NV-61

Hawaiian Electric
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A Survey of the Marine Benthos in the Vicinity of the Kahului Generating Station Maui, Hawaii

MARCH 31, 1975

HAWAIIAN ELECTRIC CO., INC.

AND

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I. INTRODUCTION

A. WORK STATEMENT

Dr. Quisenberry's (Director, Department of Health, State of Hawaii) letter to Mr. Murdoch of Maui Electric Company dated November 20, 1972, granted a Zone of Mixing for the discharge of heated water from the Kahului Generating Station until October 31, 1975. As a condition of the granting of the Zone of Mixing the following was required:

> "8. The grantee shall conduct a biological study of Kahului Bay within the area affected by the Kahului Power Plant Discharge and report the results to the Department of Health before October 31, 1975. The study time should be a minimum of one (1) year to gather data under all possible conditions. The scope of the study shall be approved by the Department of Health prior to its commencement."

A proposal for such a study was submitted to the Department of Health, and subsequently their approval of the plan was given in a letter from Dr. Quisenberry to Mr. Bell of Hawaiian Electric Company dated December 20, 1972. This report constitutes the benthic and intertidal algae surveys outlined in that plan.

B. LOCATION AND SETTING

The Kahului Generating Station is located at 20°54'N. Latitude 156°28'W. Longitude on the north shore of the Island of Maui. Figure 1 shows the location of the station site relative to Kahului Harbor which lies some 914 m (3000 ft) to the west-northwest.

Kahului Harbor consists of a fan-shaped basin with an approximate depth of 11 m (35 feet). The 1183 m (600 ft) wide entrance is bounded on either side by large breakwaters each with a length of over 610 m (2000 ft). An estimated one million tons of waterborne commerce passed through Kahului Harbor during 1970 (U.S. Army Corps of Engineers, 1972 a,b).

Two sewers empty into Kahului Bay, one on either side of the harbor entrance. The Kahului outfall is located about 457 m (1500 ft) west of the power-station outfalls. This outfall is the principal source of pollution in the area (Herschler and Randolph, 1962). At flood tide the wastes from this outfall have been reported to enter the harbor itself. During periods of calm or Kona wind conditions the plume from the outfall is carried seaward and easterly toward the area offshore of the power station. Pineapple pulp and human fecal wastes were observed in this area during the survey.

The revetment northwest of the station is used for sport-fishing to a limited extent, although signs along the revetment warn against water-contact activities due to polluted waters. Wave conditions inside the reef, which lies offshore approximately 805-1609 m (1/2 to 1 mile) are unpredictable; and, thus, boat usage in the station outfall area is slight.

C. STATION OPERATION DATA

Generation capability for the four Kahului steam turbines is 39.5 mw. The station employs a once-through cooling-water system utilizing 2.37m^3/sec. (54.6 mgd) of saltwater drawn from wells. These wells draw saltwater from a depth of approximately 58-67 m (190-220 ft) and are lined to a depth of approximately 30-37m (100-120 ft) to prevent freshwater intrusion. The salinity of the circulating water is approximately 34.5 ppt, and intake temperature is apparently stable at 22.8°C (73°F).

Outfall temperature is dependent upon unit load with three of the four units discharging cooling water at a temperature of 27.2-33.3 (81°-92°F), and the remaining unit at 30-32.8 (86°-91°F). Table 1 shows these characteristics in tabular form. Each unit terminates in a separate discharge located at approximately the high-tide level. Upon leaving the discharge ports the cooling water cascades down rock embankments and enters the sea with almost no momentum.

D. PHYSICAL IMPACT OF STATION

Buske (1972) discusses the physical impact of the Kahului Generating Station upon the nearshore marine area. His conclusion based on this study states that:

> "Under typical environmental conditions, the Kahului Power Plant discharge elevates ocean water temperatures by less than 1.5°F except within an area extending 1500 feet radially from the discharges and 3000 feet alongshore, to the east and to the west of the discharges, with a width of 500 feet. This area is an appropriate Zone of Mixing for the present plant discharge."

Figure 1 illustrates this envelope of 0.83°C (1.5°F) isotherms of temperature in excess of ambient. Since the discharge has little momentum, the horizontal extent of these isotherms is maximized while the vertical extent is minimized. Buske further concludes that this feature of the discharge keeps bottom-dwelling organisms from being subjected to appreciably elevated temperatures except within "tens of feet of shoreline." Figures 2 to 6 illustrate the thermal regime of the nearshore surface waters during typical tradewind conditions. Tradewinds from the N to ENE blow approximately

TABLE 1. Kahulu Generating Station operation characteristics (Steam Units only).

