on the site. The site could become a focal point for public environmental education involving waterbirds.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Piecemeal urban encroachment onto lands that border on Kawainui Marsh will have an impact on marsh ecology that can only be predicted with accuracy after thorough study. The movement of water throughout the marsh insures that impacts will not be localized. The interdependence of all forms of wildlife on each other and upon the amount and quality of water also suggests that seemingly "minor" impacts can have long term and far-reaching effects through the ecosystem. The most significant ongoing project involving dredge and fill activities is the accelerating construction of houses in the Maunawili area. Presumably this construction has been responsible for excessive silt loads in storm runoff in recent years. The effects of other associated pollutants in this runoff is uncertain. A silting basin to be placed in the upstream area of the marsh has been suggested as an effective means to reduce the rate of siltation.

There are at least four currently proposed alterations of the marsh or neighboring lands that would involve dredging and deposition of fill. The proposed sewage interceptor line would require some alteration of input stream flow, dredging of a channel on the edge of the marsh, and installation of more than 9,000 feet of sewer line. The "unknowns" involve potential impact of dewatering, siltation, pipe failure, construction disturbance, future sewer maintenance and conflict with proposed "nature park" plans.

The proposed hillside development would eliminate the existing watershed to allow construction of more than 1,000 housing units. In this case, the "inevitables" are increased siltation, urban-associated pollution (heavy metals, pesticides, petroleum products, etc.), loss of wildlife habitat, disturbance of neighboring endangered species habitat, and direct conflict with potential for "nature park" development. In this project, the "unknowns" relate to the extent and permanence of the adverse impact that is certain to occur.

The third proposed project involving dredging and fill deposition is the plan to expand the Kapaa landfill. The draft HWRP (346) singles out this particular impact on marsh ecology in stating that "no further sanitary landfills should be permitted within or adjacent to the marsh". An earlier study of the existing landfill in the marsh did not reveal contamination of groundwater as a result of the operation, but the study did not adequately treat the potential problem of long-term leaching of chemicals and gasses. In the absence of a thorough understanding of water circulation and marsh ecology, the results of the earlier studies can not be interpreted realistically. The proposed landfill expansion, by its sheer magnitude alone, deserves much more thorough study before it can safely be ruled harmless.

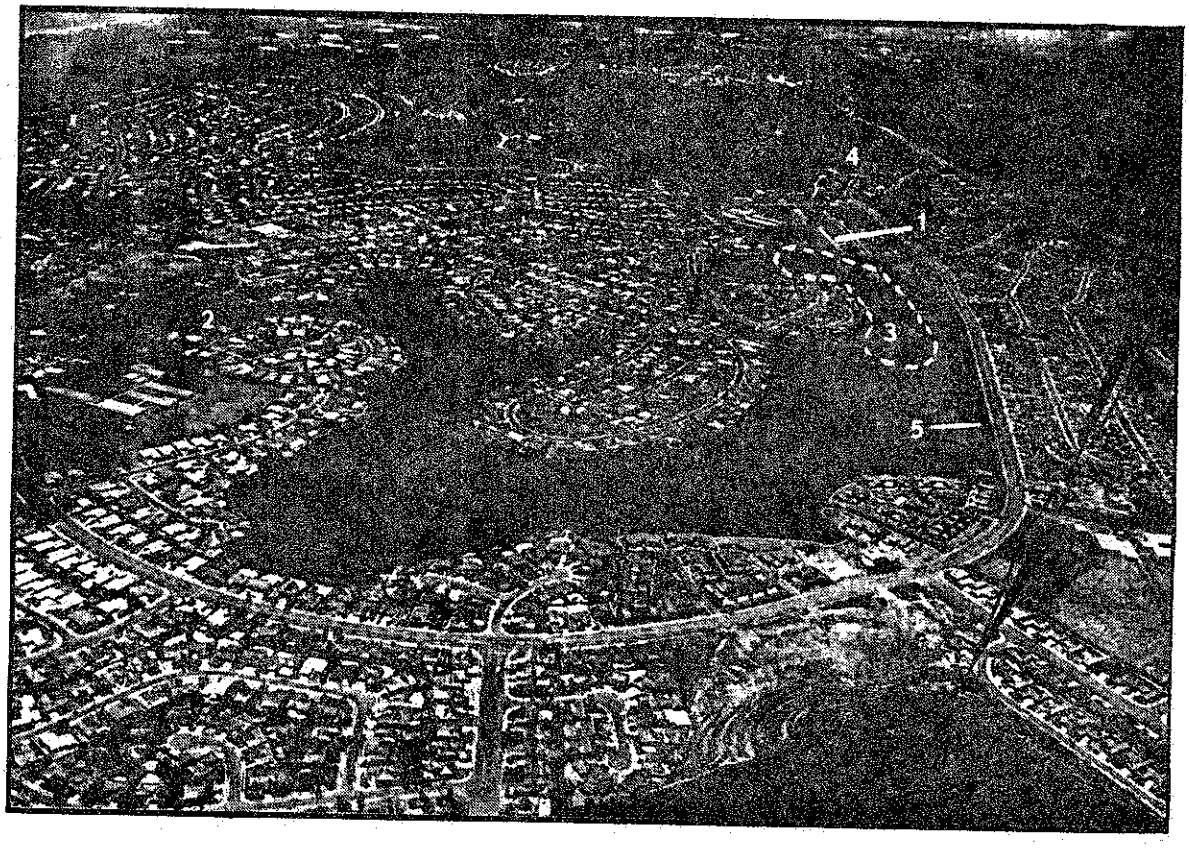
The fourth proposal that will deserve attention in the future is the "nature park" plan, and of less magnitude, proposals to improve wildlife habitat through the control of encroaching vegetation and the enlargement of existing open water. The mechanical clearing of floating vegetation will require no dredging and no deposition of fill, and could be undertaken at first on an experimental basis. Any more ambitious habitat improvement program should await the results of thorough ecological studies to avoid adverse impact on existing wildlife habitat and to maximize benefits for minimum cost and effort. Proposals to improve habitat along the Hamakua Drive Canal can be treated somewhat independently of the marsh, although a more thorough understanding of water circulation and aquatic fauna in the canal would facilitate a habitat improvement program. Any proposed land use that may conflict with the present or potential wildlife use of the canal area (i.e. road extensions, grading, building construction) should be carefully evaluated.

SITE NAME: Kaelepulu Pond (Enchanted Lake)

LOCATION: Ko'olau Poko District, O'ahu

TOPOGRAPHIC MAP: Mō-kapu

DATES OF SURVEY: 3 June, 15 July, 24 August, 1977



1. channelized inlet
2. outlet to ocean
3. primary waterbird area
4. depression "marsh"
5. drainage canal

WETLAND DESCRIPTION: Kaelepulu Pond was once more than 200 acres in size, with associated marshland increasing the overall habitat to more than 400 acres (122). It was, and still is, connected to the sea by a long stream drainage. A sand berm now blocks this drainage at the beach, except when cleared mechanically or occasionally by storm runoff. Water from nearby Kawainui Marsh originally fed into the stream drainage below Kaelepulu Pond. The connection still exists via Hamakua Drive Canal, but now a concrete channel drains the larger marsh. Kaelepulu Pond was originally fed by a direct stream drainage off the slopes of Mt. Olomana. Now a large settling basin has been created above the pond, and water moves through a long channelized stream into the pond itself.

Development of the surrounding lands began more than 20 years ago with partial draining of the pond. For a few years, water levels fluctuated with rainfall runoff, but eventually the deposition of fill shrank the pond to a fraction of its original size. The pond is now encircled with housing, and, for reasons that escape the writer, has been named Enchanted Lake by the developer.

Drainage into the pond is now routed through the settling basin above the pond and through channelized canals into the west shore of the pond. Various grasses have invaded the upper settling basin, along with koa haole, kiawe, guava and small shrubs. A few monkeypod and albizzia trees remain. This settling basin floods periodically during heavy rains, leaving a small shallow water pond for extended periods. The only shallow water within the altered main pond has been created as a result of excessive siltation during construction in the northeast end of the pond. Some of the flatland near this portion of the pond has remained undeveloped until now, but recent clearing and road construction in nearby areas indicates that some of this open land may also be developed. Grasses, pluchea, mangrove and hau have invaded this ephemerally flooded flatland bordering the pond. A dike was constructed to create a channel that parallels the west shore of the pond so that runoff would be directed into the channel rather than directly into the pond. The dike is now covered with a dense growth of pickleweed, pluchea and grasses.

The shores of the pond are now a combination of rock walls and steep dirt ledges. Even in the drainage canal to the ocean, recently constructed homes reach close to the water's edge. Much of the original vegetative cover along the canal shores is now gone, or replaced with ornamental plants and small shrubs. The water in the pond and canal is often quite turbid and is not believed to be fit for public swimming.

NON-AVIAN WILDLIFE: When connection with the ocean is maintained, large numbers of mullet and other fishes are caught from the drainage channel below Kaelepulu Pond. The most abundant fish in shallow waters, particularly in the diked channel along the west shore, is tilapia. It is not uncommon to see more than a dozen fish per square yard of surface area, with some individuals as large as eight to ten inches. Several varieties of crabs were observed during our survey at Kaelepulu Pond. Large Samoan crabs inhabit the deeper waters of this pond. Turtles were observed on floating debris near the drainage into the upper end of the pond.

Dogs, cats and mongoose run loose throughout most of the surrounding lands, although leash laws provide some control of dogs. The flatlands in the upper

end of the pond are covered with tracks left by humans, dogs, cats, mongoose and rats. There are no islands or isolated areas that are inaccessible to these predators.

NON-WATERBIRD AVIFAUNA: Urbanization of the lands surrounding Kaelepulu Pond resulted in the elimination of a large amount of exotic forest. Remnants of that forest on nearby ridges and on the slopes of Olomana support a typical lowland avifauna that includes Spotted Doves, Northern Cardinals, Melodious Laughing-thrush, Shama, Japanese White-eyes, House Finch and Red-crested Cardinals. In the housing areas around the pond, Common Mynas, House Sparrows and Barred Doves are common. Within the last five years, Red-vented Bulbuls have become increasingly common in the entire Kailua area. Several residents in the Keolu Hills area raise homing pigeons, many of which were seen during our surveys. Until recently, Hawaiian Owls (Pueo) were observed with some regularity in the Olomana Golf Course area, and occasionally at Kaelepulu Pond, but we did not see any on our survey.

WATERBIRDS OBSERVED: Kaelepulu Pond has attracted interest of conservationists for many years because of its recognized importance to waterbirds. In the first year of its organization (1939), the Hawaii Audubon Society began an active program to see that the pond was declared a bird sanctuary. Initially, the Society considered leasing the pond from the landowner, Bishop Estate. Members also recommended exclusion of cattle from the edge of the pond. Changes in numbers of birds at the site were documented in the HAS journal Elepaio during the draining and consequent urbanization of the pond area.

The last recorded nesting of Hawaiian Stilt at Kaelepulu Pond was in 1935 (492). At the time, Kaelepulu was the only known nesting site for this species on Oahu. In early years, numbers as high as 200 birds were recorded at the pond. The average number of birds reported on annual HAS Christmas Counts between 1950-60 was 22 birds, whereas the average on these counts over the last ten years is less than seven. Recent semi-annual HDF&G/USF&WS counts have also been low. We observed as many as 11 and as few as three stilt on our surveys at Kaelepulu. The principal reasons for decline in numbers have been the reduction in shallow water feeding habitat, degradation in water quality and the accelerating human disturbance in the small remaining areas where feeding is still possible.

Hawaiian Coots were also reported nesting at Kaelepulu in 1935, but the most recent report was in 1947, when several nests were found. No evidence of breeding at the pond has been recorded since that date. The maximum number of coots recorded at Kaelepulu was 2,002 birds in December, 1958. Between 1955-1960 at least seven observations recorded more than 500 birds. Numbers fluctuated dramatically for several years as water levels rose and fell during the housing development process. However, the average number of coots in the last ten years of HDF&G/USF&WS counts has been less than ten birds. We recorded a maximum of six coots on our trips to the site. All were feeding in shallow water near the channelized inlet to the pond.

Hawaiian Gallinule have always been less common at Kaelepulu Pond than stilt or coots. Although one pair of gallinule was reported nesting at the pond in 1965 (499), the numbers recorded on repetitive counts have been less than five. The species was absent at the pond on several surveys. There is very little emergent vegetation typical of other gallinule habitat in the State. We observed only one gallinule on our surveys of the pond itself, although a small number of these birds are resident in the Hamakua Drive Canal near Kawainui Marsh.

Past records of Black-crowned Night Herons at Kaelepulu Pond have ranged as high as 30 birds, but recent counts have rarely exceeded five. We observed a maximum of six birds on one trip to the site, and most of these birds were feeding in shallow water within the settling basin above the pond. Others were seen in the drainage canal that borders the west shore of the pond. Abundant tilapia in this canal provide a virtually unlimited source of food, but much of the area is too deep for herons to wade.

The most recent record of Koloa at Kaelepulu Pond was in January, 1976. Several recent releases of cage-reared birds at Kawainui Marsh and Kaneohe Marine Corps Air Station have resulted in other sightings on the windward side of the island as well. Some of these birds have nested successfully in Hamakua Drive Canal and within Kawainui Marsh, but there are no nesting records for Kaelepulu Pond. Munro (1960) reported that Koloa were nesting successfully on Mokolua Islands in the early 1940's, and indicated that parent birds were "carrying or swimming the chicks to the Kawainui Swamp at Kailua or in the outlet of the Kaelepulu Pond by Lanikai".

Prior to urbanization of surrounding lands, migratory waterfowl often visited Kaelepulu Pond in very large numbers. Pintail counts ran as high as 1,400 birds (in 1948), whereas Shovelers were much less common. The most recent high Pintail count was in 1959, when 418 birds were observed. Since that time, which coincides with the onset of major grading and land development, numbers of Pintails have dropped to a small fraction of the original populations. Excessive siltation during urban development eliminated most of the submergent vegetation and probably altered the pond ecology so radically that these birds are no longer able to find sufficient food to support large populations. Less common migratory waterfowl that have been recorded at Kaelepulu Pond include Northern Shoveler, Lesser Scaup, American Wigeon, Green-winged Teal, Ruddy Duck, Mallard and Canada Goose. Domestic (or feral) Mallards continue to inhabit the drainage canal to the ocean, where they breed successfully in small numbers.

One count of 500 Golden Plovers and 300 Ruddy Turnstones in 1951 was an abnormally high concentration of migratory shorebirds at Kaelepulu. However, typical early counts for these species were considerably higher before urbanization than in recent years. The amount of suitable feeding habitat for shorebirds is severely limited by steep shorelines and heavy growth of vegetation in the only areas that are not already converted to housing or roads. Even when water levels are down, the silt-covered substrate does not attract as large a concentration of these birds as would be expected if a well-developed bottom fauna was available as a source of food. Other shorebirds that have been recorded at the pond include Wandering Tattler, Sanderling, Pectoral Sandpiper and Semipalmated Plover. Of these, we recorded a maximum of three tattlers during our summer survey at Kaelepulu Pond.

Cattle Egrets pass over Kaelepulu Pond virtually every day enroute to and from feeding areas in Waimanalo. They return every evening to their rookery at Kaneohe MCAS. Some stop to feed with cattle along Hamakua Canal on a regular basis, but they stop far less regularly in the immediate area of Kaelepulu Pond. As many as 33 birds have been counted on recent HDF&G/USF&WS surveys of the area. We observed egrets only in the settling basin above the pond. A maximum of eight birds were noted on our surveys.

One final "wetland" species should be mentioned due to the frequency of its appearance over Kaelepulu Pond. Great Frigatebirds are often observed drinking (and possibly feeding) from the surface of the pond. Several hundred frigatebirds roost on Moku Manu Island, off Ulupau Head, and many of these pass high over the pond. Rarely are more than two to three frigatebirds observed at the pond at one time, and they never land.

HABITAT EVALUATION: It is clear from the historical data that Kaelepulu Pond was once very important habitat for coots, stilt and migratory waterfowl, and of less importance to other resident and migratory species. The pond is mentioned in the recent draft HWRP (346) only as an example of Hawaiian wetlands lost to urban development. The habitat has suffered far more than might have been expected by sheer reduction in size. Several areas in the State that are a fraction of the size of Kaelepulu Pond now support far more stilt and/or coots. All but the western shoreline has been rendered nearly worthless for waterbirds and impending housing development near the channelized inlet to the pond promises to degrade the small remaining feeding habitat even more.

Human disturbance and access of the entire shore of the pond to predators makes it likely that the site in its present condition will never be of significance as nesting habitat for any of the endangered species of waterbirds. However, there is still reason for concern regarding additional deterioration of habitat in the upper end of the pond. Runoff from urban lawns and streets all enter storm drains and much of this enters the pond immediately upstream of the feeding area. The impact of this runoff on pond ecology is uncertain but could be serious.

Even though total numbers of waterbirds in the pond are low by comparison to earlier records, the site is still one of several feeding habitats along the east coast of Oahu that, together, contribute to the well-being of stilt, coots and gallinule. The condition of the remaining feeding habitat should be protected as much as possible for this limited value to birds, and perhaps more importantly, for its potential value for environmental education. The site is convenient to schools and a densely urbanized neighborhood, so it is easily accessible to the public. It should not be written off as a lost cause just because it was so much better in the past. A cooperative management effort to insure continued use of the remaining habitat by waterbirds should be initiated.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: It was not clear when surveying Kaelepulu Pond whether or not the ongoing construction activities near the shore may already be in violation of Section 404 of the FWPCA or the Endangered Species Act of 1973. However, any further deposition of fill or dredged material on the undeveloped flatlands near the channelized inlet would impact directly on the small amount of marginal feeding habitat that still remains. Present vegetative cover on this undeveloped land protects the shallow-water feeding areas from additional siltation except that which originates higher upstream. It is unlikely that this land will be urbanized because of the frequency of flooding during heavy runoff. On the other hand, it does have some potential for improvement as habitat for waterbirds. A moat between the road and the undeveloped flatland would provide a protection against predation that may encourage greater use of the area by waterbirds. Partial clearing of vegetation would expose sites that might be selected by birds for nesting. Koloa and gallinule have nested during the past year in Hamakua Drive Canal, where human disturbance and continuing pollution of the water are an everyday occurence. This suggests that Kaelepulu, though in poor condition by comparison to earlier years, has current value and potential to waterbirds that should be recognized in evaluation of permit requests.

SITE NAME: Paikō Lagoon

LOCATION: Honolulu District, O'ahu

TOPOGRAPHIC MAP: Koko Head

DATES OF SURVEY: 2 June, 15 August, 1977

WETLAND DESCRIPTION: Paiko Lagoon was formerly managed as a coastal fishpond. A freshwater spring feeds a small private pond near the lagoon and Kuliouou Stream drains into the mouth of the lagoon through a channelized inlet. Water level in the lagoon fluctuates directly with the tides, periodically exposing extensive saline mudflats. A flat, sand-covered reef outside the peninsula is exposed by low tides as well. The maximum depth of water over the mudflat in the lagoon is .5 to .7 meters (371).

The peninsula supports a variety of native and exotic plants including pickleweek, koa haole, pluchea, kiawe, ilima, milo and others. Mangrove has encroached on the inland shore of the peninsula and threatens to spread if not adequately controlled. Much of the inland border of the pond is surrounded by homes.

Members of the Hawaii Audubon Society have been interested in Paiko Lagoon as a potential wildlife sanctuary for many years. The educational and recreational importance of the site were cited as the prime values of the lagoon when the HAS began its efforts to protect the area in 1961. Soon after nearby residents began to complain of the smell associated with exposed mudflats in the lagoon. In a combined program to improve water circulation and to create artificial nesting islets for Hawaiian Stilt, the State appropriated and released funds for a dredging effort in the lagoon. In 1974, 40 acres were designated as a State Wildlife Sanctuary. Over one million dollars were appropriated by the legislature to purchase land on the peninsula for this sanctuary. In 1976, Mr. Rodney Inaba completed construction of a private home on a 15,500 square foot lot that was omitted in the State purchase of land. Several residents in the area filed suit to stop construction of this house in the wildlife sanctuary but were unsuccessful in their case.

NON-AVIAN WILDLIFE: The saline mudflat within Paiko Lagoon supports a large variety of invertebrates, some of which are exploited as food by the waterbirds that inhabit the area. Lum (371) recorded several species of crabs and shrimp. Various marine worms are also present. Fish in the lagoon include blennies, gobies, mollies, mullet, milkfish and barracuda. Fishes that inhabit the inland brackish pond include manini, mullet, tilapia, barracuda, and according to the landowner, also bonefish and ulua.

1. dredged area
2. artificial nesting islands
3. Inaba house
4. private pond
5. Kuliouou Stream
6. Paiko Lagoon Wildlife Sanctuary boundary (approximate)

A dredged channel on the edge of the inner lagoon restricts access of predators to the mudflats, but dogs, cats and mongoose are unrestricted on the peninsula. An intensive predator control program has been suggested for the sanctuary but has not been implemented. In low tides, some of the artificial nesting islets are accessible to dogs as well. Sanctuary regulations prohibit fishing within the lagoon waters, but human access to the peninsula is permitted.

NON-WATERBIRD AVIFAUNA: The kiawe forest on Paiko peninsula supports a limited avifauna. We observed Japanese White-eyes, Barred Doves, Spotted Doves, House Sparrows, Red-crested Cardinals, House Finch and Common Mynas. Doves and sparrows are most common within the housing areas surrounding the lagoon. Northern Cardinals and Rock Doves may be expected at Paiko Lagoon as well, but they were not recorded on our survey.

WATERBIRDS OBSERVED: Original interest in Paiko Lagoon as a potential wildlife sanctuary arose from continued observations of Hawaiian Stilt feeding at the site. There are no nesting records for this species at Paiko Lagoon, but the exposed mudflats and shallow water provide important feeding habitat. Early HDF&G/USF&WS records show considerable variation in numbers, in part because many surveys were not coordinated with tidal schedules and because temporal patterns of stilt use of the lagoon were poorly understood. Yet between 1961-67, an average of 37 stilt were observed at the lagoon on annual surveys (range 6-109). In more recent studies at the lagoon, Allen and Lum (339) reported an average of 16.5 birds on 13 monthly counts during April and May. This spring exodus is typical of Paiko Lagoon and other stilt feeding habitat where nesting does not occur.

After dredging activities in 1973, numbers of stilt visiting the lagoon dropped off considerably, and it is difficult to determine from more recent data whether or not the population of stilt that visit the lagoon is now increasing. Monthly HDF&G/USF&WS count records since sanctuary designation show the species absent on several months of the year and present in numbers averaging less than seven when the birds are recorded at the site. On two prolonged visits to the site, and several brief counts during the period of this study, we never observed more than six stilt in the lagoon. We found no evidence that stilt were attempting to nest in the lagoon, although some birds were feeding on the edges of artificial nesting islets.

Black-crowned Night Herons roost on the peninsula and feed in lagoon waters throughout the year. The species is rarely missed on counts at the lagoon. Herons often feed in shallow water near the drainage from the adjourning brackish water pond. They were recorded eating small fish and crabs during our survey at the site, although no more than three birds were observed on any visit. Count records by HDF&G/USF&WS biologists show the species numbering between one to four on 8 of 12 counts between 1970 and 1976. There is no evidence that herons nest in the immediate area.

Migratory waterfowl are rarely reported within Paiko Lagoon. However, a small brackish pond that connects with the lagoon supports variable numbers of domestic Mallards. These birds are fed regularly by the pondowner and also feed on algae that grows profusely in this water. On one trip we observed a total of 13 drakes and 8 hen Mallards at the pond and near the drainage opening into the lagoon. Three broods of ducklings (three to five birds each) were also observed at the pond. The landowner indicated that the Mallards nest on the islands in the pond

and in neighboring yards. Mallards seen on earlier counts at the lagoon probably come from this pond.

The list of recorded migratory shorebirds at Paiko Lagoon include four species that are common throughout the islands: Golden Plover, Ruddy Turnstone, Wandering Tattler, Sanderling. Lum (371) found that a small number of tattlers (two to five) were present at the lagoon during all months of the year. We counted one to three tattlers on our trips to the site. Numbers of Golden Plovers and Ruddy Turnstones at the lagoon vary considerably over the year, but both species show a marked increase between December and March. We did not record either species during our trips to the lagoon. Of the four common shorebirds, only Sanderlings were totally absent in summer months during Lum's study. Published records in the Elepaio that combine data from observations at Paiko and Kuapa Pond (Hawaii Kai) include sightings of Black-bellied Plover, Semipalmated Plover and Pectoral Sandpiper.

HABITAT EVALUATION: Although numbers of Hawaiian Stilt feeding at Paiko Lagoon have diminished in recent years, the site has a long history of use by this species. Even under present conditions, the site attracts more stilt than any other habitat from Keehi Lagoon to Bellows Field in Waimanalo. Several former wetlands close to Paiko have been lost to urban development. Paiko Lagoon is the only wetland on the island that is protected as a State sanctuary. Perhaps even more important, Paiko is readily accessible to the public and serves a valuable role as a recreational and educational resource. Several teachers from elementary school to the university level bring their students to the lagoon. The birds that inhabit the lagoon play an important role in the environmental education process.

There has been considerable debate whether or not Paiko Lagoon has potential as stilt nesting habitat. Stilt will often nest close to the areas in which they feed, but the repeated movement of these birds to and from Paiko Lagoon is a long established pattern. If suitable nesting habitat can be provided at Paiko, and if human disturbance and predation can be controlled, then it is possible that this pattern may be broken and a nesting colony may develop in the lagoon. The decline in numbers of stilt at the lagoon suggests that dredging activities in 1973 may have disturbed the birds and their habitat more extensively than was anticipated. At the same time, the declining numbers may reflect other disturbance at the lagoon, or lowered breeding success in habitat where the Paiko birds choose to nest.

Construction and occupation of the new house on Paiko peninsula has created an additional source of ongoing disturbance very close to the site where artificial nesting islets were constructed. We believe that this disturbance now poses a significant new deterrent to successful colonization and nesting by stilt in the lagoon. Whether or not these birds choose to nest remains to be seen. The entire controversy does suggest the need to monitor the population of birds and to evaluate the impact of this and other man-related disturbance on their behavior.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: The overall impact of earlier dredging activities on bird populations at Paiko remains uncertain because the lagoon modifications occurred simultaneously with a pattern of increasing human disturbance on lands surrounding the lagoon. The initial plan to improve circulation by creating a channel around the entire perimeter of the lagoon was only partially implemented. The nesting islets were placed much closer to the peninsula than originally planned. Although the dredged islets are used as resting and feeding

sites by stilt and other shorebirds, there is no evidence that any nesting has been attempted to date.

Further dredging for the purposes of waterbird habitat improvement is probably unwarranted until a pattern of habitat use over time can be determined through continuing surveys. It would, however, be advisable to control encroaching mangrove as it begins to establish. Any future proposals by the State to continue dredging or to create more islets should be more carefully evaluated. One suggestion to improve circulation through an outlet under the isthmus road should be considered.

SITE NAME: Pearl Harbor Wetlands (includes Pearl Harbor National Wildlife Refuge)

LOCATION: 'Ewa District, O'ahu

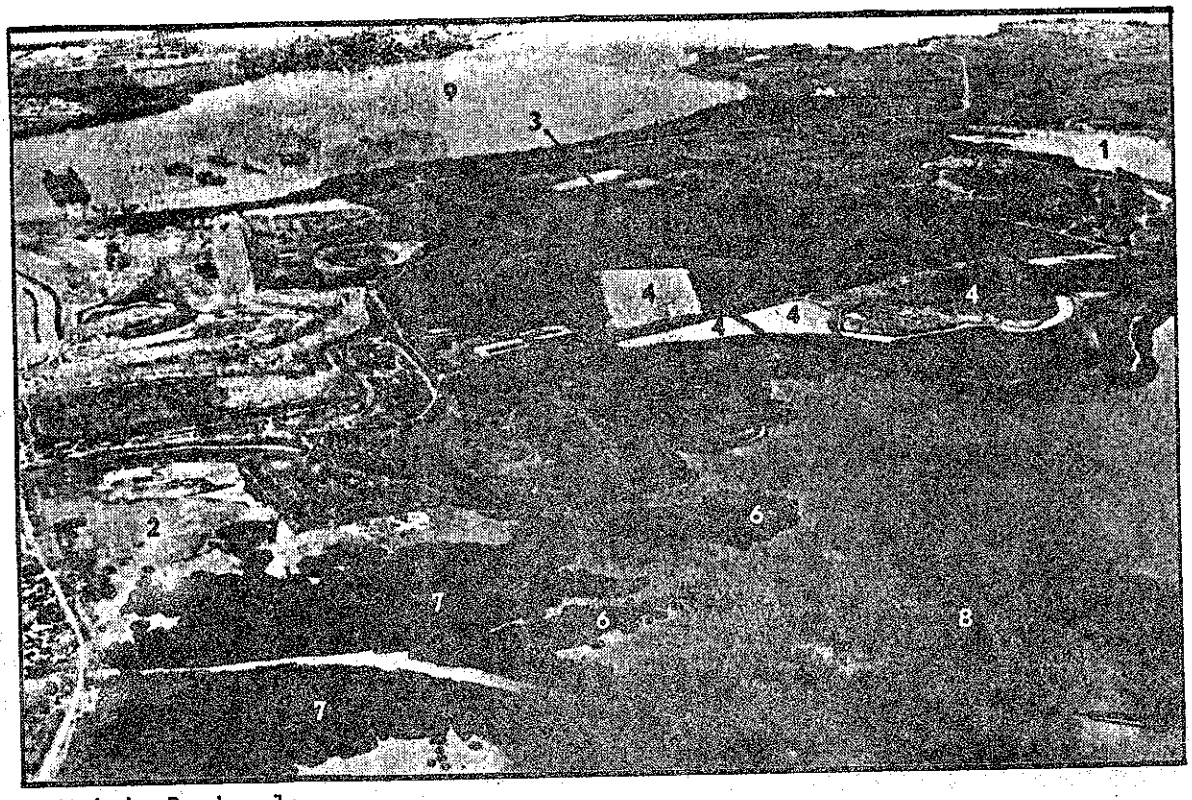
TOPOGRAPHIC MAPS: Wai-pahu, Pu'u-loa, 'Ewa

DATES OF SURVEY: 1 June, 27 August 1977 (Pearl Harbor NWR)
1 June, 19 August 1977 (Honouliuli Ponds)
1 June, 21 August 1977 (Waipio Peninsula)

WETLAND DESCRIPTION: Our survey sites in the Pearl Harbor area included a variety of man-made and "natural" wetlands; ponds along the west shoreline of West Loch (Honouliuli), the Waikele-Kapakahi stream drainage on Waipio Peninsula, and mangrove swamp and ponds on east and west sides of Waiawa (Pearl City) Peninsula. Several other small ponds, marshes and settling basins were not surveyed, but are discussed in the treatment of waterbird abundance and distribution. The nature and condition of the Pearl Harbor wetlands has changed dramatically during this century. As many as 50 fishponds lined the shores and covered the flats within the Pearl Harbor area in the late 1800's. Colonization of this estuary by American (Red) Mangrove approximately 35 years ago signalled the beginning of extensive natural modification of original wetlands.

Honouliuli Sites: Numerous fishponds and a 31 acre salt evaporation pond were found on the west shore of West Loch (Honouliuli) early in this century. At the suggestion of Federal and State biologists, the salt pond was set aside as a wildlife sanctuary by the U.S. Navy in 1971. More recently, this site was selected as one of two areas to be developed as waterbird refuges to compensate for 186 acres of silted coral mudflats that were lost in the construction of the reef runway at Keehi Lagoon. The original pond was extensively modified by the State Department of Transportation and the Federal Aviation Administration, under direction from the USF&WS. Modification involved development of separate impoundments, construction of roads, drainage channels and nesting islets and development of a pumping system to supply water. The site became a unit of the Pearl Harbor National Wildlife Refuge in 1976.

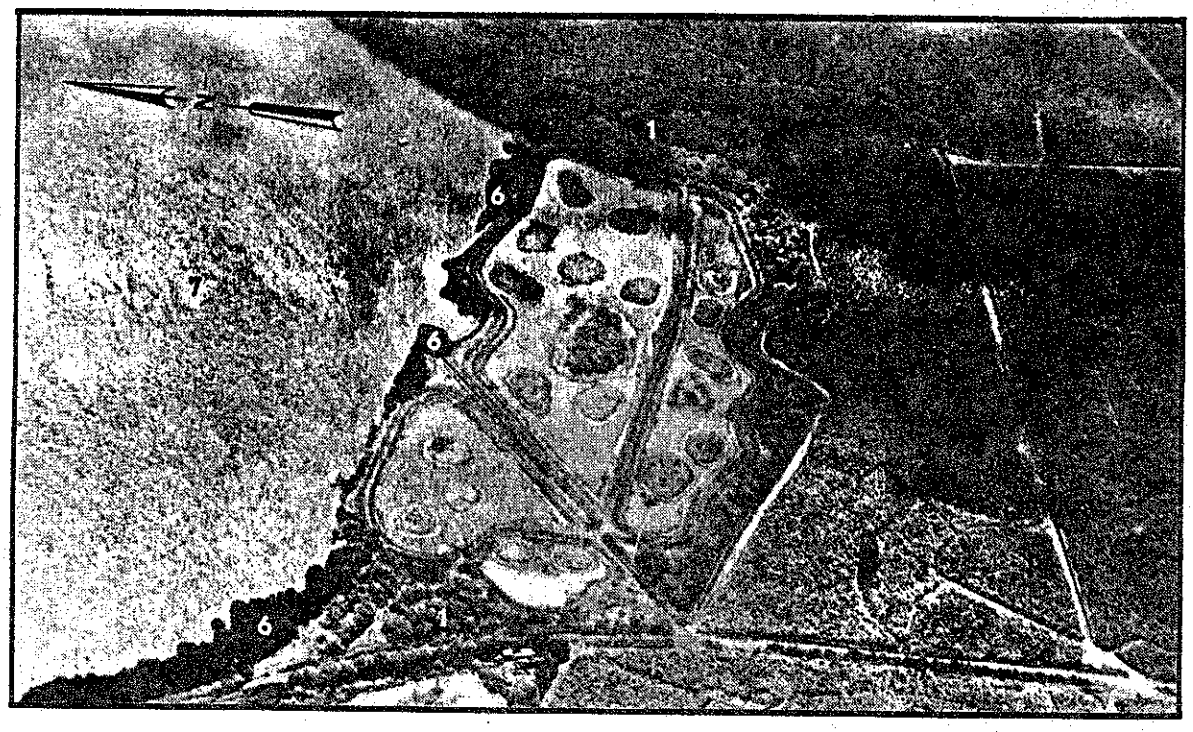
The Honouliuli branch of the Pearl Harbor NWR was not in "full" operation at the time of our survey, due to problems in maintaining an adequate supply of fresh water. Since the construction has been completed, pickleweed has encroached onto the shores of most of the nesting islands and into the drainage channels. The site is fenced except along the West Loch shore, where mangrove has taken over a large portion of the refuge shoreline. The refuge is surrounded by a narrow, but dense, kiawe forest. Most of the land west of the site is in sugar cane production.



Waipio Peninsula

1. Walker's Bay
2. Pouhala wetland
3. settling basins
4. sewage oxidation ponds
5. primary stilt nesting islets, 1977 (Reference - 510)
6. Cattle Egret nesting colony
7. mangrove
8. Pearl Harbor West Loch
9. Pearl Harbor Middle Loch

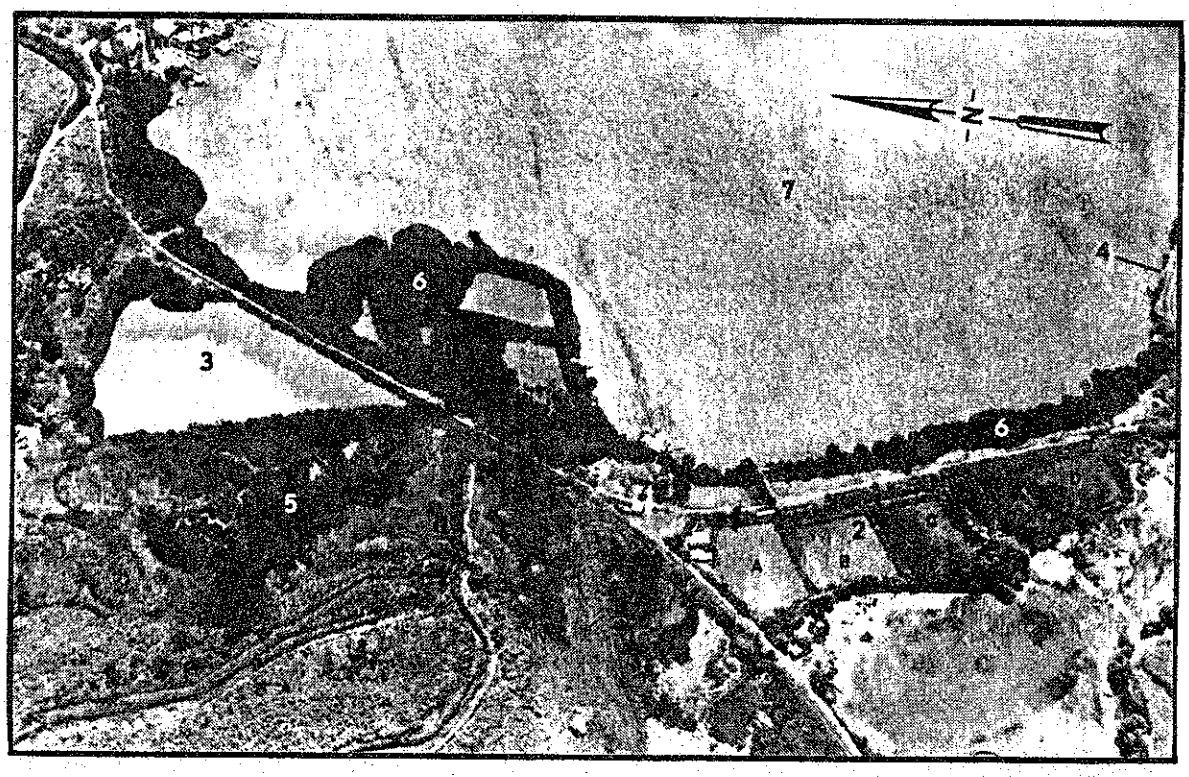
Pearl Harbor NWR, Waiawa (Pearl City) Unit



Pearl Harbor NWR, Honouliuli Unit

1. kiawe forest
2. Honouliuli prawn ponds (A,B,C,D)
3. Honouliuli fishpond
4. edge of Pearl Harbor NWR, Honouliuli Unit
5. marsh
6. mangrove
7. Pearl Harbor West Loch

Honouliuli Ponds



Immediately north of the Honouliuli refuge is a series of four 1-2 acre fishponds, now in use for production of Malaysian Prawns. This wetland was formerly a single pond, but extensive diking in recent years has allowed independent use of the four different water impoundments. The two most southern ponds (C and D on the photograph) are not presently in active use for aquaculture. As a result, cattails and pluchea have been allowed to encroach into these two impoundments. All of the ponds are between 6-36 inches in depth, with a relatively hard packed mud bottom. Water is supplied by a well and the ponds drain into West Loch.

Further north along the Honouliuli shoreline are three fishponds, the largest of which is essentially unchanged in shape from its historical configuration. This pond is now encircled with mangrove, which in turn is backed up by a small area of marshland, dominated by California grass, pickleweed, bulrush and other sedges. Water in the pond is generally very turbid. The pond is still in marginal use for aquaculture, and the surrounding lands support limited grazing of cattle.

Waipio Peninsula Sites: At the northwest corner of Waipio Peninsula, several large fishponds formerly bordered the Kapakahi Stream drainage where a very extensive mangrove swamp now exists. Inland of the mangrove swamp, between the Waipahu Dump and housing areas to the north, a remnant marsh (Pouhala) can still be found. At the suggestion of State and Federal biologists, approximately 330 acres of mangrove forest and associated shallow water and mudflats were set aside as a wildlife refuge by the U.S. Navy in 1970. Pouhala Marsh is dominated by pickleweed, with scattered patches of bulrush. This city-owned site is threatened by possible expansion of the Waipahu Dump.

Numerous other "wetlands" on Waipio Peninsula provide important waterbird habitat. Two very large fishponds (Loko Hanaloa and Loko Eo) formerly occupied most of the eastern half of the peninsula. Most of the land on the peninsula, which is leased from the U.S. Navy by Oahu Sugar Company, is now in sugar cane production. As a mechanism for removing the silt from cane irrigation and processing water, large settling basins have been constructed on the peninsula. As they fill with silt, they are dried and leveled for cane production or cleared for reuse as settling basins. In addition, large sewage oxidation ponds occupy a portion of the western half of the peninsula. Mangrove now occupies much of the Waipio Peninsula shoreline, as a result of which extensive tidal mudflats have developed in formerly open bays. Walker's Bay, along the western shore, now provides feeding habitat for some resident and migratory waterbirds.

Pearl City (Waiawa) Peninsula: This peninsula is much smaller than Waipio Peninsula. At least four fishponds formerly bordered the outlet of Waiawa Stream at the northwest edge of Pearl City Peninsula. Mangrove has now taken over the drainage and most of the western shoreline. A brackish pond and marsh north of the stream drainage provided some habitat for stilt and other birds but was threatened by expansion of a neighboring U.S. Navy landfill. In 1970, with the encouragement of the USF&WS, the U.S. Navy agreed to cooperate with the State in designation of refuge sites as mitigation habitat for the loss of stilt feeding habitat during reef runway construction. The Pearl City pond was modified by diking, nest island construction, development of a fresh water source and fencing. The 24.5 acre site became the Waiawa or Pearl City Unit of the Pearl Harbor National Wildlife Refuge in 1976. At the time of our brief survey of the refuge, USF&WS personnel were having difficulty pumping sufficient water to maintain

desired levels in the pond. Pickleweed had taken over some of the nesting islets, while others are nearly free of vegetation. It is apparent that some selective vegetation control and possibly judicious planting of other marsh vegetation may be desirable in the future.

A dense growth of American mangrove has taken over most of the northeastern shoreline of Pearl City Peninsula. Although the mangrove mudflats provide only limited waterbird habitat, several watercress farms north of the mangrove fringe are visited by waterbirds on a regular basis.

NON-AVIAN WILDLIFE: The diversity of Pearl Harbor wetland areas insures availability of a wide range of invertebrate and vertebrate organisms as potential food for waterbirds. The sites vary in salinity, substrate, water depth, circulation, degree of water level fluctuation, and age. The last of these variables has particular relevance to recently constructed wetlands (refuge sites) that are likely to develop a more diverse aquatic fauna over time.

Mangrove mudflats throughout Pearl Harbor are covered and exposed with fluctuations in tides, providing ephemeral feeding habitat for waterbirds. Most fishes characteristic of estuarine waters in Hawaii are found in waters over the mangrove mudflats in Pearl Harbor. We observed mullet, milkfish, barracuda, and aholehole. Some of these fishes are particularly abundant where they were caught in shallow pools left by receding tides. Tilapia and mosquito fish were found in numerous drainage ditches, fishponds, prawn ponds, marshlands and watercress ponds in the sites we surveyed. Bullfrogs and toads were observed in the prawn ponds, stream drainages and watercress farms.

