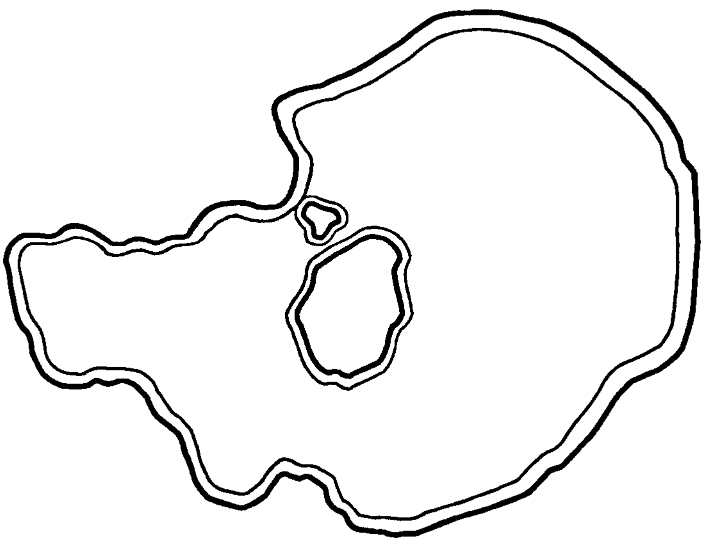
An Auxiliary Report
Prepared for the

MONO BASIN WATER RIGHTS EIR

Lake-Fluctuation-Induced Changes in the Size and Configuration of the Mono Islands



Prepared under the Direction of:

California State Water
Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95810

Prepared With Funding from:

Los Angeles Department of
Water and Power
Aqueduct Division
P.O. Box 111
Los Angeles, CA 90051

Mono Basin EIR Auxiliary Report No. 22

An Auxiliary Report
Prepared for the
Mono Basin Water Rights EIR Project

This auxiliary report was prepared to support the environmental impact report (EIR) on the amendment of appropriative water rights for water diversions by the City of Los Angeles Department of Water and Power (LADWP) in the Mono Lake Basin. Jones & Stokes Associates is preparing the EIR under the technical direction of the California State Water Resources Control Board (SWRCB). EIR preparation is funded by LADWP.

SWRCB is considering revisions to LADWP's appropriative water rights on four streams tributary to Mono Lake, Lee Vining Creek, Rush Creek, Parker Creek, and Walker Creek. LADWP has diverted water from these creeks since 1941 for power generation and municipal water supply. Since the diversions began, the water level in Mono Lake has fallen by 40 feet.

The Mono Basin water rights EIR examines the environmental effects of maintaining Mono Lake at various elevations and the effects of possible reduced diversions of water from Mono Basin to Owens Valley and the City of Los Angeles. Flows in the four tributary creeks to Mono Lake and water levels in Mono Lake are interrelated. SWRCB's decision on amendments to LADWP's water rights will consider both minimum streamflows to maintain fish populations in good condition and minimum lake levels to protect public trust values.

This report is one of a series of auxiliary reports for the EIR prepared by subcontractors to Jones & Stokes Associates, the EIR consultant, and contractors to LADWP. Information and data presented in these auxiliary reports are used by Jones & Stokes Associates and SWRCB, the EIR lead agency, in describing environmental conditions and conducting the impact analyses for the EIR. Information from these reports used in the EIR is subject to interpretation and integration with other information by Jones & Stokes Associates and SWRCB in preparing the EIR.

The information and conclusions presented in this auxiliary report are solely the responsibility of the author.

Copies of this auxiliary report may be obtained at the cost of reproduction by writing to Jim Canaday, Environmental Specialist, State Water Resources Control Board, Division of Water Rights, P.O. Box 2000, Sacramento, CA 95810.

Lake-Fluctuation-Induced Changes in the Size and Configuration of the Mono Islands

A report to
Jones and Stokes, Associates, Inc., Sacramento, CA

and the
California State Water Resources Control Board

January, 1993

Prepared by:
Scott Stine, Ph.D.
1450 Acton Crescent
Berkeley, CA 94702

Lake-Fluctuation-Induced Changes in the Size and Configuration of the Mono Islands

A report to
Jones and Stokes, Associates, Inc., Sacramento, CA

and the
California State Water Resources Control Board

January, 1993

Prepared by:
Scott Stine, Ph.D.
1450 Acton Crescent
Berkeley, CA 94702

A copy of this report has been placed in the Water Resources Center Archives, U.C. Berkeley.

Cite thusly: Stine, Scott, 1993. Lake-Fluctuation-Induced Changes in the Size and Configuration of the Mono Islands. Report to Jones and Stokes, Associates, Sacramento, and the California State Water Resources Control Board. 22 pp + appendices

Table of Contents

LAKE-FLUCTUATION-INDUCED CHANGES IN THE SIZE AND CONFIGURATION OF THE MONO ISLANDS

Introduction

Mono Lake is a hydrographically closed water body that abuts the eastern front of the Yosemite Sierra. Because it loses water only though evaporation, the lake fluctuates widely in size, rising when inflow exceeds evaporative loss, and falling under the converse conditions. These transgressions and regressions result in the expansion, contraction, emergence, submergence, insularization, and peninsularization of islands and would-be islands at Mono Lake. Changes in the size and availability of the Mono islands are of biological and environmental interest because they are used by large numbers of California gulls (Larus californicus), and by lesser numbers of other bird species, for breeding and nesting.

The future of the gull population that uses the Mono islands is one of the focal points of the Environmental Impact Report (EIR) being prepared for the California State Water Resources Control Board (State Board) by Jones and Stokes Associates, Sacramento. The two central questions at hand are as follows: Is there a correspondence between gull-nesting area on the Mono islands and historic trends in the lake's gull population? And, what is the size (or the range in size) of the gull population that can be expected to occupy the

Mono islands at various future lake levels (and thus at various future island sizes and configurations)? The first step in answering these questions is to establish the relationship between lake level and island-nesting area. The objective of this report is to provide a basis for establishing that relationship.

The Mono Islands

Negit Island. Negit Island, in the northwestern quadrant of Mono Lake, is a composite volcano composed of two domes, a cinder cone, and four blocky lava flows. An older "platform" of phreatic explosion debris lies near the center of the island. This low-gradient platform, and portions of some of the flows, are blanketed with sandy and silty tephra (volcanic ash) that was produced during eruptions of the nearby Mono Craters. These same areas have been colonized by a relatively dense shrub cover of greasewood (Sarcobatus vermiculatus). At times during the past several decades, large numbers of gulls have used this greasewood-covered platform of Negit Island for nesting, while smaller numbers have nested on more sparsely vegetated (and in some cases, unvegetated) lava flows.

The Negit islets. Historically, Negit Island has been flanked by from 2 (at high lake levels) to 22 (at low levels) volcanic islets which, individually, range in size from miniscule (at high levels) to ~15 acres (at low levels). The spires, pinnacles, and domes that constitute these "Negit islets" are made up of rock and pumice, often coated with tufa. Deposits of sand (from littoral erosion and deposition, and from tephra airfalls) occur locally on the islets. Large numbers of gulls have historically nested on portions of the largest Negit islets, with smaller numbers on the smaller islets.

The rock that composes Negit Island and the Negit islets is hard enough to resist erosion by waves and littoral currents. Rises and falls in lake level, therefore, result in relatively little geomorphological modification of the island and islet flanks.

The Paoha islets. West of Paoha Island, near the center of the lake, is a small constellation of islets informally called the Paoha islets. These features, the highest portions of which emerged during the early 1960's, are composed of fine, unconsolidated sediments that slid from the flank of Paoha Island at the time of its formation (around AD 1660). While soft sediments dominate the surface of the Paoha islets, a tufa crust occurs locally. This crust is favored for nesting sites by the gulls that use the Paoha islets (Jehl, pers. comm., 1992).

The non-resistant nature of the sediments that compose the Paoha islets makes them suseptible to erosion by waves and currents, particularly during rises in lake level. Erosion-induced changes in the islets must therefore be considered in any projection of future gull-nesting area.

This project did not include an analysis of Paoha Island itself. While it is the largest island in Mono Lake, Paoha has supported only small numbers of gulls historically.

Methodology

General. Maps of Negit Island, and of the Negit and Paoha islets, were drawn from aerial photographs. After conferring with gull biologists, mapping units were defined so as to be relevant to gull-nesting patterns. Contours at or close to the alternative lake levels set by the State Board (6372.7 feet, 6377 feet, 6383.5 feet, 6390 feet, and 6410 feet) were then superimposed on the maps. The contours were taken directly from, or interpolated from, various sources, including USGS topographic maps, and the Pacific Western Aerial Survey maps. Where possible, these contours were checked against the islet-margin configuration as depicted on aerial photos taken at various times during the past 40 years (See Appendix A). The contours can be considered sufficiently accurate for the purpose at hand.

A chrono-cartographic sequence, showing the extent of the Mono islands in January 1930, June 1940, September 1956, July 1964, August 1973, August 1975, September 1979, and October 1982 (at these respective lake levels: 6420.8 feet, 6417.9 feet, 6402.6 feet, 6391.6 feet, 6383.4 feet, 6379.5 feet, 6373.5 feet, and 6372.8 feet) is included here as Appendix A. These maps were originally produced for Hubbs-Sea World Research Institute in San Diego, and the Community Organization and Research Institute at the University of California at Santa Barbara (Stine, 1987, 1990). Inclusion of these maps here will further aid an understanding of the changes in the Mono islands that have occurred since 1930.

The Negit islets. The Negit islets were visited in the company of Mr. David Shuford of the Point Reyes Bird Observatory, Stinson Beach, California. Based on our reconnaissance, and on interpretation of large-scale aerial photographs, it was possible to produce maps that relate a simple, generalized classification of nesting density (high, medium, and low) to geomorphological and geological units on the islets. The nest-density classification is an approximation based on Mr. Shuford's many weeks on the islets counting and observing gulls during nesting seasons.

Negit Island. The greasewood-covered platform area of Negit Island was mapped from aerial and ground photos. Production of the Negit Island map did not involve a field visit, though numerous trips to Negit have been made in the past, and these earlier experiences were drawn upon in the course of the present work. Nesting areas shown on the Negit Island map were taken from Winkler (1977), and from Dierks (1991).

The Paoha islets. For the Paoha islets, the areas of "rugose substrate" (created by a broken tufa crust) were drawn from aerial and ground photos in consultation with Dr. Joseph Jehl of Hubbs-Sea World Research Institute, San Diego. Here again, no field visit was included in this work, though both the recollections and the photographs from many past visits were used in the preparation of the maps. Dr. Jehl is to depict areas of relative gull-nesting suitabilities on Figure 3 for use in the EIR.