	UNITS 1	2	3	4	Total
Generating Capability (mw)	6.2	6.4	12.4	14.5	39.5
Maximum Cooling Water m^3/min.	13.8	13.8	13.8	15.0	56.4
Flow rates (gpm)	(3700)	(3700)	(3700)	(4000)	(15,100)
Intake temperature °C	22.8	22.8	22.8	22.8	22.8
(°F)	(73)	(73)	(73)	(73)	(73)
Approximate intake salinity (ppt)	34.5	34.5	34.5	34.5	34.5
Discharge temperature °C	27.2-33.3	27.2-33.3	27.2-33.3	30-32.8	27.2-33.3
(°F)	(81-92)	(81-92)	(81-92)	(86-91)	(81-92)

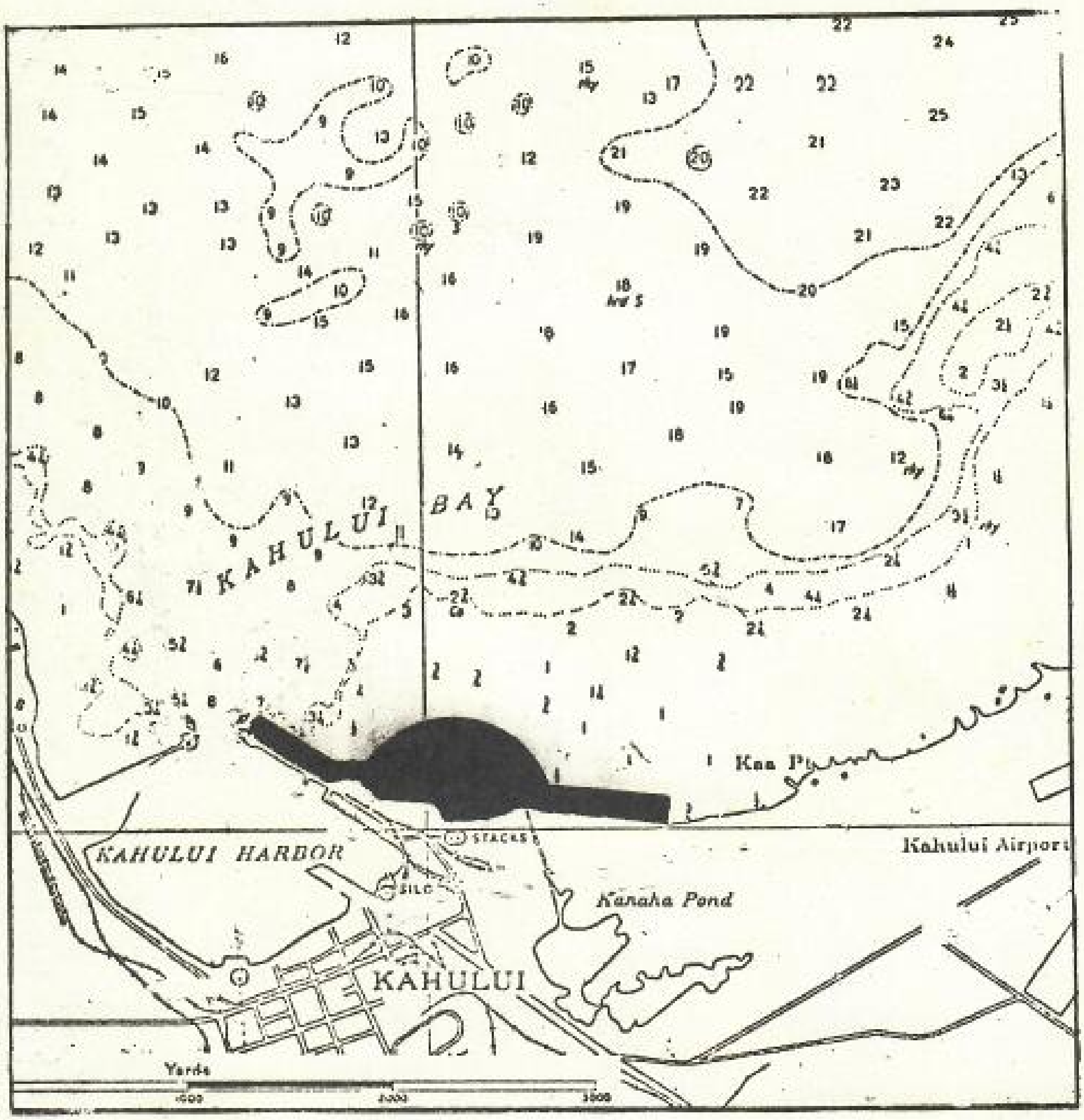

FIGURE 1. Envelope of temperatures 0.83°C (1.5°F) above ambient.

