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Lakes and Lake-like Waters Of the Hawaiian Archipelago

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ABSTRACT

THIS SUMMARY of Hawaiian lacustrine limnology is based on 12 years of field and literature surveys of archipelagic inland waters. Lakes here are distinguished from other standing waters by limits on surface oceanic area (> 0.1 ha) and depth (> 2 m), and by the absence of natural surface oceanic connection. A variety of extinct and existing water bodies, sometimes referred to as lakes, are noted. Six lakes are described. Five of them are in crater basins, 3 are freshwater, and 2 are elevated (highest = 3969 m). The scarcity of elevated lakes results from general permeability of the substrata. Among the 6 lakes, surface areas range from 0.22 to 88 ha and maximum depths from 3 to 248 m. Naturally occurring aquatic biota generally is low in species diversity except for phytoplankton; fishes and submersed vascular plants are absent. Two lowland lakes, freshwater Green (Wai a Pele) and saline Kauhakō, are described for the first time. Profundal Kauhakō, 248 m deep, has a surface area of only 0.35 ha, which results in an extraordinary relative depth of 370%. It is permanently stratified, a condition apparently due primarily to the unique morphometry of its basin.

INTRODUCTION

A large number of Hawaiian standing waters have been referred to in recent reports concerning aquatic ecosystem classification and inventory (Maciolek 1975, 1978; Shallenberger 1977). Included were pools, marshes, natural and artifical ponds, reservoirs, lakes, and estuaries. The purpose of this report is to present a comprehensive regional (archipelagic) summary of information limited to natural lakes and lake-like waters. It is based on a dozen years of sporadic field work and literature review.

Distinguishing small lakes from other lentic waters is arbitrary and thus requires a limiting definition. Size (surface area) and depth are features used to differentiate lakes from allied

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waters (Reid 1961). In this report, I define a lake as a lentic water body of natural origin with a surface are of more than 0.1 ha, a maximum depth (Z_m) greater than 2 m,[2] and absence of a natural oceanic connection (surface or subsurface) of a magnitude sufficient to cause noticeable tidal fluctuations. This definition excludes the more than 400 reservoirs in the state, as well as numerous palustrine and estuarine waters. Although lakes as defined above are emphasized here, examples of other water bodies sometimes popularly referred to as lakes are described briefly for their limnological relevance.

University of Hawaii students assisting in field surveys were Carl Couret, John Ford, Wilbert Kubota, James McVey, Rodney Nakano, Carol-Ann Uetake, and Diana Wong. The University's Water Resources Research Center provided chemical analyses of the water from 2 lakes. Special thanks are extended to Diana Wong for algal identifications and to Dr. Amadeo Timbol for assistance in locating obscure literature.

NONLACUSTRINE WATER BODIES

Several existing and extinct water bodies that might be construed as lakes, or that are referred to as lakes in literature or on maps, do not qualify as such by the definition employed here. Examples of such water bodies are described below and located by letter in Figure 1.

Extinct Waters

Oahu's 20-ha Salt Lake (Āliapa'akai) is featured prominently on current issues of road and topographic maps, including that in the *Atlas of Hawaii* (Armstrong 1973), as occupying a low crater about 2 km inland between Pearl Harbor and Honolulu. Legend held that it was "fathomless," a belief persisting until recent years despite soundings made by the U.S. Exploring Expedition in 1840 (Wilkes 1845) that proved it was "no deeper than 18 inches." Originally, Salt Lake was an evaporation basin fed by seawater seepages at highest tides and producing large quantities of crustal salt for domestic use (Alexander 1926). Analysis of its water in 1891 (Lyons 1891) indicated a salinity of nearly 400°/oo (specific gravity 1.256) and an unusual ionic content with low sulphate, and dominant sodium, magnesium, and chloride. In the early 1900s, freshwater from an artesian well and drainage from higher adjacent craters were admitted to the basin, greatly reducing its salinity (Smith 1926). Thereafter, it was used as a commercial fishpond for mullet and milkfish. Most of the basin was filled in recent years to develop a golf course. Ka'elepulu Pond, a shallow estuarine basin on windward O'ahu originally more than 80 ha in area, is another water that has been mostly filled and revetted for residential development (Shallenberger 1977).

Two large (each ca. 120 ha) and apparently perennial unnamed water bodies are shown on an old (1910 data) U.S. Geological Survey (USGS) topographic map of Kaua'i. They were located in depressions on a large low, marshy, sedimentary plain (Mānā) on the southwestern side of the island. These waters were described as "shallow, salty. . ." by Hinds (1930). Local lore holds that at one time it was possible to navigate this marsh by canoe for a distance of more than 10 km. However, it is improbable that water depth then exceeded 1 m. The marsh was drained and filled many decades ago to provide land for sugar cane cultivation.

Existing Elevated Waters

Near the remote summit of West Maui, at an elevation of 1530 m, is a water body known as Violet Lake. It is thus designated on the USGS Lahaina Quadrangle. According to a footnote to statistical tables in the *Atlas of Hawaii* (Armstrong 1973), it has a surface area of 3.0 acres. I found it to be a bog pool with a surface area of about 100 m^2 lying in an area of high rainfall (ca. 1000 cm/yr). The water was clear but deeply stained with humic leachates, much like that of lake Wai'ele'ele on East Maui (see below).

2. This depth agrees with the depth limit of Cowardin et al. (1979) for limnetic "deep-water habitats" and its biological relevance; in Hawai'i, 2 m also is the approximate lower limit at which thermal stratification can be readily observed.