Invertebrates we observed on mangrove mudflats were those characteristic of saline impoundments (i.e. grapsid crabs, portunid crabs, snapping shrimp, mud shrimp, annelid worms, etc.). Marshlands in Honouliuli and Waipio Peninsula support a variety of aquatic insects, although there was no attempt to survey these areas thoroughly. The invertebrate fauna of cane waste water settling basins warrants intensive study because it may provide some guidelines for increasing the productivity of newly-created waterbird habitat. We found crayfish and freshwater prawns in prawn ponds, watercress farms and stream drainages.

The abundance and distribution of potential predators in the Pearl Harbor wetlands provides genuine reason for concern. Dogs (or their sign) were found in virtually all habitats, except the very soft mud within some mangrove mudflats. Several dogs have been removed from the Federal refuges by maintenance personnel. Apparently the existing fences are not adequate at the present time to prevent access. Problems with water supply have rendered the nesting islets accessible to dogs and other predators during part of this year. The proximity of some sites (i.e. Pouhala, Waiawa refuge) to operating landfills insures the presence of greater than average numbers of rats and mongoose. Feral cats are sure to be present in all areas. Unlike many other wetland areas we surveyed on Oahu and on other islands, grazing animals were not a significant problem threatening the condition of waterbird habitat in the Pearl Harbor areas.

NON-WATERBIRD AVIFAUNA: The habitat associated with wetland areas of Pearl Harbor supports an unusual variety of exotic birds, including game species, cage birds and long-established varieties that are widely distributed throughout the islands. Numerous field trip reports in recent years by Hawaii Audubon Society members, as well as HDF&G and USF&WS records provide considerable background data.

Several exotic birds were common at all sites surveyed in this study: Japanese White-eye, Barred Dove, Spotted Dove, Common Myna, Spotted Munia. In sites where kiawe or mangrove forest was found associated with the wetland, we also observed Northern Cardinal, Red-crested Cardinal and less commonly, House Finch. House Sparrows were locally abundant near landfills and in suburban areas. Two additional species we recorded, that do not appear on earlier count records, were Red-vented Bulbuls and Shama. The bulbuls were locally common in mangrove forest on Pearl City Peninsula, but were not seen at other sites. Shama were observed in mangrove forest; one on Waipio Peninsula and one on Pearl City Peninsula.

On the west side of Waipio Peninsula, we observed several large flocks of Red Munia (Strawberry Finch) and Black-headed Munia (Black-headed Mannikin). Both species were seen near the Waipahu Dump, at Walker's Bay and near the settling ponds. These species have been established on the peninsula for several years. There are at least two earlier reports of Tri-colored Mannikins on the peninsula as well, but none have been observed since 1969. Other cage birds recorded from the peninsula include Red Bishop, and Golden Bishop weavers, both seen as recently as fall, 1976.

The list of additional non-wetland birds recorded in Pearl Harbor wetland areas includes Ring-necked Pheasant, Skylark, Barn Owl and Hawaiian Owl (Pueo). Of these, pheasants are by far the most frequently observed, particularly on Waipio Peninsula. We did not record any of these species on our wetland surveys in Pearl Harbor.

WATERBIRDS OBSERVED: Historical data on waterbird abundance and distribution in the Pearl Harbor wetlands also comes from field trip reports of Audubon Society members, as well as from HDF&G and USF&WS records. Few data are available prior to 1960, but there have been more recorded field trips to these areas since 1970 than any other wetland on the island. Our survey of refuge units in Pearl Harbor was complicated by difficulty in obtaining independent access, so we rely heavily upon the historical data in evaluating the different sites. The major reason for combining several Pearl Harbor wetlands together in this discussion is the well-documented movement of birds between sites.

Hawaiian Stilt are found in Pearl Harbor wetlands in far greater numbers than all other endangered waterbirds put together. In some recent surveys, nearly half of the recorded Statewide population of this species was distributed throughout the Pearl Harbor sites. Recent construction of two new refuge units promises to increase the importance of Pearl Harbor to the survival of this species. As many as 268 stilt have been counted in the Honouliuli unit of the Pearl Harbor on counts since its construction, but there have been radical variations in population, even from day to day. Average population of several counts over the last two years has been less than 50 birds. The other Honouliuli wetlands provide very little stilt habitat, although small numbers are occasionally found in flooded pastureland or in the small marsh bordering the Honouliuli fishpond.

The Waikele-Pouhala area of West Loch supported several hundred stilt in earlier years. An earlier publication (343) indicated that 300-500 stilt were consistently found in this area. Although HDF&G/USF&WS count in 1970 ran as high as 259 stilt, on several more recent surveys less than 20% of that number have been recorded. The recent decline is not fully understood, but is probably due to a combination of factors including increasing human disturbance, encroachment of vegetation and increased stilt use of other Pearl Harbor areas. The sewage

oxidation ponds and settling basins on Waipio Peninsula areas together have run as high as 353 stilt and as low as 33. On HAS counts, as many as 500 stilt were counted on the largest sewage oxidation pond ("Big Pond") in 1976, but the average of recent counts is less than 200.

Stilt counts at the Pearl City unit of the Pearl Harbor NWR have been surprisingly large for a site so small by comparison to other wetlands. Recent counts by USF&WS biologists have ranged as high as 454 stilt, but the average of more than 75 counts over the last year is only slightly above 100. Greatest numbers are found in late summer and fall months. Several pairs of stilt have nested successfully on islets within the refuge. Improvements in water level maintenance and predator control is likely to increase production significantly. The mangrove mudflats on the east shoreline of Pearl City Peninsula provide marginal habitat for a small number of stilt when tides are appropriate. On our brief surveys of refuge units, we observed 52 stilt at the Honouliuli unit and 44 at the Pearl City unit. More than 70 stilt were counted on the settling basins and sewage oxidation ponds. Less than a dozen stilt were seen in the Pouhala Marsh area.

Coots find far less suitable habitat in the Pearl Harbor wetlands than do stilt. No more than 3 coots have been reported on individual counts at Honouliuli refuge unit. Although they do not appear on count records at the Waiawa Unit, the refuge maintenance foreman reports having observed the species at this site (510). Greatest numbers in the Pearl Harbor area have generally been found in small fish ponds in the Waikele area, although recent HDF&G/USF&WS counts for this area average less than 15 birds. The largest coot counts in the Pearl Harbor area come from the sewage oxidation ponds on Waipio Peninsula. As many as 52 birds have been counted in recent Audubon field trips (9/15/76), but the species is often absent from the site. The only documented nesting of this species in recent years that we are aware of has been within the Honouliuli prawn ponds. The Principal Investigator has observed at least three pairs nesting simultaneously in the least developed ponds (c & d). In these ponds, we witnessed successful rearing of young by a pair consisting of a red-shielded adult bird and a bird with the typical white shield in 1973. This phenomenon has since been observed at several other locations in the islands. Although we have counted as many as 13 coots on the Honouliuli fishpond north of the prawn ponds, nesting has not been documented. On this survey, we observed coots at the prawn ponds (n=6) and in a large sewage oxidation pond on Waipio Peninsula (n=20).

Hawaiian Gallinule are even less common in Pearl Harbor areas than are coots. No more than two birds have been reported at the Honouliuli refuge unit in recent years. We recorded one gallinule in the algae-infested impoundment during our survey of this site. The prawn farm at Honouliuli is the only Pearl Harbor location where nesting by gallinule has been confirmed, at least in recent years. At this site, the Principal Investigator has recorded as many as 7 birds, and at least one nesting pair, each year since 1972. The fishpond north of the prawn farm also supports between 2-6 gallinule, and it is likely that nesting occurs undetected in the dense shoreline vegetation. We could find no records of gallinule on Waipio Peninsula, but it is likely that small numbers occasionally visit freshwater stream drainages or irrigation ditches. Gordon Black (510) indicated to us that he has seen gallinule at the Waiawa refuge unit, but they do not appear on count records.

Hawaiian Ducks (Koloa) appear only recently on count records in the Pearl Harbor wetlands. Although releases of cage-reared Koloa began on the windward side of Oahu in 1969, we can find no reports of the species in the Pearl Harbor area until 7/18/76, when two birds were counted on ponds on Waipio Peninsula. Since that time, they have also been observed at the Honouliuli refuge unit. Because of the distance involved, it is questionable whether or not birds from the windward side will successfully disperse in greater numbers to this area. Some consideration should be given to a future release of Koloa at Pearl Harbor wetlands, particularly after water levels are stabilized within the refuge units.

Black-crowned Night Herons ('Auku'u) have been recorded at all Pearl Harbor wetlands that have been visited in past years. The greatest numbers are found on Waipio Peninsula sites, particularly within sewage oxidation ponds and Walker's Bay area. Yet even in all these sites together, rarely are more than 20-30 birds counted. The heron population that frequents the shallow fish ponds and marsh areas near Waikele is generally larger than in any other single Pearl Harbor wetland, but even here the average number counted in recent years is less than 20. Small numbers of herons are nearly always present in the Honouliuli prawn ponds and refuge unit, but they are seen far less often in the Waiawa refuge unit. Extensive mangrove and kiawe forest on the shores of all Pearl Harbor lochs provide unlimited potential nesting habitat for herons. In view of the diversity and abundance of suitable feeding habitat in the Pearl Harbor area, it is surprising that the resident heron population is not larger. We observed herons on our survey at the Honouliuli refuge unit (n=4), at the prawn ponds (n=1), at the Honouliuli Fishpond (n=2), in the egret nesting colony area at the Kapakahi Stream drainage (n=4), and elsewhere on Waipio Peninsula (n=14).

Cattle Egrets were first found nesting in the Pearl Harbor area (West Loch) in January, 1963, four years after their introduction to the island. By April, 1963, the rookery was estimated to include a minimum of 100 active nests (351). Since that time, egrets have been observed at all Pearl Harbor wetlands. Counts as high as 500 birds have been made on Waipio Peninsula, although the observed population is generally much lower. Settling basins provide a particularly abundant source of insect food. The egrets are regularly found in the landfill area around the Pearl City refuge unit and within the Waipahu Dump. Watercress farms northeast of Pearl City Peninsula are also an important feeding site for egrets. where they consume large numbers of crayfish. The prawn ponds and fishpond at Honouliuli do not attract many egrets, but some birds are generally found with grazing animals nearby. On our survey, we observed egrets at all wetland sites surveyed, but greatest numbers were found near Pouhala Marsh, the Waipahu Dump, and the nesting colony in nearby mangrove forest.

The large numbers and variety of migratory waterfowl recorded in Pearl Harbor wetlands reflects the diversity of habitat available. Numbers vary, often daily, at different areas as large groups of ducks move from site to site. Pintail counts on the settling basins and sewage oxidation ponds of Waipio Peninsula have run as high as 250 birds. Shoveler counts are generally lower, but one count of 400 birds was recorded at the "Big Pond" in January, 1977. On the average, the Pearl Harbor population of wintering Pintails and Shovelers together runs between 100-200 birds. Both species are seen irregularly at the two refuge units, but it is expected that numbers will increase when water levels are stabilized and a more diverse and abundant source of aquatic food is avilable. The list of less common

migratory waterfowl is longer, but these species taken together represent a very small percentage of the waterfowl population. American Wigeon, Lesser Scaup, Mallard and Green-winged Teal appear irregularly on count records. Other even less common waterfowl recorded in Pearl Harbor wetlands include European Wigeon, Bufflehead, Common Teal and Canada Goose.

The list of migratory shorebirds that have been recorded at the Pearl Harbor wetlands is longer than for any other site in the State. This is in part due to the abundance of mudflats and fertile settling basins, but it is also due to the proximity of the habitat to Honolulu, and the consequent frequency of visits by competent ornithologists. Unlike most other wetlands in the State, the winter counts of Ruddy Turnstones on Waipio Peninsula often exceed the number of Golden Plovers observed. Total counts of these two species often exceed 300 birds, and occasionally run as high as 600. Sanderlings are generally more common at Pearl Harbor than in other wetlands, particularly within the sugar cane settling ponds. Wandering Tattlers are well distributed throughout Pearl Harbor but invariably in comparatively low numbers. The Honouliuli refuge unit generally attracts greater numbers of these shorebirds than does the Waiawa unit, although we counted over 400 plovers and turnstones at the Waiawa unit on 27 August, 1977.

Most uncommon or rare migratory shorebirds have been observed in the settling basins and sewage oxidation ponds on Waipio Peninsula, but there is some evidence of movement between here and other small sites. The list includes Bristle-thighed Curlew, Black-bellied Plover, Semipalmated Plover, Piping Plover, Greater Yellowlegs, Lesser Yellowlegs, Least Sandpiper, Sharp-tailed Sandpiper, Pectoral Sandpiper, Buff-breasted Sandpiper, Common/Spotted Sandpiper, Baird's Sandpiper, Western Sandpiper, Dunlin, Long-billed Dowitcher, Bar-tailed Godwit, Common Snipe, Western Phalarope, Killdeer, and Knot.

Pearl Harbor has also been the location of more sightings of other rare stragglers and unusual migrants than any other wetland on the island. A single White-faced Ibis has been observed during 1976 and 1977, on Waipio Peninsula and at the Honouliuli refuge unit. Other unusual sightings include Little Blue Heron, Black Tern, Least Tern, Ring-billed Gull, Franklin's Laughing Gull, Bonaparte's Gull, Osprey and Peregrine Falcon.

HABITAT EVALUATION: Although there is evidence of considerable interchange between wetlands in the Pearl Harbor area, it is clear that some sites are of more long-term importance to waterbirds than others. It is also clear that conflicting human use of some wetlands and neighboring lands prevents these areas from reaching their full potential as both nesting and feeding habitat for endangered waterbirds. Hawaiian Stilt appear to be dependent upon the availability of several different wetlands, as no single wetland presently supplies all their needs on a year around basis. Hopefully, when in full operation, the two federal refuge units will fill that need.

The Honouliuli refuge unit is presently limited in its suitability to waterbirds by the undependability of the water supply and the encroachment of pickleweed and mangrove onto the shorelines of islets and drainage canals. There has been considerable controversy regarding the size of the nesting islets, but it remains to be seen whether or not the abnormally large size will limit the number of nesting stilt that can be accomodated within the refuge. It is expected that after water levels have stabilized, this refuge unit will attract greater numbers of stilt and other birds on a more regular basis.

The Honouliuli prawn ponds provide very limited space for waterbirds, but have proven to be surprisingly productive for coot and gallinule in recent years. The two ponds that are not in current use for prawn farming could support even greater numbers of these birds if encroaching cattails were judiciously controlled. Hopefully, the current lessee will not find it necessary to put these two ponds back into aquaculture production. It is our understanding that the present farming operation is marginal economically and the possibility that the entire site could be converted to protected waterbird habitat under State or Federal jurisdiction should be investigated. The fishpond north of the prawn farm could be improved as waterbird habitat by restriction of human disturbance and by restoration of suitable wetland within the adjacent marsh. Together with the prawn farm, these sites probably account for most of the limited production of gallinule in the Pearl Harbor area. For this reason alone, the possiblity of refuge status or cooperative habitat improvement programs should be investigated.

The best waterbird habitat at the north end of West Loch appears to have lost much of its suitability for stilt and other waterbirds. Although 330 acres of shallow water and tidal mudflats have been designated as a U.S. Navy refuge, there has been no management of the area to increase waterbird productivity. Encroaching vegetation and the increasing levels of human disturbance on neighboring lands has lowered the value of these areas over time, but there is considerable room for improvement under proper management. The draft HWRP (346) recommends preservation of the Pouhala Marsh as a wildlife sanctuary by the City and County.

By far the best habitat on Waipio Peninsula is now provided by "artificial" wetlands created by the activities of the Oahu Sugar Company. As long as direct flow of irrigation waters into Pearl Harbor is prohibited, it is likely that some habitat will be available year around. However, radical fluctuations in past counts reflect the extreme variability in wetland habitat conditions on these lands. There are few areas within any of the Waipio wetlands that are not accessible to predators. Also, the schedules of flooding and drying of settling basins or oxidation ponds are determined without reference to varying needs of waterbirds. For these two reasons alone, it is doubtful that breeding productivity of these ephemeral sites will ever approach maximum potential. In view of the comparatively large population of stilt, coots and migratory waterbirds that inhabit these wetlands, it would be advisable for HDF&G and USF&WS biologists to work more closely with Oahu Sugar Company personnel to insure effective management of the habitat. Under cooperative agreement with the lessee (Oahu Sugar) and landowner (U.S. Navy), it may be possible to develop and maintain settling basins or more permanent impoundments that could be managed exclusively for waterbirds. If these areas were assured permanent water supply and predator protection, then together with more extensive ephemeral habitat, they would insure that all the needs of these birds were met.

The Pearl City unit of the Pearl Harbor NWR has been successful in attracting relatively large numbers of nesting and feeding stilt. Prior to construction of the refuge, the condition of the wetlands on the peninsula varied considerably over the year. Much of the habitat dried in summer months. Provision of permanent water and protection from predators will encourage continued use of the site by stilt. This site may have drawn some birds away from the deteriorating habitat at the north end of West Loch. There is considerable room for further development of wetland habitat on the peninsula on lands that have accomodated landfill and along the Waiawa Stream drainage.

Waterbird habitat within the mangrove-infested shoreline along the east shoreline of Pearl City peninsula is typical of that found throughout much of Pearl Harbor. Encroaching mangrove accelerates siltation in its roots and provides limited feeding habitat that is characterized by temporary availability of food, relative lack of submergent vegetation and exposure to wave action and wind. Of the waterbirds in the Pearl Harbor area, only herons and egrets nest within the mangrove swamps of Pearl Harbor. This vegetation has already become a problem within the newly constructed refuge units, and will require constant attention to prevent deterioration of this habitat.

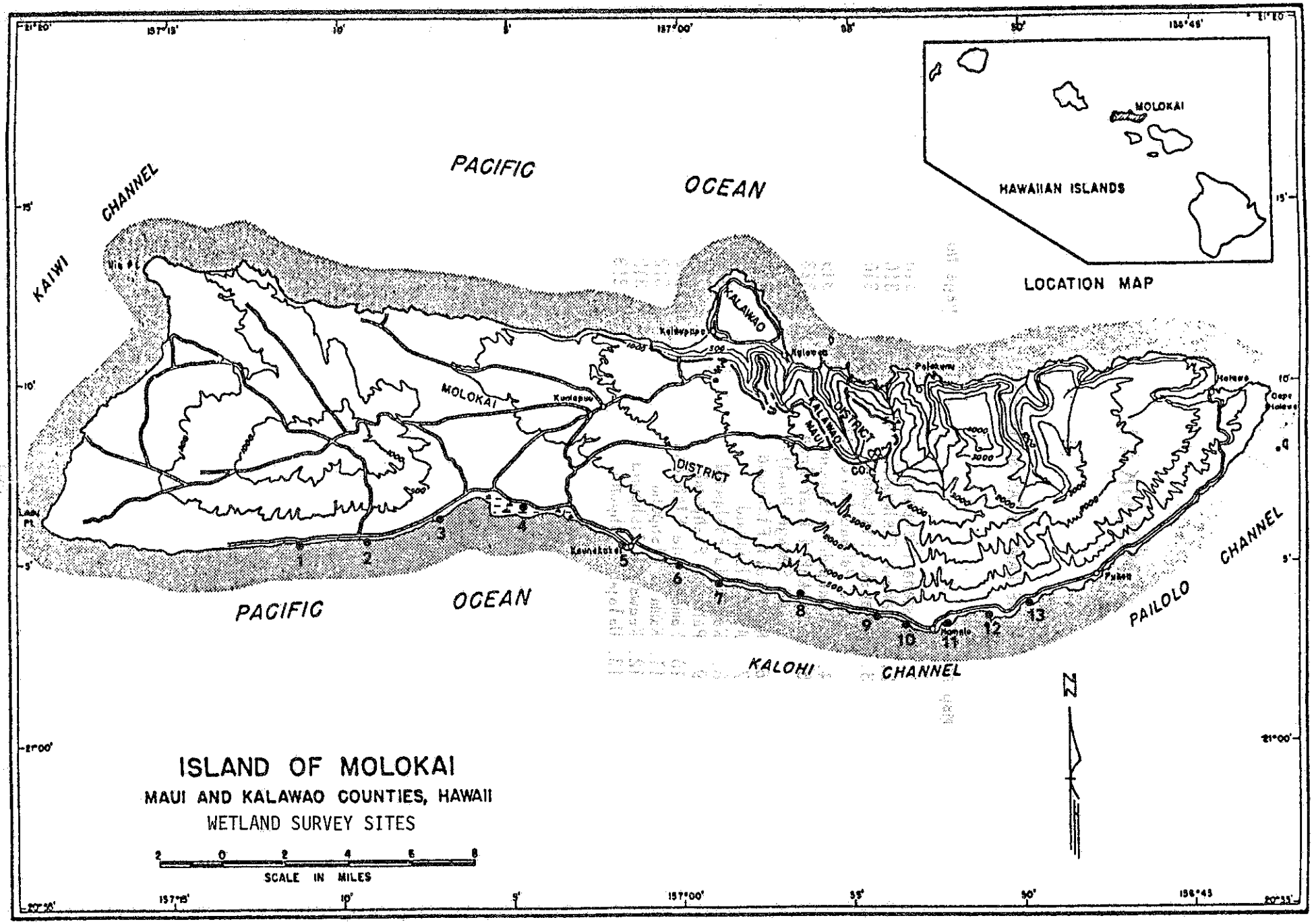
POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: An examination of earlier topographic maps for the Pearl Harbor area makes it very clear how deposition of fill and encroachment of mangrove over the last 40 years have eliminated several hundred acres of former wetlands and fishponds. Yet, much of this loss has been compensated by the development of water impoundments to remove silt from irrigation waters and to permit sewage oxidation. Maintenance of these areas requires movement of accumulated silt and the construction of dikes and diversion channels. The same methods can be used to create and maintain more secure waterbird habitat. The long-term productivity of recently constructed refuge sites is uncertain, but it is already evident that waterbirds are adaptable to this "artificial" habitat.

Dredging and filling can also be used as a tool to improve the suitability of other wetland sites for waterbirds. Encroaching vegetation in the Honouliuli prawn ponds and within the marsh adjacent to the Honouliuli fishpond can be controlled through careful dredging. On the other hand, the existing value of these sites would be lost if they were totally cleared for other use. Construction of water impoundments in the Pouhala marsh area may prove necessary to insure more permanent water supply to this small wetland. It is anticipated that expansion of the Waipahu Dump may threaten the condition of neighboring wetland, either through elimination of habitat, or more subtly, through the leaching of waste chemicals and gasses.

The established movement of waterbirds between the various Pearl Harbor wetlands increases the opportunity for maintaining overall habitat availability as current sites are altered. Although the 61 acres of Pearl Harbor NWR units do not nearly equal in size the habitat lost in Keehi Lagoon, the long-term potential of the new areas as both feeding and nesting habitat for stilt make the adjustment a good tradeoff in the end. However, since passage of the Endangered Species Act of 1973, mitigation of adverse impact on endangered waterbird habitat by creation or improvement of habitat elsewhere is no longer in compliance with Federal law. The long-term effects of habitat alteration in individual Pearl Harbor wetlands will not be totally clear until more prolonged studies of habitat use and bird movement between sites has been completed. Hopefully, the new refuge units will compensate, at least in part, for further alteration of wetlands in the Pearl Harbor area.

MOLOKA'I

WETLAND AREAS SURVEYED



ISLAND OF MOLOKAI

MAUI AND KALAWAO COUNTIES, HAWAII

WETLAND SURVEY SITES

MOLOKAI

INTRODUCTION: Molokai is by far the smallest of the islands included in this ornithological survey of wetlands. Shallow water covers a fringing reef along the entire southern shore of the island. Protection from tradewind weather has minimized the natural deterioration of fishponds built by the early Hawaiians. Some of the dated ponds are known to be more than 300 years old, and some may be considerably older. A total of 58 coastal fish ponds, nearly 30% of those in the entire state, have been identified on Molokai's south shore (122). Most of these were created by construction of rock walls to enclose pond areas as large as 200 acres. Other inland ponds were built in natural depressions or basins near the coast. The ponds served as rearing areas for mullet and milkfish. Sediment that entered the ponds from rainfall runoff was cleared by wave movement through channels in the wall, or by physical labor, often 2-3 times per year. Most of the walls of coastal ponds were constructed loosely enough to permit water to seep in and out with the tide, thereby preventing stagnation (122).

Construction of Molokai's fish ponds continued into the early 19th century. Many have been altered or even destroyed by wave action and others have been filled with sediment through hundreds of years of runoff. Soil accretion has accelerated dramatically with colonization by mangrove in 1902 (95). By 1960, only four coastal ponds on Molokai were still in use commercially (122).

Taro fields provided additional man-made habitat for wetland birds on Molokai, although the tsunami of 1946 eliminated the most important areas in Halawa Valley and in valleys along the north shore. The streams and estuaries still provide some natural habitat in these valleys, but in the absence of taro, numbers of wetland birds have diminished considerably.

The lists of sites we surveyed on Molokai included 10 coastal fishponds, all of which were similar to each other in many respects. For that reason, the characteristics of coastal fishponds as waterbird habitat will be discussed in this introduction to Molokai, and the individual ponds will be treated only briefly. Three additional sites will be treated in more detail, due to their unique nature or particular value to waterbirds.

Many of the ponds have shoreside springs that provide some nutrient replacement. Most of the ponds surveyed by Madden and Paulsen (112) demonstrated fair primary productivity and fair species diversity. Aquatic marine life in the coastal fishponds includes many species found in nearby reef habitat, but depends somewhat upon the condition of the fishpond wall and the bottom substrate. Mullet, milkfish, o'opu and tilapia are common. Mosquito fish are also frequently seen, particularly in ponds with less than average circulation. There is a variety of invertebrates in the ponds including molluscs, worms, and crustaceans. Crabs and shrimp provide

suitable food for herons and other waterbirds.

The dominant lowland tree along the southern Molokai coast is kiawe, particularly west of Kaunakakai. The kiawe forest, and associated understory grassland, supports a diversity of non-wetland birds that are widely distributed along the entire southern coast. Virtually all of the non-wetland birds we recorded could be expected to inhabit forest surrounding any of the fishponds included on this survey. California Quail, Gray Francolins and Black Francolins were all counted in small numbers, although the last of these was certainly the least common at sites visited. Barred Doves, Spotted Doves, Common Mynas, House Finch and Japanese White-eyes were the most common non-wetland birds on our surveys. Mockingbirds, Northern Cardinals and Red-crested Cardinals were most common west of Kaunakakai, but were seen in small flocks at several locations on Molokai. Rock Doves (Pigeons) and House Sparrows were only seen at sites near Kaunakakai, yet the range of each species surely includes the entire south shore of Molokai.

Cattle and deer were seen only at fishponds west of Kaunakakai, although cattle sign was noted at some other ponds as well. Mongooses were common along the entire southern coast, and are a threat to gr nd-nesting waterbirds at any fishpond. The same generalization can be made for rats and feral cats.

WATERBIRDS ON MOLOKAI: All of the endemic Hawaiian waterbirds at one time found limited, but suitable, habitat on Molokai (382, 387). Koloa were formerly widespread in the stream valleys on the north shore, but there have been no recent records of the species on Molokai. Noah Pekelo (524) indicated that the most recent report of the species was from the Kawela area in the 1930's.

Hawaiian Coots remain well established on Molokai, but recorded numbers have varied widely. The species appears on 20 of 29 HDF&G/USF&WS counts since 1956, with an average winter count of 19 birds and an average summer count of 29 birds. The highest count on record was in 1964 (n=78). Extreme variability in count results, often from year to year, lends evidence to the theory that coots regularly move from island to island. However, the absence of a clear upward or downward trend also suggests that available habitat has not changed appreciably. It is doubtful that significantly greater number of coots could be sustained on a long-term basis without a greater amount, or more productive, habitat. Coots are now found in greatest numbers in two wetlands (Kaluaapuhi Pond, Kakahaia Pond), yet visit coastal fishponds occasionally as well.

Numbers of Hawaiian Stilt counted by HDF&G/USF&WS biologists have also varied considerably (0-24). The species does not appear on 17 of 29 counts since 1956. Although none were recorded on winter counts between 1965-1972, some birds were noted at other times of the year. The variability in data also suggests interisland movement for this species. Pekelo (524) reports that he has heard stilt calling as they flew over his head at night on the west end of Molokai. The stilt counts on Molokai are likely to represent an underestimate of actual population since individuals of this species find suitable feeding habitat along the entire southern shore. Mudflats, flooded pastures and silted fish ponds attract this species to a wide variety of sites. The count records are also affected

by tidal patterns. In any event, the population of stilt on Molokai averages less than one percent of the State population, so it is unlikely that remaining habitat on this island is critical to the survival of the species.

Hawaiian Gallinule appeared on only 6 of 30 HDF&G/USF&WS waterbird counts since 1956. Pekelo (524) reports that gallinule were common in taro patches of Halawa Valley and in north shore valleys prior to the 1946 tsunami. They were counted in relatively large numbers (average 9 per count) over a four year period (1961-1964). These counts represented an average of 45% of the State total during that four year period. The last record of the species on a HDF&G/USF&WS count was in 1969, although Pekelo reports having seen the species as late as 1973 (524). Given the intensity of surveys in recent years, it is probably safe to say that the species is now absent on Molokai. Yet, the irregularity with which gallinule appeared in earlier counts suggests that birds from Oahu may appear at a later date, and that the species could probably be successfully re-introduced if suitable habitat was created and protected.

Black-crowned Nightherons have appeared on Molokai water HDF&G/USF&WS count records consistently. An average of five birds per count appear in records over the last five years. Yet the data almost certainly reflect a significant underestimate of the actual population. The distribution of these birds in coastal fishponds is directly linked to the rise and fall of the tides and the amount of human disturbance. They feed on fishes and invertebrates in shallow water, and find the partially silted mangrove habitat in old fishponds particularly suitable. Pekelo reported that herons nest as individual pairs in kiawe trees along the southern coast, usually near suitable feeding habitat in silted fishponds (524). He was not aware of any rookeries involving several pairs nesting in the same vicinity. They may also nest within deep stream valleys on the north shore, where they still find food within relatively undisturbed natural habitat.

Migratory waterfowl wintering on Molokai tend to restrict their movement to a small number of habitat areas. HDF&G/USF&WS count records indicate a distinct preference by herons for inland fishponds and artificial ponds, although some of these birds are seen in coastal fishponds as well. As is the case throughout the State, Pintail and Shoveler visit Molokai in far greater numbers than other waterfowl species. Yet count records reflect yearly variations that may amount to several hundred percent. The largest recent count of Pintail was 169 birds (1/23/75), although the recent winter average is far below this figure. The amount of open water in two of the principal habitats for migratory waterfowl (Kaluaapuhi Pond, Kakahaia Pond) has shrunk considerably in the last decade with encroaching vegetation. Other migratory waterfowl that have been recorded within the last decade on Molokai include White-fronted Geese, Canada Geese, Lesser Scaup, American Wigeon, European Wigeon and Green-winged Teal.

Migratory shorebirds find suitable wintering habitat in several of the partially silted fishponds along the southern coast, but they range widely and are not likely to be accurately counted. The four common migrants (Golden Plover, Ruddy Turnstone, Wandering Tattler and Sanderling) are seen every winter on Molokai, but the first of these species has been recorded in far greater numbers than the others. Two less common species have also been observed on Molokai in recent years: Long-billed Dowitcher and Bristle-thighed Curlew. To this list of less common species can be added two

stragglers noted in recent HDF&G/USF&WS counts: Ring-billed Gull, Belted Kingfisher. Pekelo reports that Cattle Egret have been seen in low numbers on Molokai for several years, but they have appeared on only one HDF&G/USF&WS count (8/1/74).

Coastal Fishponds on Molokai as Wildlife Habitat: The greatest number of endemic and migratory waterbirds on Molokai have been seen on HDF&G/USF&WS surveys at Kaluaapuhi and Kakahaia fishponds, but the coastal fishponds collectively provide important waterbird habitat for these and other species as well. Similarities in habitat among these fishponds outweigh the differences.

Most of the coastal fishponds have been taken over, at least partially, by mangrove. As the seedlings of this plant take root in shallow water, siltation is accelerated and the mangrove, in effect, creates more suitable wet mud for further germination. When the ponds were managed continually for fish culture, the accumulating silt was cleared regularly. The shallow mudflats that have resulted from inattention now provide feeding habitat for herons, stilt, migratory shorebirds. The deeper water may attract coots and migratory waterfowl. However, the suspended silt bottom characteristic of inactive fishponds does not provide a stable substrate for the germination of extensive submergent vegetation. The principal source of food for birds must come from the various invertebrates and fishes that are available in the mud and shallow water.

The ebb and flow of the tides may trap fishes in small pools that temporarily attract unusual concentrations of birds. However, it is more common to see only 1-3 herons and an occasional stilt in any one of the fishponds in summer months. Migratory shorebirds add to the fishpond avifauna in fall and winter months. All of the birds adapt somewhat to human disturbance, but there are generally fewer birds at ponds that are disturbed regularly. An exception to this generalization are those ponds where fishing activities may attract herons searching for food.

Potential Impact of Dredge/Fill Activities in Coastal Fishponds: Maintenance of coastal fishponds by the early Hawaiians involved repeated silt removal and construction of extensive rock walls. This can be viewed as among the earliest of dredge and fill operations in Hawaii. Both activities were, and still are, fundamental to the successful operation of fishponds for mullet and milkfish culture. Madden and Paulsen (112) have recommended that several of Molokai's coastal fishponds be renovated for commercial aquaculture operation. Their recommendations include: (1) control of predatory and competitive fishes by selective fishing and trapping; (2) banking of sand along walls that have degraded to reduce porosity and prevent escape of juvenile fish; (3) restoration of gate systems; and (4) construction of nursery ponds where they don't already exist. Clearing of encroaching mangrove is also important to successful use of these ponds.

Although uncontrolled mangrove will ultimately fill each and every pond, the temporary effect on shorebird use is probably positive. Accretion of silt insures that shallow water and mudflat feeding habitat is always available to shorebirds. Yet, suspended silt on the pond substrate limits

the development of extensive submergent flora, much of which provides important food for other waterbirds. Mangrove control, silt removal and maintenance of improved water quality in those fishponds with the best potential for aquaculture will probably have long-term positive benefits for Molokai's waterbird population. It is clear from HDF&G/USF&WS count data for many years that the amount of shoreline mudflat feeding habitat is not limiting. The few fishponds that are likely to be restored will not eliminate a significant amount of the mudflat available to shorebirds, but at the same time they will provide a different type of habitat of more value to other species.

COASTAL FISHPONDS SURVEYED

Ka-umana Fishpond

Survey: 5/23, 7/5/77

This fishpond shows signs of many years of inactivity. The wall is collapsed and incomplete and the pond is heavily silted. Mangrove trees are established throughout the pond. It has little potential for reconditioning as a fishpond and is certain to be filled totally with mangrove in the future. Water levels in this small pond fluctuate regularly with tides. Although heron tracks were seen on the shore and pond bottom, no birds were seen on two survey visits. The site probably provides marginal feeding habitat for migratory shorebirds, and appears to be too shallow and unproductive for waterfowl.

Wai-a-kāne Fishpond

Survey: 5/23, 7/5/77

Waiakane Fishpond has also been inactive as an aquaculture site for many years. Mangrove encroachment is restricted at this time to the east end of the pond. The pond wall is in poor condition, and much of it is underwater in high tide. Drainage gulches that enter the pond contain some brackish water left after earlier rains. Tilapia and mullet are abundant in these puddles, and heron tracks indicate that this limited food supply is attractive. These silt-laden pools have also been a trap for both cattle and deer that were stuck in the mud when they came to the site in search of water. The area has been used for some trash dumping in recent years and probably as a site for shoreline fishing. The mangrove area provides mudflat feeding area for shorebirds. Five Golden Plover were observed at the site on one of two survey visits.

Pakanaka Fishpond (also Pa-la'au salt flats)

Survey: 5/23,7/5/77

This is one of the largest coastal fishponds on the Molokai coast, although a very dense mangrove forest has taken over at least 30% of the original pond. The site is virtually impenetrable from the inland side, so it was surveyed by boat. The wall is in poor condition, and ocean water flows freely into the pond. Excessive siltation has left the pond quite shallow. Mangrove seedlings are taking over much of the exposed mudflat. Heron tracks and droppings were seen at several locations within the pond but no waterbirds were seen during the survey.

Extensive flat lands behind this fishpond extend for more than two miles to the east. Much of this land is the result of centuries of siltation from seasonal runoff. The primary vegetation across the flats is pickleweed although other weedy plants have encroached on much of the area. Mangrove lines the entire shoreline and has caused the accretion of so much soil that the former Palaau fishpond, once over 200 acres, is now completely gone (122).

According to unpublished USF&WS data, extensive pumping of water for a temporary sugar cane venture in the area caused the intrusion of salt water, and the eventual encroachment of various weeds and other aggressive plants. More recently, taro fields and other small wetlands were found on parts of the open flat lands. These areas provided important waterbird feeding habitat up until 15-20 years ago (524). Today these flat lands hold water only ephemerally, but they still provide at least temporary feeding habitat for small numbers of stilt and migratory shorebirds.

Ka-loko-'eli Fishpond — Survey: 5/22, 7/6/77

The walls of this pond are degraded enough to allow free interchange of water with the ocean. Silt has accumulated throughout, but the shallowest water is found along the east edge of the pond, fronting the fringe of mangrove. To restore the site's aquaculture potential, it would be necessary to repair the wall, cut back the encroaching mangrove and control predatory and competitive fishes.

The site proved to be particularly good habitat for herons on our first visit. Eleven birds were counted, including one juvenile. They were all wading in shallow water or perching on mangrove branches at the east end of the pond. They appeared to be equally spaced throughout the habitat, suggesting that they were dividing up the resource into feeding territories. No herons were at the pond on our July trip, but a single Wandering Tattler was feeding on the exposed mudflat. The heron count at this pond was considerably greater than at any other site on Molokai, although this does not necessarily indicate that the pond provides better feeding habitat on a long-term basis. More likely the high count was the result of a favorable combination of tides, wind and other factors making other ponds less attractive. In any event, extensive dredging to clear silt and mangrove in this pond would diminish the value of the habitat for herons.

Ali'i Fishpond — Survey: 5/22, 7/7/77

This 16 acre fishpond still retains most of its original wall, although ocean water exchanges freely with water in the pond (112). Part of the pond has been dredged to provide fill to repair the degrading wall. Yet most of the pond still shows extreme silt accumulation from a long period of disuse. Madden and Paulsen (122) reported that the pond is characterized by poor primary productivity and low algal species diversity. They further indicated that mullet aquaculture would be difficult because of severe competition for food with other fish (principally gobies). The pond is not currently in use for aquaculture.

Extensive mudflats are found at the east end, where a dense mangrove forest has encroached on the pond. This vegetation isolates most of the neighboring human disturbance from the best waterbird feeding habitat. Three herons were observed on our May trip to this area and none were seen on our return trip in July. Both the mangrove and the nearby kiawe forest could provide relatively undisturbed nesting habitat for this species, but we found no evidence of nesting during our brief examination of this area.

Pahiomu Fishpond — Survey: 5/21, 7/7/77

This small fishpond has been reduced in size by more than 30% through the encroachment of mangrove. Expansive mudflats in the north and east parts of the pond are exposed in low tide. Mangrove seedlings have taken root out into the middle of the pond. The fishpond is inactive at this time, but the wall is nearly intact. Construction activities on the west end of the pond are probably creating some disturbance for birds. Only a single Wandering Tattler was counted on two trips to the site. Shallow pools of water left on the southeast mudflat with falling tides probably attract herons as well.

Ka-māhu'ehu'e Fishpond — Survey: 5/20, 7/6/77

This pond was formerly 37 acres in size, but mangrove encroachment has shrunk it to a small fraction of the original pond (112). The dense mangrove forest is impenetrable from the inland side, but the pond is accessible by boat over the remnant wall. The fishpond was used commercially until the turn of the century. Only three herons were observed inside the pond in July, but it is almost certain that the combination of limited disturbance and expansive feeding habitat make this pond attractive to significantly greater numbers at other times. It is not likely that there will be any attempt to halt the encroachment of mangrove, a process which probably will accelerate in the future. The pond should be surveyed by boat in winter months to determine how attractive it is to migratory waterfowl.

Flat lands, sparsely covered with pickleweed and other plants are found behind the mangrove forest at this pond. Although they were dry during our survey, it is likely that infrequent heavy rains create temporary feeding habitat that is attractive to stilt and migratory shorebirds.

Ka-malō Fishpond (not pictured) — Survey: 5/20, 7/6/77

This site is immediately east of Kamalo pier. There is little evidence left that this fishpond ever existed at the site where it was constructed. The wall is completely gone. Most of the shoreline in the area is mangrove mudflat, mixed with patches of pickleweed, kiawe and grasses. Although not protected by a wall, the exposed shoreline provides considerable potential feeding habitat when the tide is down. The neighboring flat lands provide marginal pasture for cattle at this time, although some of the area probably floods with heavy rains, and provides a temporary source of food for waterbirds. There is little human disturbance along the shore. One heron and two stilt were feeding on this shoreline during the May survey, but waterbirds were not seen at the site in July. A long expanse of similar shoreline habitat between the Kamalo pier and Kamahuehue Fishpond to the west is probably visited regularly by migratory shorebirds and stilt. To our knowledge, there have been no HDF&G/USF&WS counts at this area.

Ke-awa-nui Fishpond — Survey: 5/20, 7/6/77

Keawanui Fishpond is different from most other coastal fishponds included in this survey in several respects. The pond is protected from the full force of northeast tradewinds by its alignment towards the southwest. Mangrove encroachment is minimal, although seedling establishment is proceeding at least 30 yards into the pond from the current limits of the mangrove forest. Growth of bulrush and other sedges is more extensive here than at most coastal fishponds. This provides better cover for waterfowl that may visit the site. The fishpond wall is broken at the south end and water flow is unrestricted. The thin fringe of mangrove at the east side of the pond is backed by expansive pickleweed mudflat up to the fishpond wall.

This pond is relatively protected from disturbance from nearby houses by a thick barrier of vegetation, although dogs and cats were running loose throughout the site at the time of our surveys. Human tracks across the mudflats suggest that the site is used regularly for net fishing, but the site is no longer actively worked as a fishpond. Remnant taro patches are also found on the flat land bordering the pond, but it has been many years since they have been farmed.