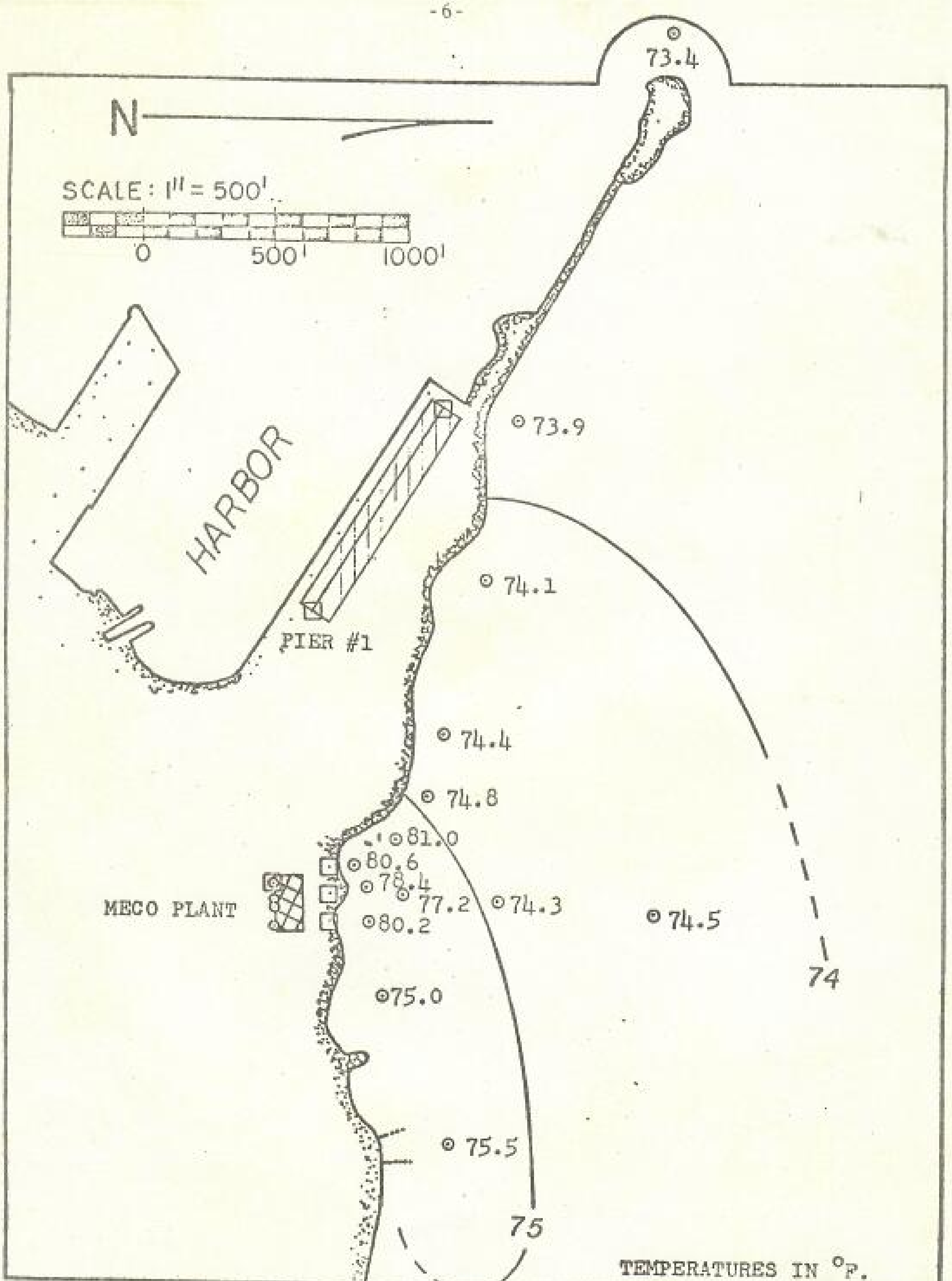

FIGURE 2. Surface water temperatures on 24 March 1972.