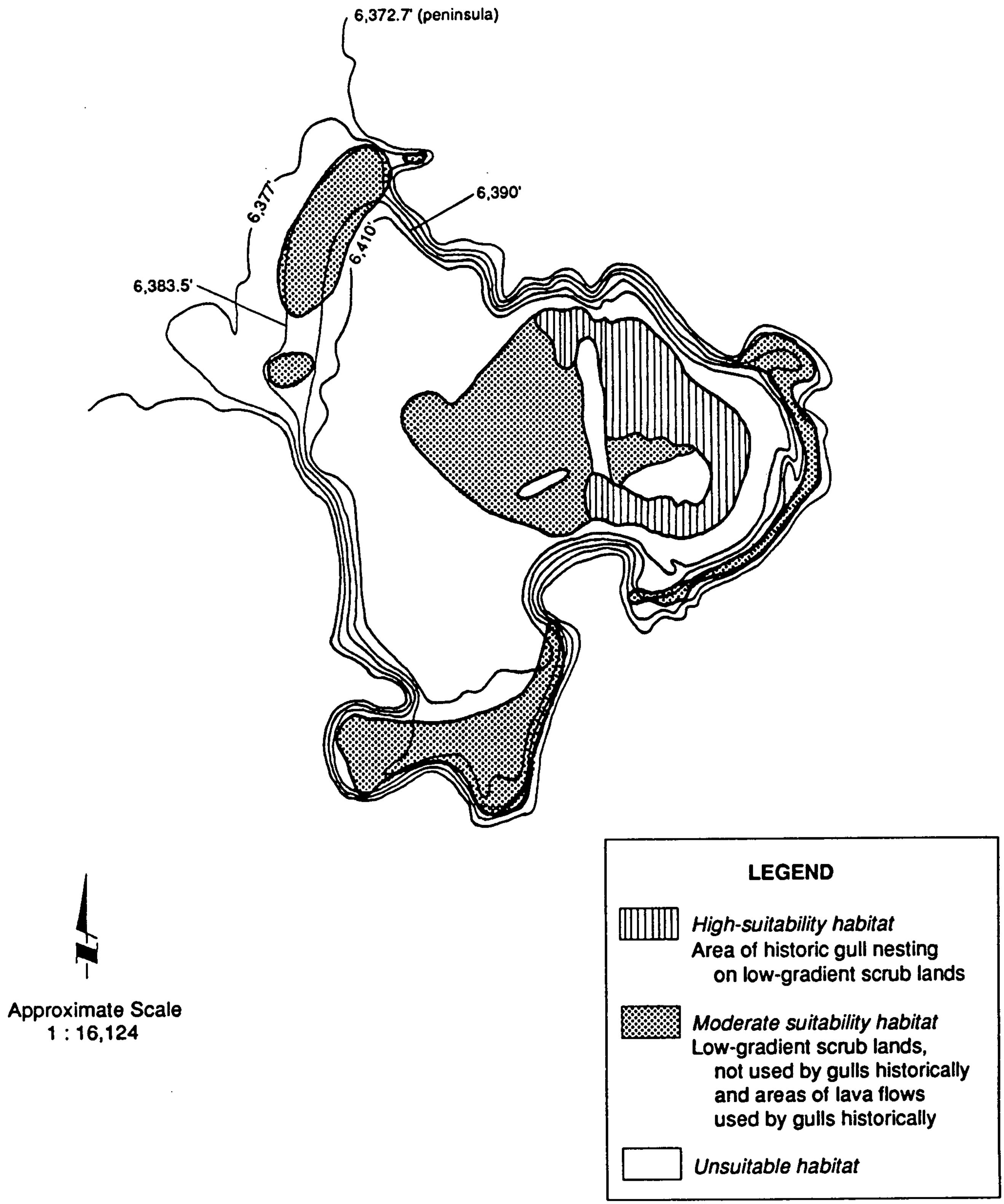
Results--Nesting Grounds on Negit Island

Negit Island maps. Figure 1 is a map of Negit Island, showing the approximate locations of the 6372.7-foot, 6377-foot, 6383.5-foot, 6390-foot, and 6410-foot contours. Also mapped on Figure 1 are the principle areas of Negit Island used historically by nesting gulls (after Winkler, 1977, and Dierks, 1991), and the low-gradient areas of dense greasewood cover not historically used by gulls. Appendix A shows cartographically the manner and extent to which Negit Island changed (through both peninsularization and growth) between 1930 (lake level 6420 feet) and 1982 (near the time of the historic low stand, at 6372 feet).

Changes in nesting area. Note on Figure 1 that much of the area used by nesting gulls on Negit Island lies high on the brush-covered platform, well above the historic range of lake level fluctuations. This area, which historically supported roughly two-thirds of the gulls that nested on Negit prior to peninsularization, is thus unaffected by fluctuations of the lake. Some of the nesting areas at lower elevations will be periodically inundated under several of the EIR Management Lake Level Alternatives. More important to understanding changes in nesting habitat on Negit is that at a lake level of 6375 feet it becomes connected to the mainland by a landbridge. (Coyotes are known to wade to Negit Island at lake levels of, and perhaps above, 6376 feet.)

Results--Nesting Grounds on the Negit Islets

Maps and elevations of the Negit islets. Figures 2a and 2b are maps of the



Note: Contours correspond to alternative management lake levels specified in SWRCB EIR.

Source: Winkler et al. 1977 and Winkler pers. comm.

Figure 1. Negit Island

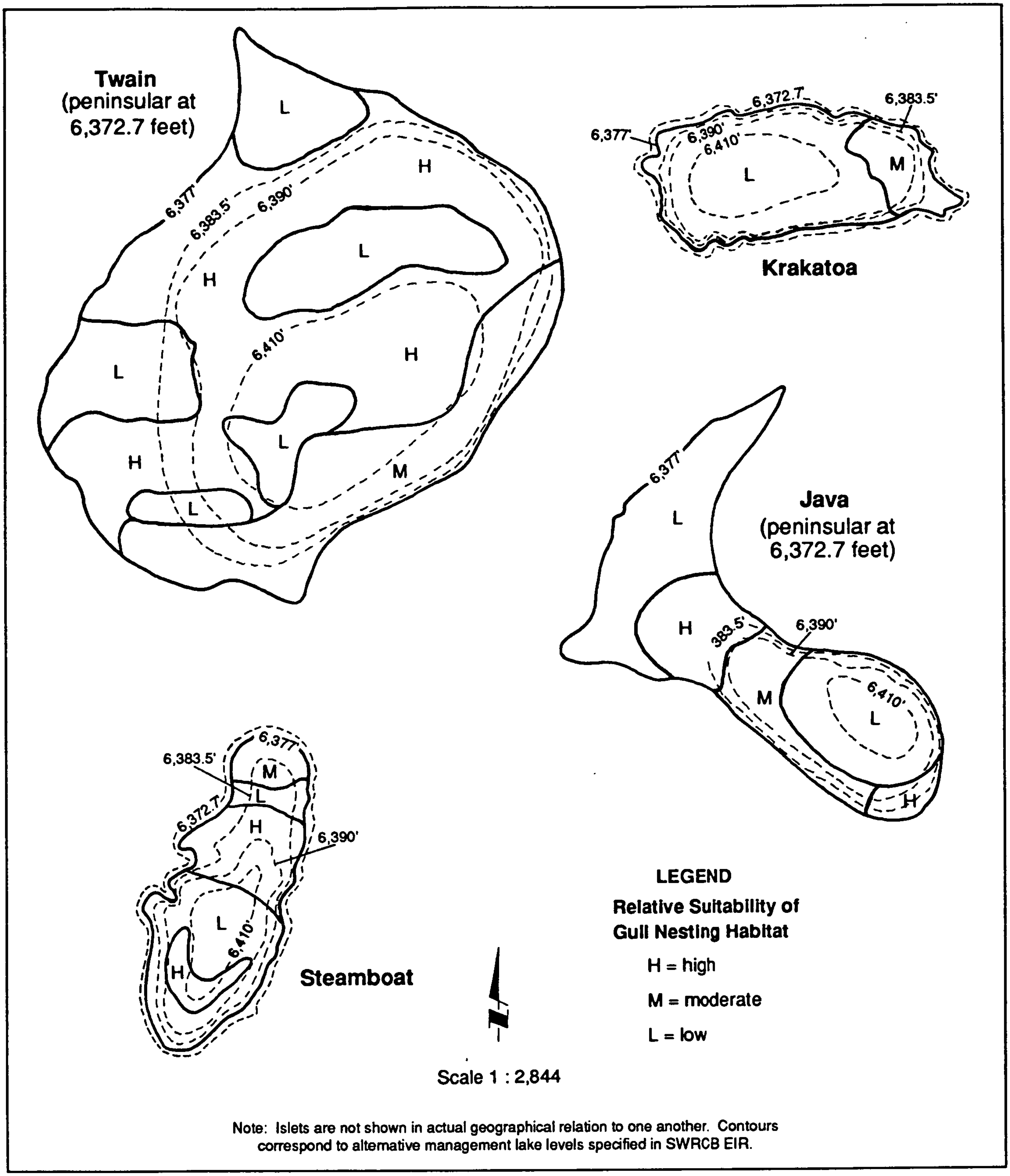
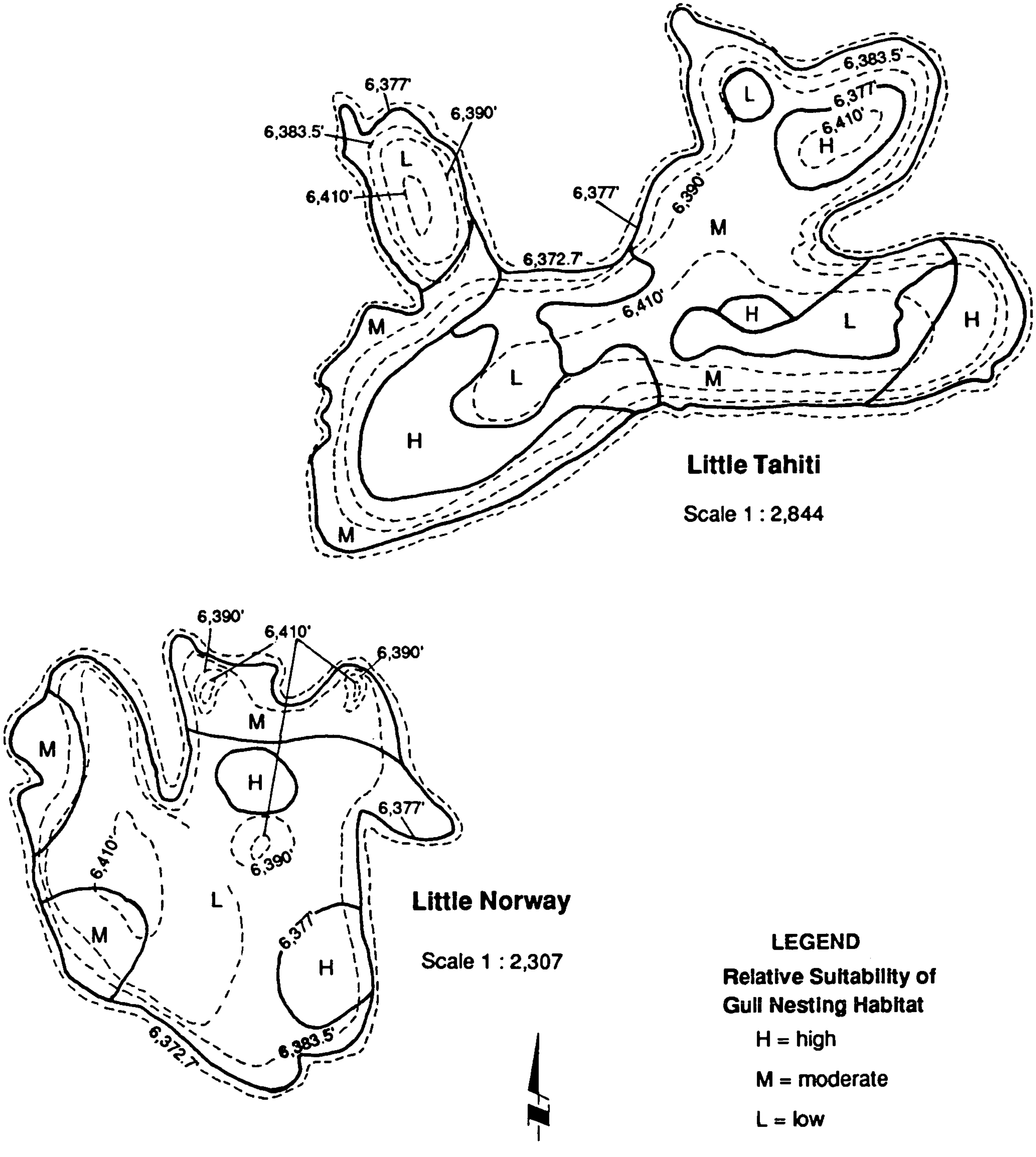


Figure 2a. Negit Islets



Note: Islets are not shown in actual geographical relation to one another. Contours correspond to alternative management lake levels specified in SWRCB EIR.