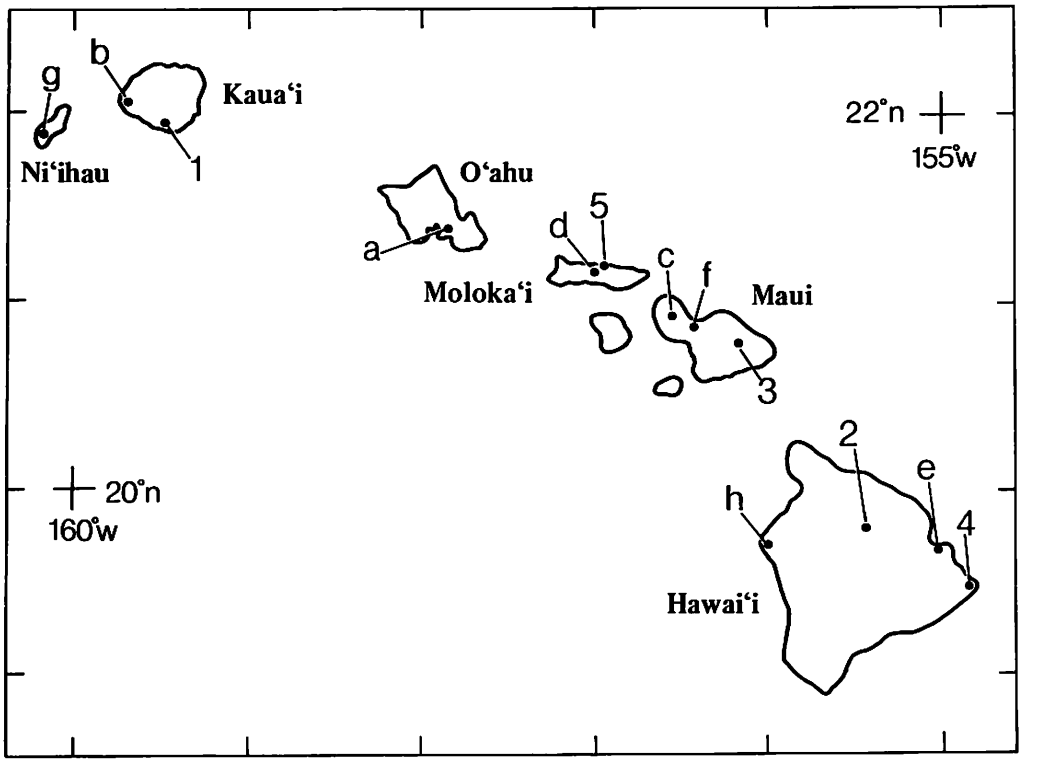

Figure 1. Windward or southeastern part of the Hawaiian Archipelago, showing island locations of water bodies described in the text. Numbers designate natural lakes (1—Nōmilu, 2—Waiau, 3—Wai'ele'ele, 4—Green, 5—Kauhakō); letters refer to other waters, existing and extinct (a—Salt Lake, b—Mānā Marsh, c—Violet Lake, d—Meyer Lake, e—Waiākea Pond, f—Kanahā Pond, g—Halulu, Halāli'i Playas, h—'Aimakapā).

Another water on Maui designated as a lake is Wai'ānapanapa, located at about 3070 m elevation on the windward slope of Haleakalā (USGS Nahiku Quadrangle). Field survey showed it to be a small (<0.1 ha) shallow marshy pond in a strongly weathered, steep-sided crater. Visible water, maintained by frequent precipitation, is said to disappear during prolonged rainless periods.

Meyer Lake is shown on the USGS Molokai Island topographic and quadrangle (Kaunakakai) maps. It is listed in the *Atlas of Hawaii* (Armstrong 1973) as the largest lake on Moloka'i: 6 acres (2.43 ha; elevation, 616 m). Meyer Lake was described earlier by Stearns and Macdonald (1947) as occurring in a natural basin whose capacity was extended by the construction of a small dam. They found it variable in surface area up to 10.3 acres (4.2 ha) and 5 ft (1.5 m) deep. Clearly, Meyer Lake now is an impoundment. It is of historic interest as the apparent site from which Sars (1904) described several species of zooplankton, including a new copepod (*Attheyella coronata*).

Existing Lowland Waters

Three sea-level water bodies are listed in the *Atlas of Hawaii* (Armstrong 1973) as the largest lakes on their respective islands: Waiākea Pond, Hawai'i; Kanahā Pond, Maui; and Halulu Lake, Ni'ihau. Waiākea is a shallow (Z_m ca. 2 m), 11-ha tidal pond in Hilo. Its basin and short outlet (Wailoa R.) have been modified in recent years by dredging, filling, and revetment. Several large freshwater springs discharge in the landward portions of the pond. Open connection to the ocean allows seawater intrusion, causing strong vertical salinity stratification in most of the

basin. Freshwater vascular plants (*Hippuris, Elodea, Myriophyllum*) grow profusely in the springflow areas. Macrofauna is varied and estuarine in character (including mugilid, gobioid, and kuhliid fishes, portunid and grapsid crabs, neritid gastropods). Waiākea, in strict classification, is an estuarine limnocrene. Other spring-fed pools in the area, such as Loko Waka (Madden and Paulson 1977), are similar in ecological character.

Kanahā Pond, Maui, is a shallow (<1 m deep) brackish coastal basin with a listed surface area of 16.6 ha (Armstrong 1973). It is a fishpond of Hawaiian cultural origin that has been strongly modified in recent decades (Shallenberger 1977). It was connected to the ocean by a channel and supported a mullet fishery at least until the 1940s. Thereafter, advanced eutrophic conditions developed and aquatic macrofauna became restricted to a few tolerant species (e.g., tilapia). Kanahā is classified as a saline marsh which has been perpetuated in a modified state because of its value as a waterbird refuge. Another saline marsh nearby, Keālia Pond, has been described elsewhere (Maciolek 1971, Shallenberger 1977).