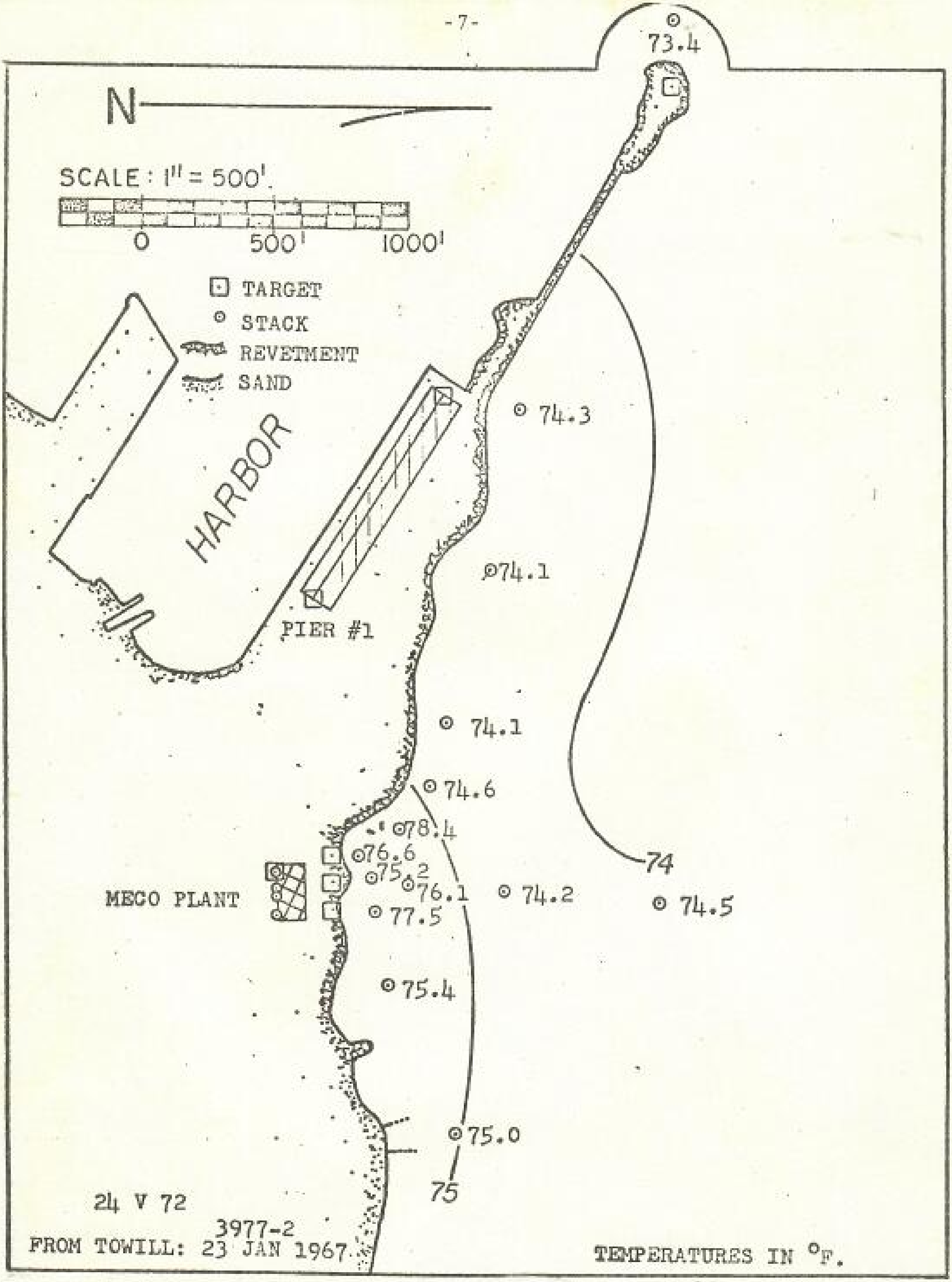

FIGURE 3. One-foot temperatures on 24 March 1972.

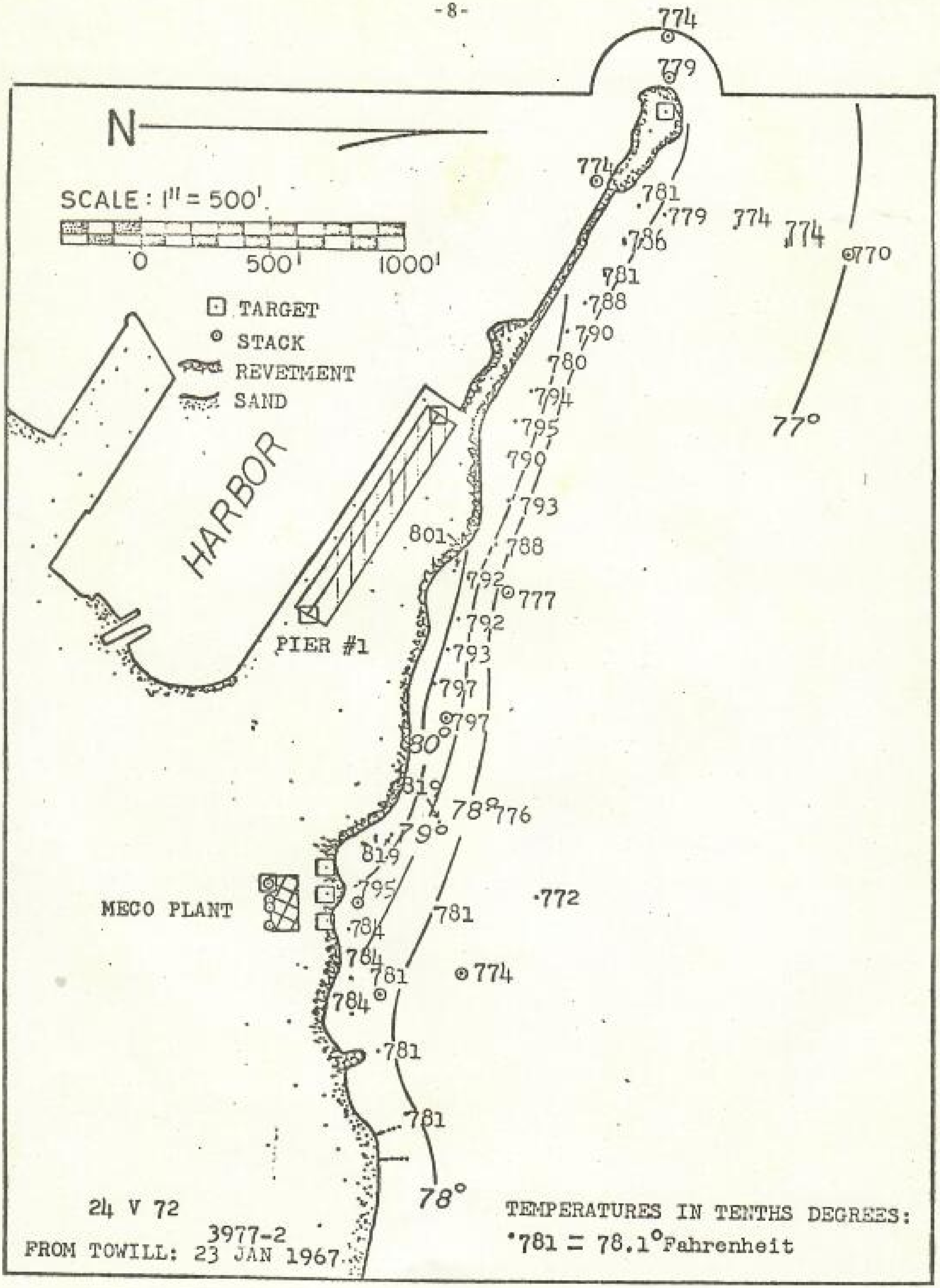

FIGURE 4. One-foot temperatures on 15 May 1972.