Figure 2b. Negit Islets

Negit islets showing the approximate location of the 6372.7-foot, 6377-foot, 6383.5-foot, 6390-foot, and 6410-foot contours. Also mapped there are nesting density designations, as estimated by Mr. Shuford and myself in the field. Appendix A illustrates the manner and extent to which the Negit islets grew in number and size between 1930 (lake level 6420 feet) and 1982 (near the time of the historic low stand, at 6372 feet). The approximate lake levels at which the individual volcanic spires and domes of the Negit Archipelago begin to protrude from the lake as actual islets are given in Table 1.

Changes in nesting area. With fluctuations in lake level, the area of nesting habitat on the Negit islets changes due to emergence (see Table 1), expansion and contraction (see Appendix A), and peninsularization. This latter factor takes on importance at a lake level of 6372 feet, when the Negit islets of Java and Twain become connected to the mainland. (Coyotes are known to

Table 1
Lake levels at which the high points of the individual domes and spires of the Negit islets begin to protrude from Mono Lake.

Krakatoa	Islet at lake level somewhat above 6420 feet
Little Norway	Islet at lake level somewhat above 6420 feet
Little Tahiti	Islet at lake level somewhat above 6420 feet
Twain	Islet at lake level somewhat above 6420 feet
Steamboat	Islet at lake level somewhat above 6420 feet
Java	Emerges at lake level ~6418 feet
Hat	Emerges at lake level ~6392 feet
Tie	Emerges at lake level ~6387 feet
La Paz	Emerges at lake level ~6387 feet
Saddle	Emerges at lake level ~6387 feet
Comma	Emerges at lake level ~6387 feet
Muir	Emerges at lake level ~6387 feet
Midget	Emerges at lake level ~6380 feet
Siren	Emerges at lake level ~6380 feet
Geographic	Emerges at lake level ~6380 feet
Winkler	Emerges at lake level ~6375 feet

wade to Twain and Java at lake levels of, and perhaps above, 6373 feet.)

Pancake islet. A peculiar islet that requires special consideration is "Pancake", a small, flattish mound of lake bottom characterized by a small heap of pumice blocks. This islet, which differs from the true Negit islets in that it is not of direct volcanic origin, nevertheless lies in the general vicinity of the Negit islets. It is used by gulls for nesting, and so is relevant to this report.

Pancake islet emerges from the lake when the shoreline drops to an elevation of ~6384 feet, though the islet does not become large enough to accomodate nesting gulls until the lake reaches ~6379 to 6380 feet. At a lake level of 6376 feet Pancake becomes connected to the mainland by a landbridge. Changes in the acreage of Pancake at elevations between 6376 feet and 6379 feet seem to have little relevence to gull nesting, since growth and shrinkage occur in those portions of the islet that gulls do not use (Mr. D. Shuford, pers. comm., 1990). Less than 2 acres of land on Pancake are used by nesting gulls.

Results--Nesting Grounds on the Paoha Islets

Maps and elevations of the Paoha islets. Figure 3 is a map of the Paoha islets showing the approximate location of the 6380.9-foot, and 6382.9-foot contours. (As discussed below, these elevations relate to past and future erosional modification of the Paoha islets.) Also shown on Figure 3 are the areas of rugose substrate. Appendix A shows cartographically the manner and extent to which the Paoha islets grew in number and size between 1930 (lake

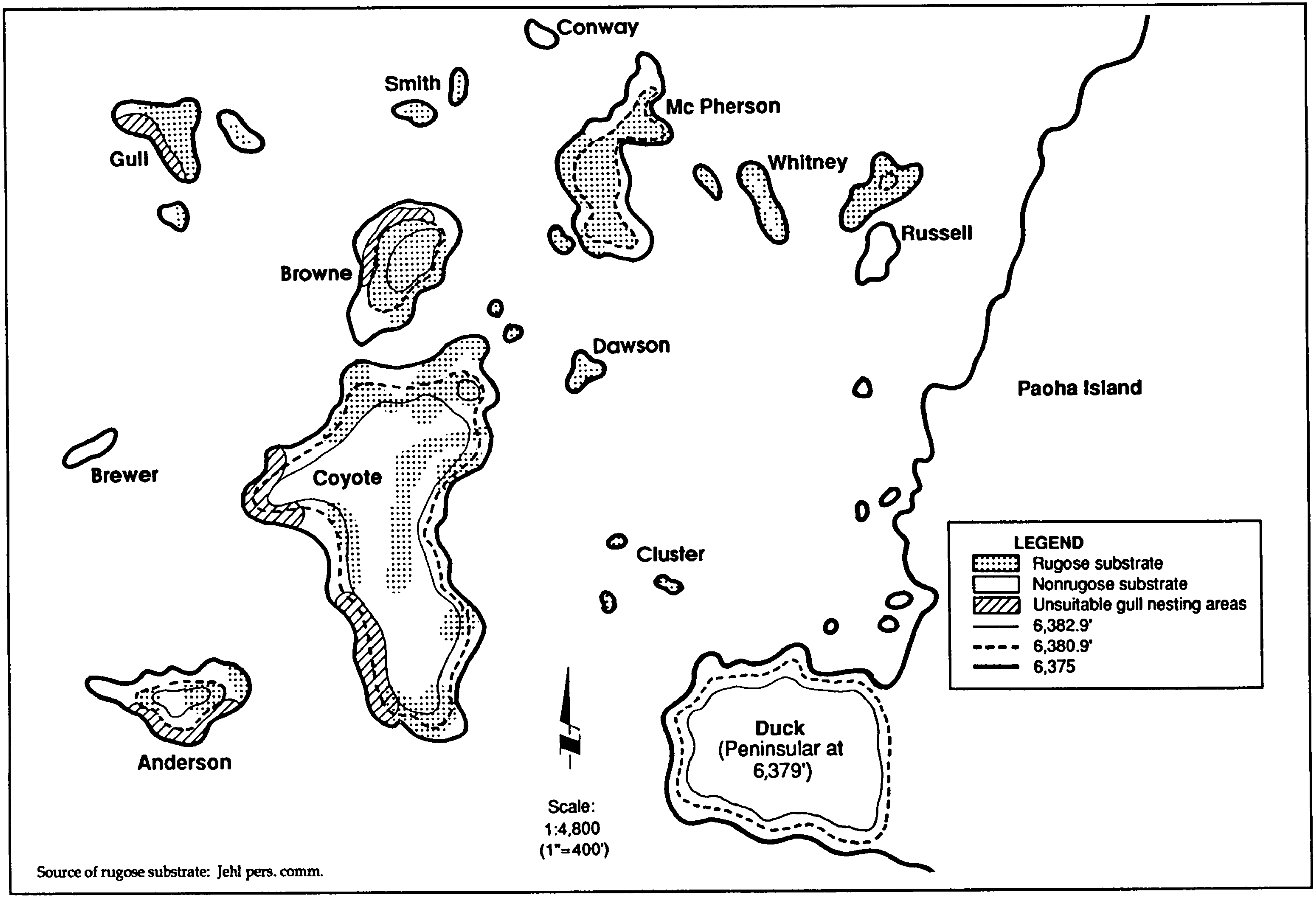


Figure 3. Paoha Islets

level 6420 feet) and 1982 (near the time of the historic low stand at 6372 feet). The approximate lake levels at which the high points of the individual Paoha islets began to emerge from the declining lake are listed in Table 2.

Table 2
Lake levels at which the highest points of the individual Paoha islets emerged from Mono Lake during the pre-1982 lake regression.

Browne	Emerged at ~6395 feet
Coyote	Emerged at ~6395 feet
Duck	Emerged at ~6392 feet
Anderson	Emerged at ~6386 feet
McPherson	Emerged at ~6384 feet
Brewer	Emerged at ~6384 feet
Gull	Emerged at ~6383 feet
Smith	Emerged at ~6383 feet
Dawson	Emerged at ~6383 feet
Conway	Emerged at ~6383 feet
Russell	Emerged at ~6383 feet
Whitney	Emerged at ~6375 feet
Hoffman	Emerged at ~6375 feet
Cluster	Emerged at ~6375 feet

Changes in island area due to the modern lake regression. During the middle and latter stages of the modern lake regression, the Paoha islets emerged (see Table 2), then expanded in area (Appendix 1). One peninsularization event--the joining of Duck islet with the main body of Paoha Island at a lake level of 6379.5 feet--characterized this period.[1]

Changes in area and configuration of the Paoha islets due to littoral erosion--theoretical background. Unlike the hard rock that composes the Negit islets, the soft sediments of the Paoha islets are easily eroded by waves and longshore currents. Littoral erosion of the islets creates a "wave-cut platform" (platform)--a low-gradient surface that terminates islandward at a "sea cliff" (cliff), and lakeward at a nickpoint (a level at which the gradient increases abruptly in the downslope direction). These platforms are of importance to matters of the Mono gull rookery because relatively few of the birds appear to use them for nesting, at least while the platforms are "active"; rather, the birds appear to use mainly the "upland" portions of the islets for nesting (see below).

A lake surface that is either receding or holding stable against the islet flanks is capable of eroding only a narrow platform. Width of the platform is limited because waves moving across it toward shore expend their energy as frictional drag on its surface. Once the platform reaches some critical width, insufficient wave energy remains at shoreline to accomplish further backwearing of the cliff, and widening of the platform ceases. During a rise in lake level, in contrast, the bases of the waves are elevated above any existing platform. This allows the waves to batter and wear back the cliff, thereby widening the platform. The waves of a rising lake thus create a relatively broad platform that widens until the transgression ceases.