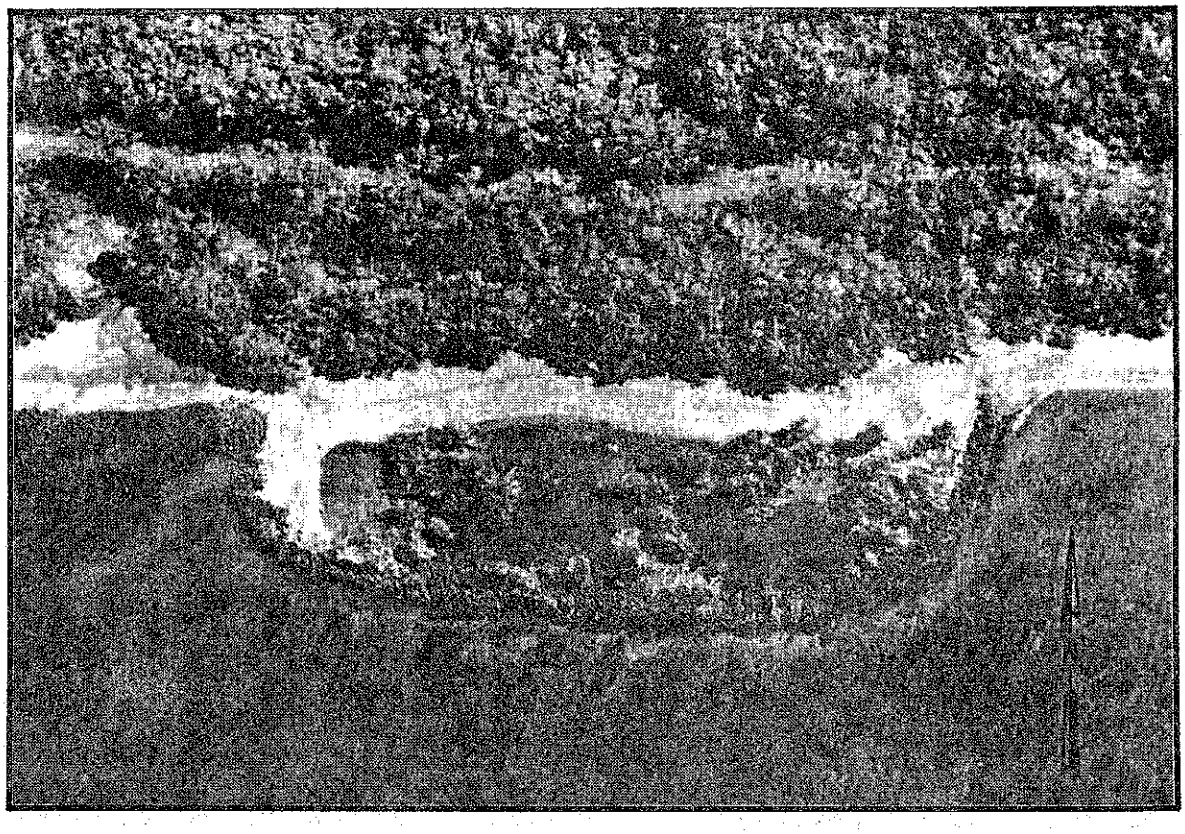
Pockets of water are left by outgoing tides on mudflats surrounding a stand of Kiawe trees on the southern peninsula. Small fish, worms, and grapsid crabs were common in the shallow pools on the mudflats. Shorebird tracks were seen in the mud at this location but no birds were seen.

'Uala-pu'e Fishpond

Survey: 5/20, 7/6/66

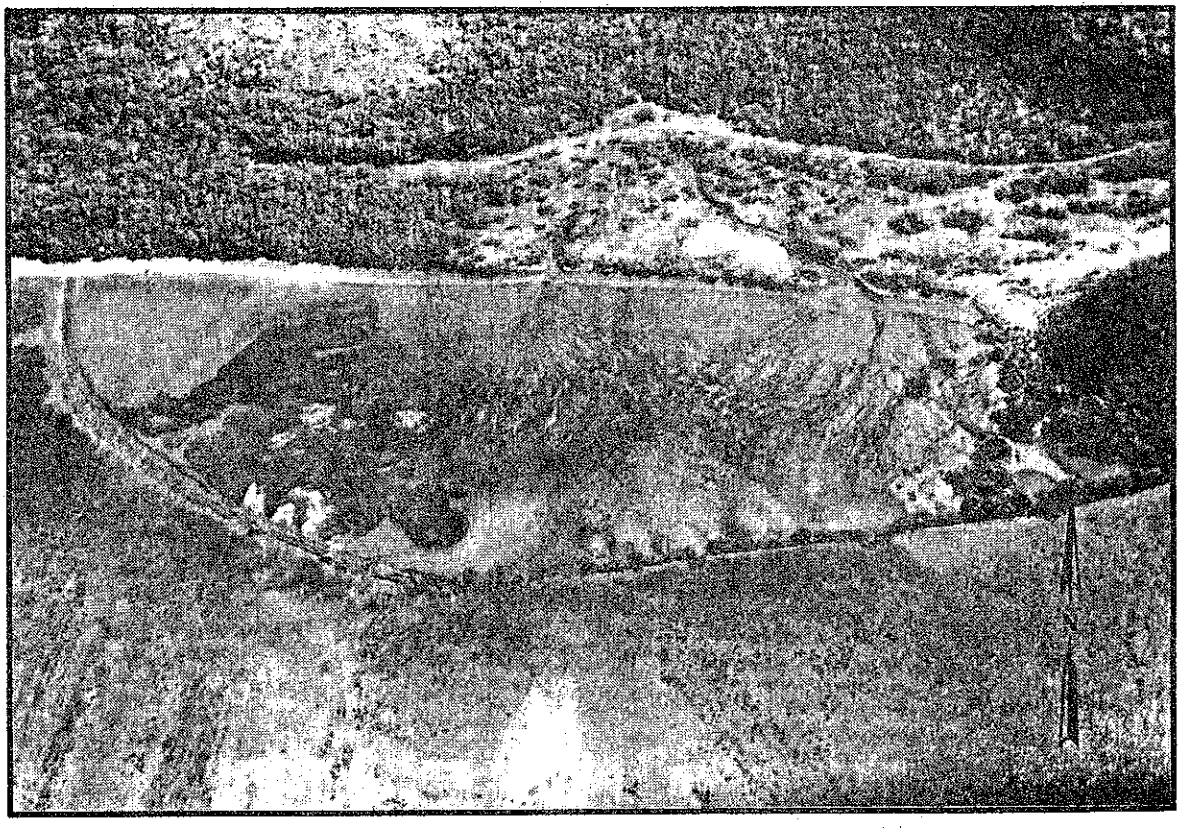
This 15 acre fishpond was still in use commercially as late as 1960 (112). Madden and Paulsen (112) found the pond to be in excellent condition for aquaculture. Shoreside springs provide some freshwater flow that increases nutrient levels. The wall is intact, with a functional gate. Mangrove encroachment is minimal by comparison to other fishponds, probably because of fresh water intrusion in the marsh area along the north and east sides of the pond. Various grasses and bulrush border the edge of the pond, and there is no suitable waterbird habitat within the neighboring grassland.

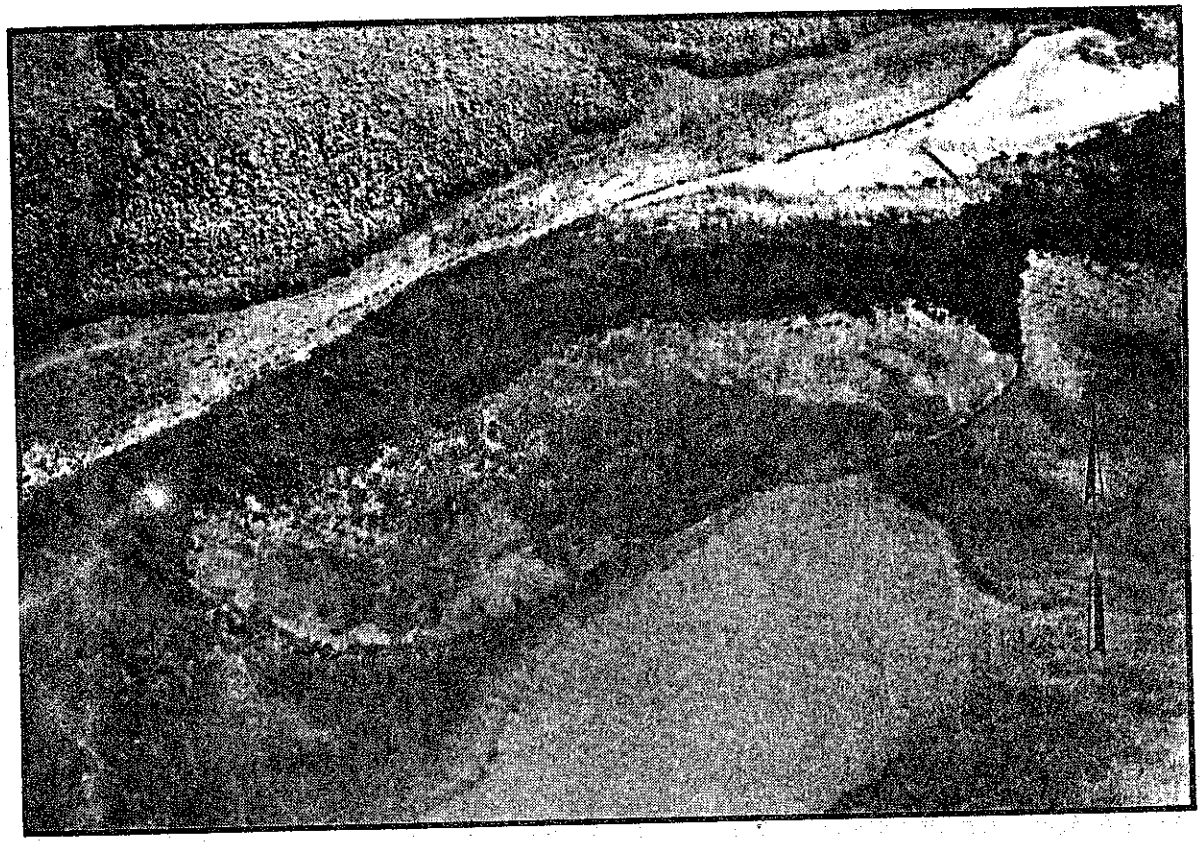
A relatively small mudflat area in front of the mangrove provides marginal shallow water feeding habitat for wading birds. Some additional feeding area is found along a mud/sand shoreline on the west side of the fishpond. The highway and neighboring houses are very close to the pond. There were several loose dogs in the area at the time of the survey, and virtually all of the waterbird feeding habitat is accessible to these animals. No waterbirds were seen on either of two visits to the fishpond.



Kaumana Fishpond

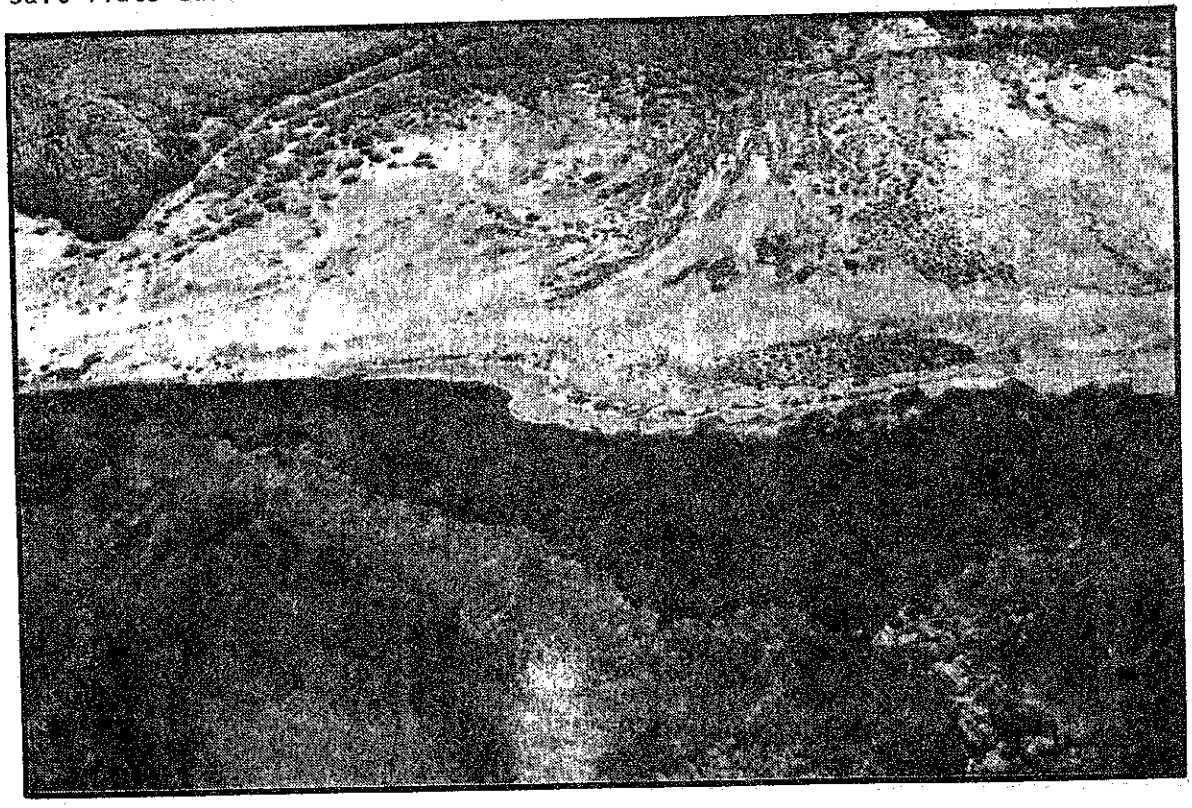
Waiakane Fishpond

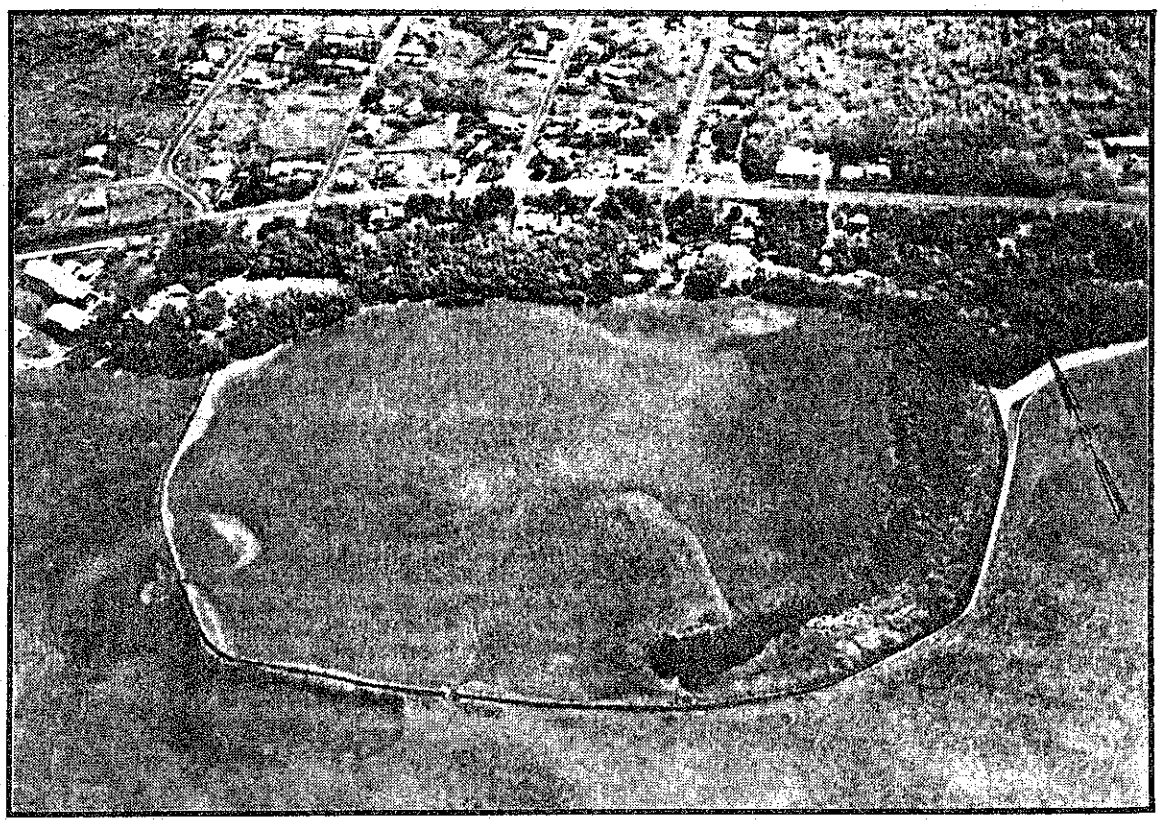




Pakanaka Fishpond

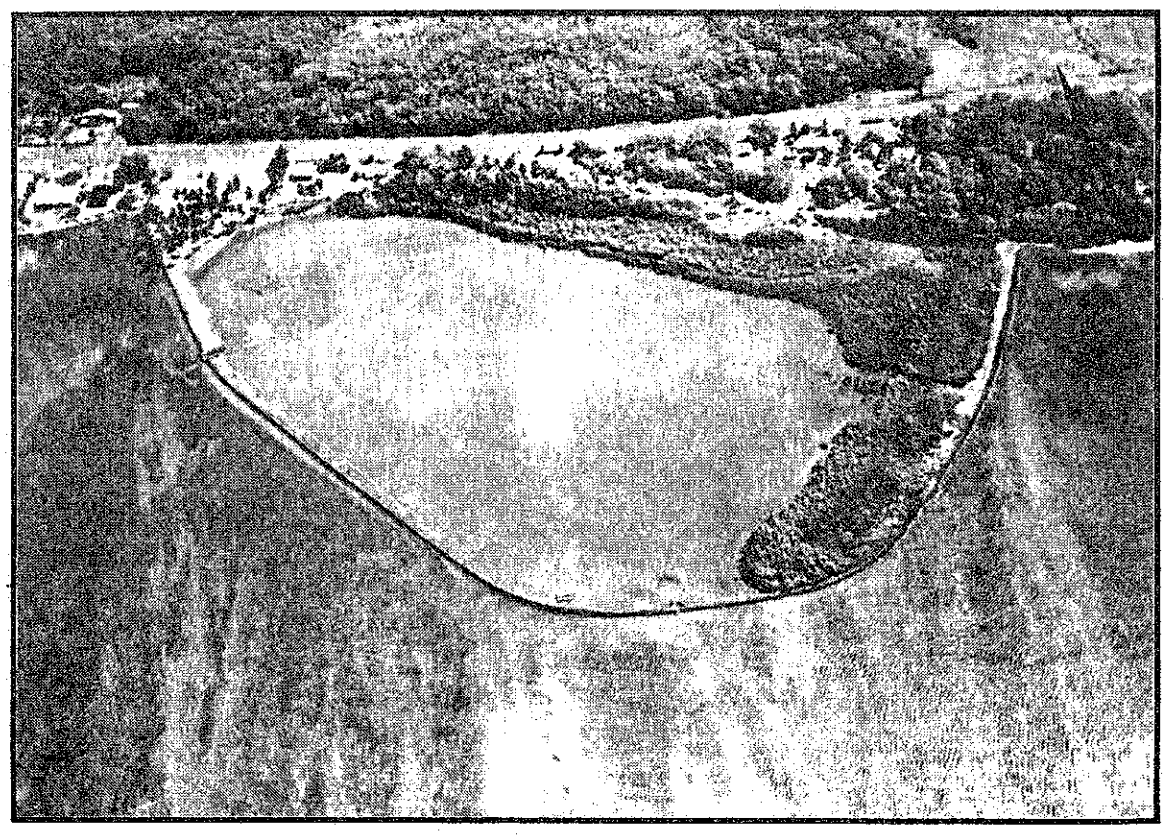
salt flats east of Pakanaka Fishpond

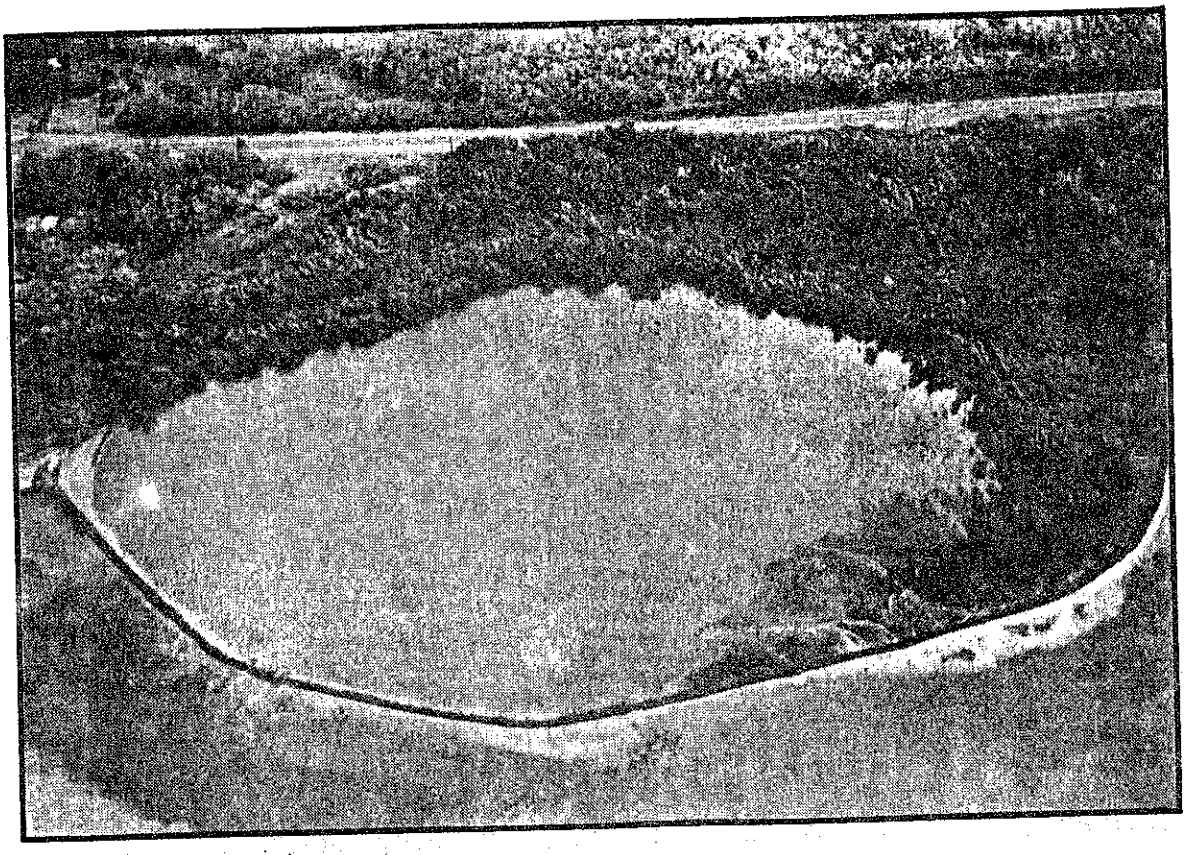




Kalokoeli Fishpond

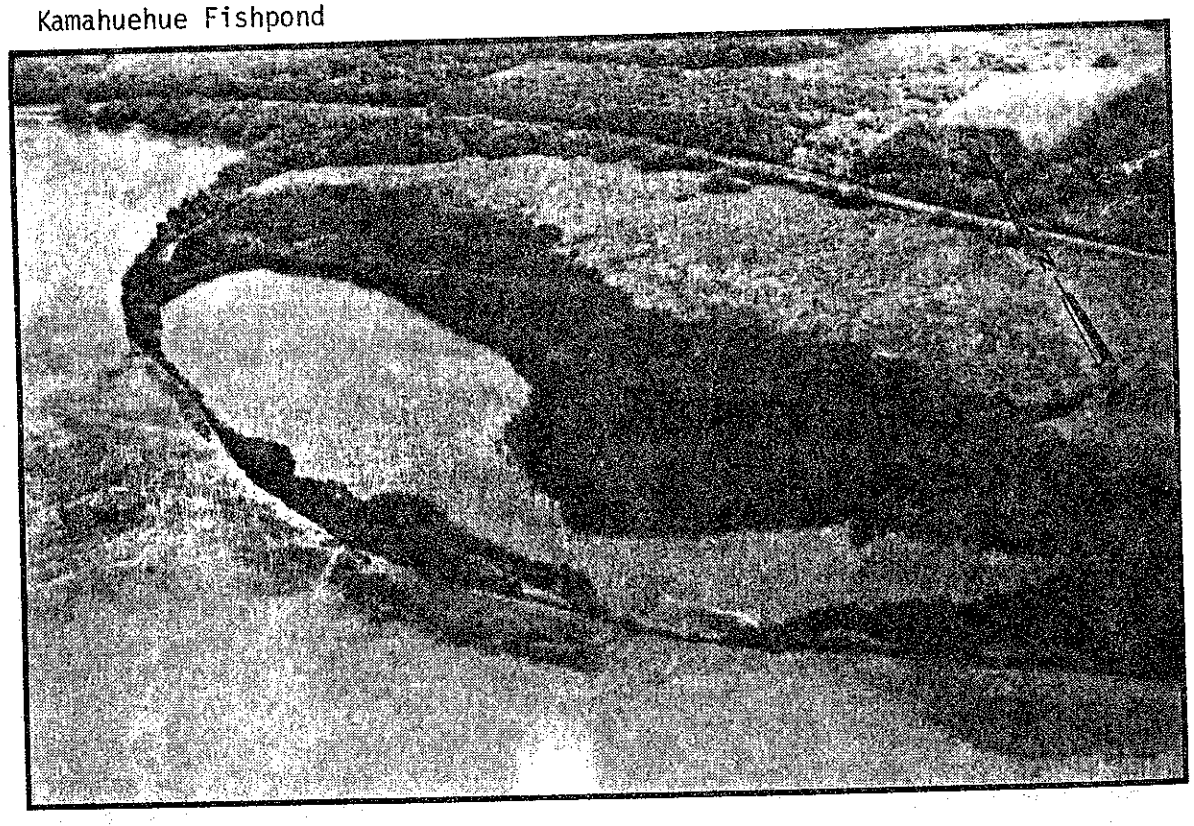
Alii Fishpond

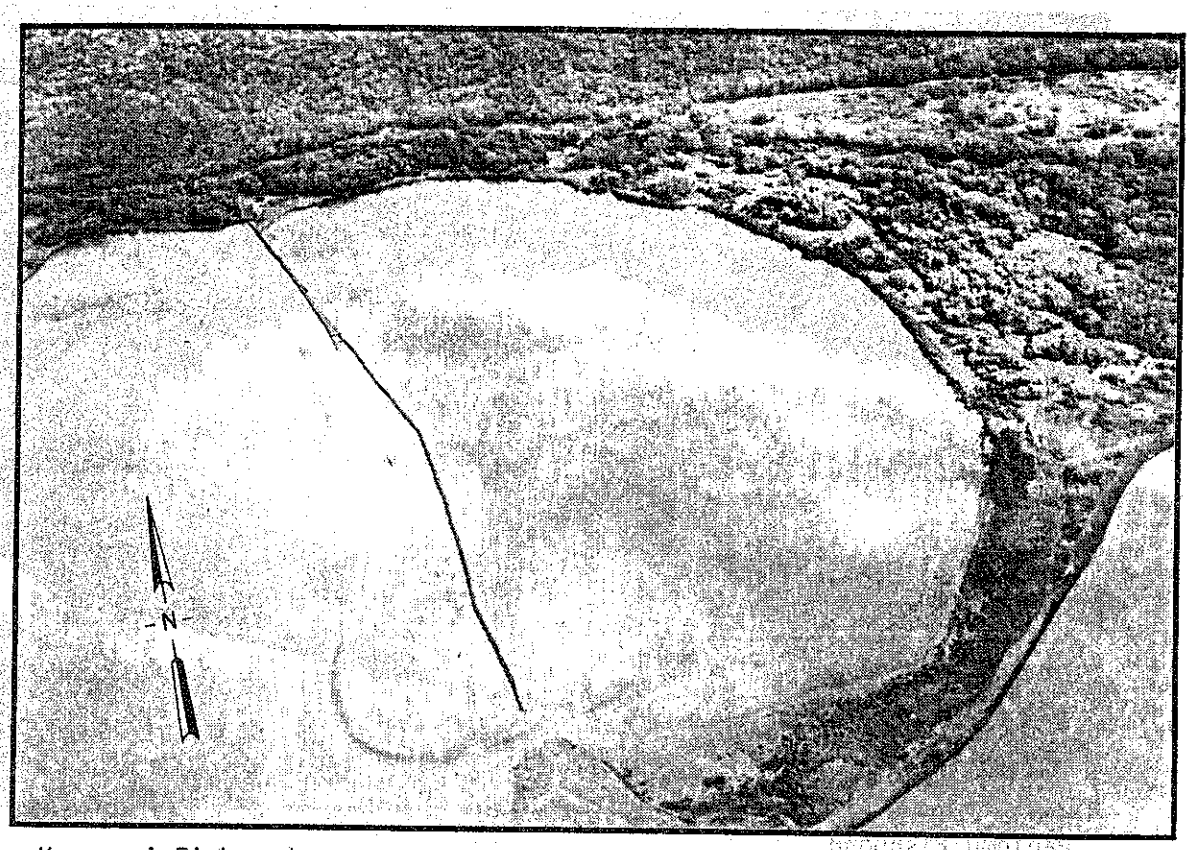




Pahiomu Fishpond

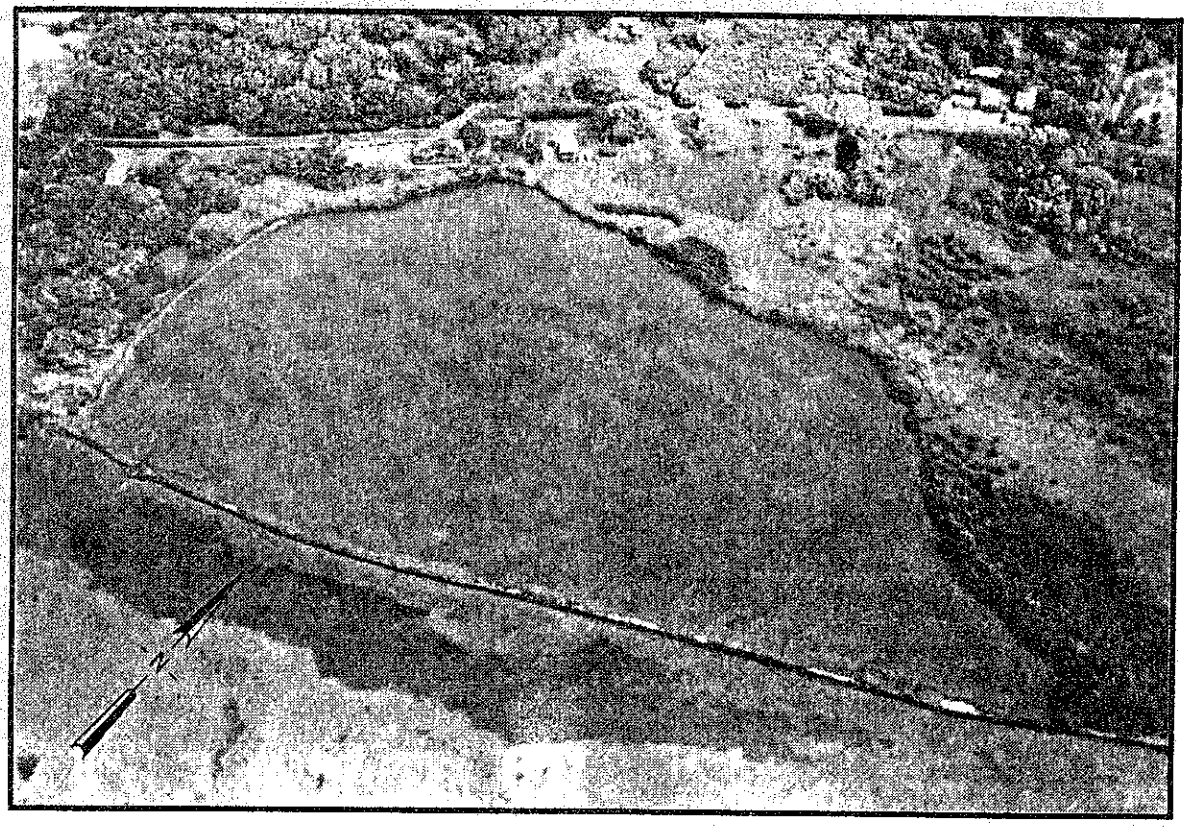
Kamahuehue Fishpond





Keawanui Fishpond

Ualapue Fishpond

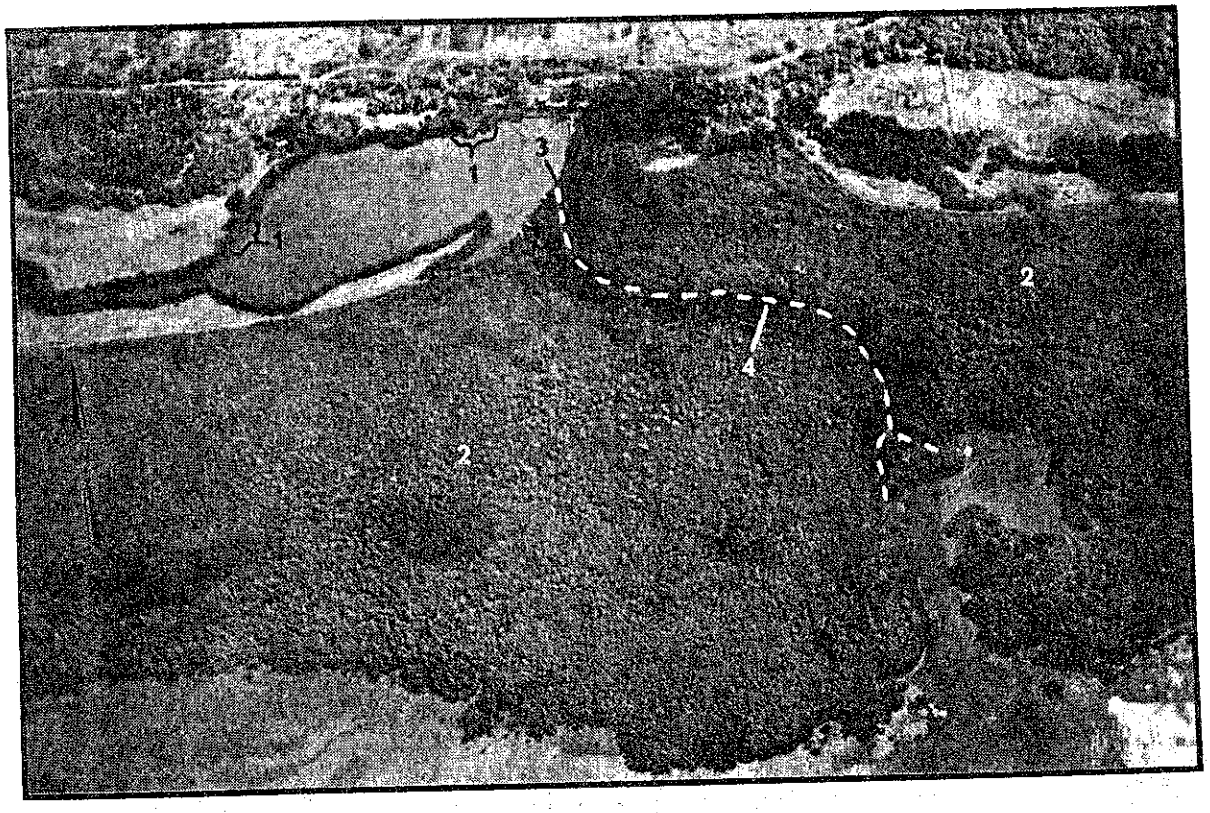


SITE NAME: Kaluaapuhi Fishpond

LOCATION: Moloka'i District, Moloka'i

TOPOGRAPHIC MAP: Kaunakakai

SURVEY DATES: 23 May, 5 July, 7 July, 1977



1. bulrush
2. mangrove
3. gate
4. drainage canal

WETLAND DESCRIPTION: Kaluaapuhi Fishpond was actually a coastal pond at one time, but encroaching mangrove has now separated the pond from the ocean by several hundred yards. This process has shrunk the pond from 22 acres to less than four. The pond is still connected to the sea by gates and a long rock channel. Mangrove encroachment has reduced the flushing rate of the pond, thereby increasing the rate of soil accretion and consequent reduction in pond size (112). The pond has a well developed fresh water spring.

The present owner uses the pond for rearing of mullet, but the site is believed to have relatively low potential for expanded aquaculture (112). Renovation would require clearing the encroaching mangrove and other vegetation to enlarge the pond, improving the access to the ocean and control of competitive fishes. The depth of the remnant pond averages about 2', but the abrupt shoreline and partial rock wall limits the potential of the site for shorebird use. Patches of bulrush and other sedges provide some cover for waterfowl.

Ooia Pond, west of Kaluaapuhi, is believed to have been dug with sticks. At the turn of the century it was more than 15 acres in size, but now it is so filled by mangrove that the site is barely visible from the air (ref: unpublished USF&WS notes).

NON-AVIAN WILDLIFE: Several species fish were seen in Kaluaapuhi Fishpond during our surveys. Mullet and tilapia appeared to be in greatest abundance, although aholehole, mosquito fish and o'opu were also seen. Crabs, shrimp, gastropod molluscs and other aquatic invertebrates were abundant. There are few residences in the immediate area, but it is certain that dogs, cats, mongoose and rats inhabit or visit the site regularly. However, much of the land away from the road is inaccessible to most of these animals due to soft mud and dense vegetation.

NON-WATERBIRD AVIFAUNA: We recorded several non-wetland birds in the kiawe forest and mangroves surrounding the Kaluaapuhi Fishpond area. Both Black and Gray Francolins were heard and seen in small numbers. Barred Doves, Spotted Doves, Spotted Munia and Common Mynas were common. Red-crested Cardinals, Northern Cardinals and Mockingbirds were more common in the surrounding kiawe forest at this pond than at most other sites on Molokai. A few California Quail were heard but not observed.

WATERBIRDS OBSERVED: The most common waterbirds on our visits to this fishpond were Hawaiian Coots. Eight birds were seen in May and four on our July trip. No nests or young birds were seen, but courtship display between adult birds was observed in May. Although there appears to be sufficient nesting habitat for at least two pairs among marsh vegetation on the inland side of the pond, we are unaware of any nesting records from the site. All the coots we observed were feeding in shallow water along the south edge of the pond. Birds were diving and tipping to feed and also browsing algae or invertebrates off the scattered mangrove seedlings. In July, a worker at the pond was removing mangrove seedlings in this area, perhaps explaining the lower number of coots observed on that trip. In recent visits to the site by USF&WS biologists, numbers of coots have varied between 1 and 4 birds, but HDF&G records for the island do not differentiate the numbers for this site from the island totals. As many as 26 coots (503) have been recorded at one visit in the last eight years, but the trend at the site appears downward for this species.

Hawaiian Gallinule were last recorded on HDF&G/USF&WS counts at Kaluaapuhi Fishpond in September, 1969. Nine birds were observed at that time. With the abandonment of taro farming in the surrounding lands, and with continuing shrinkage of this and other suitable gallinule habitat on Molokai, the species is no longer considered to be part of the island's wetland avifauna.

There is little suitable habitat for Hawaiian Stilt at Kaluaapuhi Fishpond, but they continue to appear irregularly in low numbers. Several recent USF&WS surveys have not found the species at the site. The limited shallow water feeding areas apparently are insufficient to sustain a significant population of this species, and there is no suitable nesting habitat in the pond's present condition.

Black-crowned Night Heron were observed on both our surveys of this site (n=1,4). They were roosting on mangrove branches or wading in shallow water in search of food. Tilapia were captured by herons while we were at the site. It is likely that herons nest in the vicinity, but the virtually impenetrable mangrove forest made a thorough investigation for nests impossible. Juvenile birds are regularly recorded here. Recent count records by USF&WS biologists include at least one heron on every trip. Yet, they were missing on several earlier counts at the site in the 1960's, suggesting that mangrove encroachment and associated siltation may have improved the opportunity for capturing fish.

Both Pintail and Shoveler have been observed at Kaluaapuhi Fishpond in recent years, often in surprisingly large concentrations considering the small amount of open water. The HDF&G/USF&WS records do not distinguish Molokai sites in the records, but 79 Pintails, 7 Shovelers and 3 Lesser Scaup were observed at Kaluaapuhi in November, 1969. Kridler (519) reports that migratory waterfowl often visit a small flooded area east of the fishpond (see photo). It is doubtful that the pond could sustain such numbers throughout an entire wintering period, but this should be investigated by more frequent surveys. The only other migratory waterfowl species recorded at Kaluaapuhi is the Green-winged Teal.

Migratory shorebirds are even less suited to this site than are Hawaiian Stilt. Although the water in the pond fluctuates with tides, very little open mudflat is ever exposed and the surrounding rock wall and mangrove forest leave little shoreline accessible to these birds. Although the more common migratory shorebird species may appear occasionally on future count records, the site will never by an important shorebird habitat without considerable modification of the pond bottom and shoreline.

A single heron was counted in the area of Ooia Fishpond during our survey. Although encroachment by mangrove has accelerated recently, this former pond was of considerable value as recently as 1970. Pintail, Shoveler and coots were using the pond during a recorded field trip in March, 1970 (519).

HABITAT EVALUATION: There is no question that Kaluaapuhi and Kakahaia fishponds, together, provide the best coot and migratory waterfowl habitat on Molokai. Yet, it is also clear that the value of Kaluaapuhi pond to waterbirds has diminished with encroaching mangrove and accelerating siltation. Present efforts of the fishpond manager to clear new seedlings may slow the deterioration but this will be counteracted in part by the ongoing human disturbance associated with an aquaculture operation. Ooia Pond is nearly

worthless to waterbirds in its present state, although herons may find some food available. Both Kaluaapuhi and Ooia have considerable potential for improvement through enlargement and clearing of vegetation.

The draft HWRP (346) recommends that the State of Hawaii enter into a cooperative agreement with the private landowner to preserve Kaluaapuhi Fishpond and that the State should also consider rehabilitation of Ooia and creation of additional ponds on nearby flat lands. It is doubtful, however, that the State would spend the amount of money required to accomplish this task without ownership of the land. It is even more doubtful that sufficient funds would be raised to purchase the site. Bird counts at the pond from as recently as 7-8 years ago indicate that the value of the site could be restored if the ponds were enlarged by clearing of mangrove. The possibility that gallinule may be successfully reintroduced should also be considered.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Madden and Paulsen (112) suggest that Kaluaapuhi Fishpond could be improved considerably for aquaculture, but indicated that its relatively low potential should be weighed against the costs of renovation. Dredging of accumulated silt and clearing of mangrove would probably cause a temporary reduction in bird numbers during the operation, but the long-range effect for herons, coots and waterfowl would be positive. Expanded aquaculture may require reduction in fish that now provide some food for waterbirds, but improvement of the bottom substrate would permit the development of a submergent flora that is important to both mullet and waterbirds.