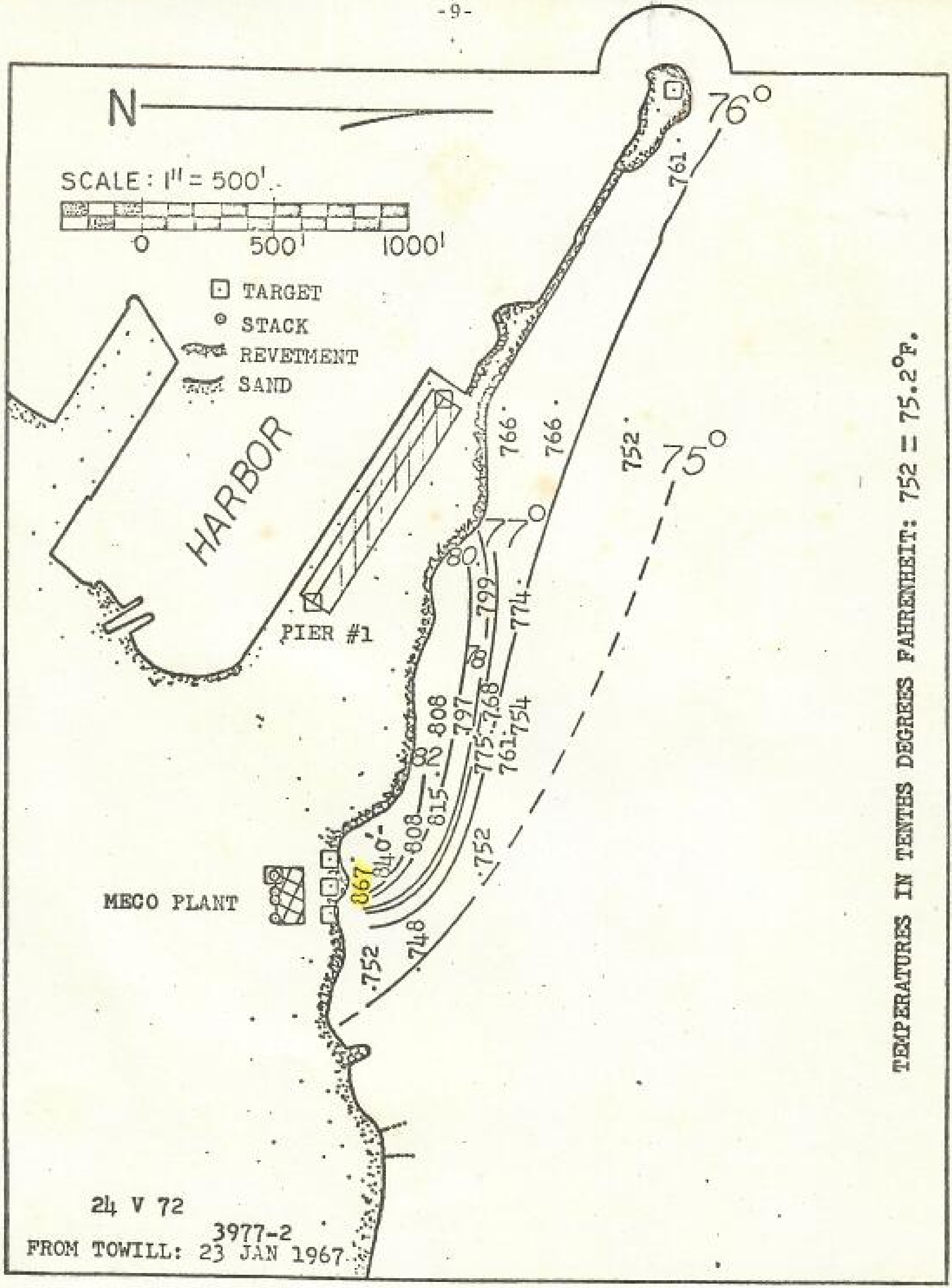

FIGURE 5. Surface water temperatures on 16 May 1972.