Once a platform has been cut by a transgressing lake, the advance and retreat of the shoreline across its surface will result in little further erosional modification (the platform surface is now in equilibrium with the littoral geomorphic processes, and so erosion essentially ceases). Only if the lake rises to a level higher than the "shoreline angle" (the break in slope at the junction of the platform and the cliff) will the platform be further widened.

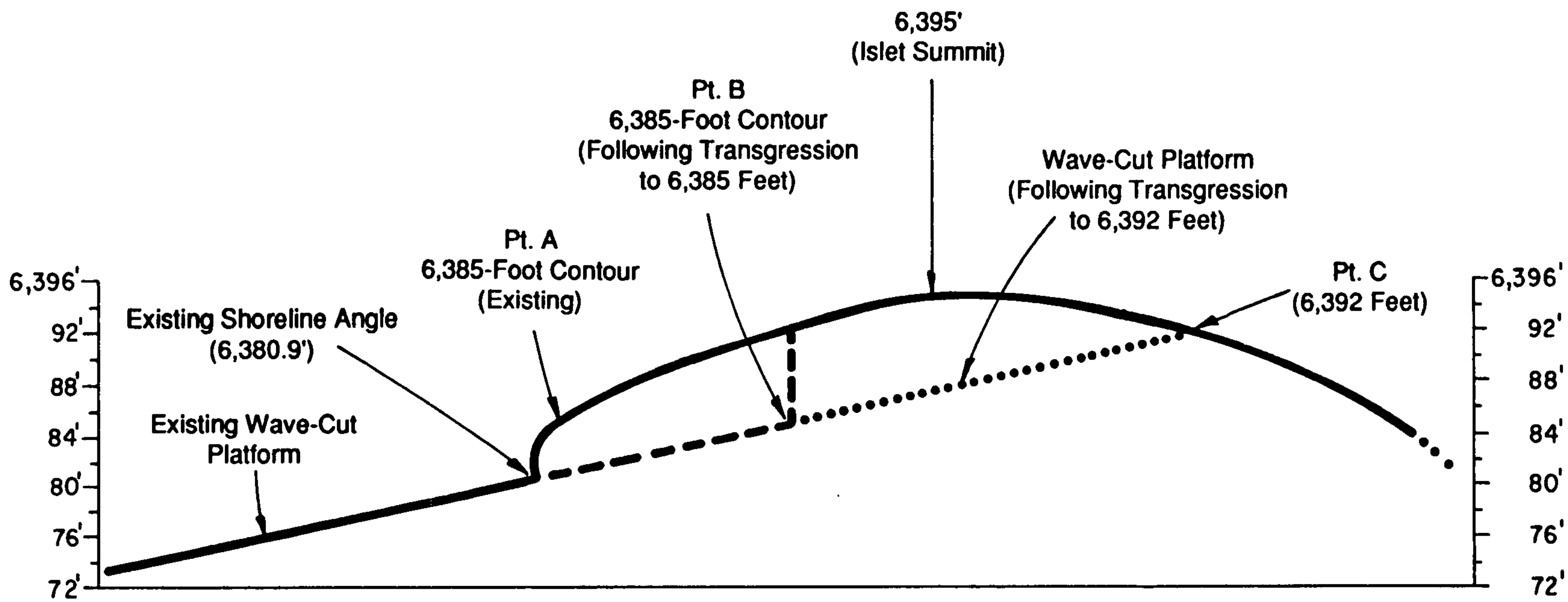
Should the lake margin fall below the nick point at the distal margin of the platform, and then re-rise, the lake will not simply regain the platform surface. Rather, the transgressing shoreline will cut a new platform at the expense of the old one. The old platform can be said to be "stranded"; it will never again be reactivated. The platform presently being cut, or currently being occupied, by the shoreline is called the "active platform". A further distinction is made between the active platform and the "upland" portions of an islet (all portions of the islet that lie above the cliff).

The degree to which the Paoha islets can be modified by a rise in lake level is well illustrated by events that occurred during the past 2 decades. In 1974, when the receding lake reached an elevation of 6381 feet, the Paoha Islets numbered one dozen and covered over 24 acres. During the ensuing years, the lake continued to fall, reaching its historic low stand of 6372 feet early in 1982. It then rerose. By August of 1986 the rising lake had reattained its 1974 elevation of 6381 feet (more precisely, 6380.9 feet). Due to erosion by the rising shoreline, however, the number of islets had diminished to just half the number exposed in 1974, and total islet area had been reduced to approximately 10.6 acres--only ~40% of the 1974 value. It is clear from these figures, and from observations made in 1982, '83, and '84 (Stine, 1988), that a rise in lake level does not simply resubmerge islets composed of easily erodible sediment; rather, the rising lake erodes the islets at waterline in the manner described above, transforming the islet flanks into platforms.

Figure 4 is a schematic profile representing hypothetically the presently existing flank of one of the Paoha islets (solid line). Note that the shoreline angle lies at an elevation of 6380.9 feet, reflecting the transgression to that elevation that occurred between 1982 and 1986. This schematic diagram illustrates two essential points:

1) Presently, the (arbitrarily selected) 6385-foot contour lies at Point A on Figure 4. But if the lake were to rise to that elevation it would enlarge the active platform (to the position indicated by the dashed line on Figure 4), and effectively move the 6385-foot contour islandward (thus, from Point A, to Point B on Figure 4). This type of modification has been taken into consideration in drawing the contours on Figure 3.

2) To completely submerge a soft-sediment islet whose summit elevation lies at, say, 6395 feet, does not require a lake transgression to 6395 feet. Because of the beveling that occurs during a transgression, the lake may have to rise to only 6392 feet (or 6388 feet, or 6393 feet . . . depending on the topography and configuration of the islet, and the gradient of the wave-cut platform) to obliterate all upland portions of the islet, and thus affect its total inundation. Referring to Figure 4, it can be seen that, in this hypothtical setting, a lake transgression to 6392 feet (Point C) would effectively remove the existing upland portion of the islet, transforming it into a wave-cut platform (dotted line on Figure 4).[2] (Note that in drawing Figure 4, it was assumed that the islet would be attacked from just one side. This is an



Note: The diagram illustrates the changes in islet topography that would result if the lake surface rose to 6385 feet (Point A) and 6392 feet (Point B). See explanatory text and footnotes (numbers 3 and 4).

Scale: Not drawn to scale

Figure 4. Schematic Profile of a Paoha Islet

oversimplification. In reality, obliteration of an islet upland proceeds inwardly from all directions, with the shoreline angle converging towards some inner point on the islet. This reality confounds precise prediction of transgression-induced changes in islet configuration, as well as precise prediction of the timing of transgression- induced obliteration of islet uplands.)

Future changes in area and configuration of the Paoha islets. Currently, each of the Paoha islets is encircled by an active wave-cut platform that rises gradually from a distal margin at 6372 feet (the elevation of the historic low stand) to a shoreline angle at 6380.9 feet (the level to which the lake rose between 1982 and 1986). (This wave-cut platform tends to be of lesser gradient, and therefore of greater width, on the windward (south and west) flanks of the islets than it is on their lee (north and east) side. This is because the windward flanks bear the brunt of the wave attack, and therefore undergo greater erosion. This same asymetry is evident on Paoha Island.) Under several of the management alternatives being considered in the EIR, further erosional modification of the islets (and in some cases, near-total, or total submergence of the islets) can be expected. The modifications per given alternative are summarized below:

--*Alternative lake level 6372.7 feet.* According to computations by Jones and Stokes Associates, Mono Lake, managed at an elevation of 6372.7 feet, would not drop below 6372 feet, and can be expected to rise as high as 6378.8 feet (Mr. Ken Casaday, pers. comm., 1992). Because this elevation range is within the elevation interval represented by the active wave-cut platform, this management alternative would have little effect on the Paoha islets. The islets in the future would have the same configuration (most importantly, the same upland configuration) as they do today. This upland configuration is represented on Figure 3 by the area within the 6380.9-foot contour.

--*Alternative lake level 6377 feet.* According to computations by Jones and Stokes Associates, Mono Lake, managed at an elevation of 6377 feet, can be expected to occasionally fall as low as 6376.6 feet, and to rise as high as 6382.9 feet (Mr. Ken Casaday, pers. comm., 1992). The active platforms will be unaffected by regressions to the lowest of these elevations. A transgression to the maximum elevation of this management alternative can be expected to further widen the active platforms at the expense of the upland portions of the islets. This change would be permanent. The configuration of the islet uplands that would exist following this transgression is approximated on Figure 3 by the 6382.9-foot contour. (For reasons described above, the 6382.9-foot contour on Figure 3 is shown in the position that it would occupy following a transgression to that elevation, rather than its present-day position.) Because of their low summit elevations, several of the Paoha islets--Gull, Smith, Dawson, Conway, Brewer, McPherson, and Russell--either have already been, or would be, transformed entirely and permanently into active wave-cut platforms by this transgression. "Duck islet" would alternate between being an islet and a peninsula under this management alternative.

--Alternative lake level 6383.5 feet. According to computations by Jones and Stokes Associates, Mono Lake, managed at an elevation of 6383.5 feet, can be expected to occasionally fall as low as 6383.0 feet, and rise as high as 6389.5 feet (Mr. Ken Casaday, pers. comm., 1992). A transgression to this maximum lake level would permanently transform all of the existing upland portions of all the Paoha islets into an active wave-cut platform. The highest portions of these low-gradient surfaces would protrude from the lake as it fluctuated within the elevational range of this management alternative. No attempt has been made to map the configuration of the Paoha islets that would exist following a transgression to 6389.5 feet, since, as low-gradient platforms, these erosional remnants would be of dubious value to nesting gulls.

--Alternative lake level 6390 feet. According to computations by Jones and Stokes Associates, Mono Lake, managed at an elevation of 6390 feet, can be expected to occasionally fall to an elevation of 6388.5 feet, and rise as high as 6395 feet (Mr. Ken Casaday, pers. comm., 1992). This transgression would permanently transform all portions of all islets into active wave-cut platforms. Only small portions of the platforms associated with Coyote, Browne, and Duck islets would ever emerge from the lake. No attempt has been made to map the configuration of the Paoha islets that would exist following a transgression to 6389.5 feet, since, as low-gradient platforms, these erosional remnants would be of dubious value to nesting gulls.

--Alternative lake level 6410 feet. According to computations by Jones

and Stokes Associates, Mono Lake, managed at an elevation of 6410 feet, would occasionally fall as low as 6407.1 feet, and rise as high as 6414.7 feet (Mr. Ken Casaday, pers. comm., 1992). At even the lowest of these elevations, all erosional remnants of all the Paoha islets would be submerged under more than 15 feet of water.

Conclusions

The foregoing provides a basis for establishing the relationship between the Management Alternative Lake Levels being considered in the EIR, and island-nesting area at Mono Lake. No attempt has been made to calculate acreages of either island area, nor nesting area, per given management level. By prior agreement, that task will be undertaken by Jones and Stokes Associates, based on the maps presented herein.

Footnotes

1 Claims by some that gulls used Paoha Island for breeding and nesting during the mid-1980s are incorrect. Rather, gulls colonized Duck islet when it was reinsularized by the high lake stand between December 1983 and July 1985, and between March 1986 and August 1987. Since the most recent repeninsularization, gulls have not used Duck as a breeding ground.