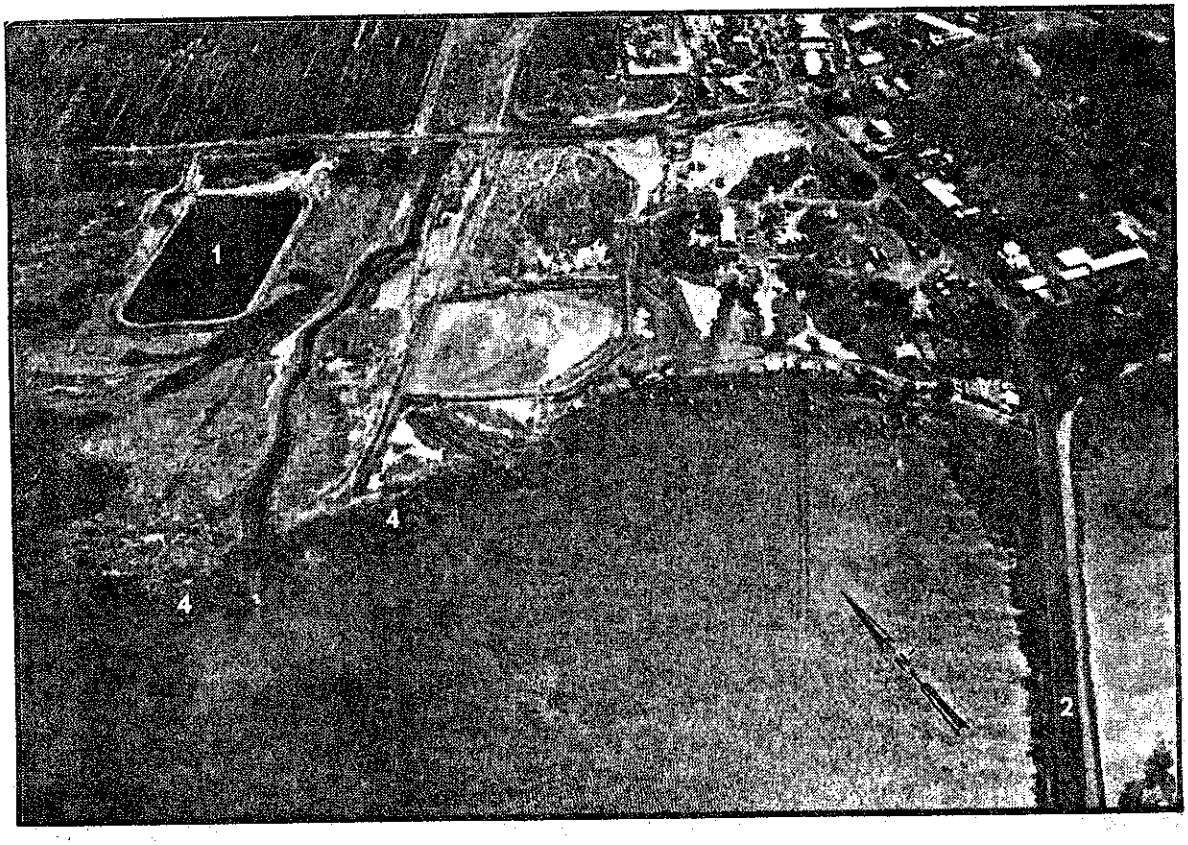
The State of Hawaii should consider a cooperative aquaculture-waterbird habitat program that will permit restoration and management of Ooia Fishpond solely for waterbirds while Kaluaapuhi Fishpond is managed primarily for aquaculture, but not to the exclusion of birds. This joint program would allow creation of loafing and nesting habitat in association with Ooia Pond and nearby lands while permitting necessary clearing of surrounding vegetation at Kaluaapuhi.

SITE NAME: Kaunakakai Pier Area (and Sewage Pond)

LOCATION: Moloka'i District, Moloka'i

TOPOGRAPHIC MAP: Kaunakakai

DATES OF SURVEY: 22 May, 6 July, 1977



1. Kaunakakai sewage pond
2. Kaunakakai pier
3. pickleweed
4. mangrove
5. Kaunakakai town

WETLAND DESCRIPTION: The list of Molokai sites in this survey included lands both east and west of Kaunakakai pier. To the west of the pier, a mixed collection of ephemeral and permanent "wetland" habitat is available to Molokai's waterbirds. The dominant plant life on undeveloped lands is pickleweed. It is evident that much of this is area flooded only ephemerally, either as a direct result of heavy rains, or due to flooding in the drainage from Kaunakakai Gulch, that passes through the middle of the site. Mangrove covers much of the shoreline on both sides of the drainage entrance to the ocean. Beyond this point to the west, mangrove, kiawe and pickleweed are the dominant ground cover plants.

The largest source of permanent water in the site is the Kaunakakai Sewage Treatment Pond. Well-manicured grass lines the sloping shoreline of this pond. The Kaunakakai gulch drainage is 8-10' wide near the mouth and as deep as 5-6' at the time of survey. The stream was extremely turbid, but shallow shoreline at the entrance to the ocean made it accessible as feeding habitat for wading birds. Silt from periods of heavy runoff in the gulch has created a mudflat beyond this point.

A small tract of housing separates the pier area from similar undeveloped flat lands to the east (not pictured). The primary ground cover is again pickleweed. Evaporating water has left shallow, highly saline puddles and salt crystals on the bare ground. Small depressions at the site must also hold pockets of rain water after Kona storms. This large lot is bordered by ocean and the highway, and housing tracts on east and west sides. At the time of survey, posted signs indicated that the land was up for sale by Molokai Ranch.

NON-AVIAN WILDLIFE: The drainage from Kaunakakai gulch that passes through the flat lands west of the pier was too turbid during the survey to detect much aquatic life. Tilapia and mosquito fish were observed in this water, but it is likely that mullet, o'opu and other anadromous fishes are found as well. Inland from the highway, this drainage is overgrown with grasses, but can be expected to support bullfrogs, toads and a variety of terrestrial and aquatic insects. Dogs, cats and mongoose were seen on flat lands both east and west of the pier and rats are surely present as well. The sewage pond fence could exclude dogs, but the gate was always open during our surveys.

NON-WATERBIRD AVIFAUNA: The non-wetland avifauna observed in the Kaunakakai area was typical of the lowland kiawe forest along the entire southern coast of Molokai, except that House Sparrow and Rock Dove (Pigeon) were more common than elsewhere. Japanese White-eye, Spotted Dove and Barred Dove were numerous. Red-crested Cardinal, Northern Cardinal and Mockingbird were uncommon at the site but easily detected by their calls. Common Myna and Spotted Munia were widely distributed in small flocks. Two Black Francolin were observed on each of two trips. One of the francolins was "trapped" within the sewage pond fence, calling loudly and unable to escape.

WATERBIRDS OBSERVED: Waterbirds were observed during our surveys only in the sewage pond area and at the mouth of the Kaunakakai gulch drainage. The sewage pond has attracted considerable attention among biologists recently because several species of waterbirds have been seen there. USF&WS biologists have included the pond in their monthly survey trips to Molokai during the last year. The average number of Hawaiian Stilt recorded at the pond between 8/76 and 8/77 was 10.9 birds per trip. This is nearly as high as a 20 year

count average for all of Molokai that includes only the 12 surveys which stilt were recorded (average = 11.9). If the HDF&G/USF&WS counts during which stilt were not seen are included, the 20 year average drops to less than 8 birds per survey. The maximum number of birds recorded at the reservoir (and not included in the average for monthly trips) was 31 (12/10/76). Stilt were present on all USF&WS counts during the last year. It is not likely that they will ever nest successfully at the site, at least in its present condition. We observed two stilt on our May trip and five in July. None were seen at other locations on the flatlands east or west of the pier, but they are probably attracted to mudflats at the opening of the Kaunakakai gulch drainage during low tides and to ephemeral wetlands on the pickleweed flats after heavy rains.

The only other endemic waterbird recorded at the sewage pond in USF&WS survey during the last year was the Hawaiian Coot. This species has been noted on only four of 12 monthly surveys, in numbers ranging from 1-4. Black-crowned Night Herons have also been observed intermittently at the site and in the mangrove area below the Kaunakakai gulch drainage. No more than six herons have been recorded at the sewage pond. We observed two herons at the site in May, but none in July. The County caretaker at the pond indicated that two herons had been found dead at the site during the fall of 1976. They appeared to have paralyzed legs, but they died of unknown causes.

The USF&WS records of migratory waterfowl at the sewage pond in the last year are interesting in that the total number (n=32) of Shovelers noted exceeds the number of Pintails (n=5) by a wide margin. Between 1971-1976, HDF&G/ USF&WS count records show a total number of Pintails observed at 249, whereas the Shoveler count totaled 31 birds. Count records going back several years also lean strongly in favor of Pintails on Molokai. Presumably, this imbalance in relative numbers reflects differences in feeding ecology and the differences in food available at the sewage pond and other waterfowl habitat on Molokai. Only a more prolonged history of count records at the sewage pond will substantiate this theory.

We did not record any migratory waterfowl at the pond during our surveys, but did observe seven Muscovy Ducks in May. The caretaker confirmed that domestic ducks fly in from nearby homes with some regularity. The only other migratory duck recorded at the pond, to my knowledge, was the Lesser Scaup (2 birds) seen by USF&WS biologists in January, 1977. The list of migratory shorebirds noted at the site includes Golden Plover (most common), Wandering Tattler, Ruddy Turnstone, Sanderling and Long-billed Dowitcher (single record). Cattle Egret have been counted on 2 of 12 recent USF&WS monthly surveys as well.

HABITAT EVALUATION: It is clear that recent construction of the Kaunakakai sewage pond has affected waterbird numbers and distribution on Molokai to some degree. However, it will be some time before it is certain whether or not this artificial habitat will help sustain significantly greater numbers of birds on Molokai, or if it will merely redistribute the birds that would normally be found in other habitats. Although the site supports some migratory waterfowl during their wintering period in Hawaii, its principal value to Hawaiian Stilt is limited by the lack of suitable nesting habitat in the vicinity. It is likely that the principal factor that limits stilt population on Molokai is the shortage of suitable nesting sites that are close to feeding habitat and protected from predation. In its present condition, the sewage pond does not change that picture appreciably. It does, however,

suggest the possibility that suitable nesting/feeding habitat could be created artificially in the immediate area. It is not likely that this will be possible in light of coastal land values, but it deserves consideration. As a less desirable alternative, some modification of the existing sewage pond site to accomodate nesting may be possible. The draft HWRP (346) recommends developing a cooperative agreement with the County of Maui to insure protection of the birds at the site.

By comparison to the sewage pond, the surrounding undeveloped lands have little current value to endemic or migratory waterbirds. The open lands east of the pier are virtually worthless to waterbirds in their present condition. The lands west of the pier show considerably more potential for habitat development, through the impoundment of water and predator control. The Kaunakakai gulch drainage will continue to provide a small amount of marginal habitat for herons and migratory shorebirds, but without adequate protection, the human disturbance from surrounding lands will prevent expanded use of the site by waterbirds.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Extensive movement of fill in the lands surrounding Kaunakakai pier has occurred in recent years. Attraction of waterbirds to the sewage pond provides clear evidence of the importance of artificial habitat, and suggests how the neighboring land could be used. The flat lands near the pier are not typical wetlands, and are only flooded ephemerally. Movement of fill to create water impoundments would improve, rather than detract from existing habitat. Also, it is not likely that further siltation of the Kaunakakai Gulch drainage would have any adverse impact on the site as waterbird habitat, as it is already of only marginal value.

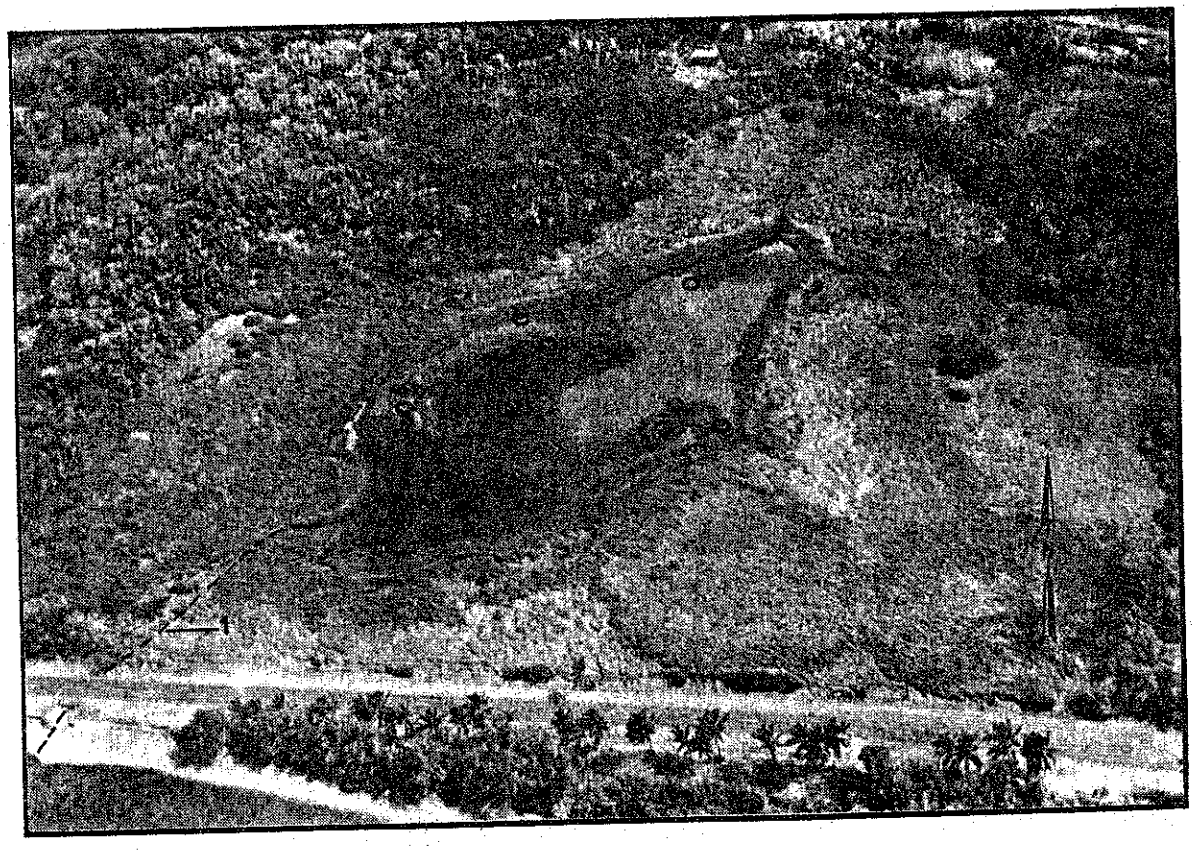
As the importance of this area to waterbirds lies primarily in its potential and not in its present value, there can be little justification in restriction of land use as a threat to waterbirds. The exception to this generalization would be a project that would lead to excessive disturbance in the sewage pond area.

SITE NAME: Kakaha-i'a Fishpond, Kakaha-i'a National Wildlife Refuge

LOCATION: Moloka'i District, Moloka'i

TOPOGRAPHIC MAP: Ka-malō

DATES OF SURVEY: 21 May, 7 July, 1977



o = coot nests, July 1977

1. drainage from pond

WETLAND DESCRIPTION: Kakahaia Fishpond is the only true inland fishpond surveyed on Molokai. The depression and surrounding lands in which the pond is now located once supported extensive rice crops but was modified for exclusive fishpond use early in this century. A 15 acre pond in the center of the site is surrounded by a dense overgrowth of bulrush and honohono grass. An extensive kiawe forest extends beyond the limits of the marshland. A growth of duckweed and azolla covered more than 60% of the water surface at the time of our survey. According to local residents, water supplies the pond from 3-4 artesian wells (514). Several drainage gullies also supply the marsh area with water during heavy rains. Kridler (519) reports that he has seen the pond completely dry in the past years. A ditch exits the pond in the southeast corner and makes contact with the ocean under the highway.

The fishpond has been of particular interest to wildlife biologists for several years because of its recognized value to waterbirds. A total of 45 acres were purchased by the USF&WS in April, 1976 and the site was designated the Kakahaia National Wildlife Refuge. The birds at the pond have been monitored on monthly counts since early 1976. There has been little modification of the area as yet under refuge status. A special use permit was recently granted to the County of Maui by the USF&WS to use a portion of the shoreline area across the road from the refuge as a beach park.

NON-AVIAN WILDLIFE: Our arrangement with the USF&WS at the time of the survey did not permit us to make a survey of aquatic fauna. The productivity of the site for waterbirds indicates that it is rich and diverse in aquatic fauna and flora. The pond has been used for rearing mullet until recently (524). Presumably tilapia, o'opu, mosquito fish and other species are also present.

Packs of 4-5 dogs have been seen on recent USF&WS surveys. A minimum of 2 mongoose were seen on each of two trips to the surrounding kiawe forest. It is questionable whether or not either of these predators find easy access into the pond itself, but USF&WS biologists have purchased fence materials and are considering construction of a moat around the pond to control predators (514).

NON-WATERBIRD AVIFAUNA: Most of the non-wetland birds seen at the site on our survey were actually counted within the surrounding kiawe forest. These included Japanese White-eye, Common Myna, Spotted Dove, Barred Dove, Mockingbird, Northern Cardinal, Red-crested Cardinal, Black Francolin and Gray Francolin. The last two of these were less common than the others, but are both known to be resident in the area year around (534). House Finch were heard and seen on the second survey but not on the May trip. California Quail are known from the site but were not seen on this survey (534). Spotted Munia were the only non-wetland birds that were resting or feeding among the marsh vegetation surrounding the pond at the time of survey.

WATERBIRDS OBSERVED: Kakahaia Fishpond has long been recognized for its value as habitat for the Hawaiian Coot. Most of the coots recorded in semi-annual HDF&G/USF&WS counts on Molokai have been found in this small pond. Recent monthly counts by the USF&WS show surprisingly little variation from month to month. Between 8/76 and 7/77, the USF&WS count ranged from 30-47 coots, with an average of 36.3. We observed 34 birds on May 21 and 48 birds on July 7, 1977. Some of the variation in past counts may be caused by difficulty in viewing the entire water surface of the pond and also by the tendency of birds to climb into the shoreline vegetation to loaf.

Kakahaia Fishpond also provides surprisingly good nesting habitat for coots. With the possible exception of some wetlands on Niihau and Kii Pond (Oahu) prior to 1972, Kakahaia probably produces more young coots for its size than any habitat in the State. Nesting has been recorded in all months of the year as well (534). At the time of our July survey, nine nests (of which seven were currently active) were counted on the pond. All were made from shoreline vegetation that had been carried out to the nest site. Many of the nests were within 5 yards of shore vegetation. All were within or at the edge of portions of the pond containing surface duckweed and azolla. At least eight of the 48 coots we observed on our July survey were young birds.

Although there was little shallow water in which small wading birds could feed during our survey, the variable water levels within Kakahaia Pond do provide feeding habitat that is temporarily accessible to Hawaiian Stilt. There have been no recorded sightings of this species in the past year, but they have been counted in low numbers (1-3) on a few occasions within the last decade.

Black-crowned Night Herons have been recorded at the site on all USF&WS monthly counts over the last year and on nearly every count previous to this. Two to four herons have been regularly observed stalking food in the shallow water, or perched motionless in the shoreline vegetation. Abandoned coot nests provide a convenient fishing perch for herons as well. Although this predatory bird may pose a threat to young coot chicks, we saw no evidence that adult coots with young were disturbed by the presence of herons in the pond.

We counted one Shoveler and one Pintail at Kakahaia during each trip to the site. As would be expected, numbers of migratory ducks increase dramatically in winter months. As many as 61 Pintails and 46 Shovelers were counted on a single visit by USF&WS biologists in the last year, but earlier HDF&G/USF&WS counts were often much higher. A total of 163 ducks of both species were counted in September, 1969 (503). Pekelo (524) has indicated that encroaching marsh vegetation is probably the explanation for diminishing numbers of waterfowl at the site. Other waterfowl have been recorded on HDF&G/USF&WS counts at Kakahaia in far fewer numbers than pintails and shovelers. These include: American Wigeon, European Wigeon, Mallard, Blue-winged/Cinnamon Teal (species uncertain) and Canada Goose. The only migratory shorebird that appears in count records for Kakahaia is the Golden Plover.

HABITAT EVALUATION: Kakahaia Fishpond is, without question, the best waterbird habitat on the island of Molokai and among the most productive areas for Hawaiian Coot in the entire State. Fortunately, it is assured future protection in federal refuge status, but the quality of the site is not likely to be retained without maintenance. Pekelo (524) has pointed out how the pond has shrunk due to encroaching marsh vegetation. When managed as a fishpond, accumulating silt and plant material were cleaned out periodically. Such activity should be incorporated into a habitat management plan for the site to insure continued productivity.

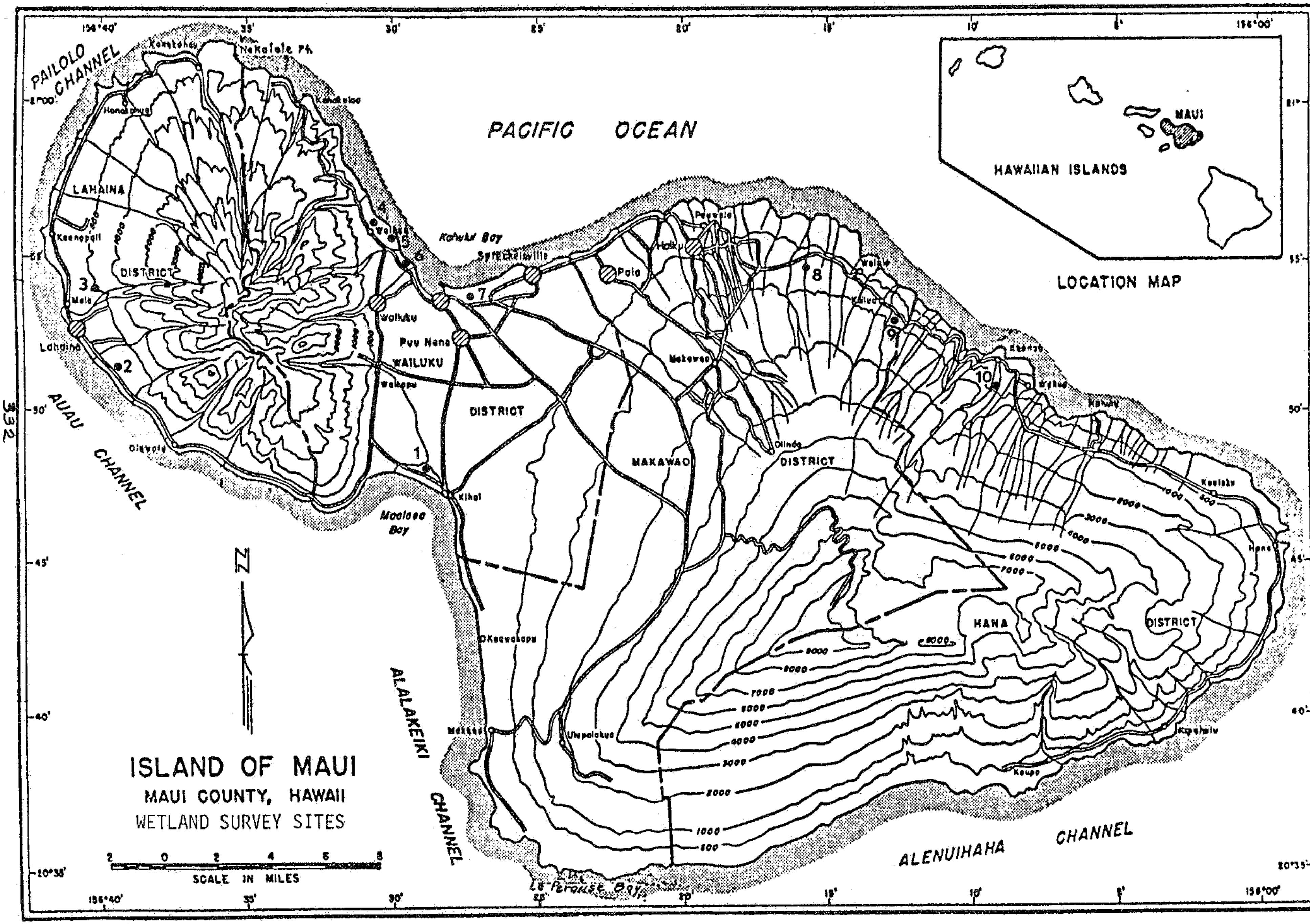
At the same time, intensive study is needed to determine why coots find this site so attractive for nesting. It appears to be a combination of limited disturbance due to a protective buffer, relatively stable water levels and a super-abundance of food for adults and chicks. A better understanding of the pond ecology would improve management efforts here and elsewhere in the State.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: The draft HWRP (346) recommends creation of additional openings in the surrounding vegetation at this pond to increase the amount of available nesting and feeding habitat. Further, the USF&WS is considering dredging of a moat around the pond's edge to prevent encroachment of bulrush and to provide fill for construction of nesting islets (514). Such extensive habitat manipulation should probably await a more thorough study of pond ecology, particularly the relationship between the birds and their food, water and cover. It may prove advisable to create adjacent potholes rather than enlarging the existing pond. The refuge boundaries will provide sufficient space for doubling the present size of the pond if thorough study indicates it would improve rather than diminish the present value of the habitat. It may also be necessary to maintain a schedule of repetitive clearing as was done when the pond was used for aquaculture.

The impact of land clearing and other fill-related activities on adjoining land, particularly above the pond, should be evaluated in light of the potential effects on silting rates in the pond. It may also be advisable to establish new drainage channels around the pond to minimize the effects of continued runoff in future years.

MAUI

WETLAND AREAS SURVEYED


ISLAND OF MAUI
MAUI COUNTY, HAWAII
WETLAND SURVEY SITES
SCALE IN MILES
2 0 2 4 6 8
LOCATION MAP
HAWAIIAN ISLANDS
MAUI
PACIFIC OCEAN
PAILOLO CHANNEL
AUAU CHANNEL
ALALAKEIKI CHANNEL
ALENUIHAHA CHANNEL
Kahului Bay
Maalaea Bay
La Perouse Bay
LAHAINA DISTRICT
WAILUKU DISTRICT
MAKAWAO DISTRICT
HANA DISTRICT
Lahaina
Wailuku
Puu Nene
Kihei
Paia
Haiku
Makawao
Olinda
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MAUI

INTRODUCTION:

Maui is the second largest island in the State of Hawaii. Its principal geological features are two large dormant volcanoes, separated by an isthmus more than eight miles wide. Haleakala, in the east, rises to more than 10,000'. Distinct windward and leeward slopes are evidenced by wide variations in climate, topography and vegetation.

High elevation wetlands on Maui include forested bogs at Puu Kukui and Kipahulu Valley and natural lakes (Waianapanapa, Eleele), east of Haleakala crater. These areas were not visited during this survey. Two major lowland sites (Kealia Pond, Kanaha Pond) provide nesting, feeding and loafing habitat for stilt and coot, and support large populations of migratory waterfowl and shorebirds. Although Kanaha Pond is a State waterbird sanctuary and negotiations are underway to purchase Kealia Pond for federal refuge status, neither wetland is assured permanent protection under present ownership. Both are listed in the draft HWRP (346) as primary areas essential to survival of Hawaiian stilt and coots.

Reservoirs for sugar cane irrigation, when considered as a unit, also provide important waterbird habitat. The HWRP (346) reports that fifty reservoirs varying in size from 1.3 to 47.6 acres are used by waterbirds, particularly during winter months. The total acreage of these reservoirs (460+ acres) is greater than the combined (normal) wetland acreage with Kanaha and Kealia ponds. Most of these reservoirs are located on the lower north and west slopes of Haleakala, but some are found on west Maui as well.

Some additional ephemeral "wetlands" were included on this survey. These lowland sites are typically overgrown with grasses and hold water only after heavy rains. Most are of little or no value to waterbirds.

Waterbirds on Maui:

The importance of wetland habitat on Maui to Hawaiian waterbirds can be seen by a quick review of past records. Although present on the island historically, both Hawaiian Gallinule and Koloa are no longer among the wetland avifauna on Maui. An attempt to reintroduce gallinule to Maui appears to have failed. Hawaiian Stilt, on the other hand, are common in lowland habitat. Over a 20 year period of annual or semi-annual waterbird counts by HDF&G and USF&WS biologists, the stilt population on Maui has averaged nearly 40% of the statewide stilt count. In some years, more than half of the stilt counted on survey were found on Maui, in part because of the concentration of birds into two large lowland sites. For the most part, the stilt counts on Maui have not fluctuated as widely as on other islands. This reflects, at least in part, the lack of major habitat change in Kanaha or Kealia ponds. As on all islands, summer counts of stilt are generally higher than winter counts, reflecting the recruitment of young into the population. By comparison to stilt, the population of Hawaiian Coots on Maui has been of less significance to the statewide picture. Over the same 20 year count period, the coot count for Maui has averaged nearly 28% of the State total in winter and nearly 15% in summer.

Migratory waterfowl populations recorded on winter HDF&G/USF&WS counts show some radical variations, probably due to movements of birds between islands and to and from other wintering areas in the Pacific Ocean. Yet, on the average, Maui's wetlands have supported more than half of the migratory ducks in the main islands at the time of the winter counts. In one year (1953) the Maui waterfowl count was 4,578 birds, but counts since that time have been considerably lower on all islands. Unlike the typical pattern for the other islands, Shovelers generally outnumber Pintails in the waterfowl counts on Maui. Presumably this inconsistency reflects differences in feeding ecology and the types of habitat available on each island. Maui's low elevation wetlands also provide suitable habitat for several regular and rare migratory shorebirds. These will be treated in the discussions of individual sites.

Reservoirs on Maui as Wildlife Habitat:

The sites we surveyed on Maui included the two major low elevation ponds (Kanaha and Kealia), a group of sugar cane reservoirs and a number of minor ephemeral wetlands or former marshlands. Only the two large wetlands will be treated individually in depth, because of their obvious long-term value to waterbirds.

The fifty or more reservoirs on Maui can be characterized by many similarities in their condition as waterbird habitat. The primary use of the reservoirs is water supply for irrigation. Most are relatively small sites, with steep mud banks. The reservoirs are often created in natural depressions that are dammed artificially to hold water. Water levels fluctuate rapidly with changing demands for water and collection of water during rainy period. Unfortunately for the resident birds, sufficient water may be lacking when they need it most during summer drought. Often the reservoirs are dried completely by the landowners and cleared of accumulating silt and vegetation. There is little chance for any of these reservoirs to develop a diverse or abundant aquatic fauna or flora. The lack of shallow water most of the year makes the bottom inaccessible to many waterbirds for feeding. Any growth of emergent or surface vegetation, important as cover or food for birds, is discouraged by management techniques that maximize the water holding capacity of the reservoirs and the frequency of draw-down.

Most of the reservoirs are surrounded by sugar cane or pasture lands, and consequently the diversity of surrounding vegetation is generally low. In some sites, planted exotic forest is found in the area of the reservoirs. This increases the diversity and number of non-wetland birds that can be found in nearby habitat. Bird species near these reservoirs include Spotted and Barred Dove, Skylark, Spotted Munia, Hawaiian Owl, California Quail, Ring-necked Pheasant, Gray Francolin, Black Francolin and occasionally Chukar. Where some forest is also present, one can also find Japanese White-eye, Melodious Laughing-thrush, Red-billed Leiothrix, Northern Cardinals, Mockingbird, and House Finch. Common Mynas are often found near the reservoirs, particularly if cattle are nearby.

Mammals in the area of the reservoirs on Maui include cattle, feral dogs, cats, pigs, mongoose, rats and mice. Very few of the reservoirs have any potential waterbird nesting sites that would be free of mammalian predation.

Cattle may interfere with waterbird use by increasing the turbidity of reservoir water and by gathering in large numbers in potential waterbird feeding habitat.

Individually, the reservoirs on Maui are of little use to endemic waterbirds when compared to the two major low-elevation wetlands. Yet, collectively, they provide important loafing and feeding habitat, at least for Hawaiian Stilt. In winter months, between 10-20% of the stilt recorded on HDF&G/USF&WS surveys of Maui are found at some of the 42 reservoirs that are regularly included in the survey. In summer months the average count drops to 5-10% of the island total for the species. Hawaiian Coots find less to eat at the reservoirs, and in some years none are counted away from the lowland ponds. An average of 2-5% can be expected to use the reservoirs during summer and winter count periods, but it has ranged as high as 17% in recent years.

Black-crowned Night Heron recorded at reservoirs have accounted for as much as 50% of the island count in past years. However, a heron rookery at Kealia Pond has expanded manifold since the establishment of a catfish farm at the site. Recent counts show that the relative importance of the reservoirs for this species on Maui has diminished, but the herons still visit the reservoirs in similar numbers as before. The average reservoir count between 1971-1976 was 27.5 birds per count.

The primary waterbird use of the reservoirs is by wintering migratory waterfowl. In the last five years, the reservoirs have accounted for 0.5-2.5 times the number of Pintails counted on both Kanaha and Kealia ponds taken together. The average count during this period was 1.34 times the total count for Kanaha and Kealia together. Not surprisingly, the reservoirs are less attractive to some other duck species. The Shoveler count has often been less than 10% the count for Pintails in the reservoirs. This is in direct contrast to the pattern for Maui as a whole, where Shoveler counts have generally been higher than Pintails. Presumably this imbalance in numbers is related to difference in feeding ecology between the birds, in particular the reluctance of Shovelers to dive for food. The relevance to diving behavior in ducks is furtherevidenced by counts of Lesser Scaup, a species that regularly dives for food. Only 55 birds of this species were counted on Maui between 1971-76 and nearly 70% of these were seen on reservoirs. Usually they were found in large groups on a single reservoir.

Migratory shorebirds find little of value at the reservoir sites. The shallow low elevation ponds provide much more suitable feeding habitat, as evidenced by HDF&G/USF&WS count records. Golden Plovers appear on all reservoir counts in part because they also seek food in pasture lands and other habitat as high as 8,000' or more. In contrast, the numbers of Ruddy Turnstones counted at reservoirs represent a small fraction of the Kanaha or Kealia Pond counts.

RESERVOIRS AND EPHEMERAL WETLANDS SURVEYED

Four reservoirs and four ephemeral wetlands were surveyed on Maui during this project. None of these areas are among those regularly included in semi-annual waterbird counts by HDF&G and USF&WS biologists, so there are no comparative data from earlier years that are relevant to this study. There are some subtle differences between reservoirs that play an important role in their respective values as waterbird habitat. A more extensive limnological study and repetitive bird survey for all of the reservoirs would help to determine which sites (and for what reasons) are most valuable to birds. This would direct biologists to establish priorities in developing cooperative agreements with landowners for effective habitat management.

Crater Reservoir/Waihukuli Reservoir

Survey: 5/14/77

Three small reservoirs on Pioneer Mill Company lands above Lahaina were included in this survey. Of these, only Crater Reservoir is located in a natural crater. Water storage in the other reservoirs has required considerable dredging and diking. None support extensive emergent vegetation, but Crater Reservoir is surrounded by a dense overgrowth of kiawe and other exotic trees. An extensive rock wall lines the shore of Waihikuli Reservoir. Some exposed mudflat is accessible to birds in all sites when they are not completely full. The water in all reservoirs was extremely turbid, but tilapia were common in shallow water. Workers interviewed at the site indicated that water levels in the reservoirs change rapidly with rainfall and irrigation demand.

Six Black-crowned Night Herons were counted at Crater Reservoir and eight at Waihikuli during our survey. Most were perched in nearby trees, but at least six birds were stalking prey in the shallow water over mudflats. One Hawaiian Stilt was observed on the Wahikuli mudflat also. Workers confirmed that both species were seen at the site with some regularity, and also noted that migratory ducks occasionally visit the reservoirs in winter months. Although not confirmed, it is likely that more herons now visit the area than in earlier years, due to the expanding rookery at Kealia Pond, east of this site.

Laniupoko Point Reservoir

Survey: 5/14, 6/20/77

This body of water, inland from Laniupoko Point, is not shown on recent topographic maps of the area. Presumably the dredged site serves to collect silt in runoff from nearby cane fields. The exposed mud shoreline showed evidence of considerable water level change in recent months. The bottom was soft mud, and the water very turbid. On the first visit, a coating of oil covered most of the water surface, possibly left there as a means to control mosquitoes. The oil was gone a month later. The surrounding land supports a dense, but localized forest of koa haole and kiawe. Some of this forest had been eliminated by earth-moving equipment used to enlarge the reservoir. No birds were observed on either visit to the area. It is doubtful that this site is ever of significance to waterbirds.

Waihee Marshland

Survey: 5/12, 6/11/77

Two separate "wetland" areas were surveyed at this location. The portion of the site above Kahekili Highway is now almost totally covered by sugar cane. Residents in the area confirmed that the site was filled and cultivated for cane only within the last two years. Prior to that time, springs and runoff maintained the site in a swampy condition during most of the year. Stilt were observed at the site prior to filling and planting of cane. A small taro patch in the area may still provide some attraction to stilt and other waterbirds, but it is very small and subject to considerable neighboring disturbance.

Below the highway, an expansive grassland is now used for grazing. The distribution of vegetation indicated that the site may flood temporarily after heavy rains. Neighboring residents confirmed that a small number of ducks may land at the site when water is present. There was no water in the open land during our survey. Presumably the presence of cattle would inhibit extensive bird use at any time of year. The site should be revisited during the rainy period of the year to provide further information on bird use.

Waiehu Point Marshland

Survey 5/12, 6/11/77

This wetland is a natural depression that is nearly choked with umbrella sedge, bulrush and various grasses. It is located approximately 200 yards from the entrance to a golf course at Waiehu Point. There was no visible water on the site at the time of survey, and it is doubtful that open water is present even during heavy rains. Some cattle tracks were seen, but it did not appear to be used regularly as grazing land. It is possible that the site could be reclaimed, and even improved for better water holding capability. However, in its present state, it is of no value to waterbirds.

Paukukalo Marshland

Survey 5/12, 6/11/77

A coastal depression approximately 600 yards in length now forms a wetland that was included in our survey. More than 75% of the site is choked with grasses and scattered patches of bulrush, and umbrella sedge, and most of it is wet underfoot. Some of the land is used for grazing, but in its present condition, waterbird use of this area is not likely. A large area of recently deposited fill bisects the wettest portion of this marsh site. The only open water contains a small amount of taro that appears to have been farmed intermittently. A surface duckweed and patches of water hyacinth keep most of the water surface covered. The pond area contains a variety of small invertebrates (shrimp, snails, aquatic insects). Mosquito fish and bullfrogs are also present. The pond is probably spring fed, as a nearby stream was totally dry at the time of survey. Three Black-crowned Night Herons flushed from the taro patch when we approached the pond. It is doubtful that the site could sustain many more birds on a continual basis, and human disturbance on neighboring lands probably keeps even the herons away much of the time.

It was evident that some of the marsh had been filled recently, but it was uncertain for what purpose. The site could be improved by clearing of the water hyacinth and grasses that are encroaching around the pond. However, it is unlikely that such change would appreciably affect the numbers of birds that use this small site.

Keanae Valley Wetlands — Survey: 5/13/77

Waiokamilo and Palauhulu streams drain the upper Keanae Valley into an open "marsh" at approximately 300' in elevation. This ephemerally wet grassland is surrounded by dense hau forest and other trees. Water permeates the grassland, suggesting that the site may be fed in part by underground springs. While it was evident on survey that the condition of the grassland must change with stream flooding and low elevation rainfall, it is doubtful that any open water (other than the streams) is ever present at the site. The grassland has been used for limited grazing in the recent past, but now appears to be largely ignored. No waterbirds were seen at the site.

Below the marshland included on survey are extensive taro fields. Two farmers interviewed in Wailua Valley and Keanae Peninsula taro fields indicated that herons had been present in their fields for as long as they could remember. We counted three herons in Wailua Valley taro and seven on Keanae Peninsula. A single Wandering Tattler was seen at the latter site as well. The farmers were also familiar with wintering ducks, but each said that these birds only visited their fields irregularly and in small numbers. Neither had seen coots or stilt in the fields. Surprisingly, one farmer reported that he had seen gallinule in his fields as recently as three years ago. He appeared to be familiar with the bird by his description, and was surprised to hear that gallinule had not been seen elsewhere on Maui for several years.

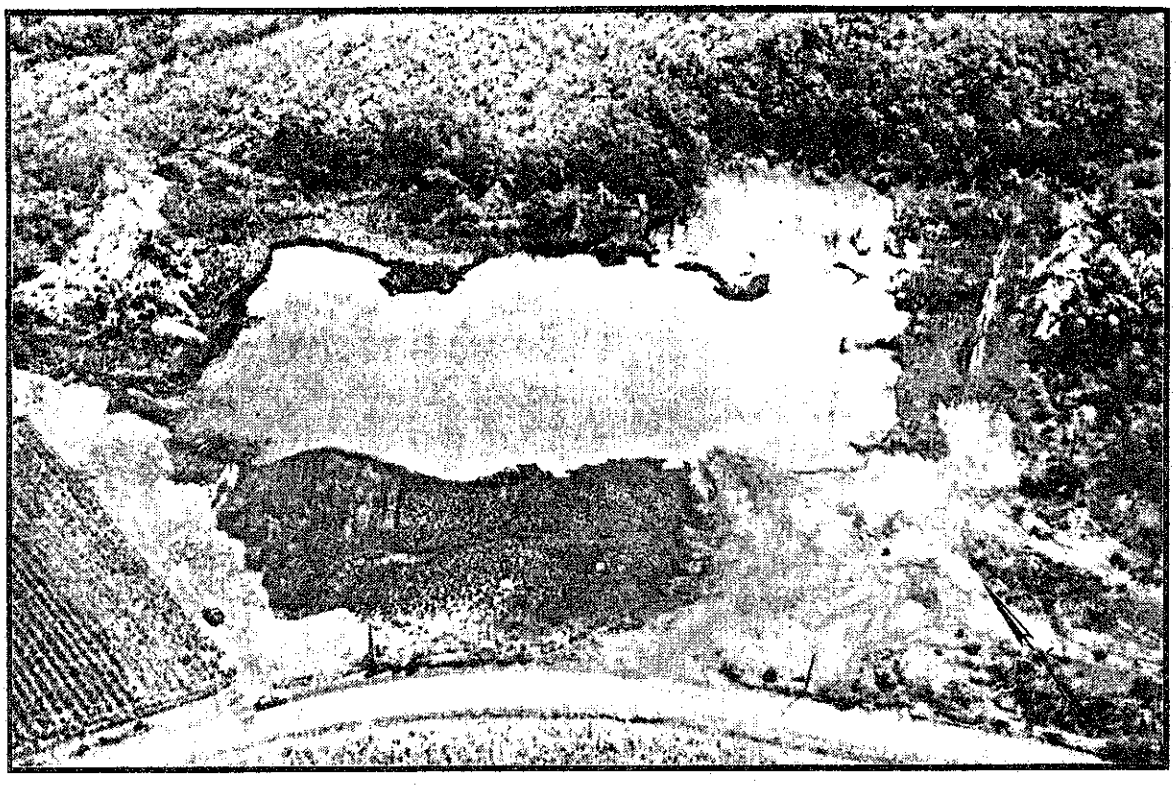
The relatively low waterbird species diversity in these taro fields raises some interesting questions about bird movements in the Islands. The habitat appears as suitable as taro fields on Oahu or Kauai, yet does not support either the variety or number of birds. Perhaps the isolation of the Keanae Peninsula from other waterbird habitat explains the relatively limited use of the area by birds. It would be valuable to survey these fields on a more regular basis to verify the reports of these farmers.

Papaaea Reservoir — Survey: 5/13/77

This East Maui Irrigation Company (EMI) reservoir was full at the time of survey but partially drained a few weeks later when aerial photographs of this site were taken. This is a natural basin that has been dammed to create a reservoir. It is fed by rainfall and a small stream. It drains into Nailiihaele Stream. The inland slope supports a small grassland marsh. When full, vegetation on the dike provides some potential cover for waterbirds, but a hard-packed mud slope is exposed as the reservoir drains. Workers at the site indicated that water levels fluctuate rapidly, and frequently, as demands for water and rainfall dictate. They indicated that some wintering ducks visit all of the EMI reservoirs in the area. We observed two Black-crowned Night Herons in neighboring trees.