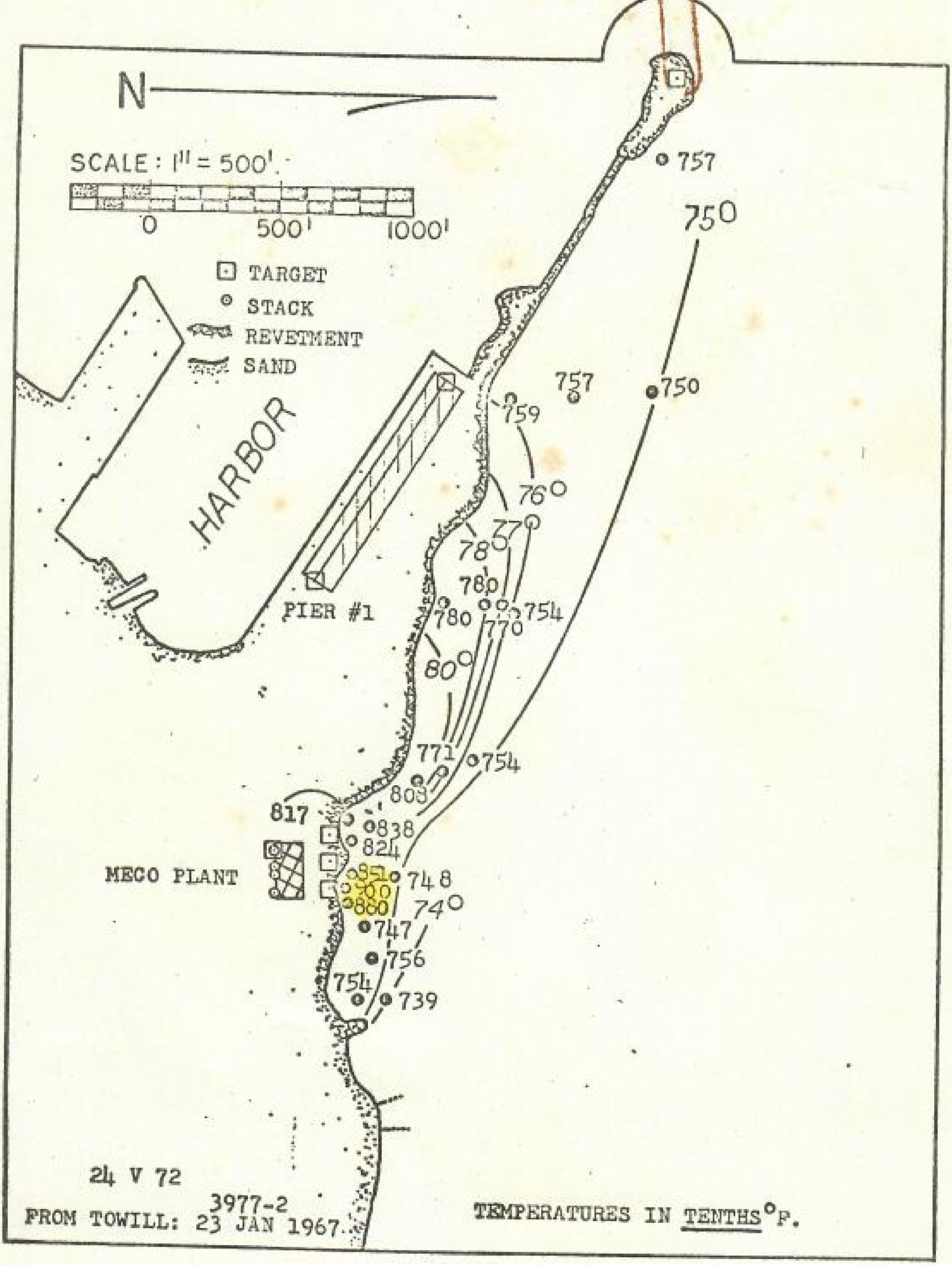

FIGURE 6. Surface water temperatures on 18 May 1972.

60% of the time. Since wind is the predominate motivator of nearshore currents in the area, it is not unexpected to find that net transport of the plume during the tradewinds is toward the harbor mouth. During Kona (southerly winds) periods the plume is driven offshore or swept alongshore to the east.

The thermal plume is primarily a surface phenomenon; however, benthic impingement does occur in the intertidal zone and for a short distance from shore. Figures 7 to 10 show the horizontal extent of the plume on the benthic areas. Since the bathymetry of this area is rather smooth and of a depth of 1.5-3 m (5 - 10 feet) (Figure 11) 8-foot depth temperatures may be considered representative of bottom conditions.

Buske found that the circulating water used for cooling at the station generally had a higher salinity than the adjacent ocean surface waters which are diluted by rainfall and runoff. He found that ambient salinities for the region near the station varied from 32 ppt to 33 ppt, whereas discharge salinities varied from 34.4 to 34.7 ppt. It is conceivable that the high salinity of the discharge may occasionally dominate the temperature effect of the plume so that the effluent would form a warm-water bottom plume. This condition, although conceivable, has not been observed in the field.

As stated above, the nearshore area is rather smooth and of a depth of 1.5-3 m (5-10 ft). Offshore at a distance of approximately 805 m (1/2 mile) the bottom drops abruptly (Figure 1). Most waves approaching the station break at this point rather than striking