2 One need not doubt that the efficacy of the littoral processes at Mono Lake is sufficient to truncate even the largest and tallest of the Paoha islets. Between 1883 and 1919, as the lake rose 18 feet to its historic high stand, the waves that buffetted Paoha Island effectively beat back a 20- to 50-foot-tall cliff a distance of up to several hundred feet, thus creating the prominant stranded platform that presently encircles that island.

Literature Cited

Dierks, J., 1991. Population size and reproductive success of California Gulls at Mono Lake, California in 1990, with emphasis on the Negit Islets. Contribution No. 497 of the Point Reyes Bird Observatory, Stinson Beach, California 94970

Stine, S., 1987. Geomorphic and geohydrographic aspects of the Mono Lake Controversy. Report to the Community Organization and Research Institute, University of California, Santa Barbara. 135 pp + appendices.

Stine, S., 1990. Geomorphic, geographic, and hydrographic basis for resolving the Mono Lake controversy. Environmental Geology and Water Science, v. 17 (2), pp. 67-83.

Winkler, D.W. (ed), 1977. An ecological study of Mono Lake, California. Institute of Ecology Pub. No. 12, Davis California, Institute of Ecology.

Appendix 1

Chrono-cartographic sequence documenting the history of changes in the size and configuration of the Mono islands, 1930-1982

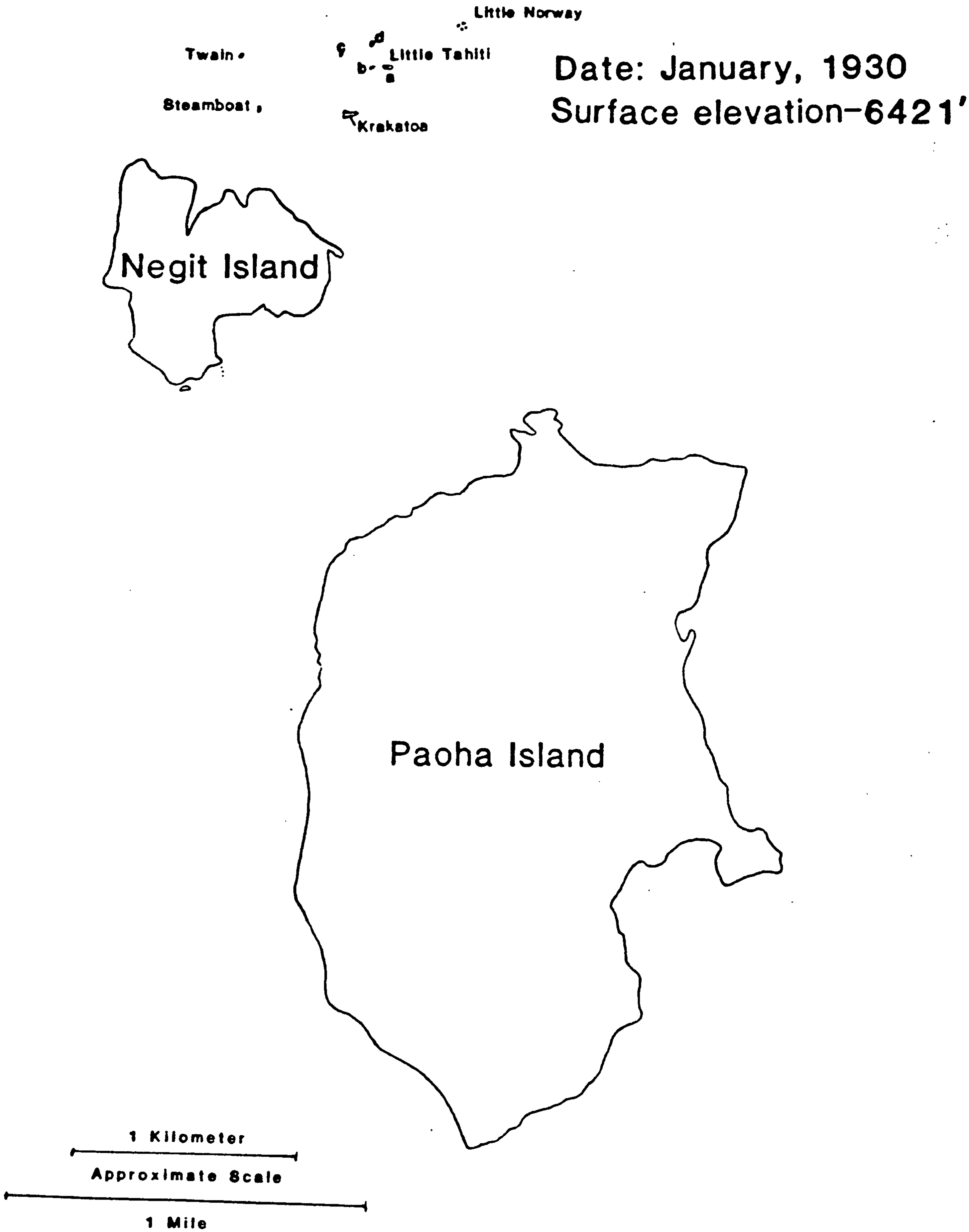
DATE: January, 1930

LAKE SURFACE ELEVATION: 6420 (±0.5) feet

DISCUSSION: The earliest aerial photographs of the Mono islands were taken in January of 1930, when the lake stood somewhere between 6420 and 6421 feet. In addition to Negit and Paoha Islands, portions of 5 of the Negit islets--Krakatoa, Steamboat, Twain, Little Tahiti, and Little Norway--existed at this time (see index map on following page). The Paoha islets are not yet visible, and in fact did not begin to emerge until the early 1960's.

AREA OF THE ISLANDS: The areas of the islands and islets are listed below.

Paoha Island	1229.865 acres
Negit Island	154.114 acres
Krakatoa	.142 acres
Little Norway	<.025 acres, total
Little Tahiti	
a.	.077 acres
b.	.037 acres
c.	<.030 acres
d.	<.010 acres
Twain	<.020 acres
Steamboat	.028 acres


Little Norway
Twain
Little Tahiti
b
a
Date: January, 1930
Surface elevation–6421′
Steamboat
Krakatoa
Negit Island
Paoha Island
1 Kilometer
Approximate Scale
1 Mile

DATE: June 24, 1940

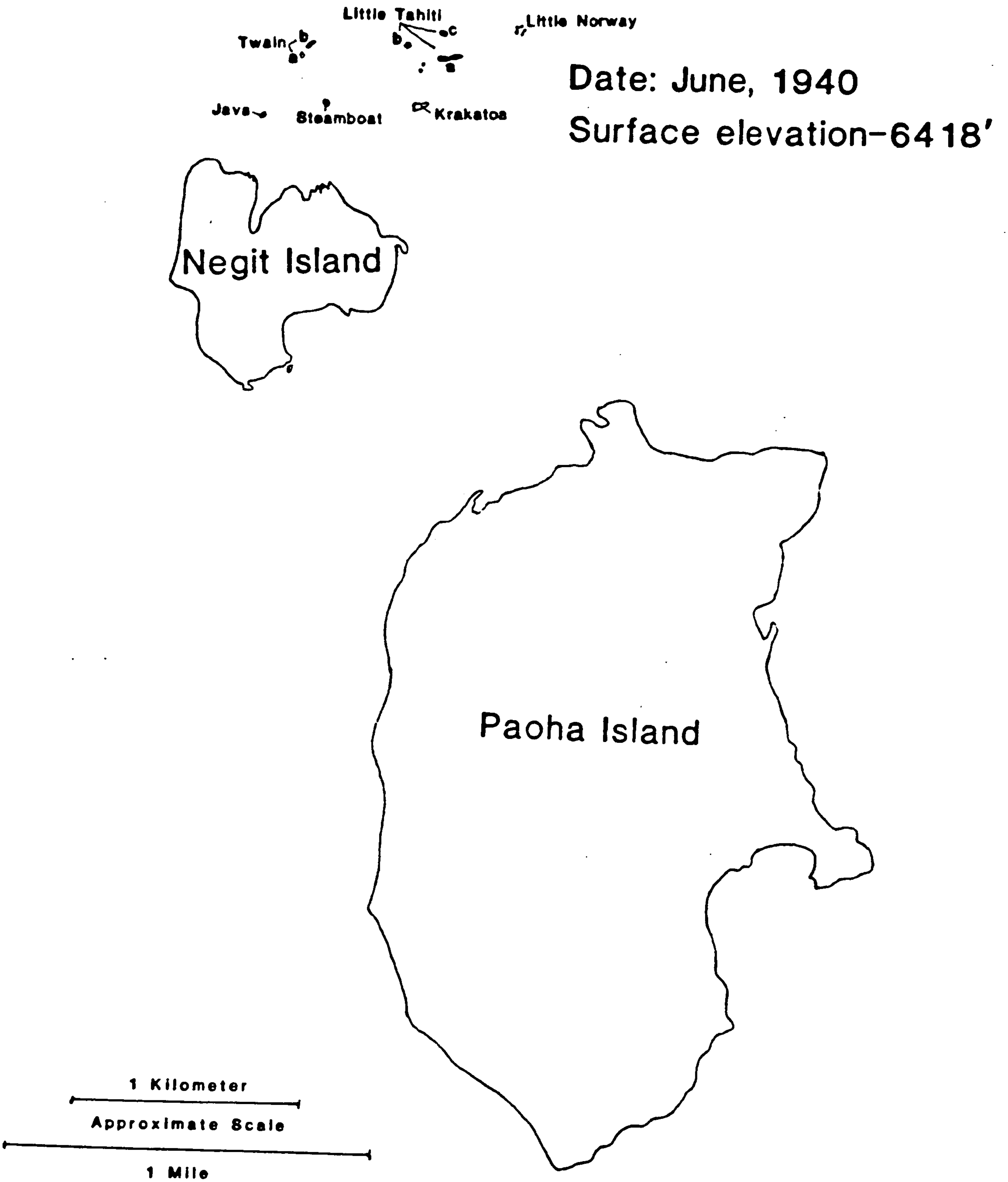
LAKE SURFACE ELEVATION: 6417.86 feet

SIGNIFICANT EVENTS: The 3-foot drop in lake level that occurred between 1930 and 1940 resulted in the growth of all previously existing islands, and in the emergence of Java, an islet of the Negit Archipelago (see index map on following page).

AREA OF THE ISLANDS: Acreage of the islands is presented below.

Paoha Island	1236.382 acres
Negit Island	162.088 acres
Krakatoa	.223 acres
Little Norway	<.025 acres, total
Little Tahiti	
a.	.272 acres
b.	<.040 acres
c.	<.010 acres
Twain	~.050 acres, total
Steamboat	.058 acres
Java	<.050 acres

DISCUSSION: The 1940 photographs depict lake elevation and island configuration essentially as they existed in 1941, when LADWP began to divert water from the basin. This is also approximately where the lake would stand today if no diversions had occurred.