Kapaalaalaea Reservoir Survey: 5/13/77

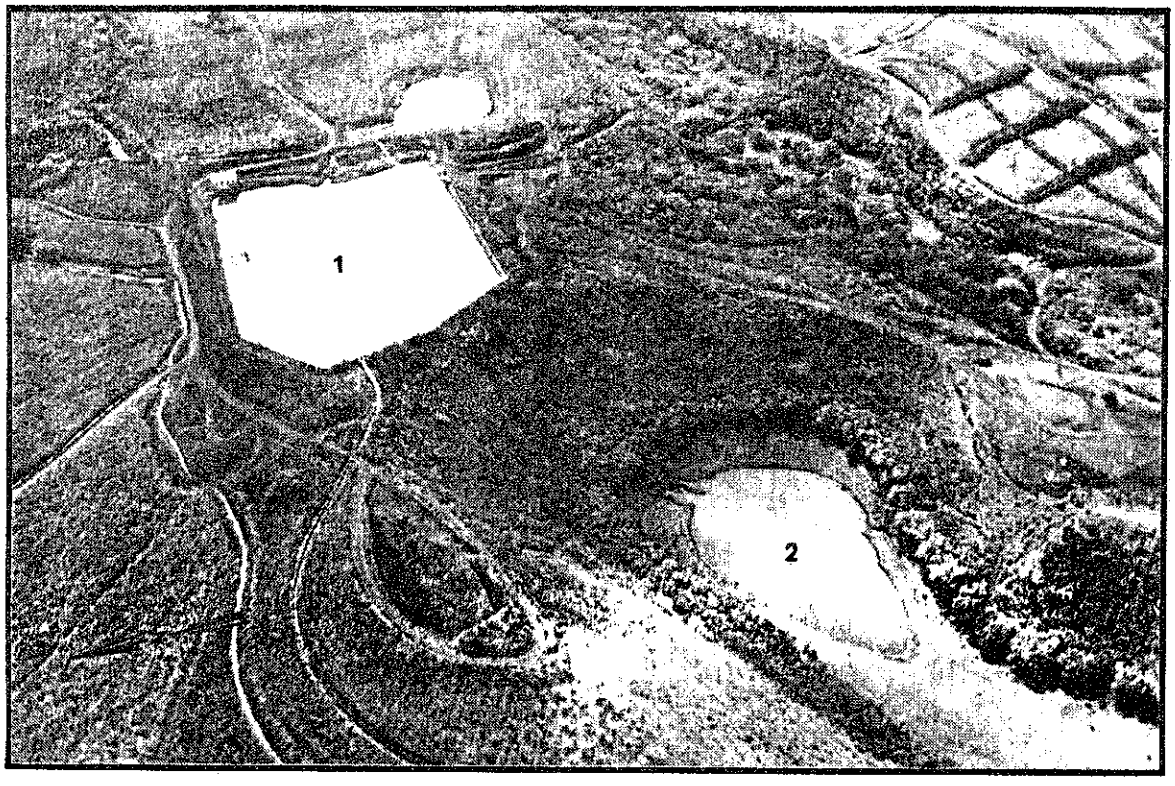
This reservoir was more than half full at the time of survey, but was dry two weeks later (see photograph). There is no emergent vegetation that would provide cover for waterbirds. Like other reservoirs in the area, this drainage (Piiloi stream) has been dammed to increase the water holding capacity of the natural depression. The bottom also shows evidence of considerable movement of fill. The water was very turbid during survey, but supported large numbers of tilapia, mosquito fish and bullfrogs. One Black-crowned Night Heron and one Golden Plover were counted at the site, but both species are likely to be found in greater numbers. Herons probably move long distances between different reservoirs as each is drained and filled independently.

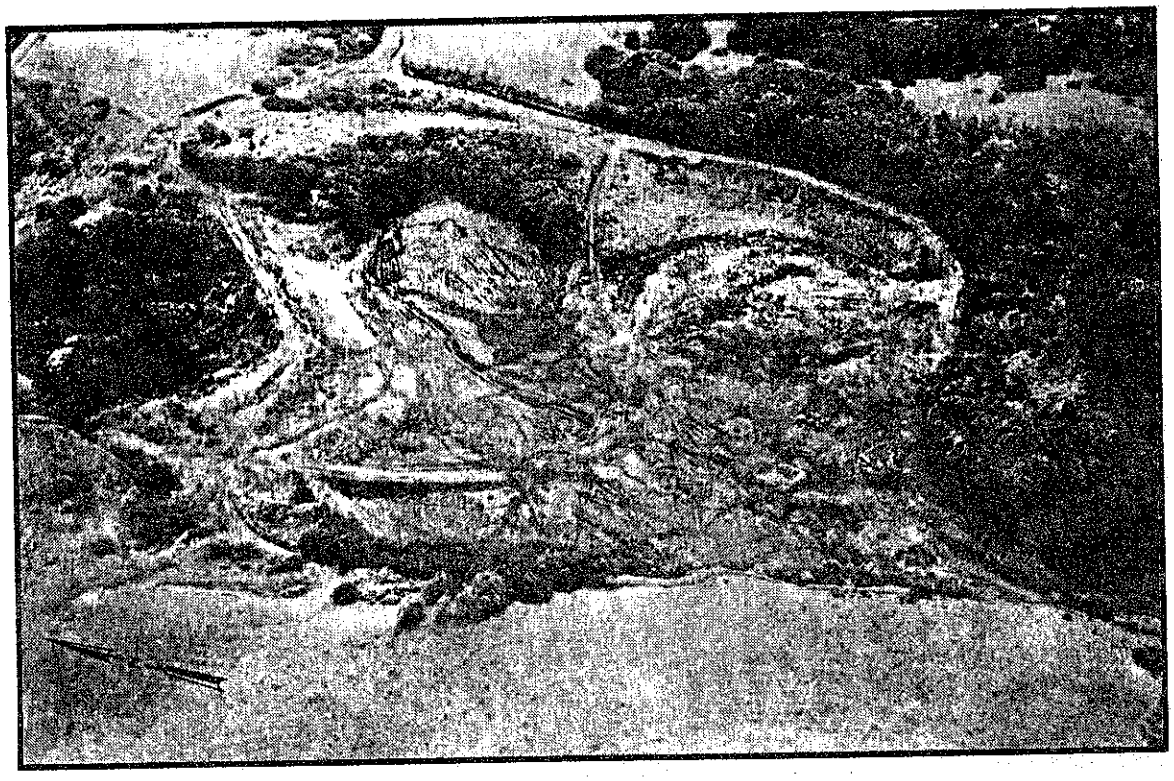


Launiupoko Point Reservoir

1. Wahikuli Reservoir

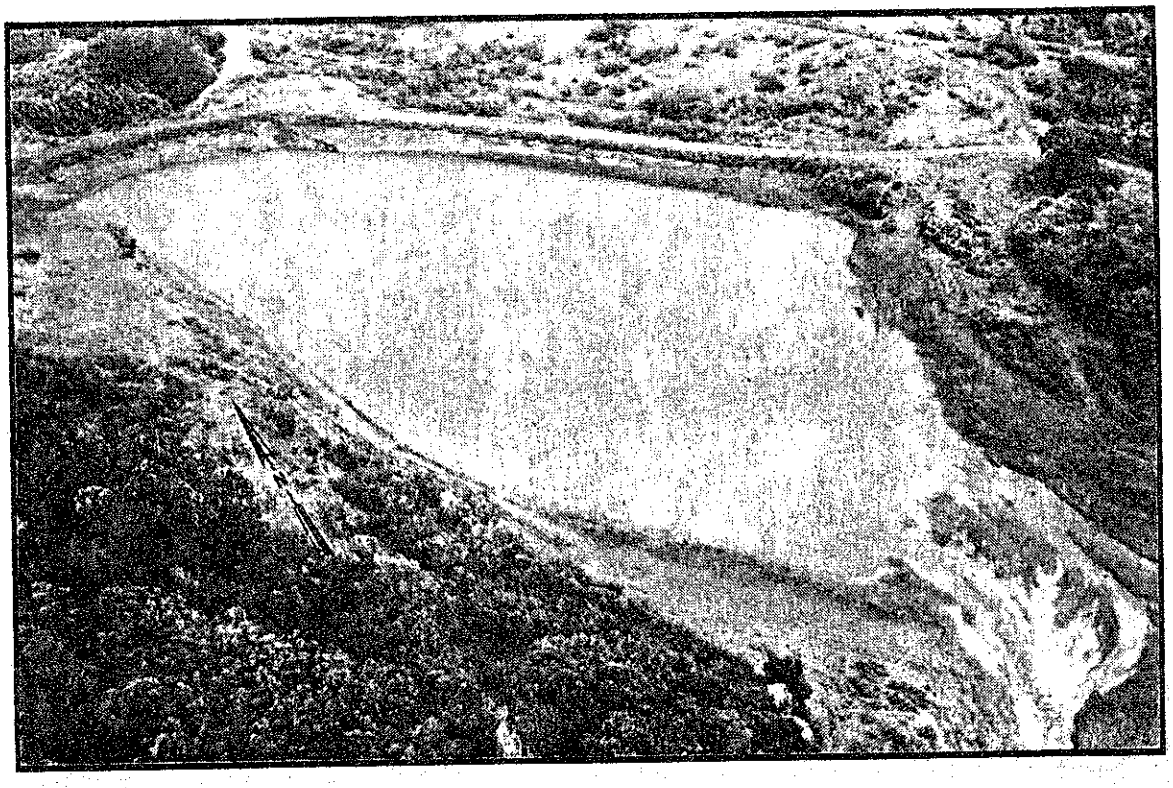
2. Crater Reservoir





Kapalaalaea Reservoir

Papaaea Reservoir



SITE NAME: Ke-ālia Pond

LOCATION: Wai-luku District, Maui

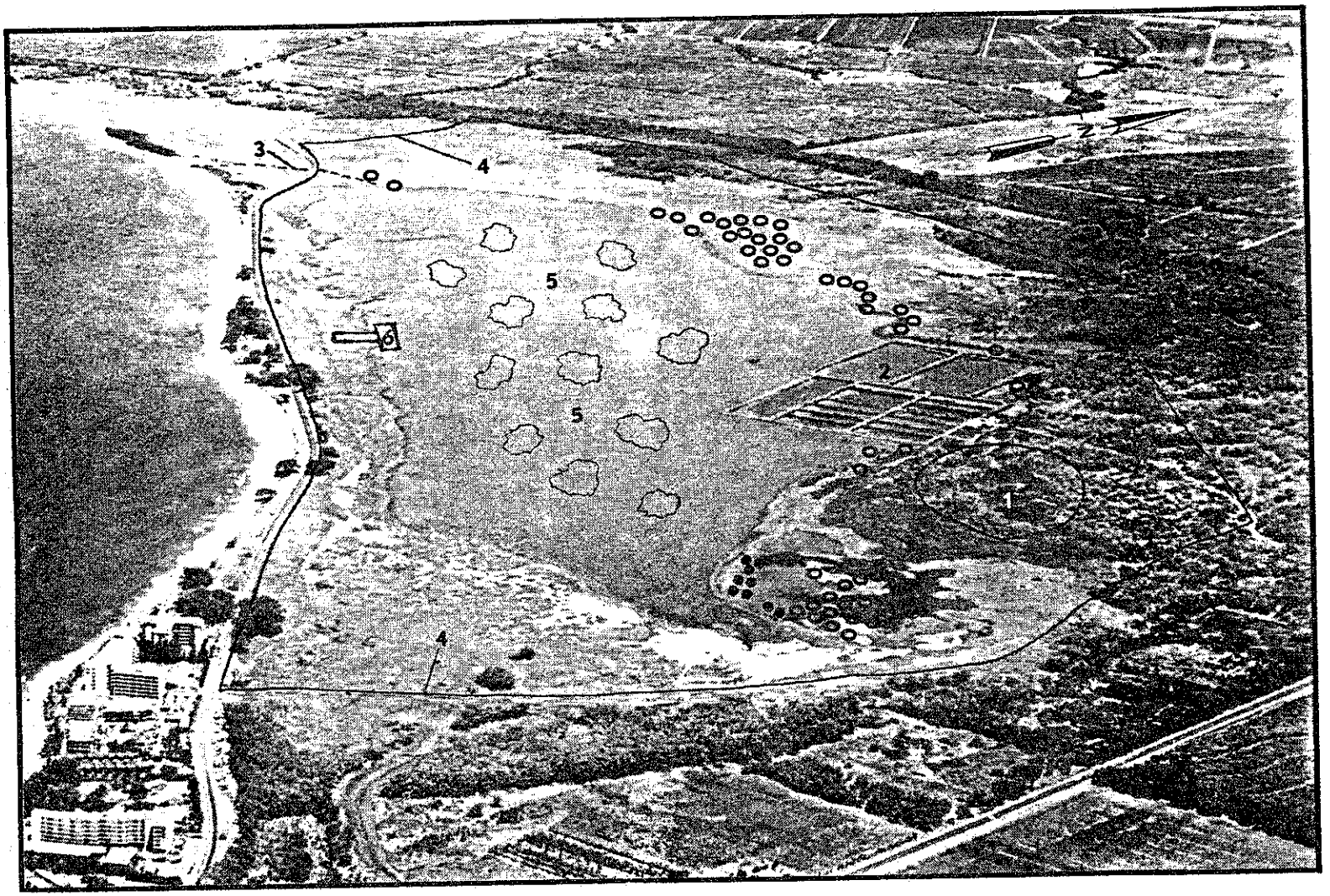
TOPOGRAPHIC MAP: Mā'alaea

DATES OF SURVEY: 14 May, 8 July, 1977

WETLAND DESCRIPTION: A recent USF&WS publication provides historical information about Kealia Pond (68). In the early 1900's, Kealia Pond was still in use as a fishpond by the Hawaiians. The brackish pond was more than five feet deep and a permanent connection with the ocean was maintained. With the development of agriculture on uplands surrounding the site, the pond began to fill with silt as rainfall run-off and irrigation water followed drainages into the pond. By 1925, only a small area of permanent water was left, and this soon became the site of a rubbish dump. The accumulation of silt in runoff filled the original basin so that the pond dried up completely in summer months. Strong tradewinds blew the dried silt off the flatlands into Maalaea Bay. In years of normal rainfall the cycle was repeated: runoff and siltation followed by evaporation and wind erosion. In abnormally wet years, some water remained throughout the summer. In recent years, the summer wind erosion has become a major source of complaint in nearby residential and tourist communities. But the cycle has been critical in preventing the heavy runoff of silt-laden waters into the Maalaea Bay and possibly destroying a rich marine ecosystem that had adjusted to the gradual and less severe impact of wind-blown silt (110).

After seasonal flooding the shallow water occupies 400-500 acres of flatlands. The development of a small aquaculture facility at the site, and the continued pumping of well water through their system, now maintains at least 150-200 acres of water coverage in the driest months. Drainage channels enter the pond from the north, east and west, but none of the streams that feed these channels are perennial. The groundwater below the pond is saline and the water table varies from zero to five feet below the ground surface (68). Under these harsh conditions, it is no surprise that the dominant pond vegetation at the site is pickleweed. A narrow fringe of bulrush lines portions of the south and north shores. Other plants in the ephemerally flooded flat lands include sedge and pluchea. A dense kiawe forest surrounds the lands that flood. When the pond approaches full capacity, extensive mudflats are found only on the east end. The drainage channel at the west end is periodically blocked by a sand plug, but clears during periods of heavy runoff.

The shallow, productive waters and mudflats of Kealia Pond provide valuable habitat for resident and migratory waterbirds. The Territorial Board of Commissioners of Agriculture and Forestry adopted a resolution in 1953 that set aside 300 acres at the site as a wildlife refuge, by cooperative agreement with the landowner. Although little active habitat management has taken place, interest in the site as a permanent refuge has continued. In 1970, 25 acres of land on the north edge of the site was leased to Pacific Aquaculture Corporation for the culture of Malaysian Prawns (Macrobrachium rosenbergii) and Catfish (Ictalurus punctatus). Several water impoundments were constructed and a shallow well was dug to feed the operation.



1. heron rookery
2. Fish Farms Hawaii
3. drainage

o coot nests, 1976 (HDF&G)

• stilt nests, 1976 (HDF&G)

proposed Kealia National Wildlife Refuge:

4. boundary (approximate)
5. islands (conceptual)
6. observation platform

Permanent water in the pond created by runoff from the aquaculture operation has made it possible for native waterbirds to stay at the pond throughout the summer months. In the past, the evaporation of water in the pond had forced these birds to seek habitat elsewhere. The aquaculture operation itself has also attracted increasing numbers of birds, particularly herons. Recognizing the possibility of creating a permanent wetland through expanded pumping of ground water, the USF&WS has entered into negotiations with the landowners (Alexander and Baldwin and several small landowners) to purchase approximately 500 acres at the site for a National Wildlife Refuge. A draft Environmental Impact Statement outlining the refuge proposal has been published recently (68). In the interim since negotiations began several years ago, much of the pond area has been recommended as "Critical Habitat" under provisions in the 1973 Federal Endangered Species Act, but formal proposal in the Federal Register has not yet been made (346).

NON-AVIAN WILDLIFE: Maciolek (110) included a brief macrofaunal survey of this pond in his study of the Kealia floodplain. In addition to many small invertebrates, his list included:

milkfish	(Chanos chanos)
mullet	(Mugil sp.)
aholehole	(Kuhlia sanvicensis)
river opae	(Macrobrachium grandimanus)
brown wi	(Theodoxus vespertina)
snails	(Melania mauiensis)
various poeciliid fishes	(i.e. Gambusia)
crayfish	
tilapia	

Occasional flooding of the aquaculture ponds has allowed Malaysian prawns to spread throughout the permanent water as well. We found small gastropod molluscs to be superabundant on the dikes of the aquaculture facility. Workers at the site confirmed that tilapia had become an almost insurmountable problem. The substrate in virtually all the ponds was covered with tilapia redds . In the past, evaporating waters in the large pond left windrows of dead fish and invertebrates. The concentration of the fauna during periods of low water has provided an important attractant to large numbers of waterbirds.

We observed packs of three to four dogs on both visits to the site. Dog tracks were common at all locations around the pond that we surveyed. Cat, rat and mongoose tracks were also observed. With the possible exception of the small artificial nesting islets at the east end of the pond, there is no feeding or nesting area that is inaccessible to predators. Mongoose were particularly abundant at the aquaculture facility. As many as 14 mongoose have been seen at the aquaculture ponds in one short visit by USF&WS biologists (517). Presumably the large numbers of dead tilapia that line the shoreline provide the primary attractant.

NON-WATERBIRD AVIFAUNA: The only endemic non-wetland bird that can be found in the Kealia Pond area is the Hawaiian Owl (Pueo). Although the species is recorded intermittently on HDF&G/USF&WS surveys, these owls are seen regularly by the fish farm employees. It has been suggested that owls are responsible for some mortality of Hawaiian Stilt at the pond (483).

The remaining non-wetland avifauna is confined primarily to the dense kiawe forest that borders the pickleweed flats. We observed or heard the following game birds at the site: Spotted Dove, Barred Dove, Ring-necked Pheasant and Gray Francolin. Of these, only the doves were common on our survey, but the other two species, and Japanese Quail, are recorded intermittently on monthly USF&WS surveys. Perching bird species observed in the forest include Japanese White-eye, Northern Cardinal, Mockingbird, and House Finch. Common Myna and House Sparrow also were seen on our survey, particularly in the fish farm area.

WATERBIRDS OBSERVED: The draft HWRP (346) indicates that Kealia Pond has supported an average of 128 Hawaiian Stilt over the last ten year period. The figure is misleading in that during most of these years the evaporation of surface water has forced birds of this and other species to find suitable habitat elsewhere, particularly during late summer - early fall. In other words, under typical rainfall conditions, Kealia Pond has not been able to sustain a stilt population throughout the entire year. Yet the potential of the habitat to support a year-round stilt population is illustrated by data for most recent years, since the aquaculture facility has supplied additional water. The average stilt population at the pond over the last 18 months of USF&WS monthly surveys is 161 birds, with a high (Jan. 1977) of 355 birds on the site. As many as 465 stilt have been recorded at the pond (8/3/72). We recorded 116 and 213 stilt on two visits to the pond. USF&WS biologists believe that, with improvement of nesting habitat and expanded coverage of permanent water, that peak populations of 350 stilt and an average monthly population of nearly 200 birds can be sustained at the pond.

In a recent study by HDF&G biologists (483), nine stilt nests were located in the area of artificial nesting islands in the east end of the pond (see photograph). The refuge development plan includes construction of numerous small islets throughout the main body of the pond to increase the amount of suitable nesting sites. We were unable to survey the recorded nesting areas thoroughly during our visit to the site with USF&WS biologists. However, we did observe (July, 1977) what appeared to be nest defense by paired birds in the area of the nesting islets (east end) and along the south shore, near the chosen location for the proposed visitor observation tower. The latter site did not appear suitable for nesting, as the pickleweed cover is complete to the water's edge. The entire southern shore is also exposed to gusty trade winds and excessive wave action. At the time of our survey, stilt did not appear to be as attracted to the fish farm facility as herons and coots. However, fish farm employees informed me that relatively large numbers of all species, including migratory waterfowl, do congregate in ponds that are drained periodically.

Hawaiian Coots are generally found at Kealia Pond in smaller numbers than are stilt. The draft HWRP (346) lists an average of 36 coots at the pond during semi-annual surveys during the last ten years. However, these counts included several "dry" years when numbers were low. More recently, with continued supply of fish farm runoff water, the numbers have been considerably higher. The monthly average for USF&WS counts over the last 18 months is 64 birds. It is likely that higher counts in recent years reflect not only the availability of food during all months of the year, but also the resulting increase in breeding activity.

There are few comparative data on coot nesting at Kealia for earlier years. In 1976, HDF&G biologists located 49 coot nests in a two month period (483). Nests were found along the entire northern shore. Presumably the high winds and wave action along the southern shore prevented nesting in this area. HDF&G biologists found that nests were built of pickleweed and/or sedge, depending upon the characteristics of the vegetation in the nesting area. A hatching success of 83.6 per cent was recorded.

We observed 80 coots on our July survey of Kealia Pond. Immature birds of at least two separate broods were seen in the fish farm area. An employee at the site confirmed that he had found two coot nests within their impoundments this year, but that adults had abandoned the nests with eggs when disturbed by harvesting in the pond. The employee indicated that other ponds on the periphery of the fish farm site were not in use at the time, and provide less disturbed habitat. We found coots to be widespread at Kealia, but greatest numbers were observed within and along the south shore of the aquaculture facility. USF&WS biologists anticipate that proposed refuge development plans will result in peak populations of 150 coots at Kealia, with an annual monthly average of over 90 birds (68).

The aquaculture facility at Kealia Pond appears to have had the most significant impact on the resident population of Black-crowned Night Heron. Kridler (519) reports that more than 70 herons have been counted at Kealia Pond in winter months prior to construction of the fish farm. However, rarely more than a dozen herons were recorded on HDF&G/USF&WS surveys at the pond. The species was even missing on some of the earlier count records for the site. Since early 1973, semi-annual HDF&G counts have averaged over 60 birds, with a high count in 1974 of 233 birds. In the last 18 months, USF&WS biologists have recorded a monthly average of more than 100 birds, and a peak of 313 birds.

On several recent USF&WS counts, more than half of the herons have been counted in the fish farm area. Employees at the site confirmed that a heron rookery northwest of the pond had expanded considerably in the last few years. Herons regularly roost on tall kiawe trees near the fish farm and visit the farm ponds by the dozens when tilapia, catfish or prawns are readily available. In the words of one fish farm employee, "the herons are robbing us blind". The expansion of the heron rookery at Kealia has not led to an appreciable increase in numbers observed at Kanaha Pond, indicating that available food at Kealia Pond is not yet limiting. On our surveys, we found herons that were not seen at the aquaculture facility were concentrated in two other locations. The largest group was observed in the pond drainage at the west end. More than 45 birds were grouped close to one another where water was leaving the pond. Presumably this drainage serves to concentrate various fishes and other potential prey entering or leaving the pond. The other large concentration of birds was observed in the shallow water surrounding the stilt nesting area at the east end of the pond.

Kealia Pond attracts large numbers of migratory waterfowl, and like Kanaha Pond, the principal species is the Northern Shoveler. Yet, in the last sixteen years, the winter count of ducks at Kealia Pond has exceeded the Kanaha Pond count on only two years (1966,1967). On other years, the duck count at Kealia has averaged less than 20 per cent of the Kanaha Pond count. The largest recent Shoveler count at Kealia Pond on HDF&G/USF&WS surveys was 420 birds (1/18/73). However, the monthly average of wintering Shovelers

on USF&WS surveys over the last year (Sept. - Mar.1976) was 469 birds, and one count (11/76) exceeded 1000 birds. Pintail counts over the same seven month period averaged only 65 birds. Whether or not the recent high counts of Shovelers is related to the presence of the aquaculture facility can only be speculated without more adequate studies of pond ecology.

Kealia Pond has been a favorite location for observing less common migratory or straggler species of waterfowl as well. Past records indicate that the following species have been observed at the pond: Snow Goose, Mallard, Green-winged Teal, American Wigeon, Canvasback, and Lesser Scaup. Migratory shorebirds also visit the pond in winter months and may gather in relatively large concentrations on the mudflats at the east end of the site. As is the case throughout the State, the most common species are invariably the Golden Plover, Ruddy Turnstone, and Sanderling. Surprisingly, the average monthly populations (n=43) of Sanderlings recorded on USF&WS counts over the last winter was greater than the Golden Plover population. Wandering Tattlers are regularly observed at the pond as well, but numbers rarely exceed two to three birds. Additional migratory shorebirds that have been recorded on one or more surveys at Kealia Pond include: Semipalmated Plover, Greater Yellowleg, Lesser Yellowleg, Sharp-tailed Sandpiper, Pectoral Sandpiper, Least Sandpiper, Dowitcher sp., Dunlin, Western Sandpiper and Willet. We added another species to the recorded list with our observations of a Bristle-thighed Curlew at the pond on 14 May, 1977.

Some unusual straggler species have been noted at Kealia Pond in recent years: Great Blue Heron, California Gull, Ring-billed Gull, Franklin's Gull and Common Tern. As many as nine Cattle Egrets have been recorded on Kealia Pond surveys as well, but the species is usually in smaller numbers or absent altogether on regular HDF&G/USF&WS surveys.

HABITAT EVALUATION: The draft HWRP (346) lists Kealia Pond as a "primary area" that "could well be the best area in the State for stilt and possibly coot" . . . " if fully developed." Proposed refuge plans include creation of numerous low islets in the center of the existing pond to encourage expanded nesting by stilt, and possibly coots. Deep water, high winds and excessive wave action make much of the open water presently unsuitable for stilt. Experience with nest site selection in other wetlands suggests that it would be advisable to provide suitable wind breaks on these exposed islets if stilt are to be attracted successfully. There is every reason to believe that food supply will not be a limiting factor as these islets will create a large amount of feeding habitat that was previously innaccessible.

The importance of Kealia Pond as stilt feeding and nesting habitat is also likely to increase if management programs at Kanaha Pond are not accelerated appreciably. Without jurisdictional control of Kanaha Pond by the State DLNR, the importance of Kealia Pond as supplementary, or even replacement, habitat is critical. Together the two sites already account for nearly 40 per cent of the world's population of Hawaiian Stilt, and because of the documented movement of birds between the ponds, these two wetlands should be thought of collectively in the preservation of this species. It is hoped that Kealia Pond, with proper development, can sustain the same or even greater population of stilt that now depends on both sites.

If one assumes that nesting data recently derived for the Hawaiian Coot at Kealia was typical for the site, then it can be concluded that the pond produces more young coots than any other single habitat in the State, with the possible exception of wetlands on the island of Niihau. Although nesting coots at Kealia Pond are distributed along most of the northern shore, there still appears to be considerable room for expanded numbers of nesting birds in suitable habitat that is presently unoccupied or supporting lower than maximum density. More constant water levels with improved water supply will increase the opportunity for development of submergent and floating-leaved vegetation, and aquatic fauna, that would be used by these birds. It would also decrease the accessiblity of nesting sites and young birds after leaving the nest to predators. Additional water impoundments managed specifically for coots would increase productivity even higher.

It is not likely that proposed refuge management programs at Kealia Pond would affect migratory waterfowl populations significantly. The number of migratory birds that visit the islands each year is affected by several other factors in their nesting areas and along their migratory routes. The availability and distribution of wetland areas in Hawaii is only one contributing factor. Also, even in the driest years in the past, there has been water available at Kealia during most of the period that migratory waterfowl were in the Islands. Therefore, it is not expected that development of a permanent pond will appreciably affect the numbers of these birds. However, as there is presently a regular movement of waterfowl between Kanaha and Kealia ponds, it is likely that a permanent pond at Kealia will increase the relative value of this area to these birds if the condition of Kanaha Pond is degraded in the absence of adequate protection.

USF&WS biologists have suggested that the present aquaculture operation at Kealia Pond is compatible with refuge development plans. At the present time, the fish farm is critical to the objective of retaining at least some permanent water in the pond. However, the USF&WS could develop independent wells and bypass the fish farm altogether. It has not been determined to what extent the water flow from the fish farm alters the pond ecology, including the patterns of waterbird use. Maciolek (110) has pointed out that an efficient aquaculture operation requires fertilization and supplementary feeding to enrich the water in which fish and prawns are cultured. The effect of the effluent discharge into the pond should be evaluated, although it is likely that any possible adverse impact would be minimal by comparison to the potential effect of such discharge into the coral reef environment of Maalaea Bay (110).

In the report on Kanaha Pond (p.350), the problem of a potentially catastrophic outbreak of avian disease is discussed. The argument will not be repeated here, but the potential problem is equally, if not more, serious at Kealia Pond. The presence of large amounts of rotting organic matter (i.e. dead fish and invertebrates) during pond evaporation is one of several factors that increase the probability of a disease outbreak, particularly botulism. There is even less potential opportunity for rapid and effective control of water levels at Kealia Pond than there is at Kanaha Pond. Contingency plans to minimize the impact of outbreak of disease should be incorporated into refuge management plans. Independent control of water in a number of separate impoundments would facilitate disease prevention or elimination.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Several projects involving extensive dredging and deposition of fill have been proposed for the Kealia Pond area. Some of these include a marina, a deep water harbor and a speedboat race course. A 200 megawatt power plant is under consideration for a 33 acre site immediately west of the pond. Additional impoundments are planned for culture of topminnows as a source of bait fish for the aku fishing industry. Much of the neighboring land southwest of the pond has been altered with the construction of numerous condominiums and hotels. It is certain that alternative demands for the land, including the present pond, will continue if federal refuge status is not finalized.

There are at least two major criteria to be considered in review of major dredging or filling projects at this site: (1) the potential effect on waterbird use of the present habitat, and (2) the long range impact on the ecology of Maalaea Bay through alteration of the normal annual pattern of silt deposition and wind erosion. Refuge designation and perpetuation of existing effluents from that aquaculture operation would insure at least 100-150 acres of permanent water year-round and would also allow the natural silting and wind erosion process to continue on the remaining wetland within the refuge. Waterbird use would presumably remain relatively constant and the Maalaea Bay ecosystem would probably remain undisturbed. An alternative of extensive refuge development, with impoundment of permanent water throughout the floodplain, could conceivably improve conditions for waterbirds at the site, but would also involve discharge of periodic flood waters directly into Maalaea Bay, with serious adverse impact on bay ecology.

Maciolek (110) has suggested, as a third alternative that settling of silt in runoff could be accomplished with a series of impoundments that could be drained alternately and cleared of silt by mechanical means. This would minimize the effects of silt in one or more larger bodies of water maintained primarily for waterbird use, and would reduce impact of turbid water in Maalaea Bay. The proposed refuge development plan includes construction of several low-profile islets in the center of the permanent pond. This would require either deposition of fill from outside the site, thereby decreasing the water holding capacity of the pond, or, as an alternative, dredging of the pond bottom to construct the islets. The dredging alternative may decrease the amount of shallow water feeding habitat that is presently available and fundamental to colonization of the islets by stilt and other waterbirds.

A compromise between expanded permanent water and retention of normal silting and erosion patterns will need to be struck unless the siltation process can be accomodated artificially, as suggested by Maciolek (110). It would be unfortunate if improved management for one natural resource (birdlife) was accomplished at the expense of another (reef ecosystem). More complete knowledge of present pond ecology is fundamental to evaluation of the potential impact of proposed refuge development other demands for the land. If the refuge is established, it is recommended that proposed habitat development be accomplished gradually, with continuing impact assessment and monitoring.

SITE NAME: Ka-nahā Pond

LOCATION: Wai-luku District, Maui

TOPOGRAPHIC MAP: Wai-luku, Pā'ia

DATES OF SURVEY: 12, 13 May, 10 June, 7 July, 1977

WETLAND DESCRIPTION: Kanaha Pond was constructed over 200 years ago as a fishpond, but demand for land has reduced the pond to less than one half of its original size. An extensive road system with numerous storage bunkers was built in the pond during World War II, and since that time kiawe forest has covered much of the former pond. Now only slightly more than half of the 143 acre site is open water. The entire pond averages less than 2' in depth, and until recently much of the bottom was exposed when rainfall runoff into the pond diminished in summer months. The pond is fed by several drainages and presumably a groundwater source as well. Yet, fluctuations of water level in relationship to tidal patterns indicates that an underground connection to the ocean also exists. The dominant surrounding forest vegetation is kiawe. The wetland supports extensive stands of bulrush and smaller patches of other emergent vegetation. Algal productivity in the pond is very high. After periods of high winds, the water in the pond may become quite turbid, but the continued presence of birds indicates that temporary turbidity in this site does not appreciably diminish the submergent food supply. The bottom varies in the pond from hard-packed mud to suspended silt.

Kanaha Pond has been under varied management since the last time it was actually used as a fish pond. After a long period under control by H. C. & S. Sugar, the U.S. Navy altered the pond site considerably for the storage of ammunition and other equipment during the war. With development of Kahului Airport, the site came under the control of the State Department of Transportation (DOT). In 1952, the pond was given written status as a State wildlife refuge by resolution of the Territorial Board of Commissioners of Agriculture and Forestry. Since that time, State biologists have managed the refuge under a space permit from the State DOT, through a cooperative agreement between the State Department of Land and Natural Resources and the Federal Aviation Administration. Although the State DLNR has tried on several occasions to secure control of the pond to insure its future as a refuge, the State DOT has refused the change in management on the belief that birds in a waterfowl refuge near the airport pose a serious hazard to air safety. Early studies of the relationship of birds to airport safety at Kanaha do not support this belief (105, 352).

In spite of the tenuous nature of the pond management, the State DLNR has continued to manage the wildlife resources in the pond. Recent management programs have included the construction of numerous artificial nesting islets for stilt,

1. moat
2. observation building
3. sewage pond
- stilt nests, 1976 (HDF&G)

dredging of a predator-control moat around the pond, and removal of portions of the storage bunker roads to improve circulation of water through the entire pond.

Kanaha Pond was declared a Registered National Natural History Landmark in 1971. Shortly after, a proposal to construct an injection well sewage plant near the pond created considerable public controversy. The sewage plant, complete with injection wells, was built after preparation of an environmental impact statement alleging that injected sewage would not penetrate the caprock below the pond, and hence would be no threat to pond ecology. Whether or not the engineers were correct remains to be seen.

NON-AVIAN WILDLIFE: There has not been an intensive study of pond ecology at this site. Such a study would contribute important waterbird management information. On our survey, we found a variety of small crustaceans on the bottom and on emergent vegetation to be superabundant. In addition, a large population of tilapia and mosquito fish is well distributed throughout the pond. Gastropod molluscs attached to the stems of emergent bulrush surely provide important food for ducks and coots. Bullfrogs were common around the periphery of the pond.

Mongooses were observed on each visit to the site, on one day numbering seven. Cats and dogs were also seen. All of these animals posed a serious threat for nesting water birds in the past, but the recently constructed moat limits their access to the nesting areas considerably.

NON-WATERBIRD AVIFAUNA: We found several species of non-wetland birds to be common at the pond during all trips: Spotted Doves, Barred Doves, Common Mynas, Japanese White-eyes, Spotted Munia and House Finch. Several Cardinals were heard and seen in surrounding kiawe trees but were less common in the immediate pond area. House Sparrows were unusually abundant in this wetland, presumably due to its location in an urbanized area. An individual Hawaiian Owl (Pueo) was observed on two of three trips to the site. Gray Francolins were heard and seen in small numbers on the May and June visits. Skylarks were seen closer to the airport, but it is unlikely that they regularly visit the pond.

WATERBIRDS OBSERVED: A long history of interest in Kanaha Pond as important water bird habitat provides comparative data on wetland birds. Both Hawaiian Gallinule and Koloa are known historically from Kanaha Pond, but there have been no recent records. An early attempt to reintroduce gallinule to Maui appears to have failed. The most recent report of gallinule at Kanaha Pond, to our knowledge, was based on a field trip in 1953 (491). Koloa were recorded at the pond in 1941, but the identification is questionable (486).

The dominant endemic waterbird at Kanaha Pond is the Hawaiian Stilt. Counts by HDF&G and USF&WS biologists indicate that the pond supports, on the average, more than 200 stilt. Count numbers have varied from as low as 77 to as high as 553 birds, with no apparent trend over the 20 year count period. In past years, numbers of stilt at Kanaha averaged nearly 50% higher in summer counts than in winter counts. This was due to a combination of factors, including the recruitment of young into the population and the drying of wetland habitat at Kealia Pond in summer months. However, since an aquaculture operation at Kealia Pond has provided water on a year around basis, the summer influx of birds at Kanaha has not been nearly so evident.

We can expect the relative role of Kanaha as stilt habitat to diminish even further as plans for purchase and development of Kealia National Wildlife Refuge are implemented. Yet, at the same time, recent moat and island construction at Kanaha can be expected to increase production of young birds through reduced predation. Berger (52) has suggested that increased production of young will lead to dispersal of birds to other habitat on Maui and on other islands. However, there is no evidence that food supply is now limiting the population of stilt at Kanaha. Predator control and provision of additional nest sites at Kanaha may significantly increase the size of the stilt population that can be sustained on a year-around basis.

During the 1976 nesting season, HDF&G biologists found 39 stilt nests with eggs at Kanaha Pond (483). Eighteen of these were built on artificially constructed nesting islets along the ammunition bunker roads (see photograph). Nearly all the others were found in the northwest portion of the pond, closer to the sewage plant. Hatching success of 88.1% was recorded and a maximum of 11 broods were observed on one day at the pond. Recent monthly surveys by USF&WS biologists have recorded wide variations in stilt numbers at the pond (31-301). On our survey, we counted a maximum of 191 birds (5/13/77). A significantly lower count (55 birds) in July included chicks of at least three different broods.

Kanaha Pond is of less importance to the Hawaiian Coot, possibly due to a shortage of predator-free nesting sites. Kridler (105) estimated the resident coot population at 130-170 birds, whereas the draft HWRP (346) indicated that the pond supports an average population of 85 coots. More recent monthly counts by USF&WS biologists have averaged less than 50 birds. This trend is probably due to improved habitat conditions at Kealia Pond (519). Our maximum count of adults was 69 birds (6/10/77). Most of these were feeding in shallow water in between the ammunition bunker roads and along the south edge of the pond. Repeated observations of young birds indicate that coots do breed successfully at Kanaha Pond, but there have been very few observations of nests. We observed chicks of one brood in our July survey.

Black-crowned Night Herons appear on most earlier count records at Kanaha Pond, but numbers have varied considerably. A maximum of 28 birds was noted on our trips to the site. Recent USF&WS and HDF&G surveys show the species absent on about a third of the counts, and averaging less than 10 birds when they were present. We are unaware of any nesting reports for the pond area but it is virtually certain that small numbers of herons do nest successfully within the extensive kiawe forest surrounding the pond. A number of trees that appear to be preferred roosting sites for herons. Most of these are located along the ammo bunker roads in the central pond area. Herons are often seen stalking fish in the grass cover that lines the edges of most of the pond, particularly along the south shore.

Over the 20 year period for which winter counts of waterbirds have been made, Kanaha Pond alone has accounted for more than 45% of the migratory waterfowl recorded in the State. The site is particularly attractive for Shovelers. The largest recent Shoveler count was 933 birds (1/18/73) although the recorded winter average is below 600. The largest recent Pintail count was 683 birds (1/12/77) but the winter average is closer to 200 birds. Numbers of waterfowl at the pond vary dramatically with

movement of birds to other sites on Maui and probably on other islands. It is also dependent upon the timing of migration to islands further south in the Pacific and upon the return trip to North America. In the absence of a more intensive study of pond ecology it is difficult to determine why Kanaha is so attractive to those species by comparison to other sites. However it is certain that relatively constant water levels and high primary productivity are important.

In addition to the common migrants, several other waterfowl species have been sighted at Kanaha in past years. These include Canada Goose, Black Brant, Green-winged Teal, Cinnamon Teal, American Wigeon, Ring-necked Duck, Canvasback, Lesser Scaup, Bufflehead and Mallard.

We found few ducks on our summer survey at Kanaha Pond, although a count of 81 Shovelers on May 12 was surprisingly high. By June 10, only three Shovelers were counted, indicating that the rest had left for their breeding grounds. Less than 5 Pintails were noted on all counts. It is not uncommon for a few non-breeding ducks to spend the summer here and at a few other wetlands in the Islands.

Count records for Kanaha Pond show relatively large numbers of Golden Plovers, Ruddy Turnstone and Sanderlings. Even when pond water is at its highest, there is extensive sloping shoreline and exposed mudflat at which these birds feed. The continual availability of feeding habitat, and limited human disturbance, make Kanaha a particularly good location for rarer migratory shorebirds as well. Wandering Tattler are present on nearly every count, including summer months, but numbers rarely exceed five birds. There are several other shorebird species for which the number of reported sightings is very low, and some for which there is only a single record. The rarer migrants reported at Kanaha include Black-bellied Plover, Semipalmated Plover, Bar-tailed Godwit, Sharp-tailed Sandpiper, Pectoral Sandpiper, Least Sandpiper, Western Sandpiper, Ruff, Wilson Phalarope, and Killdeer. Some other unusual migrants or stragglers that have been sighted at Kanaha Pond include Ring-billed Gull, Glaucous-winged Gull, Least Tern, Black Tern, Osprey and Glossy Ibis. Resident Cattle Egrets appear infrequently in count records for the pond, but rarely have more than 1-2 birds been seen.

HABITAT EVALUATION: Kanaha Pond is clearly one of the most, if not the most, important single habitats for Hawaiian Stilt in the State of Hawaii. It's primary value to this species is that it satisfies needs for loafing, feeding and nesting. Important Stilt habitat on other islands, particularly Oahu, is spread among several different areas. Kanaha pond has potential for increased production of stilt through effective management. Birds have shown rapid adaptation to artificial nesting habitat and do not presently appear to be limited by food supply. Although the site is clearly of less importance to Hawaiian Coot, it is also likely that production of this species could be increased with improved management of the habitat.