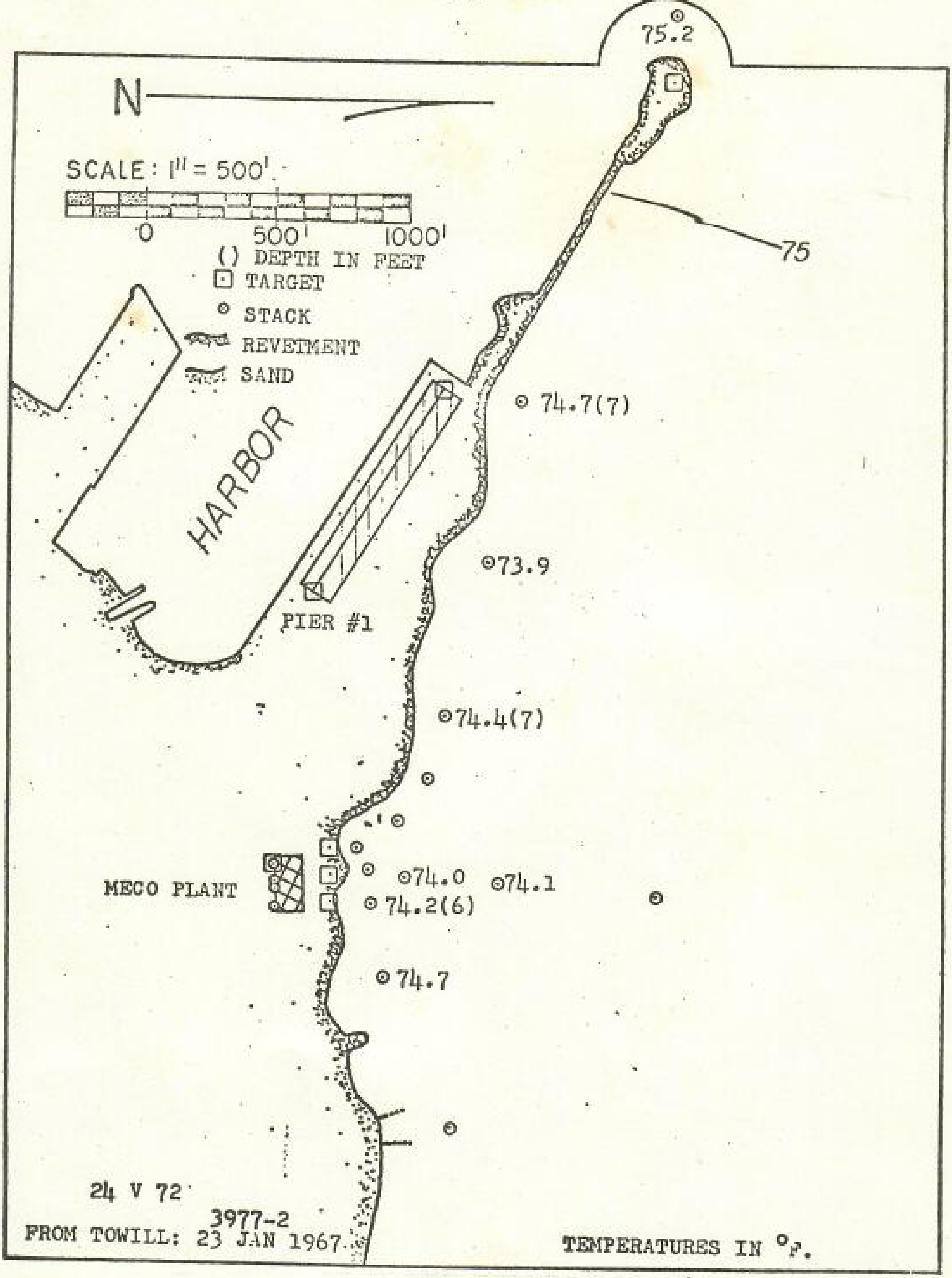

FIGURE 7. Eight-foot temperatures on 24 March 1972.