"Lake" Halulu is one of several playas on the low arid plains of Ni'ihau Island (Figures 276-278 of Macdonald and Abbott 1970). Halulu and adjacent Halāli'i are the two largest, with maximum surface areas of about 150 and 350 ha, respectively (estimated from USGS Niihau Topographic Map, 1:62,500 scale). Normally, the basins are inundated annually by winter rains. Stearns (1947) noted: "During May 1945 nearly every lake bed was covered with fresh [*sic*] water. Most of the lakes are typical playas and soon evaporate, leaving salts behind." The author further noted that Halulu does not evaporate completely because of a spring seepage that is "too salty for stock." Water, when present, apparently varies from mixohaline (0.5-30°/oo) to hyperhaline (> 40°/oo). Salt is harvested by the residents during the dry season. Inasmuch as all basins probably receive aeolian detritus when flooded, and some (such as Halāli'i) receive considerable surface runoff containing fine alluvium, the basins probably are maintained by deflation when dry.

A final type of lentic water that might be misconstrued as a lake ecosystem is represented by 6-ha 'Aimakapā. 'Aimakapā is the largest Hawaiian example of an ecologically distinct ecosystem class, "anchialine," a term proposed by Holthuis (1973) in reference to saline (mixohaline) coastal pools not surface-connected to the ocean, but showing tidal fluctuations. Ecological distinctiveness is mainly in the biota, particularly the unique decapod crustaceans. Most anchialine waters are very small and shallow. 'Aimakapā and other nonlacustrine waters of the leeward coast of the island of Hawai'i were inventoried and described by Maciolek and Brock (1974).

LACUSTRINE WATER BODIES

Locations of 5 of the 6 lacustrine waters that qualify as lakes by present definition are shown in Figure 1 (numerals). The sixth, described here first, is situated on a flat island (Laysan) about 1500 km to the northwest of O'ahu.

Laysan

The only Hawaiian lake mentioned by Hutchinson (1956) in his world-wide treatment of lakes is the closed lagoon on Laysan (Fig. 2), a flat island in the uninhabited northwestern part of the archipelago that is part of the Hawaiian Islands National Wildlife Refuge. The island and lake were described by Ely and Clapp (1973). The lake evidently has no subsurface connection to the ocean. Its water is derived mainly from rainfall, but some may result from large storm waves and tsunamis. Although the lake is perennial, it varies considerably in depth, surface area, and salinity. Nearly 20 years of guano mining (1891-1910) and defloration by feral herbivores caused sand and soil to shift, changing island topography and reducing lake depth to about 5 m. Salinity, measured on various occasions since 1858, has ranged from 40 to 150°/oo (Warner 1963 and personal observations). As shown in Figure 2, the maximum expanse of the basin is 88 ha, and the water surface area was about 65 ha in January 1966. The lake is inhabited by a