Kanaha Pond is also the most valuable single habitat for migratory Shovelers that winter or stopover in Hawaii, and of only slightly less importance to Pintails and other waterfowl in the State. As these species are not limited in their use of habitat by demand for nesting sites, and are probably not directly affected by predators in the pond area, it is doubtful that Kanaha can support significantly higher numbers of migratory

waterfowl than it has in the past. Count data do not show any increase in use of Kanaha Pond by migratory waterfowl as other important habitat in the State has been destroyed or diminished in value. Other sites on Maui, Oahu and Kauai compete with Kanaha Pond in their importance to migratory shorebirds, although Kanaha has some potential for attracting greater relative numbers through effective control of water levels.

The primary constraint to an expanded habitat management program at Kanaha Pond is the tenuous nature of land control, and the opinion of the State DOT that waterbirds present a serious hazard to air safety at Kahului Airport. After independent studies at Kanaha Pond, both Kridler (105) and Berger (352) concluded that the waterbirds in the pond do not create a significant threat of air strikes, and that the pond should be removed from the airport complex and jurisdiction transferred to the State Department of Land and Natural Resources. Unfortunately, as long as there is any possibility of aircraft collision with waterbirds, it is doubtful that the State DOT will release its control over the pond.

The long range impact of the recently constructed injection sewage plant is uncertain but potentially serious. There is considerable disagreement among scientists as to whether or not the environmental studies that preceded construction provide an adequate data base for predicting impact on pond ecology. It is certain, however, that without more effective means to raise, lower and even flush out the pond, the effects of sewage pollution in the pond could be devastating and long-lasting.

Ongoing pollution by industrial chemicals should also be investigated. On 16 May, 1977 we observed a yellow surface scum in the northwest end of the pond that appeared to have originated in the area of neighboring industrial storage tanks. The scum covered several hundred square yards of the pond. Birds were seen in this area of the pond on survey days before the scum was first noticed and in trips during June and July. The nature of the pollutant and the impact on pond ecology was not determined, but the observation does point out the need to protect the habitat from potentially serious problems in the future .

The fact that Kanaha supports large numbers of waterbirds, particularly endangered species, is both encouraging and dangerous. Recorded incidence of botulism in Hawaii has been infrequent to date, but there remains a threat of serious outbreaks in the future. Kanaha Pond exhibits several characteristics that are common to other waterbird habitat that has been affected by this disease: low water levels, slight alkalinity, dense concentrations of birds, and regular movement of potentially infected birds, and regular movement of potentially infected birds (i.e. migratory species). The disease has often been controlled in large mainland wetlands by manipulation of water levels. Raising water levels will lower the water temperature to a point that is no longer favorable for toxin production, and will disperse and dilute the toxin as well. It may also make the site temporarily less attractive to waterbirds, thereby reducing mortality. As an alternative, complete drying of a site may achieve the same objective. In any event, we can not ignore the possibility, if not probability, that there will be a future outbreak of botulism or some other waterfowl disease at Kanaha Pond. Without adequate means to control water levels through pumping, diking and efficient drainage, the losses of both endemic and migratory waterbirds could be serious.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: In 1976, 40% of the stilt nests discovered on survey by HDF&G biologists at Kanaha Pond were located on artificially-created nesting islets (483). This is a clear demonstration of the effective use of fill deposition in waterbird habitat management. Also, the recently constructed moat around the periphery of the pond involved considerable excavation and movement of fill material. This was an important step towards effective predator control on the site. Removal of portions of the dike roads has made it possible to increase circulation of water, although it does preclude the independent control of water level within at least four individual impoundments.

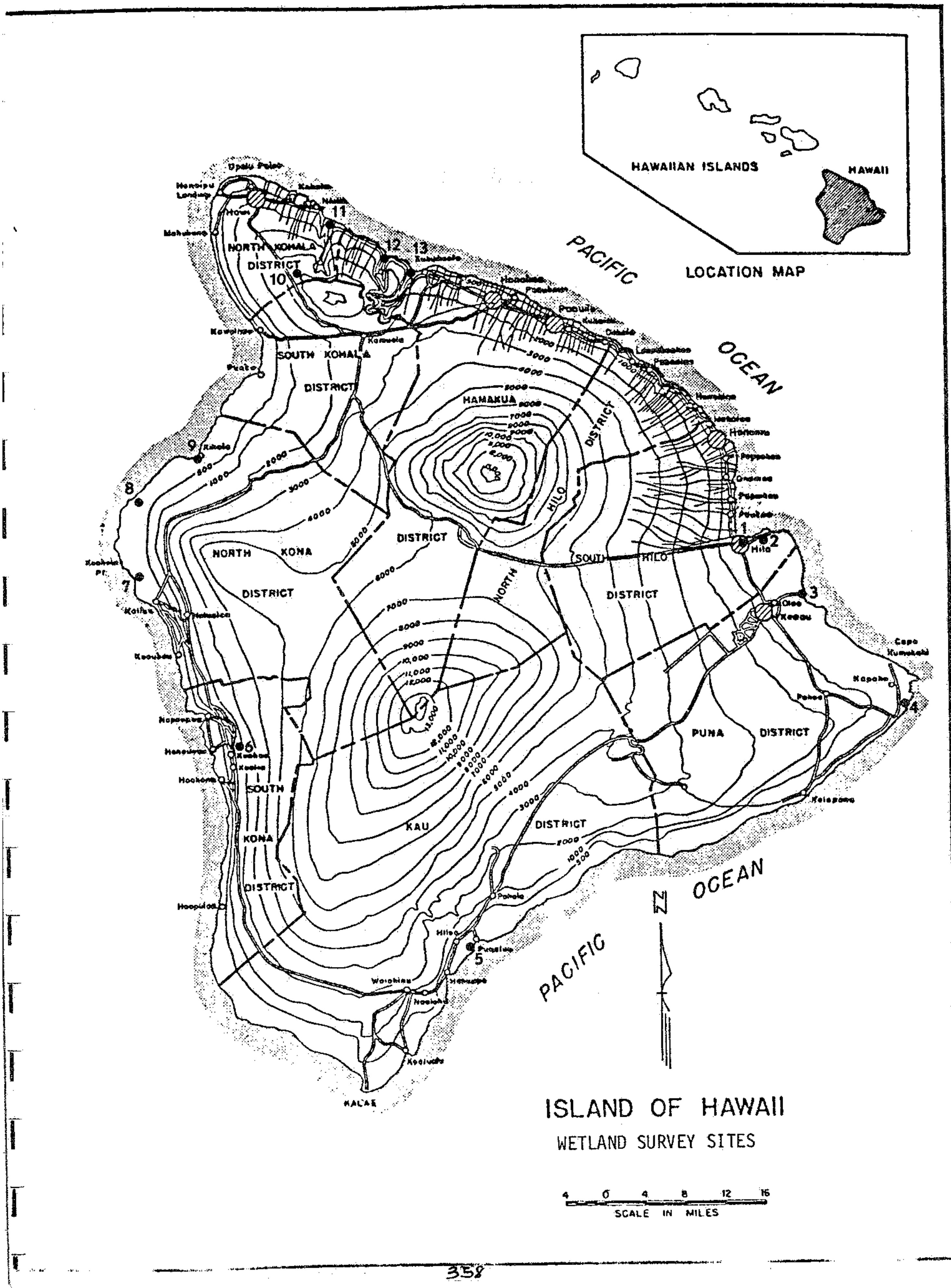
The localized concentration of nesting stilt at Kanaha suggests that production could be increased by providing additional nesting islands at other locations in the pond. It appears that coot nesting at the site may be limited now by the lack of suitable nest sites as well. This could be remedied by managing a portion of the pond in a way that maximizes its suitability for coot nesting. It would also be advisable to extend the predator-control moat around the entire pond complex so that its full potential effectiveness can be realized. In the present configuration, dogs, and potentially cats and mongoose, can reach the area of the stilt nesting islets by following themain dirt roads. From this point on, it is only the shallow water that separates the predators from the nesting birds. In the absence of means to insure adequate water supply, prevention of predator access can not be assured.

At the present time, very little of the land between the sewage plant road and the central ammo bunker road provides suitable habitat for waterbirds, other than for herons. Most of this area is covered with dense kiawe forest. Extensive clearing of vegetation and dredging of accumulated silt would expand the present useful size of the habitat considerably. It would also be advisable to reevaluate the plan to forsake independent control of the three (and potentially four) separate water impoundments by cutting several holes into the ammo bunker roads. As an immediate and stopgap measure to insure the presence of water in the flat lands between the raods, the recent modifications have proved their worth. However, if the dike roads were reestablished and independent water level control developed, then the area probably could be managed to fulfill the varied need of different species. One impoundment could be managed to maintain an extensive growth of emergent vegetation under constant water levels that would provide more suitable nesting habitat for coots. Water level could be manipulated more frequently in another impoundment to maximize fertility of the substrate and to provide a maximum amount of suitable feeding habitat for wading and probing birds. A portion of the useless nearby forest land could also be used for growing of crops (i.e. millet) that would enable the pond to sustain greater numbers of both migratory and endemic waterbirds.

In sum, it appears that the possibilities for expanded habitat management at Kanaha Pond are considerable. Continued use of the habitat by waterbirds after extensive dredging and filling in recent years suggests that these activities can be undertaken without threatening the quality of the habitat. However, prior to additional habitat manipulation of any significance, it would be advisable to undertake a thorough study of pond ecology, including an investigation of the relationship of bird populations and diversity with the available food supply. The influence of human disturbance and pollution from neighboring lands should also be evaluated. Most importantly, the long-term security of the pond should be insured through a shift in jurisdiction from tne State DOT to the State DLNR or USF&WS.

HAWAI'I

WETLAND AREAS SURVEYED



ISLAND OF HAWAII

WETLAND SURVEY SITES

HAWAII

INTRODUCTION: Hawaii is the youngest and largest island in the Hawaiian archipelago. Its major topographic features are five shield volcanoes. The effects of erosion on volcanic slopes is far less evident than on older islands, except along the eastern and northeastern coast where the only significant perennial streams on the island are found. Major ecosystems are represented by extensive rain forest, grassland, dry forest, marshland, bogs, and barren lava and alpine stone desert.

High elevation wetlands include, among others, ephemeral wetlands and forested bogs in the mountains, Na Manu'a Ha'alou and Ki'ilae bogs on the slopes of Mauna Loa, and Lake Waiau, at 13,030' on Mauna Kea. Of these, only the Ki'ilae bog was surveyed on this study. Coastal wetlands are few and widely scattered on the island of Hawaii. Most are found in the Kona, Kau, Puna and Hilo areas, with the exception of marshland and taro fields in coastal valleys of the Kohala Mountains. Included in our surveys on Hawaii were forest bogs, flooded pastureland, fishponds, brackish marshes, freshwater marshes, taro fields and estuaries. In all, 13 separate areas were surveyed.

No wetlands on the island of Hawaii are currently protected by law as waterbird sanctuaries. The draft HWRP (346) recommends that Aimakapa Pond be acquired and managed as a State waterbird sanctuary, but there are currently no funds appropriated for this purpose. The USF&WS is negotiating with Bishop Estate for purchase of Opaeula Pond for National Wildlife Refuge status. In the opinion of some scientists, including ourselves, refuge status for either or both areas will have little if any bearing on the long-range survival of endangered waterbirds, as evidenced by the long history of limited use of the areas under consideration by these species. Others argue that protection of these areas will help to insure that present distribution of birds within the island group is maintained. The argument continues that maintaining separate "reservoirs" of birds on different islands may help to prevent eventual elimination of a species as a result of disease or catastrophy in part of the species' range. Although unresolved, this controversy underlines the need to assess more than the current or potential use of a particular site by waterbirds in evaluating its long-term significance to the State's unique wetland avifauna.

WATERBIRDS ON HAWAII: Wetlands on the island of Hawaii support only a small fraction of the statewide waterbird population, with surprisingly little variation from year to year. The population of Koloa on Hawaii, as on Oahu, has been replenished to some degree by HDF&G releases of captive-reared birds in the Kahua Ranch area of the Kohala Mountains. Small numbers of Koloa are seen regularly in the Kahua Ranch/Kehena area during HDF&G surveys.

The Big Island population of Hawaiian Stilt has never exceeded 10% of the statewide count and averages less than 3%. An estimated 20-30 birds regularly inhabit Kona Coast ponds (principally Aimakapa and Opaeula), although some have been seen at higher elevation cattle reservoirs as well.

The range of Hawaiian Coots on the island includes Kohala valleys and Hilo ponds, but again, the principal concentration is found at Aimakapa and Opaeula ponds on the Kona coast. The island coot population has only once exceeded 100 birds on HDF&G/USF&WS counts, averaging less than 10% of statewide totals.

Black-crowned Night Herons are widely distributed, with greatest numbers found in Kohala valleys and at ponds near Hilo. For unexplained reasons, numbers of Cattle Egrets on HDF&G/USF&WS counts rose considerably in 1972, but the population is still comparatively small and localized in distribution, being found primarily in the Hilo area.

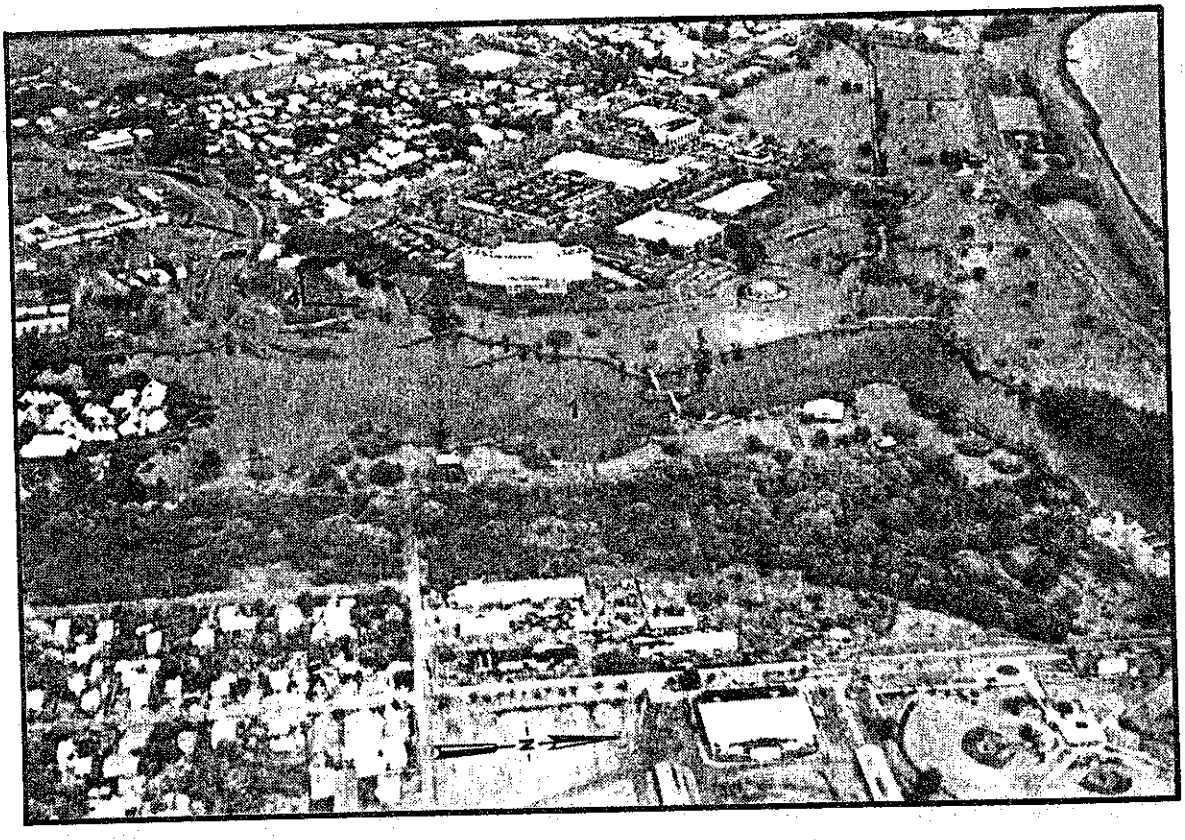
Migratory waterfowl on the Big Island have favored Hilo and Kona ponds historically. Total island population on winter counts has rarely exceeded 250 birds, less than 10% of the statewide total. One notable exception to this was the winter 1976 count in which 20% (n=547) of the migratory waterfowl population in the State was counted on Hawaii. This was due, primarily, to recent construction of new settling basins in North Kohala, where 265 pintails were counted. Migratory shorebirds counted on the Big Island have typically been fewer than on Oahu and Maui, and almost invariably less than 10% of the Statewide count. These surveys, however do not reflect the large numbers of Golden Plovers that inhabit higher elevation pastureland on Hawaii, as on other islands.

SITE NAME: Wai-ākea/Mohouli Ponds/Wailoa River

LOCATION: South Hilo District, Hawai ʻi

TOPOGRAPHIC MAP: Hilo

DATES OF SURVEY: 31 May, 3 June, 22 June, 6 September, 1977



1. Waiakea Pond
2. Wailoa River
3. Mohouli Pond
4. coot nests (June, 1977)

WETLAND DESCRIPTION: Waiakea Pond is an estuarine pond near the mouth of Wailoa River, in Hilo, Hawaii. An extensive rock wall lines most of the shoreline at this pond. Extensive lawns cover the surrounding land, most of which is included within a State park facility. Hotel developments also border the pond on both east and west sides. Wailoa Stream has been channelized for flood and tsunami control where it runs into Waiakea Pond. A 1963 topographic map shows a separate pond (Mohouli) on the southwest edge of Waiakea Pond. Mohouli pond now connects with the larger pond via a narrow channel.

The primary water source for Waikea Pond is the Wailoa River, but the pond may fluctuate more than a foot with tidal influence. Although the pond may be several feet deep in the center region, the bottom slopes slowly from the shoreline, where it is generally less than two feet in depth. Mohouli pond is considerably shallower than Waiakea. Much of the bottom is covered with a dense algal mat, some of which floats to the surface throughout the pond. Azolla and filamentous algae for a thick surface mat over much of the channelized stream entrance, and within Mohouli pond. An extensive growth of emergent California grass, waterweed and small patches of bulrush and umbrella sedge line both shores of the peninsula that separates Mohouli and Waiakea ponds.

The pond complex is surrounded by urban development, and the park is used extensively for recreation. Fishing from shore and by unpowered boats is permitted year-round within the ponds (mullet season closed December-February). Other activities on the water are prohibited. The surrounding lawns are carefully manicured and vegetation along the edge of the pond complex is controlled manually and by use of herbicides. The only area that is left to grow largely unmanaged is the peninsula that separates Mohouli and Waiakea ponds. Some surface floating vegetation is removed on an irregular basis by county employees.

NON-AVIAN WILDLIFE: Waiakea Pond has an aquatic fauna typical of estuarine habitats in Hawaii. Fish in the pond include mullet, milkfish, aholehole, papio, o'opu, tilapia, mosquitofish and carp (koi). Large schools of carp are particularly common within Mohouli pond. Bachman (509) indicated that channel catfish and small-mouth bass had also been introduced into the pond prior to 1970. Bullfrogs and presumably toads, are also common in the pond area. Aquatic invertebrates are varied and include, among others, brine shrimp, native shrimp (opae), prawns, dragonflies, damselflies, and crabs. The proximity to urban areas insures that dogs, cats, and rats are present in the area. Mongoose are common in the Hilo area, and were observed on our survey of this site.

NON-WATERBIRD AVIFAUNA: The list of non-wetland birds that we recorded as common on survey included Common Mynas, House Sparrows, Spotted Doves, Barred Doves, Japanese White-eyes, and Spotted Munia. One flock of nearly 35 Spotted Munia was observed within a stand of umbrella sedge in Mohouli Pond (6/22/77). At least one-third of these birds were young birds, and most were seeking food and bathing on the algal mat that floats on the surface of this pond. Several Common Mynas also fed on the algal mat during our surveys. Only Northern Cardinals were uncommon during our surveys.

WATERBIRDS OBSERVED: The list of waterbirds observed on our summer surveys of the Waiakea Pond complex included both native and introduced species. The max-

imum number of Hawaiian Coots we recorded was seven. We found coots only within or immediately outside the Mohouli Pond area. Two active coot nests were discovered within Mohouli Pond on 5/31/77, and were monitored during repeat visits later in the summer. When examined on 6/3/77, one nest contained four eggs and the other held six. At this time, both pairs were continuing the process of collecting nest material and weaving it into their nests. One pair had constructed a second platform within eight feet of their nest, that was used for loafing and preening by the non-incubating bird. All the coots in the area fed regularly on the surface algal mat, and also dove for food in shallow water. Numbers of coots recorded on HDF&G/USF&WS survey in recent years at Waiakea Pond generally varied between four and eight, with a high of 12 (8/75). Counts of this species are generally much higher at Aimakapa Pond on the Kona coast.

No stilt or Koloa were recorded during our surveys at Waiakea Pond, nor have they appeared on recent HDF&G/USF&WS count records for the site. The small number of stilt that are resident on Hawaii are confined, for the most part, to ponds along the Kona coast. According to Baldwin (494) some Koloa were released in "Wailoa Pond" prior to 1960, but all were killed directly or indirectly as a result of the tsunami of May 23, 1960. Koloa are now generally restricted on the Big Island to the Kohala area, where they have been reintroduced to native habitat in recent years by HDF&G/USF&WS biologists.

Black-crowned Night Herons ('Auku'u) were observed on all trips to Waiakea Pond, and were particularly common in the Mohouli Pond area. Between five and eight birds were counted on each visit, including both adults and immatures. Due to the water depth and steep shorelines in Waiakea Pond, it is not surprising that herons are more common in the Mohouli Pond area. Herons were seen stalking fish and crabs in the shallow parts of this pond, and also on top of the dense floating mat of vegetation. In one case, a heron flew from a perch in a nearby tree, captured a crab in open water, and floated there for more than ten seconds before taking off again. Although there is little possibility that herons nest in the immediate vicinity of Waiakea Pond, there is almost certainly a regular pattern of movement of herons between this site and Lokoaka Pond, northeast of Waiakea.

The most common waterbird at Waiakea Pond during our survey was the domestic Mallard. A total of 19 adults was counted on one trip, and at least three different broods of downy chicks were observed during the summer. In every brood, chicks with wild type plumage and chicks with domestic (yellow) type plumage were observed. A white domestic duck with a brood of six chicks was also seen. It was not determined where the Mallards were nesting at Waiakea, although the relatively undisturbed peninsula separating Waiakea and Mohouli ponds is probably the most likely site. A Black Swan and a Canada Goose, presumably released from Waiakea Resort, were also observed.

Wild migratory ducks have been observed regularly in the winter HDF&G/USF&WS counts at Waiakea Pond. Not surprisingly, they were not present during our survey. The list of regular migrants to Waiakea includes Pintails, Shovelers, Lesser Scaup, and American Wigeon. Rarer migrants at Waiakea have included Canvasback, Bufflehead, White-fronted Geese, Canada Geese, and Glaucus-winged Gulls. Although Pintail counts are typically much higher at ponds on the Kona coast, the birds seen at Waiakea each year generally represent

between 10-20 per cent of the Big Island population. A major exception occurred during the 1975-1976 winter, when a new pond at Kohala Biogenics attracted 265 Pintails on the winter count.

Migratory shorebirds recorded recently at Waiakea Pond include Wandering Tattlers, Golden Plovers and a single Bristle-thighed Curlew (1/75). Between three to six Wandering Tattlers were seen on each of our trips to Waiakea. They were searching for food along the shore in rocks and in the mud. Although Cattle Egrets were not observed at the pond on our survey, there is at least one recent record of this species for the site. They are becoming increasingly common near Lokoaka Pond, in Keaukaha. The presence of cattle and limited disturbance make the Keaukaha site more attractive to egrets than is Waiakea Pond.

HABITAT EVALUATION: When populations of waterbirds on all the Main Islands are considered, the number of birds that regularly inhabit Waiakea Pond is not impressive. The site is considered of "secondary" importance in the recent draft HWRP (346). Although coots regularly nest in Mohouli Pond, there is little opportunity to expand the amount of habitat suitable to this species. The amount of reproduction may now be limited, at least in part, by the territoriality of nesting birds. Regular occupation of the Mohouli Pond area by six to eight coots is probably at or near saturation level for this small habitat. The site could be improved for coots by limiting human disturbance, and by preventing the unnecessary control of shoreline vegetation with herbicides. It would be advisable to restrict or prohibit access by fishermen to this portion of the pond complex to insure that coots can nest successfully without disturbance.

The principal value of the site is not in the number of coots that nest, but in the unique opportunity for residents and visitors to observe an endemic waterbird behaving naturally. There is no waterbird habitat in the State where nesting coots can be so easily observed by the public without disturbance to the birds. The same educational and recreational value holds true for the observation of migratory waterfow. Although total numbers of birds that visit the pond may be relatively small, the variety is impressive and the opportunity for observation unsurpassed by other wetland habitat on Hawaii.

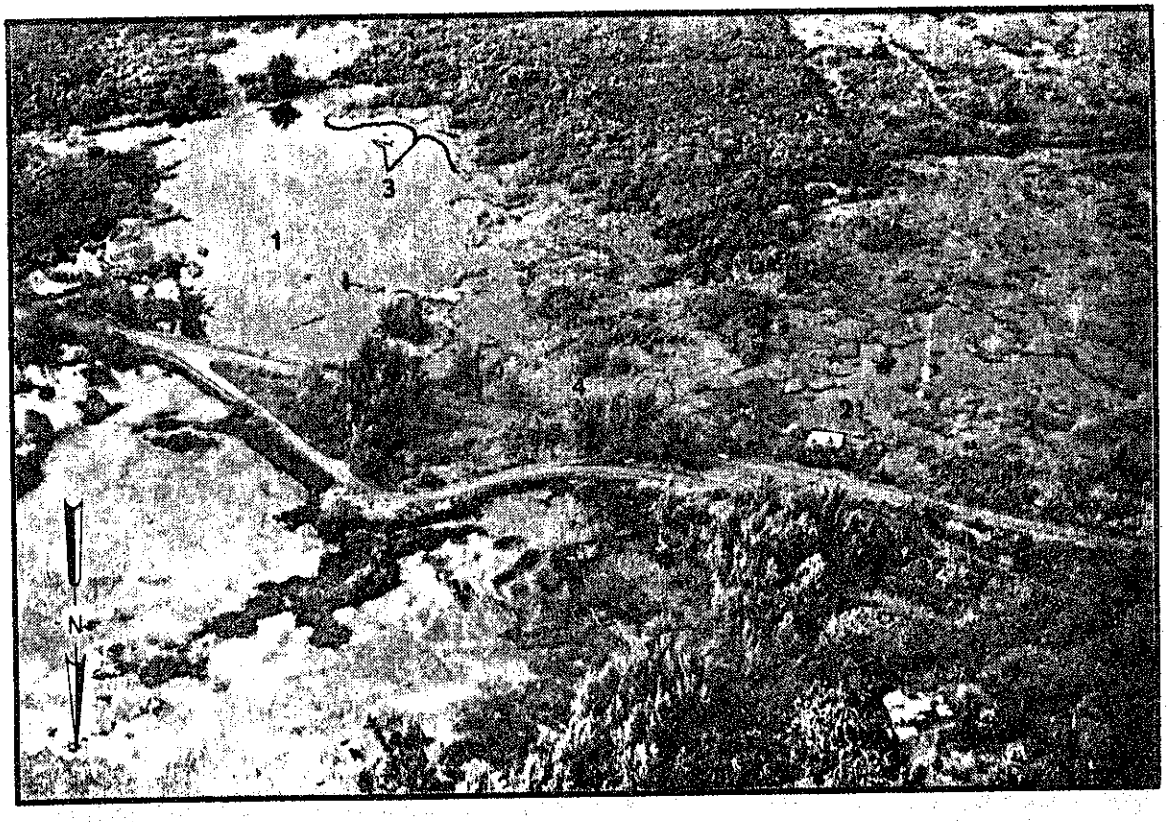
POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: The floating vegetation and submergent algal mats are cleared in Mohouli Pond on a repetitive basis by State Parks personnel (509). Although this may be valuable to avoid complete encroachment of floating vegetation in waterbird habitat, it is also important that clearing be handled in a way that insures continued use of the area by coots. Wildlife biologists should work cooperatively with State Parks personnel to avoid unnecessary disturbance of the birds and their habitat. Dredging of bottom silt would disturb an extensive growth of submergent and emergent vegetation, particularly within Mohouli Pond. Also, increasing the water depth through dredging would inhibit use of the area by wading birds and reduce the amount of bottom vegetation accessible to nesting coots and other waterbirds. On the other hand, some deposition of fill along steeper shorelines would make additional feeding habitat accessible to wading birds.

SITE NAME: Lokoaka (Nakagawa)/Kionakapahu (Ahn) Fishponds

LOCATION: South Hilo District, Hawai'i

TOPOGRAPHIC MAP: Hilo

DATES OF SURVEY: 4 June, 22 June, 6 September, 1977



1. Lokoaka Pond
2. Kionakapahu Pond
3. coot nesting (Reference - 509)
4. flooded grassland connecting ponds

WETLAND DESCRIPTION: At this site, two connected ponds form an inland spring-fed pond system connected to the sea by channels. The ponds are presently managed for culture of mullet, milkfish and tilapia by residents that live on site. The surrounding topography is flat, and the dominant peripheral vegetation is California grass. Numerous patches of bulrush and various grasses line the edges, particularly within Lokoaka Pond. A dense forest of kukui, guava, eucalyptus and other large trees borders the ponds. Aquatic vegetation includes scattered clumps of floating or submergent filamentous algae, as well as patches of waterweed. The water in the ponds is very clear and low in salinity. The bottom is rocky for the most part, although some silt has accumulated in areas where circulation is slow. The bottom slopes steeply from the shore in most areas, particularly within Lokoaka Pond. The pond is high in primary productivity, in part due to nutrients derived from adjacent cattle pastures (112).

NON-AVIAN WILDLIFE: Fish in the ponds include mullet, aholehole, o'opu, milkfish, tilapia, carp (to 30" or more), mosquitofish and swordtails. Bullfrogs are common, particularly within California grass at the pond's edge. Invertebrates observed on survey include opae, Macrobrachium prawns, gastropod molluscs and both damselflies and dragonflies (naiads and adults). Presumably, crabs and other brackish water crustaceans enter the ponds from the ocean as well.

Mongooses and dogs were seen near the pond. Ron Bachman (509) reported that he has seen dogs in the grass and in the water in the south edge of Lokoaka Pond on several occasions. Cattle are regularly grazed near both ponds but the grass surrounding Kionakapahu pond shows impact of more intensive grazing than near Lokoaka Pond.

NON-WATERBIRD AVIFAUNA: Most of our survey time was spent within the ponds, and relatively little effort was put into a survey of surrounding forest lands. Most non-wetland birds recorded were seen or heard in the edge of this forest. Common species included House Finch, Myna, Japanese White-eye and Northern Cardinal. Spotted Doves and Rock Doves (Pigeons) were seen near the houses. Flocks of Spotted Munia were seen within California grass at the edge of both ponds.

WATERBIRDS OBSERVED: A maximum of two Hawaiian Coots was recorded during our three trips to this site. This is typical of count records for the last several years. In nearly every case, coots have been observed only on Lokoaka Pond. On our survey, coots were tipping or diving for food within scattered patches of submerged or floating algae. Suitable food did not appear to be nearly so abundant in these two ponds as it is within Mohouli Pond (Waiakea Pond complex). Bachman (509) reports that coots have nested along the south shore of Lokoaka Pond. The depth of water at the shoreline, and the accessibility of the entire edge of the pond to predators are probably important deterrents to successful coot nesting in this pond. Presumably the lack of cover and more continual disturbance at Kionakapahu Pond explains the limited number of coot sightings on that pond.

The most common waterbird at this pond system is the Black-crowned Night Heron ('Auku'u). Between two to ten birds were counted on our surveys, with the greatest number found in trees or in flooded grass along the edge of Loko-

aka Pond. One bird was observed swimming with a tilapia in its bill in the center of the pond, whereas most of the birds were stalking food in shallow water.

No more than 13 herons have been noted on recent HDF&G/USF&WS counts that included both ponds, although numbers have been highly variable. Herons are generally more common near Lokoaka Pond, possibly because the smaller pond provides fewer roosting sites and less cover near the water. We are unaware of any records of this species nesting near the ponds, but the extensive surrounding forest is large enough that a small rookery could easily go undetected. We noted that herons at these ponds appeared quite tame by comparison to habitat that is not regularly fished by people. HDF&G/USF&WS biologists are concerned that some birds may have been shot at this site, because there have been unexplained fluctuations in numbers over the last several years. Herons can become a costly nuisance in a marginal aquaculture operation, so it is not surprising that residents at these ponds are not pleased with the number of birds that inhabit the area.

We could find no records of Mallards reported at either pond, but a pair of these birds was seen at Lokoaka Pond on our September survey. The list of migratory waterfowl reported from this site is not long, but contains a curious assortment of common and unusual species: Pintail, Northern Shoveler, American Wigeon, Lesser Scaup, Redhead and Garganey Teal (497). Numbers of ducks observed on semi-annual HDF&G/USF&WS counts have not been large, although Bachman reports that he has often counted more ducks at the site in the early weeks of January than appear on the winter survey in late January (509). A single Osprey has been recorded at the ponds in recent years also (1/23/75).

Golden Plovers and Wandering Tattlers are the only migratory shorebirds that appear occasionally, albeit in low numbers, in HDF&G/USF&WS records for these ponds. We noted a single tattler on our September survey. There is very little suitable habitat for shorebirds due to deep water and heavy grass cover at the shorelines.

Records maintained by the HDF&G/USF&WS indicate that Cattle Egret numbers in the vicinity of Lokoaka and Kionakapahu ponds began to increase noticeably around 1972. A regular movement of birds between this site and Keaau Ranch pond (southeast) was also verified at this time. We observed between 12-16 egrets at the ponds on three trips to the site. Most of the cattle at the time of survey were on the Lokoaka Pond siade of a fence that separates the two sites, so it is not surprising that nearly all the egrets were seen near the larger pond.

HABITAT EVALUATION: Lokoaka and Kionakapahu ponds provide one of the best habitats for heron on the island of Hawaii. Not only is there an abundance and variety of food, but there is also adequate cover for feeding and roosting. The undisturbed forest behind the ponds provides suitable nesting habitat as well. These birds have accomodated to low levels of human disturbance associated with aquaculture operations. Increase in fish populations with expanded aquaculture could sustain greater numbers of this species, although size of feeding territories would probably become a limiting factor before the population was much higher than it is today. Also, if extensive shoreline cover (grasses and bulrush) is cleared for aquaculture, the total amount of suitable

feeding habitat for herons would be reduced considerably.

It is obvious from count records that these ponds, in spite of their greater size and comparatively lower human disturbance, can not sustain as many coots or migratory waterfowl as Mohouli Pond, within the Waiakea Pond complex. This is probably related, at least in part, to the comparatively low amount of submergent and floating-leaved vegetation, and the generally deeper water of Lokoaka Pond. The only observations of coots feeding away from the shore at Lokoaka were at an isolated clump of algae in the center of the pond, that was attached to a large rock. Differences in available food plants may be due to the colder water temperature at Lokoaka Pond. If the aquaculture potential of Lokoaka Pond is fully developed, it will require elimination of shoreline cover that would be critical to the continued or expanded use of the site by coots. Elimination of suitable loafing sites would also make the site less suitable for migratory waterfowl. The lessee at Kionakapahu Pond (Mr. Ahn) indicated that it was a requirement in his lease from Bishop Estate that the edges of his pond be kept clear of weeds and grasses. Obviously this policy is not conducive to maintaining quality wetland bird habitat.

The HWRP (346) lists Lokoaka and Waiakea ponds as areas of "secondary" importance to waterbirds. Although the draft plan states that "they appear to lack the well-balanced flora and fauna necessary for waterbirds," there has been no intesive study of these two aquatic ecosystems. Such a stydy would help to define why Mohouli Pond supports a greater number of coots than either Waiakea or Lokoaka/Kionakapahu.

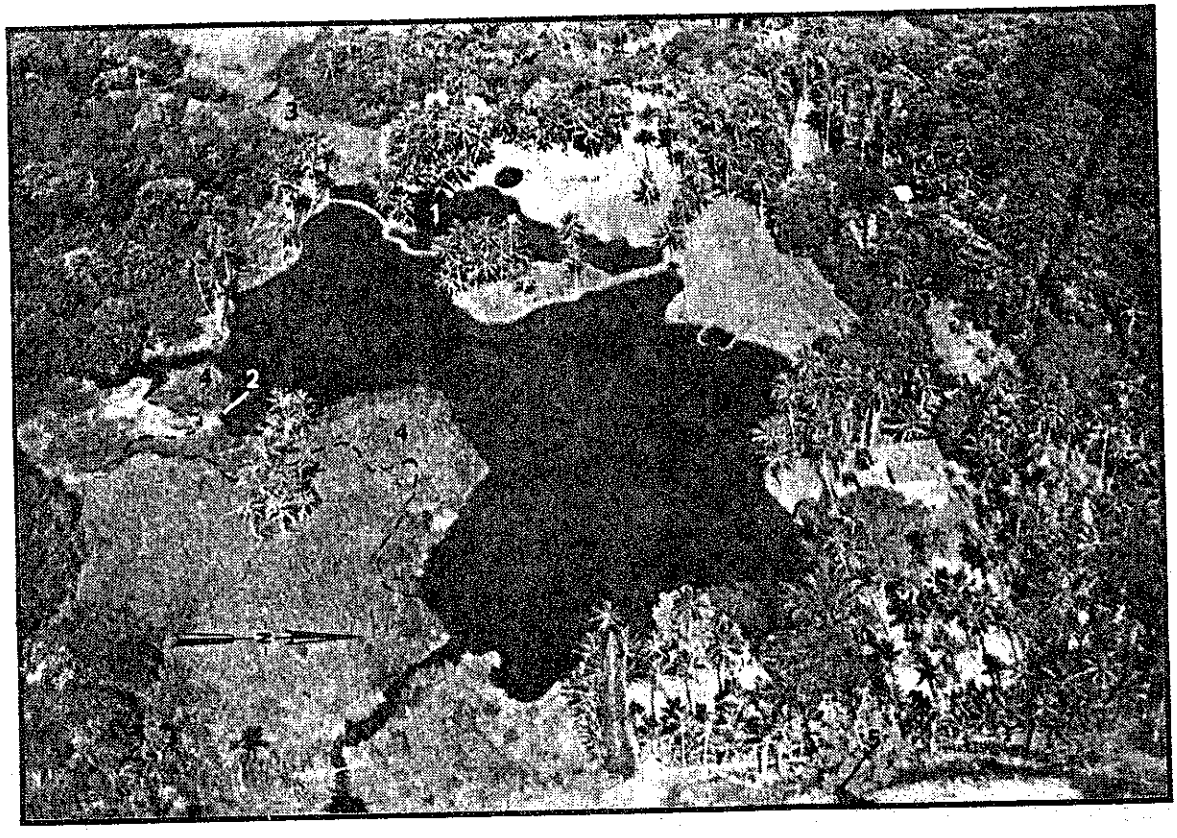
POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Development of Lokoaka Pond for expanded aquaculture activity would require a series of pond alterations that would have a long-term impact on waterbird use (112). Clearing of shoreline vegetation, as indicated earlier, would eliminate important cover and loafing sites, and disturb what limited plant food is available for coots and other waterfowl. Elimination of floating vegetation in areas of low circulation would further reduce important plant food and associated invertebrates. It is not likely that extensive bottom dredging would be required, although some alteration of bottom topography would aid in the use of nets in the pond. Refurbishing gates and channels, and construction of nursery ponds would require addition of some fill material to the pond, but the adverse impact of this activity on pond ecology would be slight and temporary. Use of these ponds by a small number of widely distributed waterbirds provides little justification for limiting aquacultural development, but it is possible that both uses can be accomodated. Cooperative management plans should be implemented to insure that some areas of ponds are left undisturbed. Further, it would be advisable to restrict cattle grazing from edges of the ponds, so that vegetative cover will be maintained and feeding, loafing or nesting sites are left undisturbed.

SITE NAME: Kea'au Ranch Fishpond (Hā'ena)

LOCATION: Puna District, Hawai'i

TOPOGRAPHIC MAP: Kea'au Ranch

DATES OF SURVEY: 8 June, 22 June, 1977



1. nursery pond
2. coot nesting (Reference - 509)
3. freshwater spring (choked with water hyacinth)
4. bulrush
5. outlet

WETLAND DESCRIPTION: Keaau Ranch Pond is a spring fed pond with connection to the ocean. This natural wetland has been altered considerably through construction of a shoreline rock wall and gate system, as well as a central island and nursery pond. The depth of the pond is approximately three feet at the wall and as much as seven to ten feet in the center. The bottom is rocky, and covered with an extensive algal mat, particularly within the nursery pond. Surrounding lands slope gently towards the pond. On the north side, extensive lawns border the pond, while to the south a flooded pasture dominated by California grass and various sedges reaches to the edge of the pond. The surrounding forest includes planted coconut palms, as well as banyan, rose apple, guava, kukui, monkeypods and other trees. The main spring is located beneath a dense surface cover of water hyacinth at the inland end of the pond. The Keaau Ranch manager (Mr. Ray Blackshear) indicated that he was planning to have all the hyacinth in this portion of the pond cleared within a few months after our survey.

Until recently, the pond area has been used for limited grazing only. At the recommendation of aquaculture specialists (112), 2000 juvenile mullet were introduced to the pond during spring, 1977. Additional introductions of mullet are planned for the future. The pond receives only minimal and infrequent disturbance from residents at the site, although the presence of gardeners and burning of debris may have limited bird use on the first day of our survey.

NON-AVIAN WILDLIFE: Aquatic life within the ponds includes large schools of juvenile mullet, as well as smaller numbers of o'opu, aholehole, mosquitofish and bullfrogs. Functioning gates at the seaward end of the pond prevented movement of other estuarine species between the ocean and the pond. Dragonflies and other unidentified aquatic insects were common in the marsh edge of the pond. Several cattle were grazing in flooded grassland. Dogs and mongoose were also observed during survey.

NON-WATERBIRD AVIFAUNA: The most abundant non-wetland birds were Common Mynas, although Japanese White-eyes, Spotted Doves and Spotted Munia were also common. Barred Doves and Northern Cardinals were less common. A small flock of House Finch was observed south of the pond, in a grove of ironwood trees. Ring-necked Pheasants were seen in cane fields inland from the pond. Presumably other exotic birds, including Melodious Laughing-thrush, would be recorded on a more prolonged survey of the forest. The Ranch manager also reports having seen Barn Owls, Hawaiian Hawks and at least one Osprey at the pond in past years (511).

WATERBIRDS OBSERVED: Our trips to this site provided little indication of the actual extent of bird use in the pond. Black-crowned Night Herons were recorded on both trips, but in surprisingly low numbers (n=2,3). Both Mr. Blackshear and the resident caretaker confirmed that herons frequently roost in trees near the pond, but they were not sure whether or not they actually nest in the area. We found evidence of roosts in banyan trees near the pond, but found no evidence of nesting. Probably herons found both at Keaau Ranch pond and Lokoaka Pond come from a rookery located somewhere in forest near one or the other sites. An intensive survey of this forest, during the spring breeding season, would maximize the chance of finding the rookery. Numbers of herons recorded on HDF&G/USF&WS surveys at Keaau Ranch pond in recent years have ranged as high as seven birds, but average less than three. Mr. Blackshear confirmed that

herons feed regularly on the juvenile mullet introduced into the pond. However, only the limited shoreline on the south side of the pond provides accessible feeding habitat. Most of the pond is too deep for this species to successfully capture food.