Little Tahiti
Little Norway
Twain
b
a
c
b
a
Java
Steamboat
Krakatoa
Date: June, 1940
Surface elevation-6418'
Negit Island
Paoha Island
1 Kilometer
Approximate Scale
1 Mile

DATE: 1956 (From USGS topographic map of 1958)

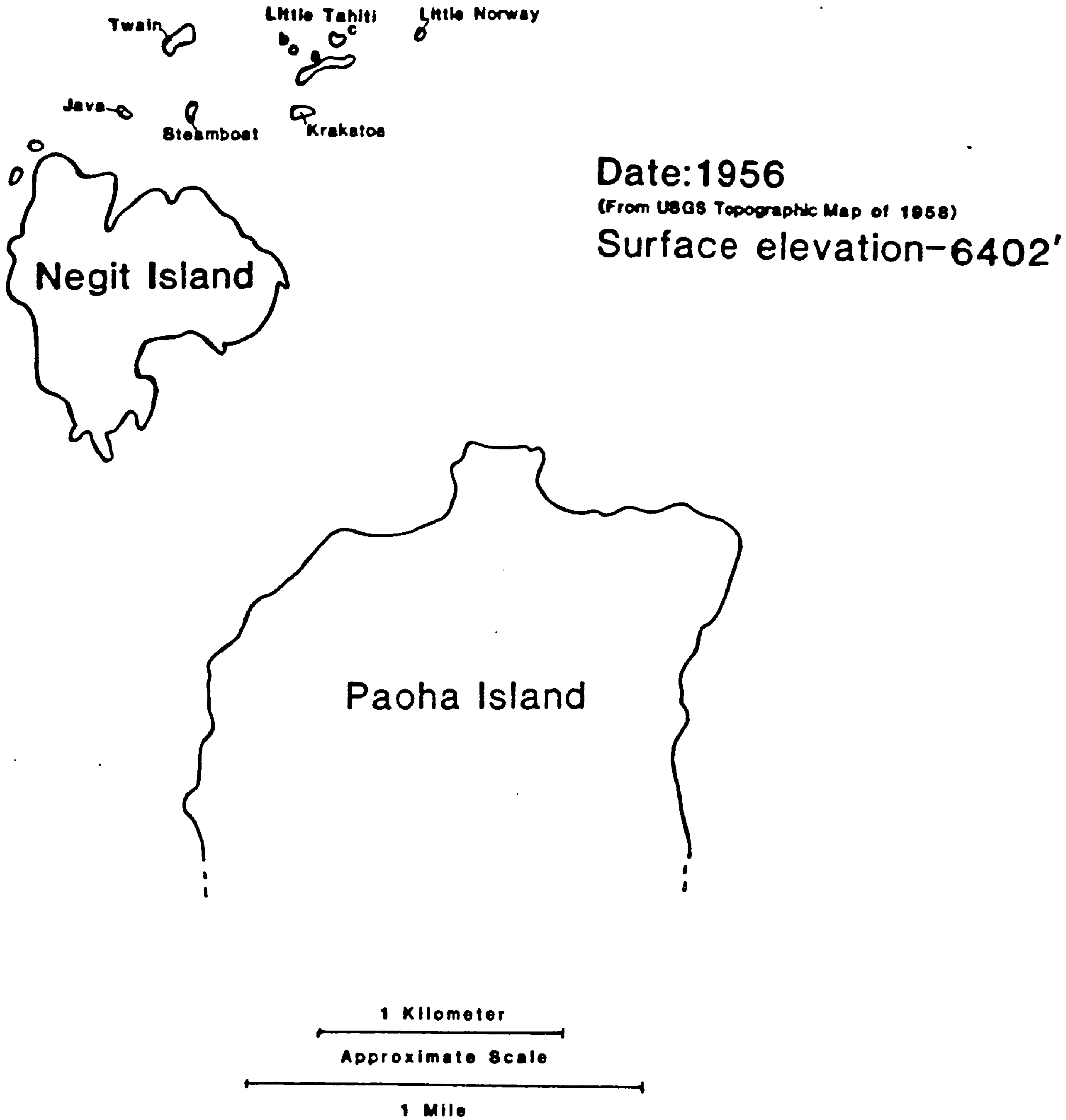
LAKE SURFACE ELEVATION: 6402.64 (±0.63) feet

SIGNIFICANT EVENTS: Growth of all previously existing islands (see index map on following page).

AREA OF THE ISLANDS: Acreage of the islands is presented below.

Paoha Island	Unavailable (see discussion below)
Negit Island	187.550 acres
Krakatoa	.940 acres
Little Norway	~.100 acres
Little Tahiti	
a.	1.630 acres
b.	~.120 acres
c.	.540 acres
Twain	1.630 acres
Steamboat	.271 acres
Java	.241 acres

DISCUSSION: Aerial photographs from 1956 are available, but because of the high obliquity of the photo angle they cannot be used to accurately determine island area. Planimetering was instead done on the 1958 Bodie Hills Quadrangle, which was drawn from aerial photos of 1956. The quadrangle includes only the northern half of Paoha Island; it was therefore impossible to derive an area for that island.


Twain
Little Tahiti
b
a
c
Little Norway
Java
Steamboat
Krakatoa
Negit Island
Date:1956
(From USGS Topographic Map of 1958)
Surface elevation–6402′
Paoha Island
1 Kilometer
Approximate Scale
1 Mile

DATE: July, 1964

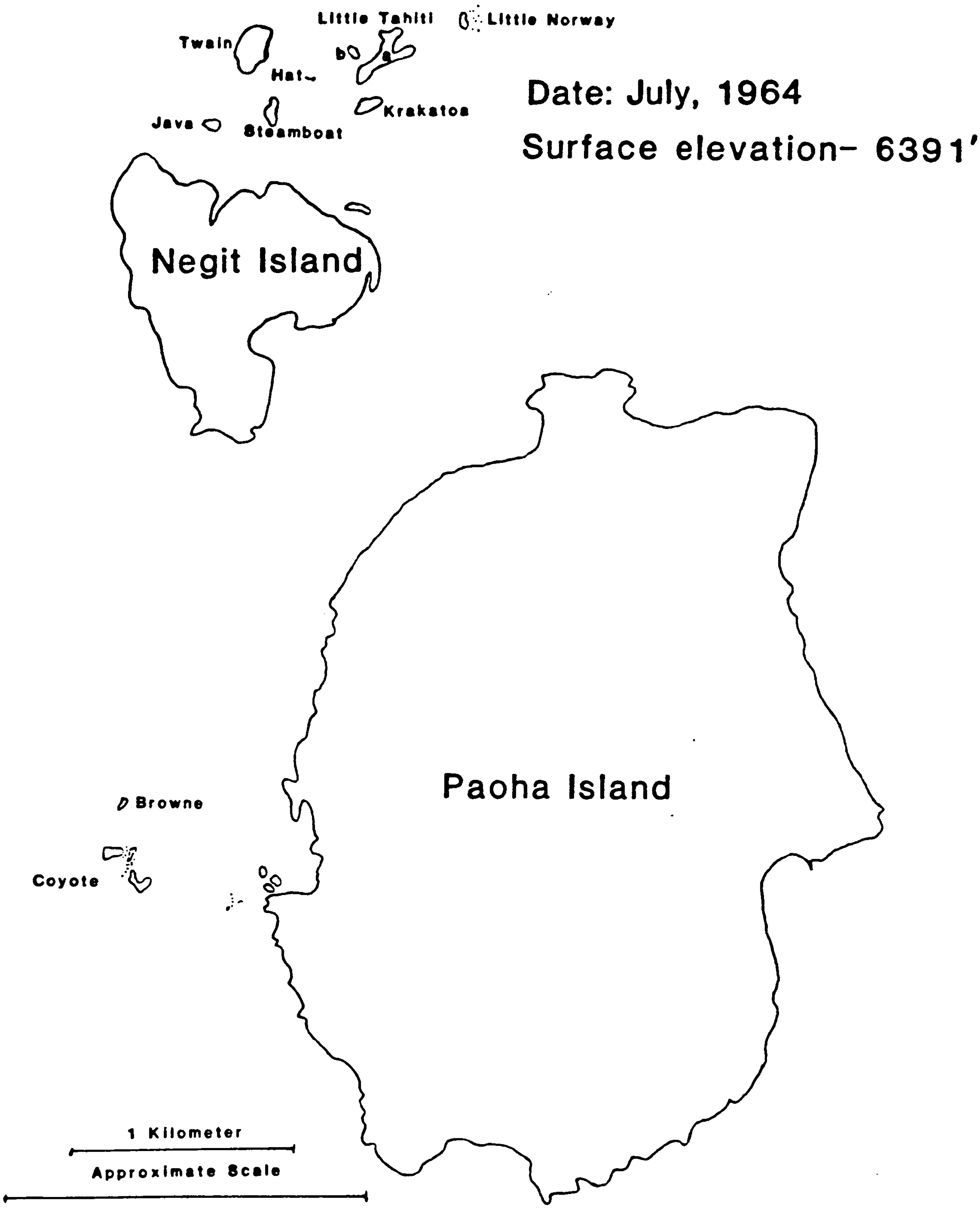
LAKE SURFACE ELEVATION: 6391.57 (±0.15) feet

SIGNIFICANT EVENTS: Growth of previously existing islands; emergence of Browne and Coyote, two islets of the Paoha island-complex; emergence of Hat, an islet of the Negit Archipelago.

AREA OF THE ISLANDS: Acreage of the islands is listed below.

Paoha Island	1822.968 acres
Coyote	~2.504 acres, total
Browne	.208 acres
Negit Island	222.335 acres
Krakatoa	1.510 acres
Little Norway	
main island	.451 acres
spires	~.200 acres, total
Little Tahiti	
a.	6.365 acres
b.	.397 acres
Twain	7.246 acres
Steamboat	1.251 acres
Java	.908 acres
Hat	<.010 acres

DISCUSSION: The subaqueous "ghosts" of 3 islets of the Negit group--La Paz, Muir, and Castle Rocks--and of the Paoha islet Anderson, can be seen on these photos.



Date: July, 1964
Surface elevation- 6391'
Little Tahiti
Little Norway
Twain
b
a
Hat
Java
Steamboat
Krakatoa
Negit Island
Paoha Island
Browne
Coyote
1 Kilometer
Approximate Scale
1 Mile

DATE: June 15, 1972

LAKE SURFACE ELEVATION: 6385.47 feet

SIGNIFICANT EVENTS: Growth of all previously existing islands; emergence of Anderson; emergence of Tie, La Paz, Saddle, Comma, Muir, Spot, and Castle Rocks of the Negit Archipelago; emergence of portions of the Negit landbridge.

DISCUSSION: These high-altitude oblique photos are unsuitable for determination of island area.