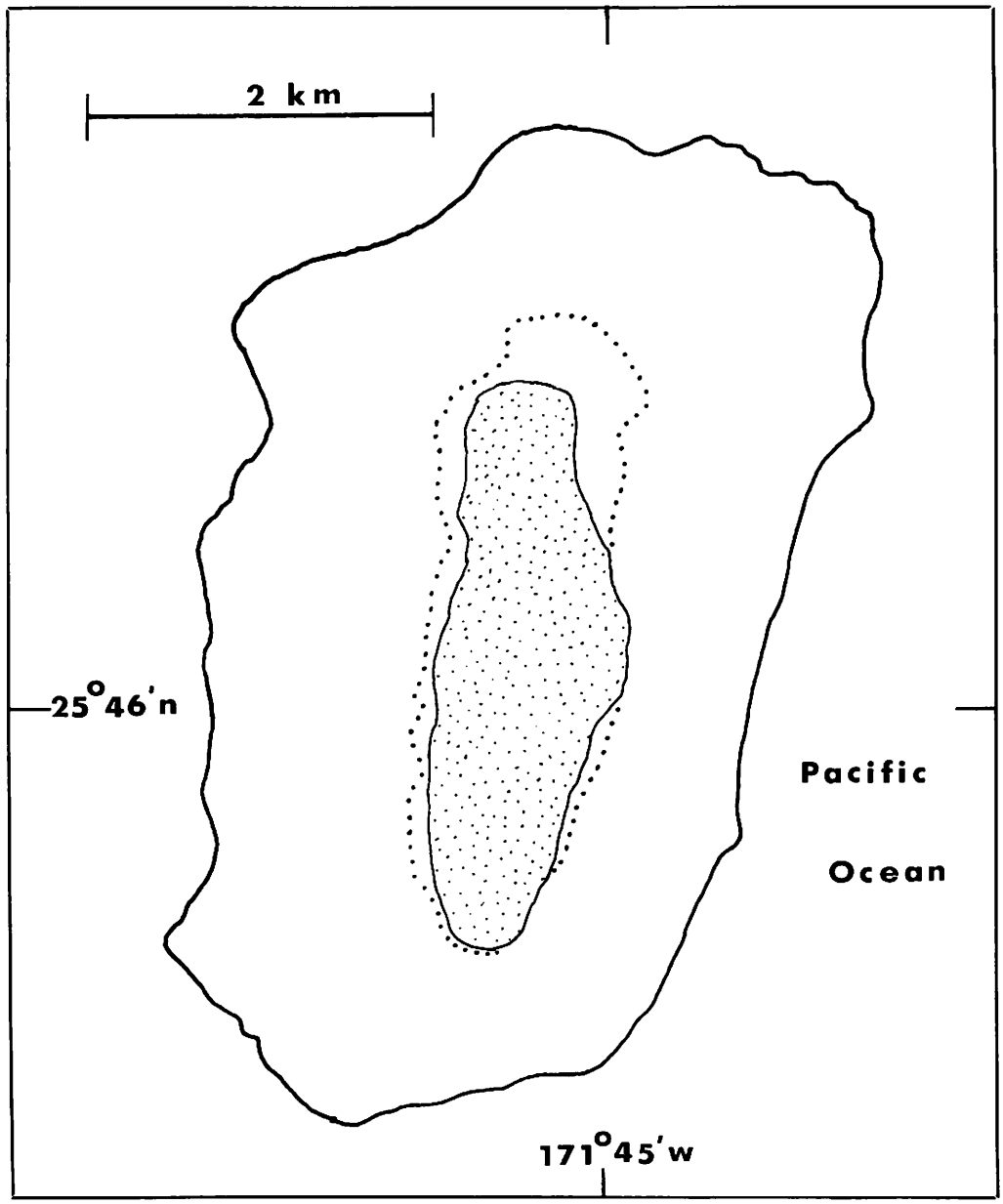

Figure 2. Laysan, a flat island in the leeward archipelago about 1500 km northwest of O'ahu, contains a hypersaline lake (stippled area; dotted line is maximum extent of lake basin indicated by vegetation line). Laysan map drawn from U.S. Navy photograph taken January 1966 (see Ely and Clapp 1973).

duck (*Anas laysanensis*) endemic to the island. Aquatic fauna is limited to salt-tolerant invertebrates such as brine shrimp (*Artemia*) and brine flies (*Neoscatella*) (Warner 1963). Laysan is the only lake in Hawai'i that is not primarily volcanic in origin.

Nōmilu

Nōmilu, on the south shore of Kaua'i Island has a surface area of about 8 ha and is in a shoreline crater whose seaward side is sealed by a broad beach bar. Soundings made more than a

century ago indicated a maximum depth of 20 m (Bates 1854). The lake basin apparently was flooded by euhaline basal ground water, but its original water character and biota are unknown. It was long used for fish rearing (e.g., mullet) by Hawaiians, as it is today (Kikuchi and Stauder

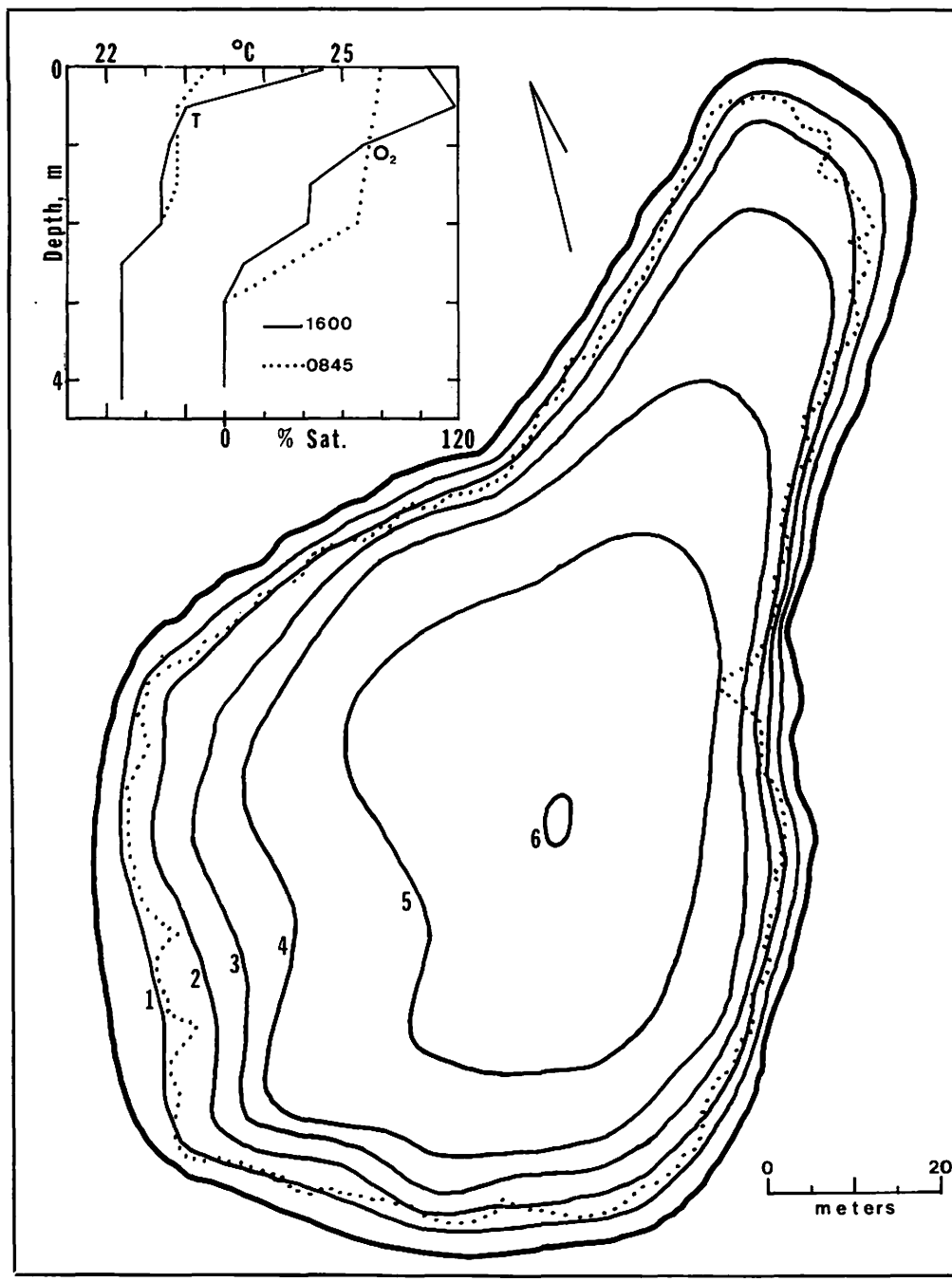

Figure 3. Green Lake (Puna District, Hawai'i Island) is situated in Kapoho Crater about 2 km from the ocean. Depth contours are in meters; dotted line indicates extent of overhanging riparian vegetation. Inset contains depth profiles of temperature (°C) and dissolved oxygen (% saturation) recorded in afternoon (1600 h) and following morning (0845 h), 27 and 28 December 1973.