The use of the pond by coots is more open to question. Only one recent bird count of the pond included coots (n=5, 8/1/75) and the caretaker, although familiar with the bird, insisted that they do not visit the pond (530). Yet, Ron Bachman indicated that he has seen nests and young of this species in the marsh portion of this pond more than once (509). It is surprising that the species does not appear on more HDF&G/USF&WS count records. There is a large amount of suitable cover and abundant algal food in the pond. Perhaps the continued use of the flooded pastureland, and accessibility of the site to dogs and other predator, inhibits greater use of the area by coots.

Two domestic Mallards were observed at the pond on both survey days. The caretaker indicated that these two birds represented all that was left of a large group of ducks given the late Mr. Herbert Shipman approximately six years ago (530). Mongoose and dogs were blamed for the loss of these birds. The caretaker also noted that he had seen duck eggs floating in the pond in the past, but no chicks were ever hatched successfully (530).

Migratory waterfowl are regular visitors to Keaau Ranch Pond. The list of recorded species includes Pintails, Northern Shovelers, Black Brant, White-fronted Geese and Canada Geese. The last three of these involved one to three birds each, and movement of these birds between Keaau Ranch Pond and Waiakea Pond (and/or Lokoaka) was confirmed. Pintail and Shoveler numbers at Keaau Ranch Pond have varied considerably, although on the January 1973 HDF&G/USF&WS survey over 36 per cent (n=62) of the Pintails recorded on the Big Island were found in the Keaau Ranch Pond. Both Ruddy Turnstones and Golden Plovers have been recorded at the site as well. Presumably the expansive lawn and nearby rocky shoreline and beach provide feeding habitat for these species.

We could find no confirmed record of a Cattle Egret rookery in the vicinity of Keaau Ranch Pond, but numbers of birds recorded at the site on past HDF&G/USF&WS surveys suggest that such a rookery does exist. As many as 60 egrets have been observed at the pond, although numbers are generally much lower. Between 8-15 egrets were in close association with cattle near the pond during our surveys. Larger concentrations are often found in pasture land between the pond and the town of Keaau. Movement of Cattle Egrets between Keaau Ranch Pond and Kionakapahu Pond has been confirmed in earlier surveys (509).

HABITAT EVALUATION: Keaau Ranch Pond provides only marginal habitat for native waterbirds. However, for its size, this site continues to be surprisingly sttractive to impressive numbers of wintering ducks. Birds using the site confine most of their movement to the marsh edge, so are limited in their use of the site by small amounts of habitat suitable for loafing, feeding and nesting. There is very little shoreline that is totally free from predation or disturbance by cattle. A signficant portion of the best potential feeding habitat is choked with water hyacinth and therefore useless to waterbirds. Current programs to clear this encroaching vegetation will prove useful to birds.

Other than ponds in the Hilo area, there are very few other sites on the entire northwest portion of the island that provide suitable habitat for endemic or migratory waterbirds. Taken together, this complex of ponds provides an important resource that should be recognized collectively. They may, in fact, all be necessary as alternative habitat to sustain the group of waterbirds that regularly inhabit this area of the Island. Cooperative management plans should be implemented with all landowners involved, and further surveys coordinated to allow simultaneous counts of all sites, several times during the year.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: In the case of Keaau Ranch Pond, the landowner may have already initiated some dredging operations prior to publication of this report. The immediate plan was to clear water hyacinth from the inland end of the pond. It is likely that this will improve the site both for aquaculture and for waterbirds. However, extensive dredging and vegetation removal is also contemplated for the marsh-flooded pasture area on the south side of the pond. This, in effect, would destroy the only viable waterbird loafing, and potentially nesting, area in the pond. Although the submergent algae and small fish would continue to provide one source of food for birds, it is certain that removal of bulrushes and flooded grass would diminish the supply of alternative foods as well.

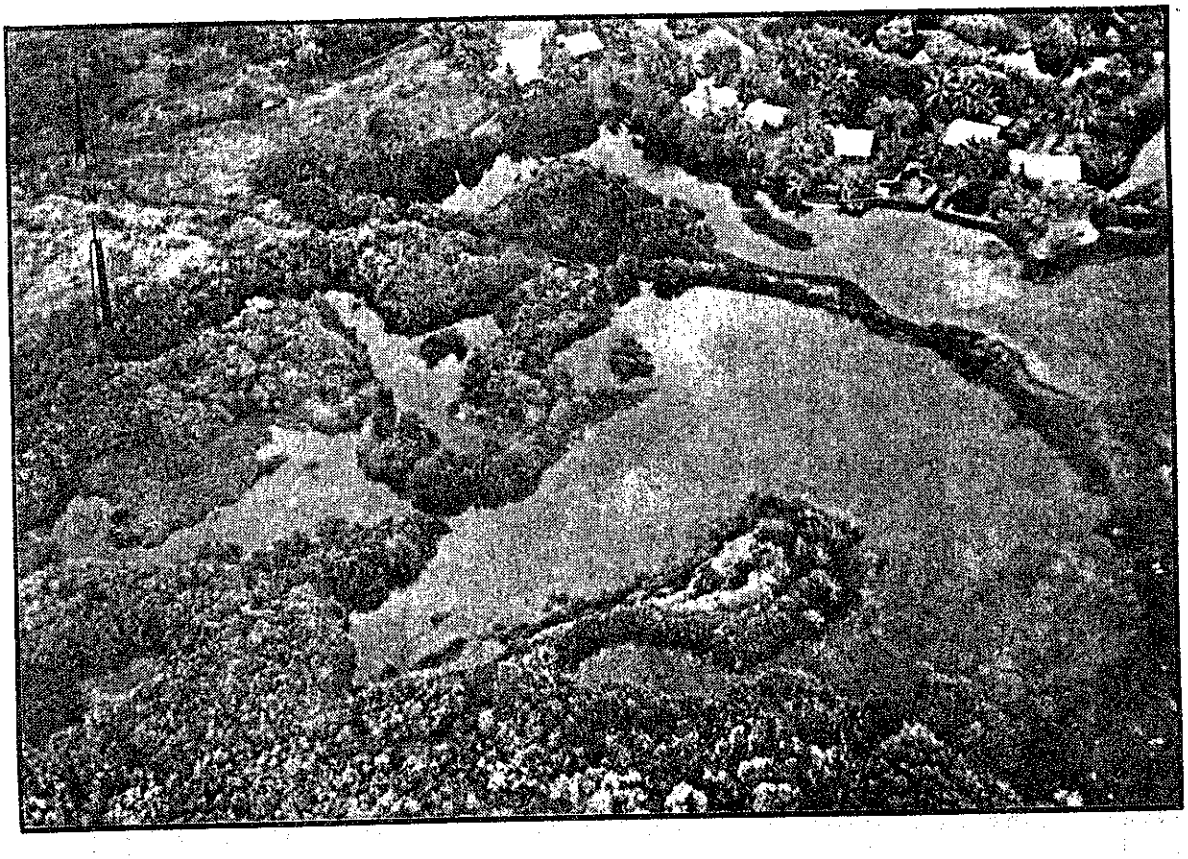
As the pond in its present state can be effectively managed for aquaculture, any modification of the limited waterbird habitat should be stronly discouraged. Also, biologists should seek the cooperation of the landowner in restricting the use of nearshore flood grassland as pasture for cattle. Fencing of this area, particularly along the southern edge of the pond, would serve to keep both cattle and dogs out of the best waterbird habitat.

SITE NAME: Ka-poho Fishpond (and Green Lake)

LOCATION: Puna District, Hawai'i

TOPOGRAPHIC MAP: Ka-poho

DATES OF SURVEY: 6 June, 1977



Kapoho Fishpond

WETLAND DESCRIPTION: Two separate sites in the Kapoho area of the Big Island are discussed here. Kapoho Fishpond is a coastal tidepool that has been walled off historically. Although partially spring fed, the water within the pond is highly saline. Water levels fluctuate with the tides. The surrounding lava is covered with beach naupaka, pickleweed and other shrubs. The inland edge supports more extensive mangrove and hau. The lava bottom in the ponds is covered with coral and coralline algae. Depth ranges from 3-12 feet or more. The pond is presently used for recreational swimming and limited fishing. Several house lots have been developed recently in the adjacent lands.

Green Lake (not pictured) is found within Kapoho Crater, approximately one mile west of Kapoho Fishpond. The name is obviously derived from color caused by dense algal growth. Floating waterweed covers much of the surface near the edge of the lake. The depth was not determined away from the shore, where it is less than 6-12 inches in some areas. The surrounding slopes are densely forested (kukui, hau, monkeypond, koa haole, guava, coconut, breadfruit, mango, etc.).

NON-AVIAN WILDLIFE: The aquatic fauna of Kapoho Fishpond is typical of a relatively undisturbed tidepool anywhere along this coastline. Several species of reef fish were seen, as well as sea cucumbers, sea urchins, corals and associated other invertebrates. No aquatic survey of Green Lake was made due to lack of permission for access. However, the pond appeared to contain a dense population of fishes, but the water was too murky to identify them. A nearby resident indicated that catfish were in the pond, but it is more likely that the fish observed were tilapia. The entire shoreline of the fishpond and Green Lake are accessible to all varieties of terrestrial predators.

NON-WATERBIRD AVIFAUNA: The non-wetland bird list for these sites included Spotted Doves, Barred Doves, Northern Cardinals, Japanese White-eyes and House Finch. With the exception of the Barred Dove, all species were considerably more common in the forest surrounding Green Lake than in the area of the fishpond. One person interviewed near the fishpond indicated that Hawaiian Owls were seen regularly in the area. Botanists on survey of this pond observed a Hawaiian Owl in April, 1977 (95).

WATERBIRDS OBSERVED: Kapoho Fishpond is not typical waterbird habitat, so we were not surprised that no wetland birds were observed on our survey of the site. Botanists on an earlier survey of the area did observe a single Black-crowned Night Heron (95). However, no one we talked to at the site could remember having seen them there. The area is not surveyed regularly by HDF&G/USF &WS biologists. However, Ron Bachman indicated that he had seen Pintail and Shoveler ducks at the site, but irregularly and always in very small numbers (509).

Residents indicated that Wandering Tattlers feed on the coast, but they had not seen other shorebirds here. An unidentified resident near Green Lake indicated that he also had seen ducks within the lake. Bachman (509) recalled having heard residents speak of coots within the lake, but there is no published record of these observations. We observed two herons during survey of the site. Both were perched in kukui trees above the water. An accumulation of droppings under another tree suggested that herons inhabit the site with some regularity.

HABITAT EVALUATION: Although historical data are lacking, it does not appear that either Kapoho Fishpond or Green Lake are of significant importance to waterbird populations on the island of Hawaii. However, winter surveys would be necessary to confirm use of Green Lake by migratory waterfowl. The lake is small and provides little shoreline habitat suitable for loafing or nesting. Submergent and floating-leaved vegetation may make the site attractive as feeding habitat on a short-term basis.

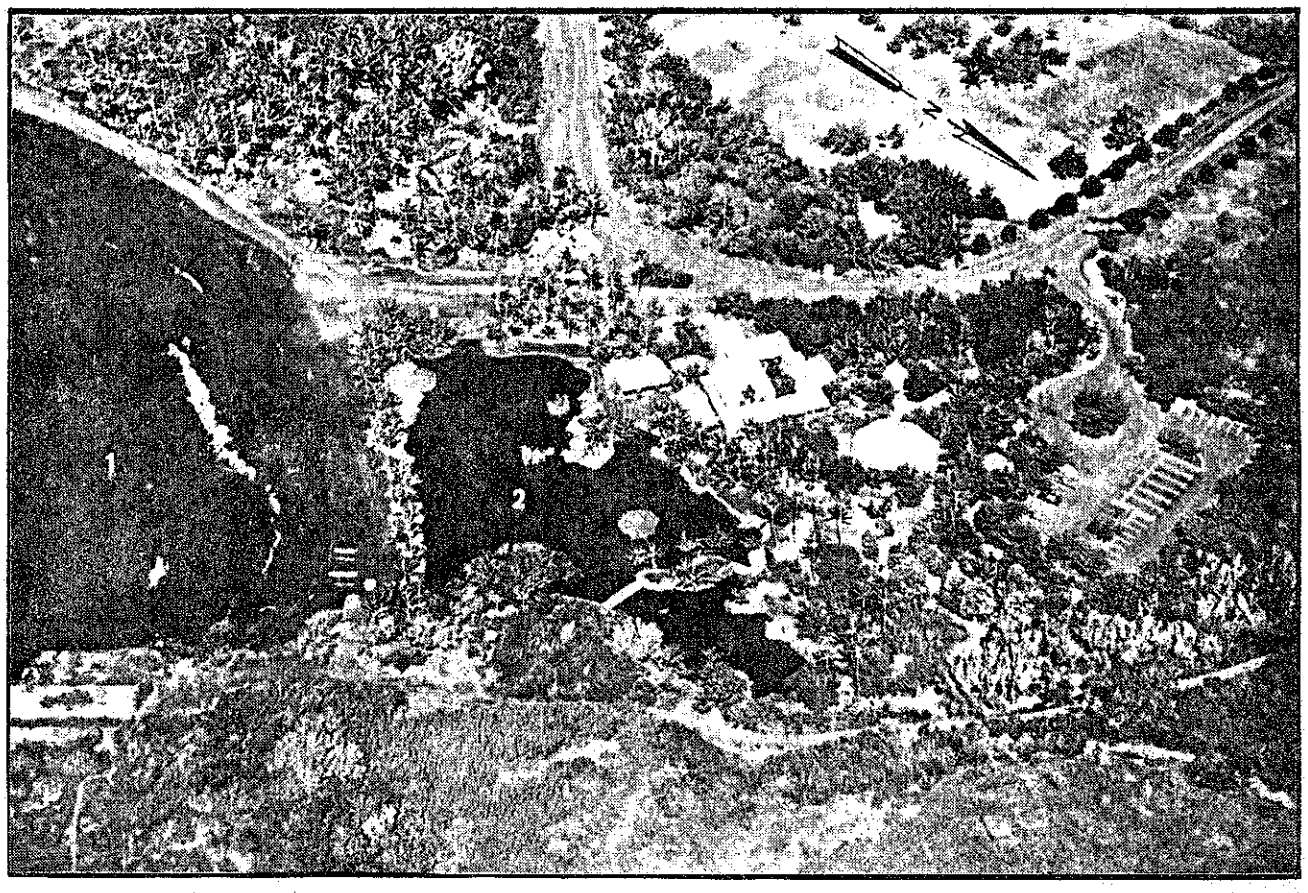
POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: Dredging and filling activities at these sites are not likely to have any significant impact on Big Island populations of Hawaiian waterbirds.

SITE NAME: Puna-lu'u/Nīnole Fishponds

LOCATION: Ka'u District, Hawai'i

TOPOGRAPHIC MAP: Puna-lu'u

DATES OF SURVEY: 5 June, 1977



1. Punaluu Harbor

2. Punaluu Pond

WETLAND DESCRIPTION: A series of small ponds are found along the southwest coast of Hawaii, between Punaluu and Naalehu. Two of these ponds, in the area of Punaluu Harbor, were surveyed. Similar habitat, at Honuapo, was not surveyed. The ponds are fed by springs and artesian wells. There is probably some fluctuation in levels (and salinity) in these ponds as a function of underground salt water intrusion and patterns of rainfall. The pond that is inland of Punaluu Harbor has been altered considerably by dredging associated with hotel development (see photograph). Prior to dredging the pond was largely overgrown, with small patches of open water. Other ponds nearby have been less affected by development. Vegetation near the ponds is a combination of planted trees (mostly palms), other exotics (koa haole, false kamane, etc.) and some native species (wiliwili, beach naupaka, ilima and beach morning glory). Various grasses and bulrush stands are also found within the ponds and on land surrounding the open water. Pond bottoms are largely black sand and lava rock. Some silt has collected deeper parts of the ponds, resulting in localized turbidity. Submergent vegetation is well-developed in parts of all ponds, although it is least abundant in the pond closest to the resort. All of the ponds along this coast were inundated and modified by the 1960 tsunami.

NON-AVIAN WILDLIFE: A thorough aquatic survey was not undertaken at this site. Principal fish observed in the ponds included mullet, mosquitofish and aholehole. In those ponds where there is ready access to the ocean, one can expect to find a large variety of fishes typical of brackish estuaries. Dragonflies, fresh water snails and frogs were observed as well. Dogs and mongooses were observed near the ponds, and it can be assumed that feral cats are present as well.

NON-WATERBIRD AVIFAUNA: The most common non-wetland birds at the ponds were Barred Doves and Spotted Munia. Common Mynas, House Finch and House Sparrows were most common in the resort area, while Spotted Doves and Northern Cardinals were uncommon in that area but widely distributed elsewhere. Japanes White-eyes were found in all habitats, but in relatively low numbers.

WATERBIRDS OBSERVED: Although ponds at Punaluu continue to be included in semi-annual HDF&G/USF&WS surveys, they have provided little suitable habitat for waterbirds for most of the last decade. We could find no count records for the Ninole ponds. Between 1970-1975, no birds were counted at Punaluu on survey, and frequent mention was made in Job Progress Reports regarding the degradation of waterbird habitat due to resort development. Bachman (454) indicated that "all ponds are being dredged for resort development. This habitat is no longer suitable for waterfowl and shorebirds". The increased human disturbance was also blamed for the lack of birds recorded. More recently, Bachman (458) wrote that "the pond areas had been cleared and there was good habitat available. Human disturbance was heavy, but expected to diminish after the pond improvements had been completed."

Evidence that the site had, in fact, improved as waterbird habitat with the cessation of dredging and construction activities is indicated in more recent count results. Four species of waterfowl (Pintail, Northern Shoveler, Lesser Scaup and Black Brant) were recorded on 15 January, 1976. Bachman indicated that herons were also present in the resort area prior to development (509). None have appeared on recent records for Punaluu but a single heron was

counted at Honuapo in 1974. Botanists surveying Ninole ponds in April 1977 observed at least one heron (95). Surprisingly, coots also appear in the records (1/18/73) for Honuapo but not for the Punaluu ponds.

Wandering Tattlers and Golden Plovers are the only migratory shorebirds recorded in recent years at Punaluu. The only waterbirds recorded on our survey at Punaluu were Wandering Tattlers and Ruddy Turnstones. These birds were feeding on the shoreline and not within the ponds.

HABITAT EVALUATION: The long-term effect of recent dredging within the resort pond at Punaluu may eventually be positive, as the pond was badly overgrown with vegetation prior to the beginning of construction several years ago (509). It may take some time for submergent vegetation to reestablish in the resort pond, but existing bulrushes and floating plants will provide important cover and food plants for resident and migratory waterbirds. However, it is certain that human use of the pond and surrounding lands will be a deterrent to extensive waterbird use in the future. Further, the remote nature of these and other ponds along the southwest coast will probably continue to inhibit regular movement of birds between these sites and more important habitat along the Kona coast or in the Hilo area.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: It appears that extensive dredging activities associated with resort development at Punaluu are largely complete, although future development may require modification of additional pond sites. The continued use of a site by waterbirds after extensive modification is dependent upon the availability of suitable cover and food plants, and the overall effect on water quality. The pond closest to the resort is still quite turbid. This will slow the rate of submergent vegetation development by decreasing available light. Any additional dredging or deposition of fill material would magnify the problem. What is left of the original emergent vegetation should be left intact and undisturbed. A cooperative plan for effective waterbird habitat management should be developed with the resort personnel.

SITE NAME: Ki'i-lae (Forest) Bog (not pictured)

LOCATION: South Kona District, Hawaii

TOPOGRAPHIC MAP: Honaunau

DATES OF SURVEY: 8 June, 1977

WETLAND DESCRIPTION: This site is a forested upland (elev. 2600 ft.) stream drainage with only localized areas of exposed wet grass and small springs. There is no open water other than the stream itself, which runs only after steady rains. The site is on sloping ground, with no large, flat land to collect standing water. The forest is dominated by ohia and koa, with a dense understory of tree fern and false staghorn fern. The site is within fenced forest reserve, and maintained as watershed.

NON-AVIAN WILDLIFE: Mongoose were seen on approach to the site and are surely found within it as well. Feral cattle are found within the site boundaries according to the McCandless Ranch Manager. Although pigs were not seen on survey, they are found in this forest. No attempt was made to survey the stream fauna.

NON-WATERBIRD AVIFAUNA: As this is not a typical low elevation wetland site, it is not surprising that only forest birds were seen on survey. The list of birds observed on our survey includes 'Apapane, 'Amakihi, I'iwi, Japanese White-eye, Red-billed Leiothrix, Omao and Hawaiian Hawk or I'o. Only a single sighting each was made of the last two species. The known range of the Hawaiian Crow ('Alala), a critically endangered endemic bird species, includes the higher elevations of this forest.

WATERBIRDS OBSERVED: No waterbirds were observed on this survey. Ron Bachman (509) indicated that he has seen both Hawaiian Geese (Nene) and Black-crowned Night Heron ('Auku'u) within the boundaries of this site. He speculated that herons may be resident there and fly to coastal ponds in search of food. Alternatively, they may only visit this upland site when suitable food is available in the stream or wet bog.

HABITAT EVALUATION: Although this site contains some relatively undisturbed native forest, it is of little or no significance to waterbirds.

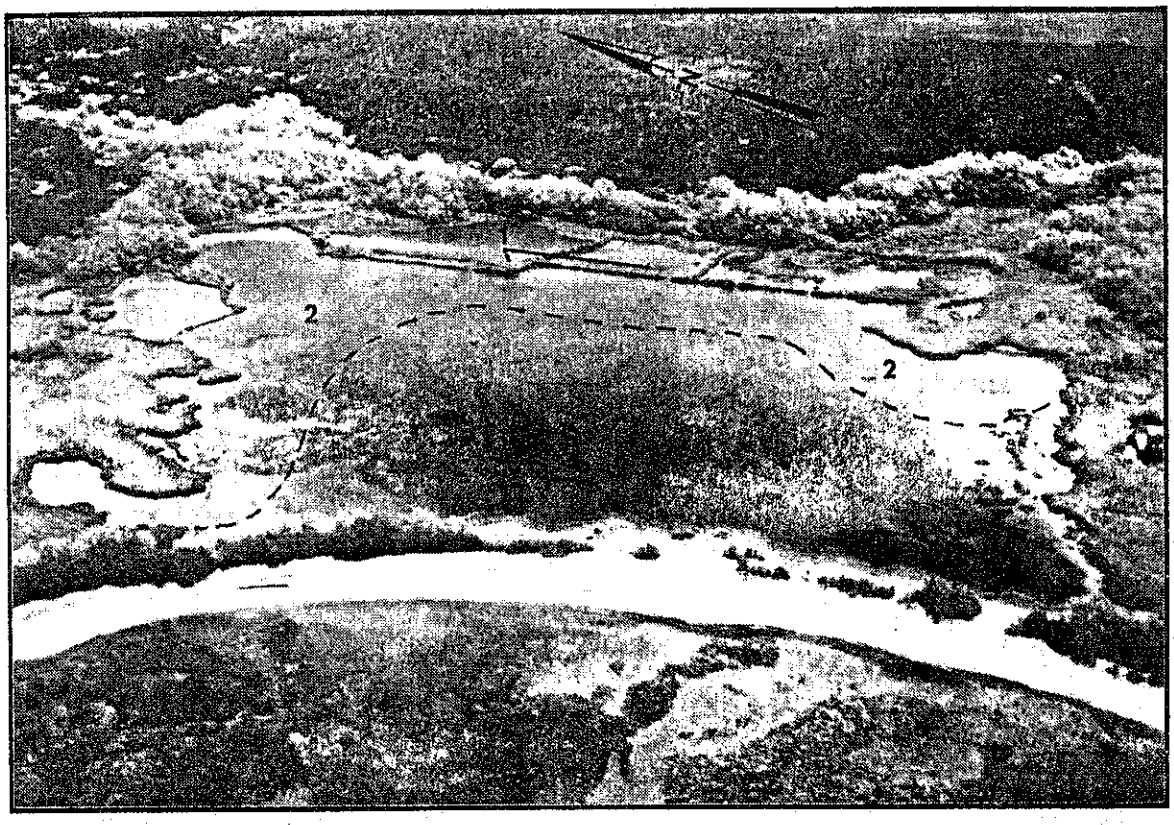
POTENTIAL IMPACT OF DREDGE/FILL ACITIVITIES: Dredging or filling activities at this site would not have any significant impact on Big Island populations of Hawaiian waterbirds, but could have adverse impact on native forest birds, including some endangered species. This area should be included in more intensive survey of high elevation wetlands at a later date.

SITE NAME: Aimakapa/Kaloko Fishponds

LOCATION: North Kona District, Hawai'i

TOPOGRAPHIC MAP: Ke-āhole Point

DATES OF SURVEY: 7, 8 June, 24 June, 8 July, 1977



Aimakapa Fishpond

1. coot nests (June, 1977)
2. primary coot & duck distribution during our surveys

WETLAND DESCRIPTION: Two coastal brackish water fishponds are located immediately north of Honokohau Harbor, on the Kona coast of Hawaii. Both Aimakapa and Kaloko ponds are separated from the ocean by a narrow sand and rock berm. Springs feed fresh water into the ponds, but salt water intrusion creates a slightly brackish condition. Aimakapa Pond is less than two feet deep for most of its 20 acres of open water. Another 12-15 acres of ephemerally flooded paspalum and kikuyu grassland surrounds the open water. Remains of former aquaculture nursery ponds are left on the inland side of the pond, although the dikes around these enclosures are in poor condition structurally and heavily overgrown with grasses and other vegetation. The forest surrounding the pond is largely kiawe. Kaloko Pond (not pictured) is considerably deeper, in part due to recent dredging activities when a hotel development was planned for the site. Most of our survey effort was devoted to Aimakapa Pond.

NON-AVIAN WILDLIFE: Large schools of small (one inch) unidentified fish were common throughout Aimakapa Pond during survey. Gastropod molluscs, crabs, isopods and dragonfly naiads were also observed. Several loose dogs were seen on the beach and in the mudflats bordering Aimakapa pond. Although there was a worn path through the grass around the pond, it is doubtful that dogs can negotiate the suspended silt bottom without sinking too deep to maneuver. At least four mongoose were seen in the vicinity of the pond on the first day of survey. The beach was visited throughout the day by tourists, fishermen and a surprisingly large number of nude bathers. Movement of people on both sides of the beach berm creates considerable disturbance for the birds. Kaloko pond, situated farther north, appears to receive less continual human disturbance.

NON-WATERBIRD AVIFAUNA: The most abundant non-wetland birds near the pond were Spotted Munia, Common Mynas, Spotted Doves and Japanese White-eyes. Barred Doves, House Finch and Northern Cardinals were seen in lower numbers. Two Grey Francolins were observed at the pond as well. The most unique non-wetland bird at the site is the Yellow-billed Cardinal. More than 12 birds of this species were counted on the first day of survey. The population of Yellow-billed Cardinals at Aimakapa was described only recently. Birds of this species have also been observed at Opaeula Pond, in Makalawena (see pg. 385).

WATERBIRDS OBSERVED: Aimakapa Pond is best known for its population of Hawaiian Coots. USF&WS/HDF&G records of coots at this site over the last decade show an average of nearly 50 birds per trip. Although recent numbers have varied from 11-83 birds, the coot count at Aimakapa typically represents between 60-80 per cent of the coots recorded for the entire island on survey days. Coots at Aimakapa depend on the extensive submergent growth of algae and widgeongrass, as well as the shoreline vegetative cover. Coots are most often observed in the northeast portion of the pond, an area where they quickly retreat when people approach the pond. This raises the question whether or not the pond could sustain a greater number of birds if the human disturbance was better controlled.

Although juvenile coots have been reported at the site, and nesting has been assumed, we are unaware of any nest observations prior to this survey. We observed 38, 36, and 42 coots on our three trips to the site. On the 28 June visit, immature birds of three separate age classes were observed. From youngest to oldest, the broods contained four, three and two birds each. In

addition, two active nests were located in shallow water within two separate nursery ponds. The water in which the nests were built was approximately 12 inches deep, and the top of each nest was at least six to ten inches above the water surface. Adults were incubating eggs in both nests at the time of survey. Estimating the age of the oldest immature birds at eight weeks, and assuming that eggs in these two nests hatched in Jly, one derives a minimum figure of five coot broods from this wetland habitat between April and September. The question remains as to whether or not predation or some other factor can explain the relatively small broods observed. It would also be valuable to determine whether nesting territory size is the limiting factor controlling the number of nesting coots at any one time in Aimakapa Pond.

Hawaiian Stilt inhabit Aimakapa Pond on a year-round basis, with numbers ranging on most HDF&G/USF&WS counts between four to eight birds. No recent counts have exceeded 11 birds. Yet the stilt at Aimakapa typically account for 30-50 per cent of the island population on count days. Aimakapa Pond appears to share its stilt population with Opaeula Pond, and occasionally with Kaloko Pond. The latter site is too deep to provide much suitable habitat for this species. Our counts of stilt at Aimakapa ranged from four to seven birds. In each case, stilt appeared to be paired, and some apparent "nest defense" was observed. However, no nests were located. Stilt probably do nest at Aimakapa on vegetated dikes that line the remnant nursery ponds. Such a nesting site would provide the chicks ample cover near the dikes, but suitable feeding habitat would be limiting. Construction of small islands or partial draining of one or more nursery ponds would facilitate stilt nesting at Aimakapa.

We made only one observation (two birds) of Black-crowned Night Herons at Aimakapa Pond during our surveys. Two immature birds were roosting in Kiawe trees behind the pond on 8 June, 1977. Only three records of this species at the pond were found in more than 25 recorded counts in the last decade, although one of these (1/12/71) involved seven birds. The species appears more regularly at Opaeula Pond, but invariably in very low numbers.

Winter HDF&G/USF&WS counts of migratory waterfowl at Aimakapa Pond have shown fluctuations from year to year, and even day to day, as both Pintails and Northern Shovelers move regularly between Aimakapa and Opaeula Ponds. Yet, the maximum number of these birds at Aimakapa in recent years has rarely exceeded 100. Even in January, 1976, when 265 Pintails at a new artificial habitat in Kohala raised the island duck count more than three times the yearly average, the count of Shovelers and Pintails at Aimakapa was still only 117. This appears to indicate that winter duck populations at Aimakapa approach the carrying capacity of the habitat in its present condition. We recorded two Pintails and one Shoveler at Aimakapa Pond during each of our counts this summer. The list of other migratory waterfowl recorded at this pond in the past includes American Wigeon Lesser Scaup, Black Brant, Canvasback and Cinnamon Teal. Only the first two of these species appear with some regularity.

Migratory shorebirds find only limited suitable feeding habitat at Aimakapa Pond, but the variety of birds recorded in recent years at the site is impressive: Golden Plover, Wandering Tattler, Ruddy Turnstone, Sanderling, Black-bellied Plover, Semi-palmated Plover, Dunlin, Northern Phalarope, Long-billed Dowitcher. The first four of these species are recorded regularly in winter

HDF&G/USF&WS counts, with total numbers ranging as high as 40 birds. We recorded one to three tattlers on each trip to Aimakapa Pond this summer. At least one straggler seabird species (Franklin's Gull) has been noted at the site as well. Cattle Egrets appear occasionally on count records for Aimakapa Pond, but rarely are more than one to three birds seen.

By comparison to Aimakapa Pond, the recorded counts of birds at Kalako Pond have been incredibly low. We could find only one instance in the last decade when the count exceeded ten birds. Although stilt and coots have been noted there, most of the birds that appear in count records are the more common migratory shorebirds (Golden Plover, Wandering Tattler, Ruddy Turnstone).

HABITAT EVALUATION: Aimakapa Pond was recognized in 1970 as a "key area to be preserved and developed as a wildlife refuge" (343). More recently, the draft HWRP (346) recommended that the pond and surrounding buffer area be acquired and managed by the State as a waterbird sanctuary. Results of semi-annual HDF &G/USF&WS waterbird counts make it clear that both Aimakapa and Opaeula ponds and to a lesser degree even Kaloko Pond, should be thought of as a unit of a habitat for waterbirds on the island of Hawaii. Count data indicate that the primary value of Aimakapa is for coot and migratory waterfowl, while Opaeula supports the greatest number of stilt. The extent to which birds are dependant upon both sites to fill their varied needs is uncertain. The loss of either site as waterbird habitat may have a direct impact on the other site as well. Each on its own may be unable to support reproducing populations of either stilt or coot.

Aimakapa Pond is not assured protection from radical modification in the future. Human disturbance in the area is increasing rapidly. The surrounding lands are under consideration for housing and resort development while other interests would like to see the fish pond resored and operated as before. As indicated in the draft HWRP (346) either change would be undesirable from the standpoint of waterbird habitat management. The site appears to have considerable potential for improvemnt through predator control and reduction of human disturbance, yet, even in its present condition, is already as valuable or more so than any waterbird habitat on the island.

POTENTIAL IMPACTS OF DREDGE/FILL ACTIVITIES: It appears that the increasing level of human disturbance at the southwest portion of Aimakapa Pond is, at least in part, responsible for the concentration of birds into the east and north portions of the available habitat. Yet, virtually the entire pond bottom is accessible for feeding in its present condition. An intensive limnological study of the habitat may explain why birds are generally not evenly distributed over the pond, and would suggest means to improve habitat condition, although Kridler (519) believes that the observed distribution of birds is due to human disturbance, not variation in habitat. Some deposition of fill within one or more of the remnant nursery ponds could improve the suitability of the area for stilt feeding and reproduction, but in so doing, it may also eliminate some important coot habitat. Deteriorating dikes could be repaired for better water level control in the inland portion of the pond, but the disturbance and siltation associated with the activity would probably not be warranted by the limited advantages of such a plan.

Restoration of Aimakapa pond for aquaculture purposes (either for display or for commercial use) would create excessive disturbance within important coot nesting and feeding habitat. Dredging anywhere in the pond would decrease the accessibility of submergent plant and animal foods. Any manipulation of the pond bottom at Aimakapa Pond should await thorough study of pond ecology. Although it is reasonable to assume that moat construction around the pond would decrease accessibility to predators, such an extensive dredging operation could have serious adverse impact that may outweigh the advantages.

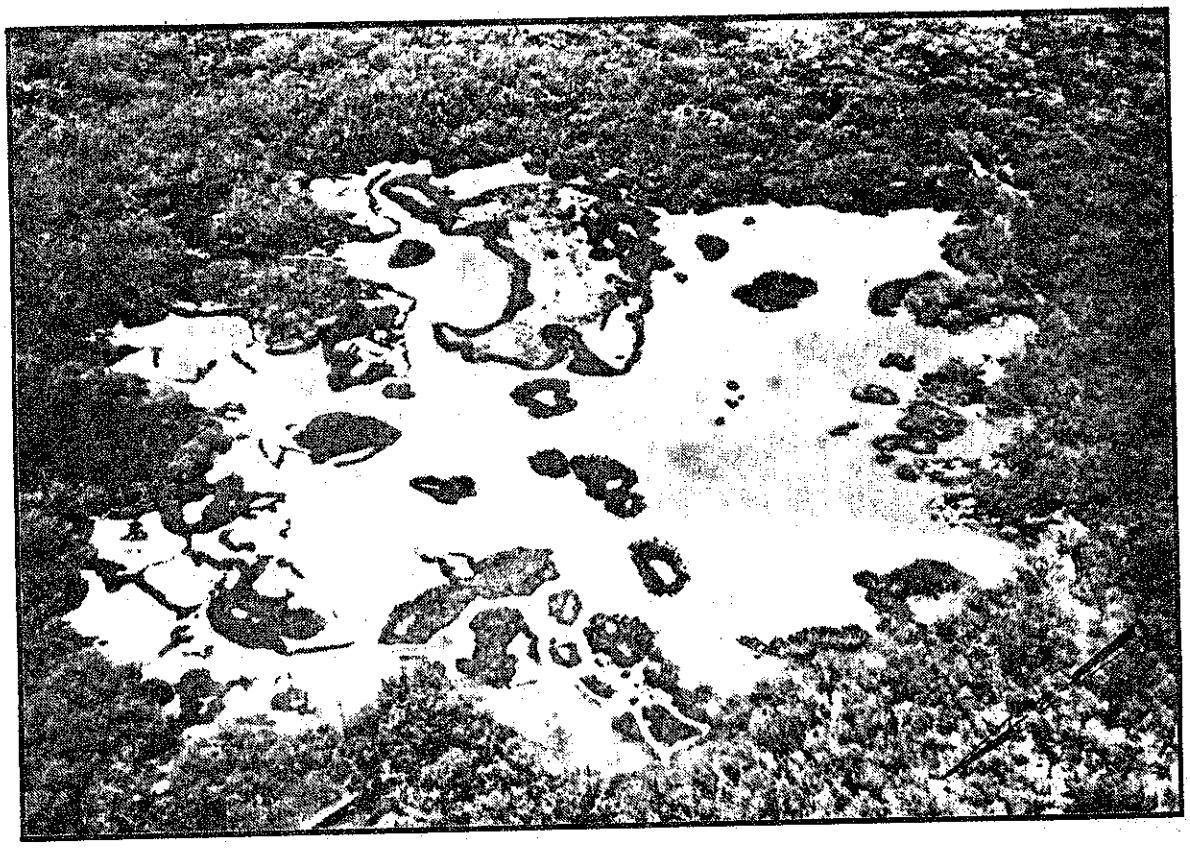
Extensive dredging within Kaloko Pond, in anticipation of hotel development, has rendered the habitat nearly worthless by comparison to Aimakapa (505). It may be possible to increase the current value of Kaloko to waterbirds by deposition of fill to render bottom vegetation and invertebrates more accessible to birds, but it is probably not warranted because of expense and limited potential.

SITE NAME: Ōpae-'ula (Makala-wena) Pond

LOCATION: North Kona District, Hawai'i

TOPOGRAPHIC MAP: Makala-wena

DATES OF SURVEY: 9 June, 8 July, 1977



(beach side)

WETLAND DESCRIPTION: This wetland is a coastal brackish water pond surrounded by ironwood and kiawe forest. Recent lava flows border the pond on three sides and the ocean lies to the west. Fluctuation of pond level with the tides suggests an underground connection to the sea, but this water is diluted by a combination of rainfall and frest water seepage (salinity 3.9-5.6 ppt). The pond itself is only 7.5 acres in size, and less than 12" deep over most of its area. Maciolek (109) describes the bottom of the ponds as "flocculent, marl-organic". Several peninsulas and islets within the pond support growth of various emergent plants. Submergent algae and widgeon grass growth is also extensive at several locations in the pond.

The pond is not used for any purpose at this time, although the USF&WS is currently negotiating with the Bishop Estate for purchase of the pond and an additional 25-30 acres of surrounding land as a national wildlife refuge. A caretaker is now resident at the site, and much of the nearby shoreline is visted regularly by local fishermen.

NON-AVIAN WILDLIFE: Maciolek (109) conducted a thorough survey of the aquatic inverterbrates within Opaeula Pond and found annelid worms, gastropod molluscs, shrimps (including the native "Opaeula" of the family Aytidae) and a variety of insects (Odonata, Diptera, Hemiptera). We also observed small unidentified crabs and some juvenile mullet. As indicated by Maciolek (109), there was no apparent shortage of animal food for waterbrids at Opaeula Pond.

The caretaker at the pond raises domestic goats, and many run loose around the site and mix with other feral populations. We saw more than 40 goats on our first trip to the site, although past records within the last year include numbers greater than 60. Only the portions of the pond with a very soft, silty bottom are innaccessible to these animals. We also observed mongoose scats at several locations around the pond, and mongoose have been observed on several earlier visits by USF&WS biologists.

NON-WATERBIRD AVIFAUNA: The most abundant non-wetland birds at the site during our surveys were House Finch and Japanese White-eyes, both in the kiawe and ironwood forests. Common mynas, Spotted Doves and Barred Doves were also observed in lesser numbers. Less than five Yellow-billed Cardinals were noted on both trips to the site. This species is confined in distribution to the Kona coast, and is more common in kiawe forest bordering Aimakapa Pond, at Honokohau. Other non-wetland birds recorded by USF&WS biologists at Opaeula include Grey Francolins, Mockingbirds, Spotted Munia, Warbling Silverbills, House Sparrows and Northern Cardinals.

WATERBIRDS OBSERVED: Interest in Opaeula Pond as a potential waterbird refuge stems primarily from continuing observations of Hawaiian Stilt at the site. Although HDF&G/USF&WS count records suggest a regular movement of birds between Opaeula and Aimakapa ponds, the stilt counts at Opaeula are almost invariably higher, often as much as 200-300%. Stilt records at Opaeula in the past have generally ranged between 10-20 birds, although one recent count of 26 birds was noted. A minimum of 24 birds were reported by one observer (PB) on our first visit to this site, although several birds took flight after the initial count and made it impossible to determine if there were actually more birds present. Stilt nesting at Opaeula has been confirmed by HDF&G and USF&WS biologists on several occasions. On our July survey, three different age classes of young birds were observed.

The number of coots observed at Opaeula in recent HDF&G/USF&WS surveys typically ranges between 5-15 birds, although 25 coots were recorded on 1/23/75. Kridler recorded an average coot count for the pond at 11.2 birds between 1963 and 1973 (unpublished USF&WS data). We observed only 3 and 4 coots at the pond during our two visits. Titcomb reports observations of a coot nest at Opaeula Pond in 1965 (500). Young coots have been observed at the pond on earlier visits to the pond by USF&WS biologists (519). Yet the scarcity of additional nesting records, and smaller adult population, suggests that the pond is of less significance as coot nesting habitat than is Aimakapa Pond. However, what the data do not make clear is the extent to which individual coots on the Kona coast may be dependent upon both habitats to meet their varied needs.

Although Koloa do not appear on recent HDG&G/USF&WS count records at Opaeula there have been at least a few sightings on non-survey days. A single Koloa on the pond was observed during our first trip to the pond although non were recorded on our July trip. Presumably any Koloa that visit the pond are birds (or their offspring) that have been released in recent years in the Kohala Mountains.

The Black-crowned Night Heron or 'Auku'u is the only remaining non-migratory native waterbird that has been recorded in recent years at Opaeula Pond. The species appears infrequently in count records for the site but never in recent years have more than three birds been counted.

Migratory waterfowl visit Opaeula Pond in winter months, but in considerably less numbers than inhavit Aimakapa Pond to the south. Kridler computed an average number of ducks at the site between 1963-75 at 35 birds, but also noted an unusual concentration on 15 January, 1964, of 298 birds. (Unpublished USF&WS data) A more recent average for migratory ducks is closer to 31 birds per visit. As was the case at Aimakapa Pond, there was no significant increase in duck numbers during the 1976 winter count, when 265 Pintails were counted at newly constructed artificial havitat in Kohala. Again, this suggests that Opaeula Pond regularly supports a migratory waterfowl population that is close to its saturation level in present condition. The list of additional waterfowl reported for Opaeula includes Mallard, Green-winged Teal and Blue-winged/Cinnamon Teal.