DATE: August 11, 1973

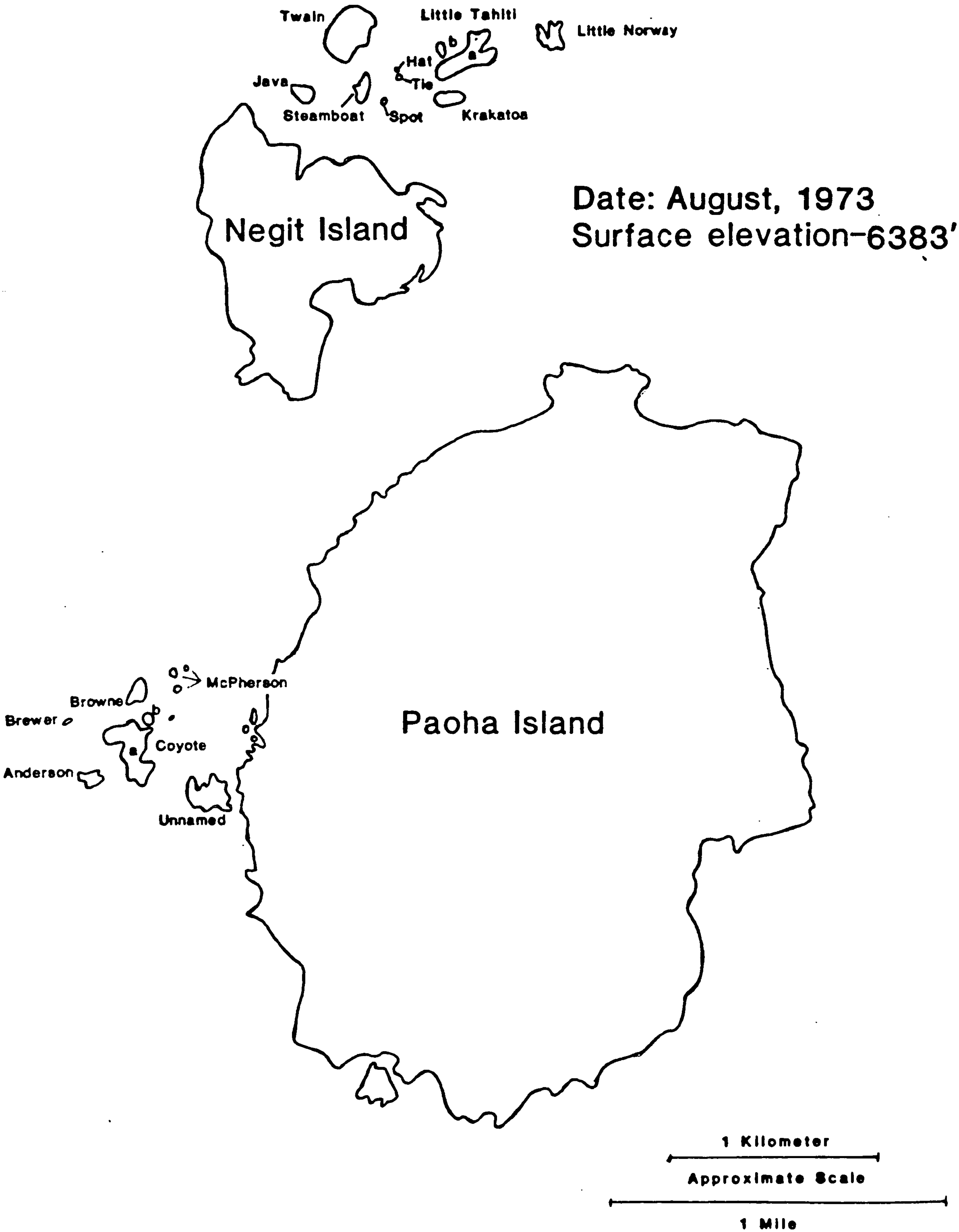
LAKE SURFACE ELEVATION: 6383.41 feet

SIGNIFICANT EVENTS: Continued growth of all previously existing islands; emergence of McPherson and Brewer, 2 islets of the Paoha island-complex (see index map on following page).

AREA OF THE ISLANDS: Acreage of the islands is presented below.

Paoha Island	1923.858 acres
Coyote	
a.	11.023 acres
b.	.779 acres
Browne	1.792 acres
Anderson	2.025 acres
McPherson	~.500 acres
Brewer	~.300 acres
Unnamed	7.089 acres
Negit Island	242.619 acres
Krakatoa	1.870 acres
Little Norway	3.661 acres
Little Tahiti	
a.	7.673 acres
b.	.874 acres
Twain	11.218 acres
Steamboat	1.714 acres
Java	1.558 acres
Hat	<.100 acres
Tie	<.100 acres
Spot	<.300 acres
Castle Rocks	<.050 acres
Muir	<.050 acres
La Paz	<.050 acres
Saddle	<.050 acres
Comma	<.050 acres

DISCUSSION: The following Paoha islets are just beginning to emerge on these photographs: Gull, Smith, Conway, Dawson.


Twain
Little Tahiti
Little Norway
Hat
Tie
Java
Steamboat
Spot
Krakatoa
Negit Island
Date: August, 1973
Surface elevation-6383'
McPherson
Browne
Brewer
Coyote
Anderson
Unnamed
Paoha Island
1 Kilometer
Approximate Scale
1 Mile

DATE: August 29, 1975

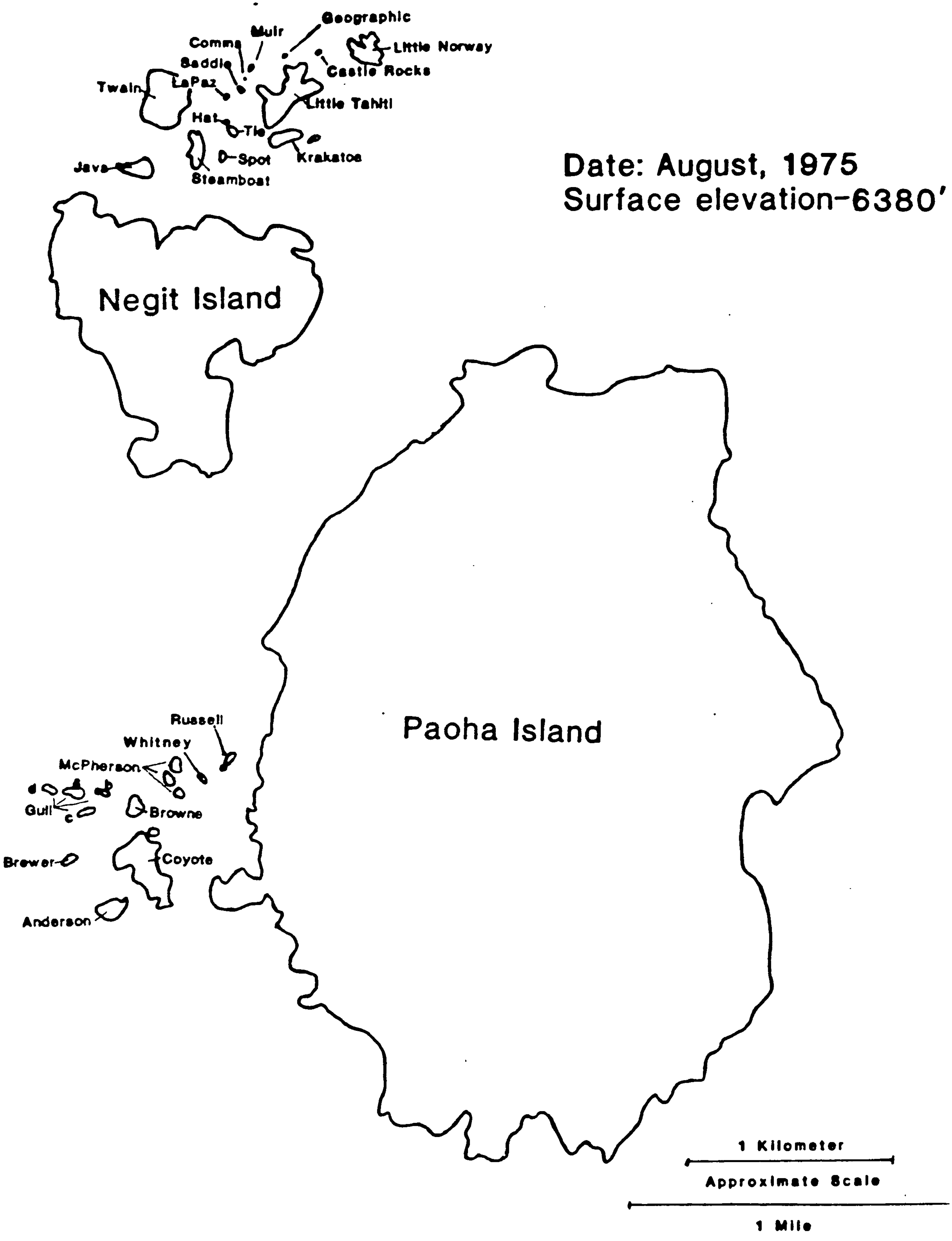
LAKE SURFACE ELEVATION: 6379.5 feet

SIGNIFICANT EVENTS: Growth of all previously existing islands; emergence of Midget, Siren and Geographic, 3 islets of the Negit Archipelago; emergence of Gull, Smith, Conway, and Dawson of the Paoha island-complex.

AREA OF THE ISLANDS: Area of the islands is presented below.

Paoha Island	2004.111 acres	Negit Island	251.576 acres
Coyote	13.229 acres	Krakatoa	2.027 acres
Browne	1.801 acres	Little Norway	3.941 acres
(see discussion below)		Little Tahiti	10.189 acres
		Twain	12.103 acres
		Steamboat	1.914 acres
		Java	1.576 acres
		Hat	<.100 acres
		Tie	<.225 acres
		Spot	.225 acres
		Castle Rocks	<.100 acres
		Muir	<.100 acres
		La Paz	<.100 acres
		Saddle	<.100 acres
		Comma	<.100 acres
		Midget	<.100 acres
		Siren	<.100 acres
		Geographic	<.100 acres

DISCUSSION: Glare reflected from the lake surface precludes accurate planimetering of most of the Paoha islets.



Geographic
Muir
Comma
Little Norway
Saddle
Castle Rocks
Twain
LaPaz
Little Tahiti
Hat
Tie
Krakatoa
Spot
Java
Steamboat
Date: August, 1975
Surface elevation-6380'
Negit Island
Paoha Island
Russell
Whitney
McPherson
Gull
c
Browne
Brewer
Coyote
Anderson
1 Kilometer
Approximate Scale
1 Mile