1976). Isolation from the ocean was disrupted by the digging of one or more channels through the beach bar. Because channels proved difficult to maintain, a tunnel was excavated through the crater's side in about 1921, making a narrow connection to the ocean. The water is now slightly hyperhaline (38-42°/oo, Madden and Paulson 1977), and diverse inshore marine algae and invertebrates (crustaceans, mollusks, etc.) occur there.

Waiau and Wai'ele'ele

These two elevated lakes were described by Maciolek (1969). One of them, Waiau at 3969 m on Mauna Kea, on the island of Hawai'i, has been noted in older geological literature (Gregory and Wentworth 1937, Stearns and Macdonald 1946, Wentworth and Powers 1943). Physicochemical features listed in Table 1 were adapted in part from Woodcock and Groves (1969) and Massey (1978a). Waiau, 0.73 ha in surface area when overflowing and situated in a low glaciated cinder cone in a dry alpine tundra (the "Puna" region of Löffler 1964), is the shallowest Hawaiian lake (Z_m = 3 m). Dissolved mineral content is moderate (ca. 70 mg/ℓ). Aquatic species are few, presumably because of the lake's isolation and low temperature. Diatoms dominate the phytoplankton, and the bottom has an extensive benthic mat of blue-green algae (Hartt and Neal 1940, Neal 1939). Massey (1978a, b) described a new species of diatom (*Stauroneis maunakeaensis*) and noted a relatively high maximum rate of primary production (350 mg C/m^2 per day). In addition to the few invertebrates reported previously (cladoceran, midge, oligochaete), a small immigrant beetle (*Hygrotus medialis*) recently became established in the lake.

Wai'ele'ele, at 3040 m on windward Haleakalā, island of Maui, is the smallest Hawaiian lake (0.22 ha) as well as the deepest freshwater lake (6.4 m). As a result of its location in a small, heavily vegetated crater in a high rainfall zone (ca. 800 cm/yr), water is extremely low in minerals (8 mg/ℓ) but high in humic acids (12 mg organic C/ℓ). Aquatic biota is also species-poor but differs from Waiau's, particularly by the presence of two types of Odonata.

Green Lake

One of 2 sea level lakes not described previously is in a prominent crater (Kapoho) on the island of Hawai'i about 2 km inland near Cape Kumukahi, the easternmost land point of the archipelago. It is in an area of active volcanism along the eastern rift zone of Kīlauea Volcano (Macdonald and Abbott 1970). Results of a 1973 limnological survey are presented in Figure 3 and Table 1. This lake, which has a surface area of 0.8 ha and a dissolved mineral content of 300 mg/ℓ, is the largest natural freshwater lake in Hawai'i. It occurs in an area of moderate precipitation (ca. 250 cm/yr), and water-level fluctuations were not observed. Although Stearns and Macdonald (1946) speculated that Green Lake is "probably perched water," the absence of surface level fluctuation suggests that it is an exposure of the limnetic portion of the basal water table, elevated a meter or so above sea level. An interesting environmental feature is the extensiveness of dense overhanging vegetation (mainly *Hibiscus tiliaceous*), which shades about 20% of the lake's surface.

Measurements made during the afternoon of 27 December 1973 (inset, Fig. 3) showed that the lake was stratified thermally between 25 and 22.2 °C, and that water below 3 m was anoxic. A slight chemical stratification also was present (specific conductance was 430 μmhos above 2 m and 440 μmhos below). A brisk wind ensued during the night, weakening the stratification on the morning of 28 December (dotted lines in inset, Fig. 3). These data (extent of anoxia, water temperature and conductivity, location, and climate) suggest that Green Lake is stratified during most of the year, but overturns in winter and thus is warm monomictic.

Green Lake (originally Wai a Pele) probably derives its name from the apparent color of the turbid, phytoplankton-rich surface layer. The following algal genera were identified from samples taken in December 1973:

Bacillariophyta
Amphora
Gomphonema
Nitzchia

Chlorophyta
Ankistrodesmus
Chlamydomonas
Closteriopsis
Crucigenia
Dictyosphaerium
Gonium
Kirchneriella
Oocystis
Scenedesmus
Selenastrum

Chrysophyta
Chromulina

Cyanophyta
Aphanothece
Merismopedia
Microcystis
Oscillatoria

Euglenophyta
Euglena
Phacus
Trachelomonas

Pyrrophyta
Gymnodinium
Peridinium

Observed among the diverse invertebrate fauna were copepods, ostracods, chironomid larvae, thiarid and ancylid gastropods, leeches, dytiscid beetle larvae and adults, backswimmers, and bryozoan colonies (*Plumatella*). The bluegill (*Lepomis macrochirus*) was stocked in the lake in 1952 (Brock 1952), but angling and gillnetting produced no evidence of that fish during the