The list of migratory shorebirds recorded in past years at Opaeula Pond is interesting in its diversity: Golden Plover, Wandering Tattler, Ruddy Turnstone, Sanderling, Semipalmated Plover, Sharp-tailed Sandpiper, Pectoral Sandpiper, Dunlin, Western Sandpiper, Least Sandpiper and Long-billed Dowitcher. Only the first five of these species are recorded with regularity at the site. No migratory shorebirds were recorded on either of our two summer visits to the pond.

HABITAT EVALUATION: Opaeula Pond was recognized in earlier publications as a waterbird habitat worthy of priority attention (343,346). Barring unforeseen complications, the site will soon be a national wildlife refuge. Expected management programs will include predator control and exclusion of goats by fencing. Protection of the site as a refuge will help to insure future use by waterbirds, but without similar protection at Aimakapa Pond, the number of birds inhabiting Opaeula may diminish nonetheless.

Effective control of goats and predators at Opaeula Pond may increase stilt

and coot productivity, but the site is limited in its potential for expanded nesting by its small size. The joint value of Kona coast ponds, particularly Opaeula and Aimakapa, to waterbirds on Hawaii was discussed in the report for Aimakapa Pond and will not be repeated here.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: In light of proposed refuge management plans, it is unlikely that extensive dredging or fill operations will be contemplated at Opaeula Pond. There is some opportunity to increase available nesting havitat and to reduce predation by island and/or moat construction However, as Maciolek (190) points out, the pond in its present state is highly productive. Count records suggests that a significantly larger population of waterbirds probably can not be sustained in the pond. Further, it is certain that extensive dredging would distrub the well developed bottom fauna and flora. The nature of the bottom is such that excessive turbidity would result, and the long-term adverse impact may be serious.

SITE NAME: Kīholo Fishpond

LOCATION: North Kona District, Hawai'i

TOPOGRAPHIC MAP: Kīholo

DATES OF SURVEY: 8 June, 1977

WETLAND DESCRIPTION: Kiholo Ponds are similar in many respects to any of several fishponds along the north Kona coast. They are spring fed and connected to the ocean through man-made channels. Salinity in the pond varies considerably with rainfall, fresh water seepage and tidal patterns. The ponds are surrounded by recent lava flows that are covered with a dense kiawe forest. Planted coconut palms border the southwest edge of the ponds. Much of the neighboring land has been developed for housing in recent years, and construction is still underway. It appears as if the gate structures associated with the ponds have been repaired, but it was uncertain whether or not the present landowner has plans to work the ponds for commercial aquaculture.

Most of the pond area is less than 2' deep, with a sand and lava bottom. Deeper "sink" holes are also found in the southern pond. In areas where water moves slowly, a surface mat of leafy pondweed and algae has collected. Some of the shoreline is covered with grasses, providing a limited amount of cover for waterbirds.

NON-AVIAN WILDLIFE: The permanent connection to the ocean, and consequently wide range of salinity in the ponds, makes it likely that a large variety of fishes inhabit this site. Mullet, aholehole and papio were seen in the pond. Milkfish, o'opu and barracuda are almost certainly present also. Various other fishes characteristic of coral reefs probably enter the ponds through the channel or during heavy storms that cause waves to break over the wall. Both marine and freshwater invertebrates can be expected within the site.

Several mongoose were seen in the area of the ponds during our survey. Herds of feral goats roam widely along this coastline, and can be expected to visit the site. Dogs and cats are associated with housing near the ponds, and have access to the entire perimeter.

NON-WATERBIRD AVIFAUNA: Common birds observed on survey included Soptted Doves, Barred Doves, Common Mynas, Japanese White-eyes and Spotted Munia. Four Yellow-billed Cardinals and three Warbling Silverbills were also observed. These last two species are recently established exotic birds. The former appears confined to the Kona coast, while silverbills have been seen at Mahukona and Pohakuloa as well.

WATERBIRDS OBSERVED: The only waterbirds observed at the Kiholo ponds on our survey were Pintail ducks. Two birds took off from the southern pond when approached, and they flew to the northern pond. Residents at the site confirmed that small numbers of ducks visit the ponds, particularly in the winter, but no one we talked to had ever seen coots or stilt at the site. Ron Bachman also reported having seen a few pintails and shovelers here in the past (509). Kridler visited the ponds in September, 1965, but found only a single Wandering Tattler (500). The site was included in the winter, 1974 HDF&G/USF&WS waterbird survey, but no birds were recorded. Bachman also reported he has seen as many an four Black-crowned Night Herons at the pond on a single visit, but we found no evidence (droppings, pellets, nests, etc.) that they inhabit the area regularly.

HABITAT EVALUATION: Several fishponds with connections to the sea are found along the Kona coast from Puako to Anaehoomalu. Virtually all of these provide

habitat for small numbers of migratory ducks, herons, and occasionally endemic waterbirds. Most of them, including Kiholo, are lined with rock walls and provide little shallow water feeding habitat for stilt or other wading birds. Some are actively worked for aquaculture, or in the process of restoration.

Relatively limited human disturbance in the remote portions of the northern Kiholo pond, together with available shoreline cove and suitable waterfowl plant food, give this area greater potential for waterbirds than many of the other fishponds along the Kona coast. Repetitive survey, preferably by boat, would be necessary to fully understand the current value of this site as waterbird habitat. If additional clearing of vegetation is undertaken around this portion of the site, and if the pond is worked actively for its aquaculture potential it is unlikely that this site will ever be of any long-term significance by itself to resident or migratory waterbirds. However, the cumulative value of all the Kona coast ponds, including Opaeula and Aimakapa, should be considered in the evaluation of projects that may limit the availability of habitat.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: The land bordering the southern pond at Kiholo has already been modified considerably for housing development. Vegetation has been cleared in some areas, and land has been leveled for construction. However, most of the pond has been left untouched. It is likely that housing will soon spread to other sides of the pond. This will increase disturbance to birds that visit the site, but it is uncertain whether or not limited dredging or fill deposition associated with this construction will have any long-term adverse impact on pond ecology. If all the existing shoreline vegetation is removed, it will destroy the limited amount of potential loafing and nesting habitat available to waterbirds. Dredging of portions of the ponds supporting extensive pondweed growth will reduce the availabilty of food for waterfowl. There will be some increased siltation due to runoff, but this could be controlled and the effects would be temporary.

SITE NAME: Ka-huā Ranch Ponds/Kehena Reservoir (not pictured)

LOCATION: North Kohala District, Hawai'i

TOPOGRAPHIC MAP: Hāwī

DATES OF SURVEY: 10 June, 1977

WETLAND DESCRIPTION: The high elevation sites we surveyed in the Kohala Mountains included a number of small reservoirs and natural depressions that hold water ephemerally. The larger Kehena Reservoir and other artificial reservoirs and small ponds were examined briefly. The listed sites are all located above 3500', on Kahua Ranch property. Virtually all of the surrounding area is pastureland, grazed regularly by large herds of cattle. Some were grazing within depressions that hold water only during winter months. Ditch systems for water transfer to lower elevation agricultural lands provide additional habitat for waterbirds in the area.

NON-AVIAN WILDLIFE: Cattle are well distributed throughout the pastureland. Several of the depressions that retain water are unprotected by peripheral fencing, and use of these areas as a source of water for cattle inhibits development of wetland vegetation and use by waterbirds. Mongoose and pigs are also present in the area, but were not observed on survey. The aquatic fauna of the ponds was not examined.

NON-WATERBIRD AVIFAUNA: The most numerous birds during our survey were Skylarks. They were distributed widely. Spotted Munia were also abundnat, traveling in flocks. Several were seen feeding within tall grasses protected from grazing by fencing. Common Mynas, Barred Doves and Spotted Doves were less common in the area. Hawaiian Hawks, Hawaiian Owls and Ring-necked Pheasants are also seen with some regularity on Kahua Ranch (527).

WATERBIRDS OBSERVED: Waterbird count data are available for recent years in the Kahua Ranch area because of an ongoing attempt by HDF&G biologists to reintroduce Koloa into their native range in the Kohala Mountains. Nearly 300 birds, reared in captivity at Pohakuloa, have been released on Kahua Ranch since 1968. The original release site is now largely overgrown by grasses, and provides little habitat for waterbirds. HDF&G/USF&WS count records since the first releases indicate that antural reproduction in the wild is occurring. At least three broods of young were observed each year between 1971-74 (476). Some birds have extended their range to the Upper Hamakua Ditch system, but most are found in pot-holes and reservoirs in the Kahua Ranch area. Drought conditions reduce the amount and diversity of wetland habitat available to this species.

Kehena Reservoir has been included in semi-annual HDF&G/USF&WS waterbird surveys. Koloa numbers have ranged from zero to 13 birds on survey days, but on other days as many as 17 adults and young have been observed on a single reservoir (476). These Koloa counts provide a poor extimate of actual populations because the birds range widely and utilize a large number of small bodies of open water, streams, ditches and other havitat. Other migratory waterfowl species (Pintail, Mallard) appear on only one recent semi-annual survey, although Ronald Bachman and Monty Richards both reported having observed Pintails and Shovelers on several occasions in the area (509. 527). Black-crowned Night Herons also appear on a single recent count record (8/8/73) when two birds were seen.

The most common waterbird on ranch property is the Golden Plover. Counts at Kehena Reservoir have been as high as 27 birds, but these birds are widely distributed across all pasturelands during fall and winter months and actual numbers surely are several times that recorded. A single plover we recorded at the reservoir was the only waterbird seen on our brief survey.

HABITAT EVALUATION: The condition of wetland habitat in the Kahua Ranch area is entirely dependent upon rainfall and patterns of water use for cattle by the landowner. Although ranch personnel have been cooperative in the release program, it is clear that waterbird habitat management is of secondary priority in the ranching program. There are conflicting practices that inhibit expanded use of the area by Koloa and other ducks. Grazing of cattle into the edge of ephemeral ponds and larger water bodies destroys the limited available aquatic vegetation, increases the water turbidity, and disturbs birds that might use the habitat. Recently constructed rubberized water storage ponds make it possible to retain water during drought periods, but inhibit the development of a well-balanced pond flora and fauna. Unless a cooperative program is implemented to create, maintain and protect suitable wetland habitat in the area, the primary value of the ranch lands will be to provide a diversity of well-distributed ephemeral wetlands, most of which are individually of marginal value to birds. Koloa will probably continue to occupy Kohala streams and valleys where they originally were found, but predation and natural habitat loss will make their survival precarious.

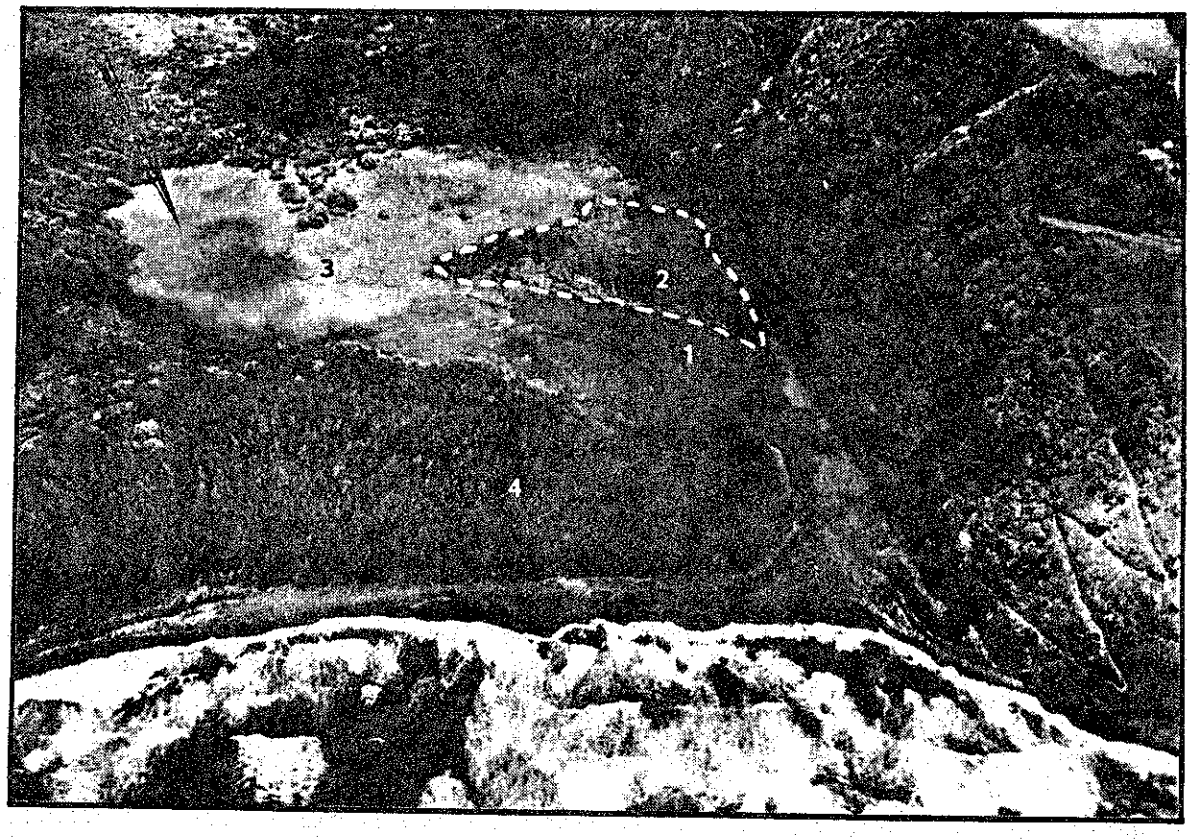
POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: As it is in the best interest of the land owner to maximize the amount of water available to cattle on his lands, it is unlikely that the water holding capacity of any existing natural depressions or artificial reservoirs will be lowered intentionally by dredging or filling. Emphasis in the future will most likely be directed to provision of year around water for cattle by construction of additional artificial reservoirs. Clearing of all vegetative cover and food plants within existing habitat will inhibit continued use by Koloa and should be discouraged. An exception to this would apply to wetlands (i.e. Koloa release pond) where encroaching vegetation has lowered the quality of the site for waterbirds. Portions of wetlands that are regularly used by birds should be fenced so that birds will find undisturbed cover available.

SITE NAME: Pololū Valley

LOCATION: North Kohala District, Hawai'i

TOPOGRAPHIC MAP: Honokāne

DATES OF SURVEY: 5 May, 10 June, 1977



1. open water
2. bulrush
3. pasture
4. ironwood forest

WETLAND DESCRIPTION: Pololu Stream is one of the larger perennial streams on the island of Hawaii. As it reaches the seaward end of a deep valley, the stream channel becomes poorly defined, and stream flow spreads out into a large marsh, separated from the ocean by a natrual dike. During periods of high stream flow there is some interchange of fresh and salt water at the seaward end of the marsh. A well-developed stand of bulrush covers much of the marsh, while flooded California grass covers the rest. The drier land behind the marsh is well-grazed pasture, although the marsh itself is not fenced, and cattle penetrate the entire vegetated area. Some large patches of waterweed cover the surface in areas where water movement is slow. Heavy rains prior to our survey left much of the pastureland under several inches of water. The deeper stream channel lies along a dense hau forest on a ridge that separates the lower valley from the beach. The floor of Pololu Valley is nearly flat, but steep walls on each side rise 600' or more. An extensive exotic forest covers the valley slopes and the back of the valley floor.

In the 18th century, most of the valley floor was in rice production and limited taro farming (520). Cattle and horse grazing in the valley began early in the present century, and continues to this day. Some domestic pigs run loose in the valley as well.

NON-AVIAN WILDLIFE: Water in the marsh and estuarine habitat at Pololu was excessively turbid, making observations of aquatic life difficult. However, both mullet and tilapia were observed. Some tilapia swimming in the flooded pasturelands were 6-8" long. Bullfrogs were common in the flooded grass, particularly along the stream drainage. The most obvious insects were dragonflies, both adults and naiads. The marsh bottom is a fine suspended silt, so it is doubtful that it supports a diverse invertebrate fauna.

Between 30-40 cattle and horses were grazing behind the marshland during our survey. Tracks and droppings of cattle throughout the flooded pasture and patches of trampled bulrush indicated that there is no part of the vegetated marsh that is free from grazing animals. We also observed two small pigs on the valley trail.

NON WATERBIRD AVIFAUNA: Northern Cardinals and Japanese White-eyes were the most common passerine birds in the neighboring hau forest. Less than a half dozen Spotted Doves were observed in the valley during the survey. House Finch were common in the ironwood forest fronting the beach. No time was spent in the exotic forest inland of the marsh, where it is certain that several other exotic birds are found. Endemic honeycreepers are restricted to native forest in the rear of the valley. Hawaiian Hawks ('Io) are seen at higher elevations in the valley with some regularity (520).

WATERBIRDS OBSERVED: There are few data available on corrent populations of waterbirds in Pololu Valley. Probably the area supported large numbers of coots and ducks when the valley was in rice and taro production. In an unpublished USF&WS Biological Ascertainment Report reviewing the potential of Pololu as a possible wildlife refuge, it was stated that "Pololu is primarily a gallinule and coot area". However, we could find no records of visits to the valley in which these species were seen. It is highly unlikely that gallinule visit the valley at this time. That coots use the valley was confirmed by our sighting of a single bird on 9 June, 1977. The bird was feeding in the seaward portion of the open water. The turbid waters within the marsh support very little suitable

food plants or animals that could sustain coots on a continual basis. The cattle rancher in the valley informed us that he only observed coots in the valley very rarely (520).

Koloa from HDF&G release experiments at Kahua Ranch probably visit the upper stream with some regularity. William Lum stated that he frequently observed color-marked Koloa in the marsh until approximately two years ago (520). He had no explanation for the decrease in visits by Koloa, as his use of the land had not changed appreciably. He did speculate that use of herbicides on Kohala Ditch trails may help to explain decreasing use by birds. Mr. Lum informed us that migratory ducks visit the marsh area in winter, but only in small numbers. Fluctuations in numbers of ducks in the valley during the winter season suggests a pattern of movement between the valley and other habitat.

We observed six Black-crowned Night Herons on the first day of survey and three on the second. Immature birds were among those sighted on both survey days. This was the only species actually inhabiting the marsh and flooded pasture at the time of surveys. Some herons were flushed from pot-holes within the bulrushes. Others appeared to be stalking tilapia or other prey in the flooded pastureland near the open water. When disturbed, they left the marsh and flew to roosts in nearby hau forest. Whether or not they nest in the valley was not determined, but a small nesting colony would easily go undetected. Suitable feeding habitat for this species probably varies considerably with rainfall patterns. It is likely that herons move regularly between Pololu and other valleys to the southeast, particularly Waimanu and Waipio.

Two Wandering Tattlers were seen at the seaward edge of the marsh, and two others along the rocky shoreline during our survey. Black Noddies were observed along the rocky coast at the front of Pololu Valley. This is typical nesting and roosting habitat for this species, but it is doubtful that they find suitable food in the open water of the Pololu Marsh. William Lum indicated that a small number of Cattle Egrets visit his cattle occasionally, but we did not observe any egrets during our survey.

HABITAT EVALUATION: Our observations, and the information supplied by the resident cattle rancher, indicated that Pololu Valley is currently of marginal value to waterbirds other than herons. It is doubtful that any wetland birds nest in the marsh although a small population of herons may nest in the surrounding forest. The marsh water is so turbid that submergent vegetation does not grow in abundance. The bulrushes are trampled throughout by cattle and provide little refuge for native or migratory birds, as the habitat is now managed primarily for cattle.

The observed reduction in Koloa sightings by the cattle rancher in recent years probably reflects the inability of these hand-reared birds to find suitable nesting or feeding habitat within the lower portion of the valley. Nesting of Koloa and coots is surely inhibited by fluctuating water levels and continual alteration of the habitat by cattle. It would be simple enough to undertake more regular surveys of the site by spotting scope from the overlook above the valley. A series of observations throughout the year would increase our understanding of the site considerably.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: It is hard to imagine how dredging

or filling deposition in this wetland would create conditions of higher turbidity than existed at the time of our surveys. However, the water may clear up naturally some time after rains have ceased. Continuous use of the site by cattle surely increases nutrient levels in the water, but the possible advantages of this are far outweighed by the increased silt load and the damage to potential nesting and feeding habitat.

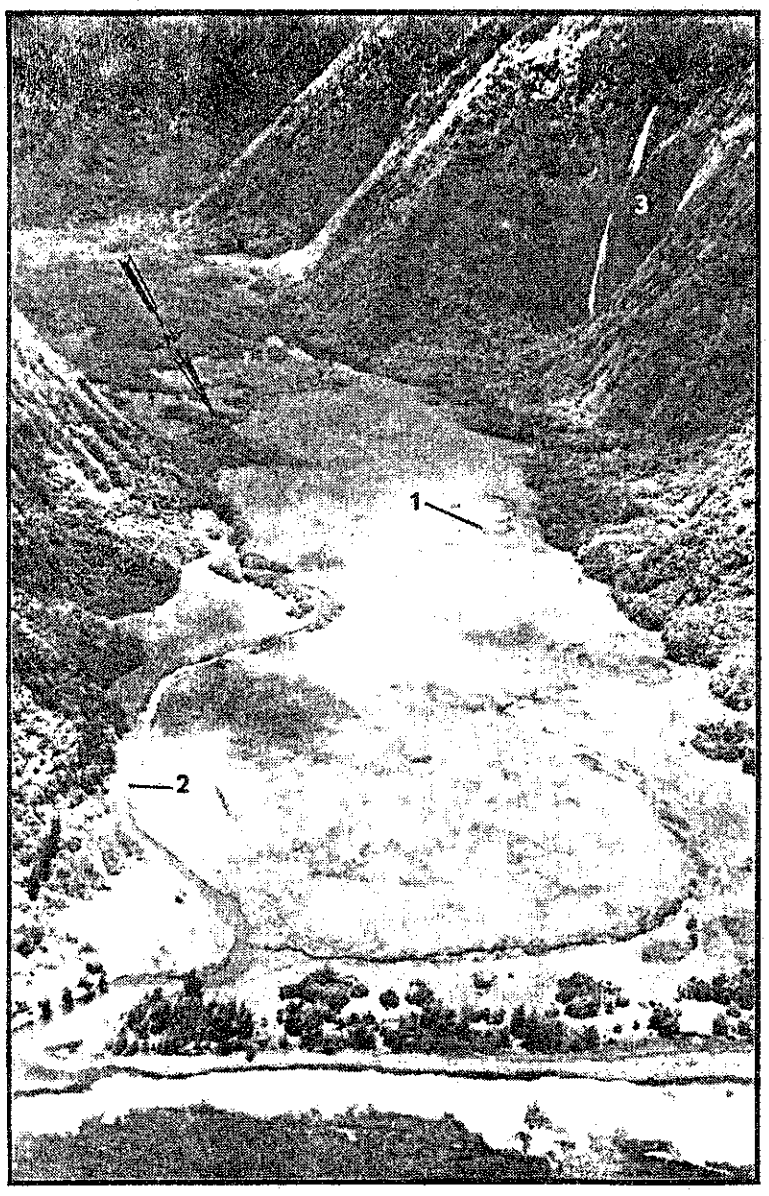
Construction of a rock dam at the outlet has been suggested by USF&WS biologists as an effective means of water level control in the wetland. It is likely that this effort would be a waste of energy in itself if further steps were not taken to improve water quality in the marsh. This would require the exclusion of cattle by fencing from the best potential waterbird areas. Further, dredging of accmulated silt in portions of the marsh would ultimately increase the likelihood that suitable submergent vegation would establish. More extensive dredging in the pastureland bording the marsh could be used to create additional water impoundments, but it would not be justified unless expanded surveys of the area indicated substantial numbers of waterbirds in the present marsh.

SITE NAME: Wai-manu Valley

LOCATION: Hāmākua District, Hawai'i

TOPOGRAPHIC MAP: Honokāne

DATES OF SURVEY: 13-15 September, 1977



1. open water pond
2. Waimanu Stream
3. Waiilikahi Falls

WETLAND DESCRIPTION: Waimanu Valley is one of several stream valleys that cut deeply into the Kohala Mountains. The valley floor is approximately a mile deep and more than 1/4 mile wide at the ocean. The valley walls rise to over 1600 feet. Waimanu Stream, fed by several other streams draining the rear and western valley slopes, runs down the southeast side of the valley floor. The stream is perennial, and is not diverted along its course for irrigation. At the time of survey, Waimanu Stream was running slow and clear. A smaller stream below Waiilikahi Falls, on the west slope of the valley, drains directly into the marsh.

Periodic flooding of Waimanu stream and drainage from west valley slopes have created an extensive marsh in the lower half of the valley floor. The primary vegetation of the marsh includes California grass and bulrush. Some cattails can also be found along the lower portion of the stream. Water permeates the entire marsh but the only open water is a small pond along the west edge of the valley floor. The upper valley floor is predominantly guava forest. The slopes of the lower valley are heavily forested with guava, kukui, mango and hau, while native ohia forest covers the higher elevation interior slopes.

The valley was occupied by humans for many centuries. Remains of water ditches and dikes provide evidence of the extensive rice and taro agriculture in the valley. Mule trains used to carry the harvested crops out of the valley. The trail to Waipio Valley is still existent. The tidal wave of 1946 destroyed all remaining houses and taro fields, and the valley has been undeveloped ever since.

Waimanu Valley has recently been proposed as a federal estuarine sanctuary, as defined in the Coastal Zone Management Act of 1972. The purpose of the estuarine sanctuary program is to provide federal funding on a matching basis to states to acquire and manage estuaries for research and education. Although Waimanu Valley has been officially selected as Hawaii's candidate site, it has not been designated as an estuarine sanctuary as yet. A draft environmental impact statement on the proposed sanctuary, published in 1976, describes Waimanu Stream as the "last perennial, undiverted stream on the island of Hawaii" (78). Designation as a sanctuary would prevent incompatible development, alteration of the flora and fauna and diversion of the stream.

NON-AVIAN WILDLIFE: After brief survey, the macrofauna of Waimanu Stream was recently described in the draft EIS for the estuarine sanctuary (78). Species observed in the stream included:

aholehole	(Kuhlia sancvicensis)
mullet	(Mugil cephalis)
o'opu anihaniha	(Awaous genivittatus)
Tahitian prawn	(Macrobrachium lar)
hihiwai	(Neritina granosa)
brown wi	(Theodoxus vespertina)
bullfrog	(Rana catesbiana)
toad	(Bufo marinus)

The draft EIS also listed several species likely to be present in the stream:

black opae	(Ayta bisulcata)
opae oeha'a	(Macrobrachium grandimanus)
o'opu nakea	(Awaous stamineus)
o'opu nopili	(Sicydium stimponi)
papio	(Caranx sp.)
milkfish	(Chanos chanos)
awaawa	(Elops hawaiensis)

We also found Swordtail fish to be common in all streams. A variety of aquatic insects, including dragonfly adults and naiads, were observed on our survey as sell.

The presence of both rats and mice in the valley was documented on this survey and by Woodside (130). Pigs were also found to be widely distributed in the valley on both studies. Numerous pig trails through the marsh and scats containing seeds of guava were found. Woodside found pigs to be in greatest concentrations at the upstream end of the marsh, but they were fewer in number at the head of the valley and near the mouth of the stream (130). He estimated the pig population at the time of his survey at just under 100 animals.

Mongoose scats and other sign were observed throughout the valley on both surveys. No feral dogs were seen, but hunters regularly bring their dogs into the valley in search of pigs, so it is likely that a small feral population is present. Woodside reported observing two to three Hawaiian Bats or 'opea (Lasiurus cinerius semotus) feeding over the shoreline and inner bay during the evening (130). He estimated the valley population at 6-12 individuals. The species is listed as "endangered on Federal list of endangered species, but it is distributed widely on Hawaii. Bats were not observed during our survey.

NON-WATERBIRD AVIFAUNA: Along the coastal strip of ironwood trees, House Finch, Spotted Doves, Japanese White-eyes and Spotted Munia were common during survey. Common Mynas and Northern Cardinals were less common at this location and elsewhere in the valley. Spotted Munia were also observed in flocks within the march and along Waimanu Stream. All species except the Common Myna were also recorded within the guava forest inland of the marsh. Presumably Melodious Laughing-thrush are also found occasionally in the forested parts of the valley, but they were not recorded on either survey. Woodside also reported Red-billed Leiothrix, 'Elepaio, 'Amakihi and 'Apapane in survey of native forest above 3600 feet, northwest of the valley (130). Hawaiian Hawks ('Io) were observed by Woodside and during our survey but only in small numbers above the ridge trail and along the rim of the valley. Unusual calls heard in the early morning and evening on this survey are believed those of Newell's Shearwaters (Puffinus puffinus newelli). Although largest concentrations of this "threatened" species are found on Kauai, there have been recent sightings (and sound records) of this species on the Hamakua coast and higher elevation forest (528).

WATERBIRDS OBSERVED: It is probably safe to assume that several wetland birds frequented Waimanu Valley when rice and taro were in production. We are unaware of any recent records of ducks in the Waimanu watershed or marsh area, but is likely that both Koloa and some migratory waterfowl visit the stream and the limited open water of the marsh. The undisturbed stream, particularly in the upper valley, is typical of Koloa habitat and could be expected to attract at least some of the captive-reared birds that have been released in recent years on the Kahua Ranch.

Woodside observed "several" adult and juvenile Black-crowned Night Herons along the stream in Waimanu Valley (130). We observed no herons on our survey, although most of the survey time was spent within the marsh. Although herons may nest in the valley, it is more likely that they are temporary visitors that range widely along the Kohala coast. Taro fields and greater coverage of open water in other sites provide more suitable feeding habitat.

Wandering Tattlers were observed regularly along the beach and lower stream on both surveys. The entire length of the stream provides habitat typical of this species. Golden Plovers were observed on Woodside's survey in early October. As our survey was conducted at the time of year (early September) when migratory shorebirds are just returning to Hawaii from their breeding grounds, it is not surprising that no Golden Plovers were seen. White-tailed Tropicbirds and Black Noddies were recorded along the ocean cliffs on both surveys, and are probably present in the area throughout the year.

HABITAT EVALUATION: Even in light of the limited historical data on waterbirds in Waimanu Valley, the recent evidence suggests that the site is of limited value to waterbirds in its present condition. The Black-crowned Night Herons find suitable feeding habitat in the valley, but our surveys indicate that the population is smaller than that in Waipio Valley. There are no taro fields in Waimanu. Those in Waipio provide still, shallow water with a relatively constant supply of food. The only open water in Waimanu, other than the stream itself, is too deep, and its shores too densely vegetated, to provide an accessible source of food for herons. Although the open pond may be attractive to migratory ducks, it is too small to support a significant number of birds on a long-term basis.

If designation of the site as an estuarine sanctuary is finalized, the regulations imposed on human manipulation of the site will probably preclude any ambitious program to improve the habitat for waterbirds. Under sanctuary designation, any diversion of the stream water will be prohibited, as will any clearing, logging, or construction of buildings (other than a resident manager's cabin) (78). A wooden walkway may be constructed over portions of the existing marsh, but there will be no attempt to clear vegetation as a means to increase open water.

Planned efforts at mammal (mongoose, pig) control may have long-range benefits for waterbirds, as there is presently very little habitat that is not accessible to these species. It is also possible that Waimanu may be considered as a possible site for reintroduction of Koloa, as the valley is certainly within its former, if not present, range. Yet, this may also be viewed as an unnecessary manipulation of the natural environment, and may be considered contrary to the intent of estuarine sanctuary designation. If a "no change" attitude is maintained in the future management of the area, it is likely its present limited value to waterbirds will remain constant or even diminish with the natural encroachment of marsh vegetation.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: As estuarine sanctuary designation is almost certain in the near future, dredge or fill operations are not likely to occur in this wetland. Even without this designation, the isolation of the site makes the transport of man and necessary equipment difficult and costly, if

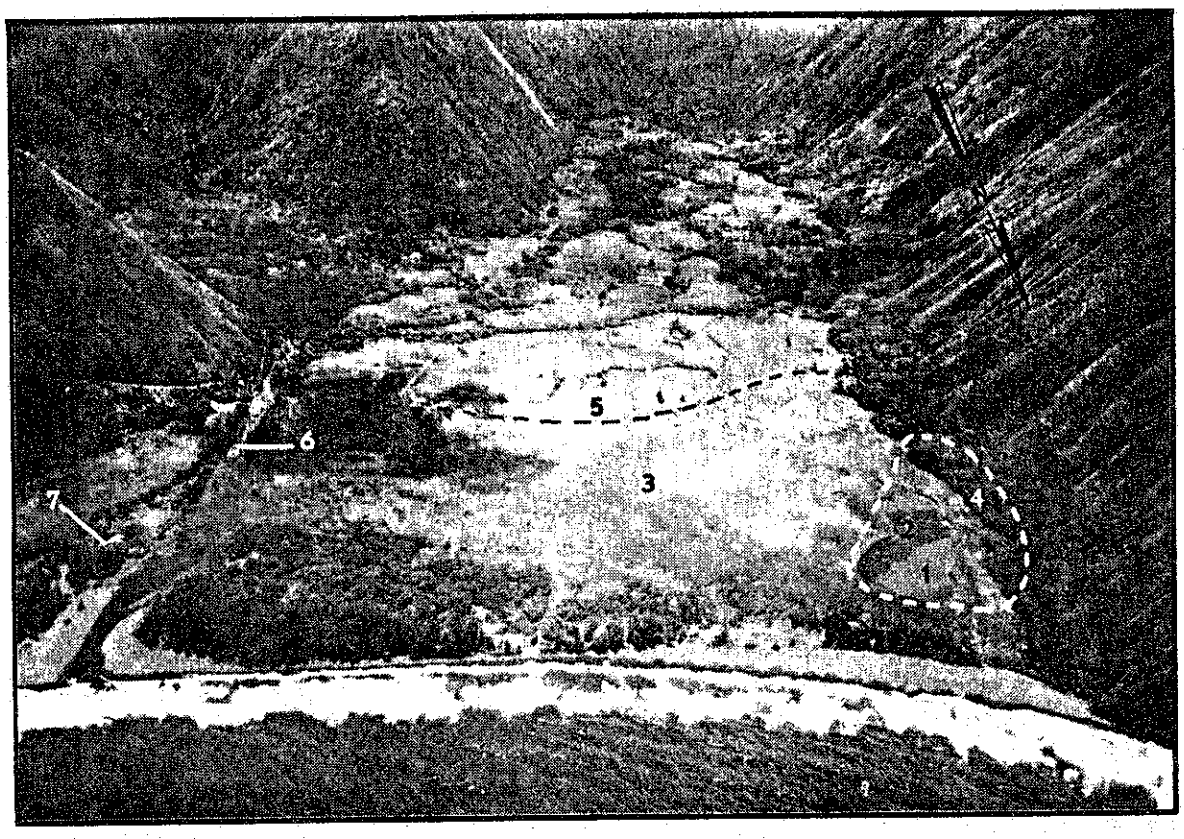
not impossible. Improvement of waterbird habitat could best be accomplished, under these circumstances, by blasting of potholes in areas where grasses and sedge have over taken wetlands. This would increase the amount of open water available to waterbirds with little, or no, long-term impact on marsh ecology. However, it is likely that such habitat modification would not be in keeping with estuarine sanctuary plans.

SITE NAME: Wai-pi'o Valley

LOCATION: Hāmākua District, Hawai'i

TOPOGRAPHIC MAP: Kukui-haele

DATES OF SURVEY: 7 May, 13 September, 1977



1. pond
2. water hyacinth
3. cattail marsh (formerly rice & taro)
4. primary heron distribution on survey
5. lower limits of taro
6. Waipio Stream
7. Lalakea Fishpond site

WETLAND DESCRIPTION: Waipio Valley one of several deep valleys that penetrate the northeast coastline of the Kohala Mountains, Several tributaries feed Waipio Stream, although some of the flow has been diverted into extensive ditch systems for irrigation along the way. Even the base flow in the valley floor has been diverted by smaller ditches to feed taro fields and fill other needs for water. The slopes of the valley are steep and rocky, but heavily forested. The upper half of the valley floor is also forested where it has not been cleared for agriculture. The central valley is dominated by taro fields, while the lower third of the valley floor is now covered by an extensive marsh, dominated by cattails, California grass and bulrush. Forested sand dunes separate the marsh from the beach. The lower marsh was actively cultivated for rice production in the late 1800's and converted to taro in the early part of this century. The tidal wave of 1946 eliminated this lower valley crop, and the encroachment of cattails and other marsh vegetation has continued ever since.

A large pond on the north edge of the lower valley provides the only still-water wetland bird habitat other than the taro fields. This pond is partially covered by a surface mat of water hyacinth that changes in size and location with patterns of wind and rainfall. The stream in the lower valley runs between 2-4' deep, and moves at a rapid rate throughout its course. Areas of low circulation along the lower portion of the stream have also been invaded by water hyacinth. Water floods the stream banks during heavy rains, and permeates the entire cattail marsh. Salinity in the marsh and pond of the lower valley may vary somewhat with underground salt water intrusion and as a result of periodic storm conditions that cause the ocean water to flood over the dunes. (unpublished USF&WS data).

NON-AVIAN WILDLIFE: The aquatic fauna of lower Waipio Stream is largely typical of other estuarine areas in Hawaii when connection to the ocean is maintained. Mullet, o'opu and probably milkfish enter the lower stream. Mosquito fish were observed in the stream and in the north edge of the lower marsh. Tilapia were abundant in the north pond. One taro farmer indicated that he periodically fished the pond for mullet as well. Bullfrogs were heard and observed around the entire periphery of the cattail marsh and at the north pond.

The most abundant invertebrate at the edge of the marsh and in the taro fields was the freshwater snail, Melania. Other smaller gastropod molluscs were seen also, but not identified. 'Opae shrimp and introduced prawns (Macrobrachium lar) are surely present in the stream drainage. Several kinds of aquatic insects, as well as a large number of dragonfly naiads, were observed within the taro fields.

NON-WATERBIRD AVIFAUNA: The most common birds throughout the forested areas of Waipio Valley were Japanese White-eyes and Northern Cardinals. House Finch, Common Myna and Spotted Munia were locally common but not widely distributed during our surveys. Only four Barred Doves were observed on the first day of survey. Two Melodious Laughing-thrush were heard in the south side of the upper valley, although the species is probably distributed widely in low numbers within the forested lands throughout the valley. Hawaiian Owls and Hawaiian Hawks have been reported within the valley as well.

WATERBIRDS OBSERVED: The only waterbird species recorded in the valley during our two widely separated visits were the Black-crowned Night Heron ('Auku'u)

and Wandering Tattler. There were at least eight herons in the valley during the first trip. Most were feeding at the north pond or roosting in nearby monkeypod trees. Two of those observed were juveniles. A thorough examination of the monkeypod forest that follows the trail on the northwest side of the valley revealed no heron nests, but it is quite possible that they do nest farther up in the valley. Of more than a half dozen landowners we talked with, none could recall ever seeing a heron nest or rookery in the valley.

Herons at the north pond were walking across the hyacinth, searching most of the time, but occasionally striking at fish and possibly bullfrogs. The water is too deep in this pond to permit the birds to wade for food, so the hyacinth provides the only platform from which to feed. The shallow water at the edge of the cattail marsh is somewhat protected by dense forest, but herons probably feed in this area as well. Taro farmers reported that herons regularly enter their fields to feed as well. It seems likely that the shallower portions of Waipio Stream also provide suitable feeding habitat. Gill reported on a trip into Waipio Valley shortly after the war when he counted "two score" herons at rest in kukui trees (488).

At least two published reports on wetland birds have mentioned that Waipio Valley is occasionally attractive to a few Hawaiian Coots (343,346). However, we could find no records of HDF&G or USF&WS surveys during which this species was noted in the valley. Further, none of the taro farmers that we consulted had seen coots in their fields, although some were familiar with the species from other locations. The Hawaiian Gallinule does not appear in HDF&G/USF&WS count records for the valley and taro farmers we spoke to did not recognize pictures of the bird. However, a USF&WS "Biological Ascertainment Report" written in 1971 mentions the value of the valley for coots, gallinules, stilt and ducks. Although it is virtually certain that all these species inhabited the area when the lower valley was in rice or taro production, we could find no evidence that any of these except the ducks still visit the site.

Migratory ducks appear on only one recent semi-annual HDG&G/USF&WS count for Waipio Valley, yet several landowners confirmed that these birds visit the area every year. At one time, during World War II, permits were issued to shoot "wild ducks" because they pulled up the newly planted taro (487). Both Pintails and Shovelers feed in the north pond and within the taro fields in mid-valley. Other species may be there as well, but the landowners are not qualified to distinguish them. The taro farmers agreed that numbers of ducks in the valley were never great in recent years, but that winter populations varied considerably, often from day to day.

One landowner that appeared to be quite familiar with waterbirds indicated that he had observed a flock of 10-12 Koloa in the north pond two years prior to this survey. It is likely that Koloa from recent releases on Kahua Ranch now inhabit the ditch systems and upper stream in Waipio Valley. Waipio Valley has been considered by HDF&G biologists as a potential future release site for Koloa (476). Problems of security, access and human disturbance lessen the value of the site for this purpose. The species does not appear on recent winter count records, but the valley is not covered completely on these surveys. This is evidenced by the fact that herons also appear on only one recent count, even though taro farmers report that they are well-established in the valley

throughout the year.

Three Wandering Tattlers were observed on our survey. All were searching for food along the beach. It would not be surprising to find them feeding at any point along the stream as well. Although Golden Plovers were not seen, it is quite certain that they visit the valley in considerable numbers during fall and winter months.

Although the Valley has not been surveyed regularly except during semi-annual HDG&G/USF&WS counts, some unusual straggler species have been noted. Walker reported observation of a Bonaparte's Guss and a Ring-billed Gull feeding along the shore in January, 1959 (497).

HABITAT EVALUATION: There is no question that the amount of suitable waterbird habitat in Waipio Valley has diminished with the reduction in taro and rice crops. The remaining open water and dense cattail marsh provides only marginal habitat for waterbirds in the present condition. The lower valley is relatively undisturbed by human activity and shows considerable potential for habitat improvement. There appears to be a good opportunity to combine waterbird habitat management with commercially viable agriculture. Most of the taro farmers with whom we discussed the condition of the cattail marsh felt strongly that it was wasted wetland in its present state. It does not support a large number or wide variety of waterbirds, and will continue to deteriorate with disuse.

POTENTIAL IMPACT OF DREDGE/FILL ACTIVITIES: The potential of the lower valley as waterbird habitat can only be realized with extensive clearing of vegetation, creation of water impoundment areas, and diversion of stream water. Each of these activities requires some dredging and fill deposition. The lower valley could be developed principally for birds, or alternatively, a combined taro/waterbird habitat program could be implemented. The latter approach would be attractive to valley farmers and may be more economically and politically feasible. The remnant water impoundments used in rice and taro production could be repaired after dredging of encroaching vegetation and accumulated silt. Extensive deposition of fill along the beach berm may be necessary to protect the habitat, and the lower valley farms, from damage during future tidal waves. Damming and diversion of the stream at the upper end of the new habitat, and a water control structure at the outlet, would allow effective water level manipulation. If the lower valley habitat is improved, it may then be advisable to reconsider the possibility of Koloa releases at this site.

It should be noted that the condition of the habitat in the lower valley, whether improved or left as it is now, is dependant upon the condition and amount of stream flow that reaches it. Some taro farmers in the mid-valley area complain bitterly about excessive diversion of water from the stream at points inland from their farms. A more effective plan to insure equitable distribution of water throughout the valley should be implemented.