DATE: September 30, 1979

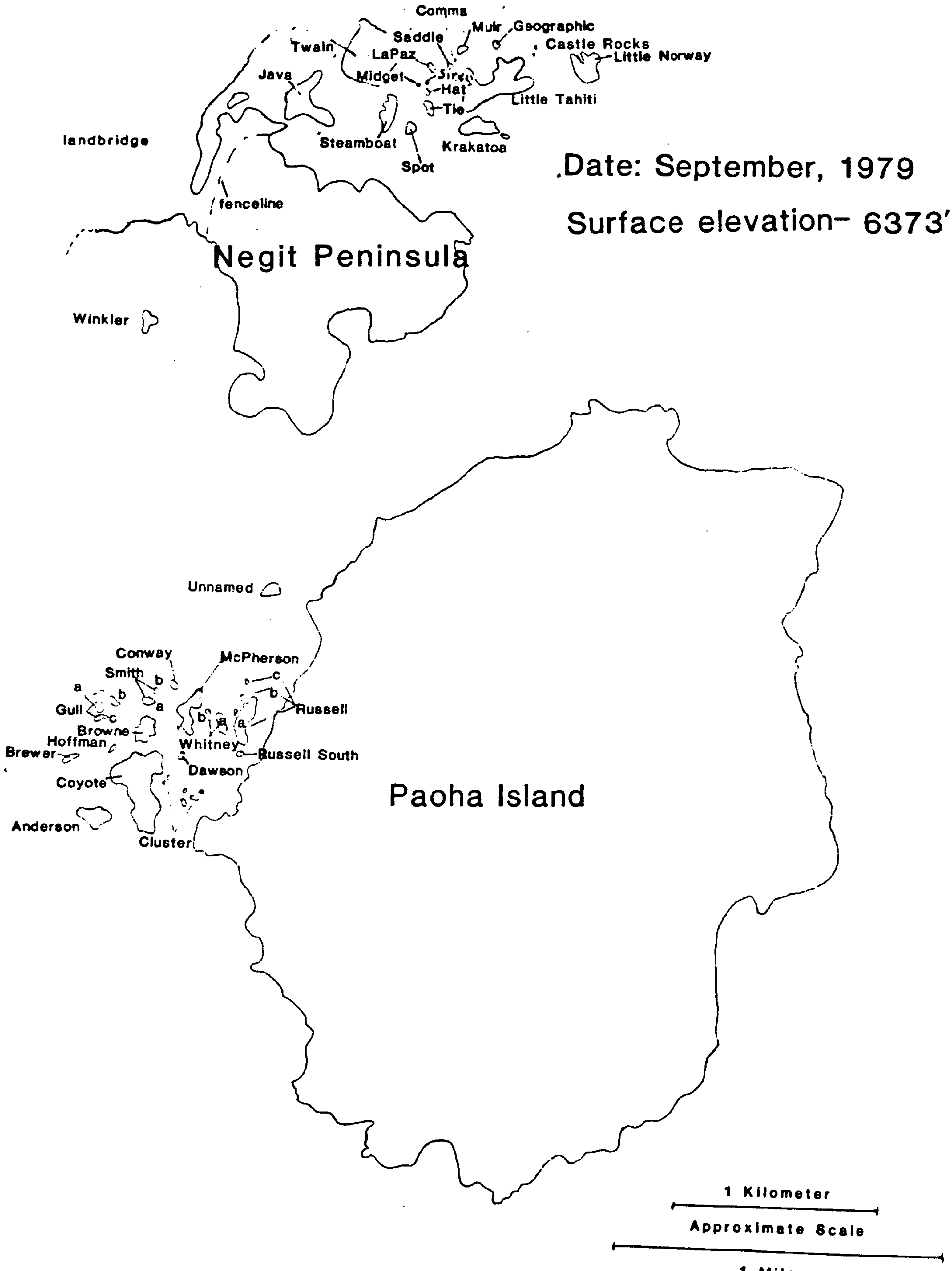
LAKE SURFACE ELEVATION: 6373.46 feet

SIGNIFICANT EVENTS: Peninsularization of Negit Island; growth of previously existing islands; emergence of the following Paoha Islets: Russell, Whitney Hoffman, Cluster, and an unnamed islet off the northwest coast of Paoha; emergence of Winkler, an islet west-southwest of Negit Island (see index map on following page).

AREA OF THE ISLANDS: Island areas are listed below.

Paoha Island	2059.522 acres	Negit Island (at fenceline)	257.408 acres
Coyote	14.752 acres	Krakatoa	2.417 acres
Browne	2.440 acres	Little Norway	4.215 acres
Anderson	3.088 acres	Little Tahiti	10.914 acres
McPherson	3.320 acres	Twain	14.728 acres
Brewer	.174 acres	Steamboat	2.516 acres
Russell		Java	7.364 acres
a.	2.914 acres	Hat	.059 acres
b.	.125 acres	Tie	.277 acres
c.	.050 acres	Spot	.540 acres
Russell South	.055 acres	Castle Rocks	<.050 acres, total
Whitney		Muir	.079 acres
a.	.864 acres	La Paz	.184 acres
b.	.181 acres	Saddle	.151 acres
Gull		Comma	<.010 acres
a.	1.645 acres	Midget	<.010 acres
b.	.265 acres	Siren	<.010 acres
c.	.216 acres	Geographic	.092 acres
Conway	.293 acres	Winkler	.279 acres
Smith			
a.	.237 acres		
b.	.081 acres		
Dawson	.160 acres		
Unnamed	.627 acres		
Cluster	.150 acres, total		
Hoffman	<.100 acres		

DISCUSSION: The area of Negit, which on the 1979 photographs is a peninsula, was measured using the fenceline (see map on following page) as the northwestern boundary. This accounts for the unexpectedly slight increase in the size of that feature between 1975 and 1979.


Comma
Muir
Geographic
Saddle
Castle Rocks
Twain
LaPaz
Little Norway
Siren
Java
Midget
Hat
Little Tahiti
Tie
landbridge
Steamboat
Krakatoa
Spot
Date: September, 1979
fenceline
Surface elevation– 6373'
Negit Peninsula
Winkler
Unnamed
Conway
McPherson
Smith
a
b
c
b
Gull
a
b
Russell
c
b
a
a
Browne
Hoffman
Whitney
Brewer
Russell South
Dawson
Coyote
Paoha Island
c
Anderson
Cluster
1 Kilometer
Approximate Scale

DATE: October 1, 1982

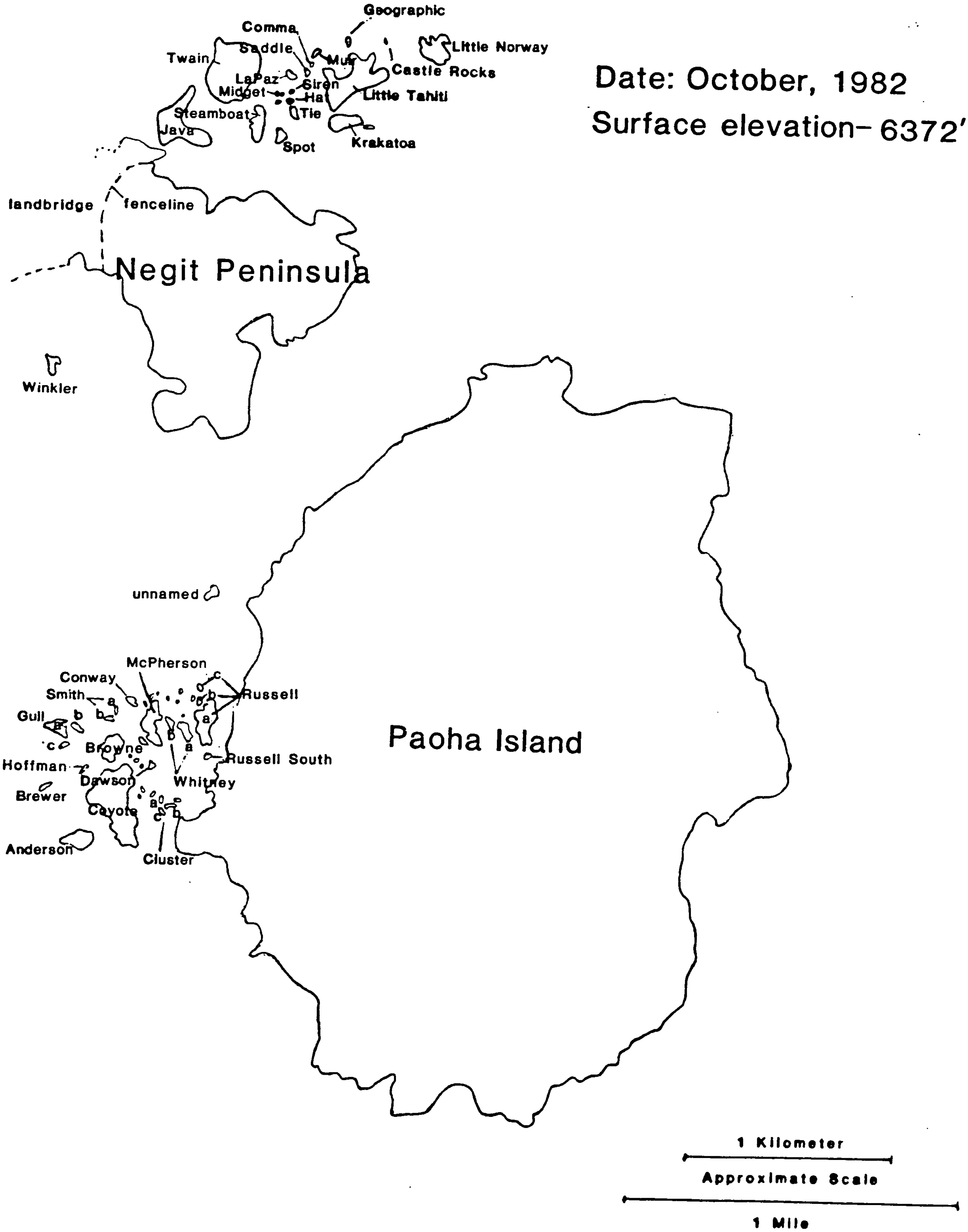
LAKE SURFACE ELEVATION: 6372.77 feet

SIGNIFICANT EVENTS: Lake reaches its historical lowstand; growth of all islands of the Negit Archipelago, and many of the islets of the Paoha island-complex; shrinkage, or unexpectedly small growth, of certain islets of the Paoha island-complex.

AREA OF THE ISLANDS: Acreage of the islands is listed below.

Paoha Island	2130.074 acres
Coyote	14.981 acres
Browne	2.486 acres
Anderson	2.300 acres
McPherson	3.214 acres
Brewer	.205 acres
Russell	
a.	4.247 acres
b.	.158 acres
c.	.062 acres
Russell South	.116 acres
Whitney	
a.	1.138 acres
b.	.405 acres
Gull	
a.	1.634 acres
b.	.431 acres
c.	.300 acres
Conway	.435 acres
Smith	
a.	.126 acres
b.	.325 acres
Dawson	.200 acres
Unnamed	.745 acres
Cluster	
a.	.154 acres
b.	.223 acres
c.	.188 acres
Hoffman	<.050 acres

Negit Island (at fenceline)	263.474 acres
Krakatoa	2.464 acres
Little Norway	4.476 acres
Little Tahiti	11.013 acres
Twain	14.837 acres
Steamboat	2.664 acres
Java	9.535 acres
Hat	.074 acres
Tie	.526 acres
Spot	.638 acres
Castle Rocks	~.040 acres, total
Muir	.100 acres
La Paz	.207 acres
Saddle	.165 acres
Comma	<.100 acres
Midget	<.100 acres
Siren	<.100 acres
Geographic	.112 acres
Winkler	.803 acres


Date: October, 1982
Surface elevation- 6372'
Geographic
Comma
Saddle
Little Norway
Twain
Mur
Castle Rocks
LaPaz
Siren
Midget
Hat
Little Tahiti
Steamboat
Tie
Java
Spot
Krakatoa
landbridge
fenceline
Negit Peninsula
Winkler
unnamed
McPherson
Conway
c
Smith
a
b
Russell
Gull
b
b
a
a
c
b
Browne
a
Russell South
Hoffman
Dawson
Whitney
Brewer
a
Coyote
c
b
Anderson
Cluster
Paoha Island
1 Kilometer
Approximate Scale
1 Mile