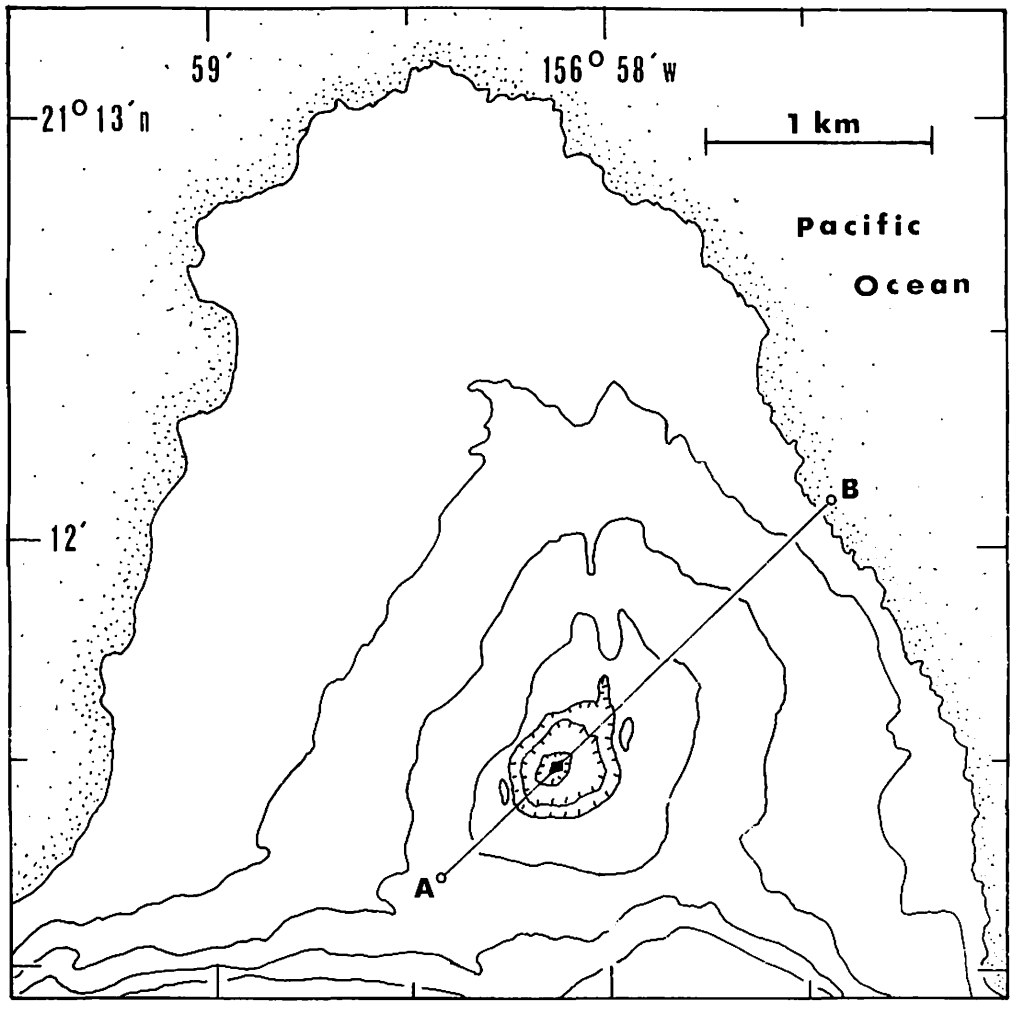

Figure 4. Kalaupapa Peninsula, Moloka'i Island, is a small basaltic shield produced during the late Pleistocene by Kauhakō Volcano whose crater now contains the profundal lake basin shown in Figures 5 and 6. Transect line A–B is the vertical profile in Figure 5.

1973 survey. The after-effects of a spectacular volcanic eruption in 1960 (Macdonald and Abbott 1970), only 1 km away, may have killed the fish; local residents recalled a thick, floating layer of pumice and ash that persisted on the surface of Green Lake for several weeks. The 1973 fish sampling did, however, yield a few specimens of the Asian catfish, *Clarias fuscus*, and also solved the mystery of "rises" (disturbances) on the lake surface. Demersal *Clarias*, not previously recorded from this lake, apparently survives the partly anoxic habitat by periodically surfacing to gulp air into its accessory lung. Guts of the catfish contained remains of invertebrates, as well as a filamentous alga (*Draparnaldia*?) and fragments of higher plants.

Kauhakō

The other sea-level lake is a smaller body of water in Kauhakō, a precipitous crater which is the source of late Pleistocene basalt forming Kalaupapa Peninsula, Moloka'i (Fig. 4). in geological literature (Stearns and Macdonald 1947, Macdonald and Abbott 1970) the water is described only as a brackish pool. A survey conducted in part during August 1973 and April 1974 showed the water to be nearly 250 m deep. The depth of Lake Kauhakō was first noted by Maciolek (1975). Topographic relations of the lake, crater, and peninsula are profiled in Figure 5. The lake surface is well protected from prevailing trades and other strong winds. The lake basin was formed during terminal stages of volcanic activity by magma withdrawal, the vertical magnitude of which is unusual in so small a crater. Short-term surface level fluctuations of a few centimeters, possibly tidal, were observed in 1973 but not in 1974.

The apparent basin morphology of Kauhakō is shown in Figure 6. Bathymetric accuracy is unknown because of the difficulty of detecting bottom contact with a sounding weight in places where the basin declivity is extreme. Derived morphometric characteristics are listed in Table 1. The small surface area (0.35 ha) and great depth (Z_m = 248 m) result in the remarkable 370% relative depth (Z_r) and 237% basin mean slope. Cole (1975) noted that some types of lakes, including those in calderas, may have high relative depths; highest among examples of extreme relative depths he cited was a Z_r of 23.2%. He also noted that small lakes can have high relative depths but large lakes cannot, a condition also applicable to percent slope.

Measurements of temperature, salinity, and oxygen (inset, Fig. 5) show a dichothermic profile (coldest water at intermediate depth) with definite salinity stratification (euhaline below 8 m) and anoxia below 5 m. Physicochemical conditions at 10 m (Fig. 5) continued unchanged to at least 30 m (measurement depth limited by length of instrument leads). Similar temperature and oxygen conditions were observed in August (1973), except that above 4 m the water tem-

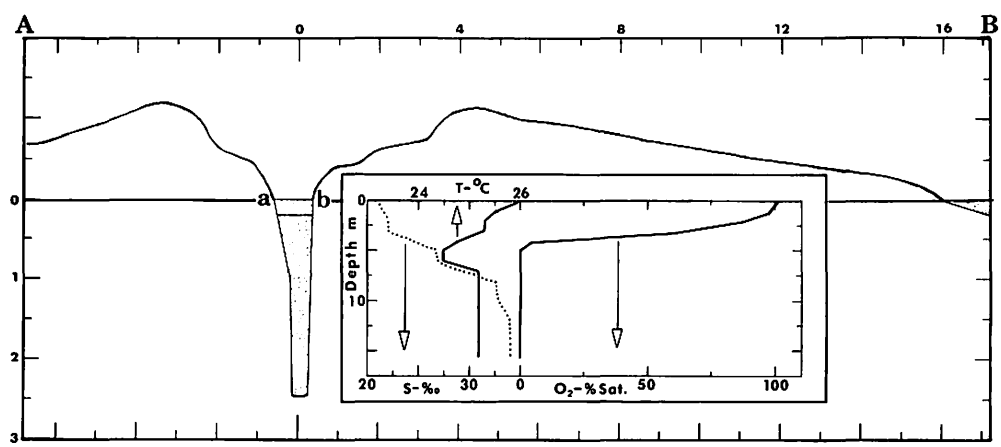

Figure 5. Vertical profile through Kalaupapa Peninsula, Moloka'i Island, along a 2400 m southwest-northeast line centered on Kauhakō Crater (cf. Fig. 4) and sea level. Scale values are in hundreds of meters. Line transects Lake Kauhakō (stippled area) through long axis (cf. Fig. 6); coastline is at extreme right. Inset contains oxygen, salinity, and temperature profiles recorded at 1400 h, 9 April 1974.

perature was 1 °C higher. Lower salinity at the surface (21°/oo) probably is the combined result of direct precipitation and ground seepage (rainfall ca. 100 cm/yr). Considering the crater-basin morphology (Fig. 5), it seems unlikely that wind could ever effect complete mixing (holomixis). Wind effect, however, was apparent in the surface layer where salinity and temperature profiles (inset, Fig. 5) indicate mixing to a depth of about 4 m. Thus, Kauhakō is strongly meromictic (partially circulating), 99% of its volume consisting of a stagnant lower zone.

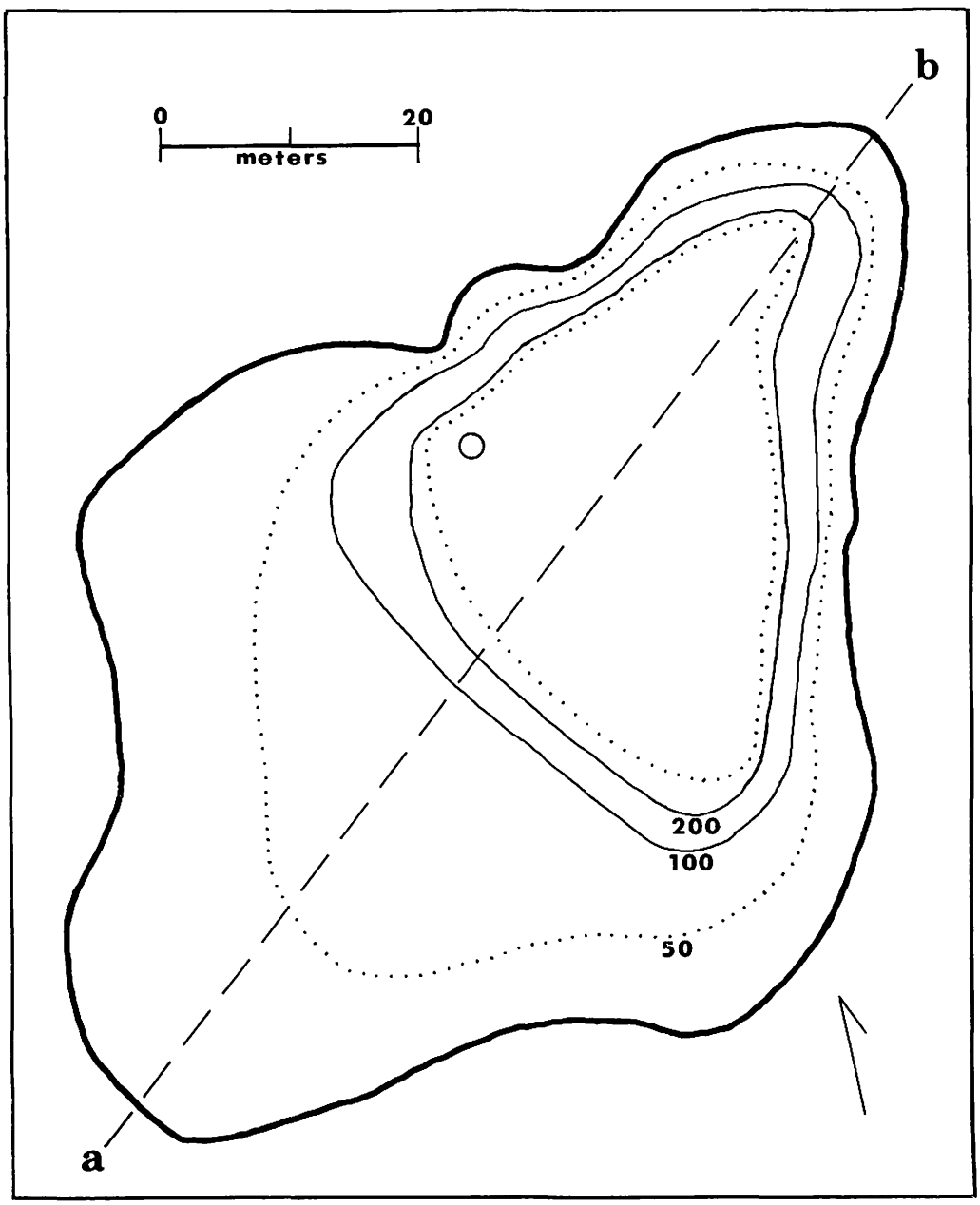

Figure 6. Apparent bathymetry of Lake Kauhakō, Moloka'i Island, based on 32 soundings. Depth contours are in meters; inner dotted line is 240-m contour; open circle denotes deepest point measured, 248 m. Line a–b appears in vertical profile in Figure 5.

Table 1
Some Physical and Chemical Features Of Four Natural Lakes in Hawai'i

[Morphometric parameters are described in limnological texts such as Cole (1975).]

A. Locations and Morphometric Features

Lake	Island	Elevation (m)	Surface area (ha)	Depth related factors			Basin features		
				Z_m (m)	$\bar{Z}$ (m)	Z_r (%)	D_L	D_V	Slope (%)
Kauhakō	Moloka'i	0	0.35	248.0	105.0	370	1.2	1.3	237
Green	Hawai'i	1	0.80	6.0	3.6	6	1.2	1.8	12
Waiau	Hawai'i	3969	0.73	3.0	1.6	3	1.1	1.6	2
Wai'ele'ele	Maui	2040	0.22	6.4	2.6	13	1.2	1.2	8

B. Hydrochemical Features*

Lake and date sampled	Sample depth (m)	Dissolved inorganic constituents, milligrams per liter										
						Anions			Cations			
		Total solids	Hardness	SiO_2	Total Fe	Cl^-	SO_4^{-2}	HCO_3^-	Na^+	K^+	Ca^{+2}	Mg^{+2}
Kauhakō	2	22,000	4559	30.4	0.2	12,017	439	155	5700	221	320	913
April 1974	20	34,000	7038	75.4	--	17,654	834	450	9000	340	670	1303
Green Dec. 1973	1	300	86	31.6	--	68.4	1.7	(109)	50	7	28.5	3.5
Waiau July 1977	0-2	71	--	0.4	0.8	18.5	1.2	(29.5)	6.4	3.8	6.3	4.1
Wai'ele'ele Sept. 1967	0-6	8	--	0.3	0.3	0.4	0	2.7	1.5	0.5	0.2	0

* Waiau data from Massey (1978a); Wai'ele'ele data from Maciolek (1969); Kauhakō and Green analyses by Water Resources Research Center, University of Hawaii. Total inorganic solids in Kauhakō estimated refractometrically. Bicarbonate values for Green and Waiau calculated from analyses to provide ionic balance, assuming all anionic deficit was HCO_3^-.

Chemical composition of Kauhakō water (Table 1) is indicative of sea water intrusion from the basal water table, diluted by freshwater at the surface. The only significant ions that were proportionately lower in concentration in the surface stratum were calcium and bicarbonate, suggesting the precipitation of lime (see algae, below). Deeper water was rich in hydrogen sulfide. This condition was evidenced by the strong odor of H_2S in the sounding line, which persisted for many days after the survey.

Kauhakō surface is very turbid with phytoplankton (Secchi disc visibility 12 cm in April 1974). Organisms responsible were identified to genus as *Chromulina* (dominant), *Peridiniopsis, Gymnodinium, Melosira* (2 spp.), *Pleurosigma, Navicula, Cylindrospermum,* and *Oscillatoria.* Weakly mineralized marginal algal deposits resulted from a *Lyngbya* or *Schizothrix* matrix containing *Dictyosphaeria* and occasional groups of *Valonia* (*V. vesiculoides*?). No fishes were found. Along with copepods, the oxygenated upper layer contained an abundance of palaemonid shrimp (*Palaemon debilis*), and a scattering of small red atyid shrimp (*Halocaridina rubra*) that are characteristic of Hawaiian anchialine pools (Maciolek and Brock 1974). Small demersal crustaceans (isopod, amphipod) and brine fly larvae (Ephydridae) were observed along the lake margins.

CONCLUDING REMARKS

The limiting definition employed here excludes many lentic waters from consideration as lakes. Among the 6 waters in the archipelago that are recognized as lakes, all are essentially in closed basins, 5 are in craters, and only 2 are elevated. Laysan and Nōmilu are the most modified by human activity; Wai'ele'ele and Kauhakō are pristine by virtue of difficult access. Character of the biota varies considerably with salinity and elevation. Faunal diversity generally is low, and fishes are lacking as a natural component. Flora has high phytoplankton diversity in some lakes but submerged macrophytes are absent. Drainage lakes are absent, even though Hawai'i has about 360 perennial streams (Maciolek 1978). The scarcity of elevated lakes, despite the abundance of potential basins (craters, stream channels) is a consequence of high permeability of the substrata (Maciolek 1969).

Traditional classification of meromixis by primary causative factors (ectogenic, crenogenic, biogenic) appears not to apply to the conditions observed in Lake Kauhakō, nor does the cryogenic type more recently described (Cole 1975). It seems unlikely that holomixis would occur in Kauhako's protected, tube-like basin under ambient climatic conditions, regardless of the chemical nature of the water present. If primary cause is paramount in descriptive classification, Kauhako's meromixis probably should be considered morphogenic.

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