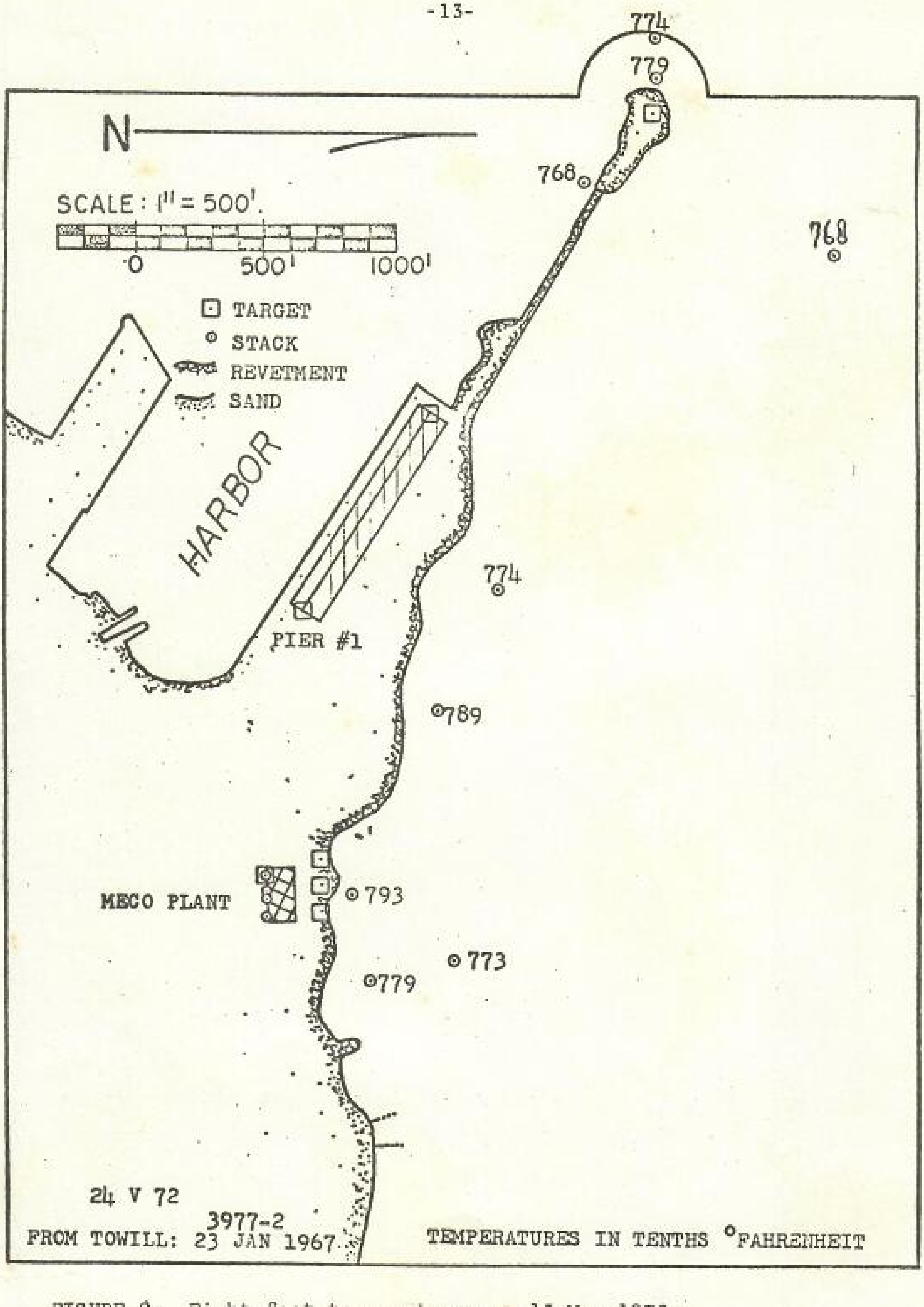

FIGURE 8. Eight-foot temperatures on 15 May 1972.

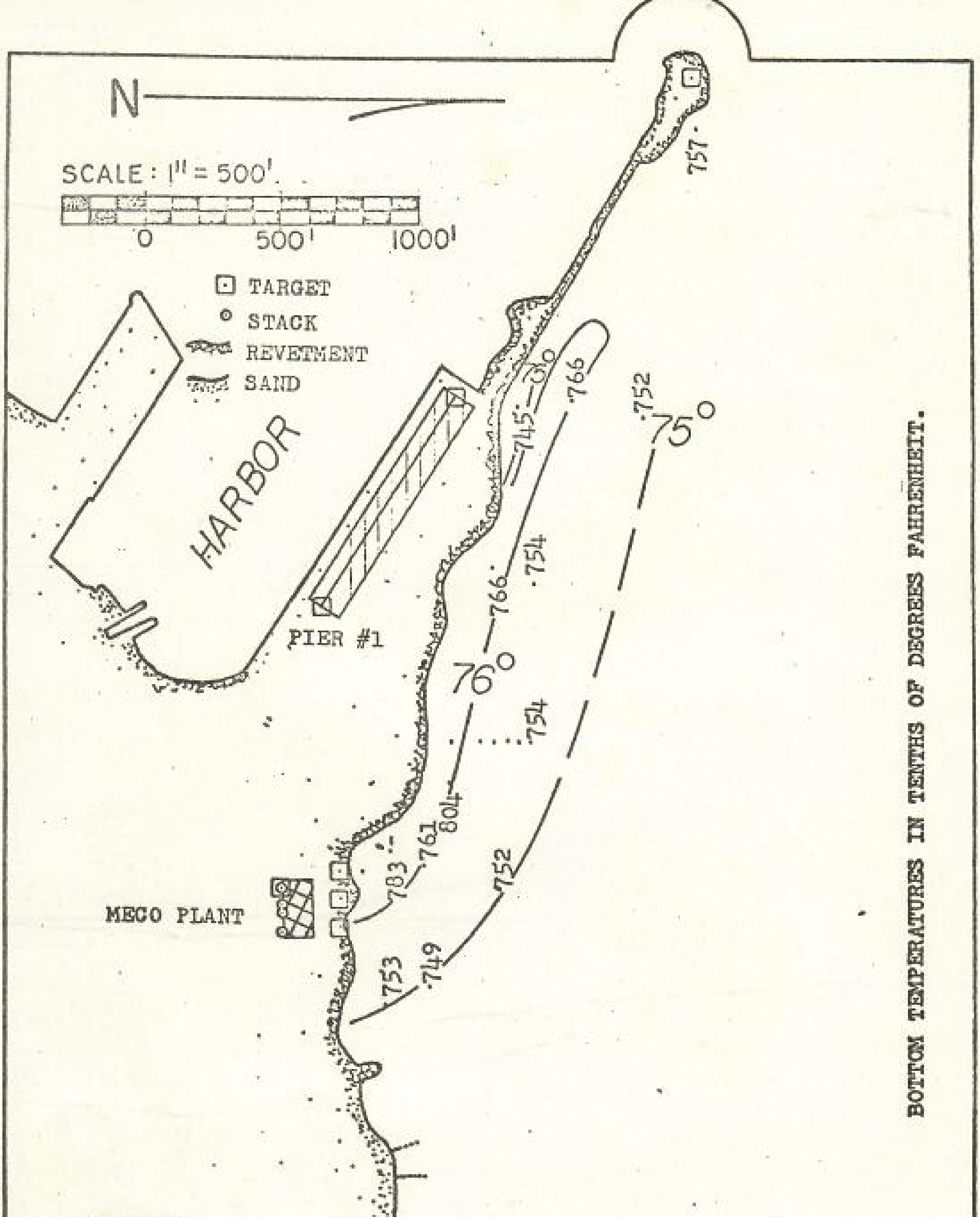

FIGURE 9. Bottom temperatures on 16 May 1972.

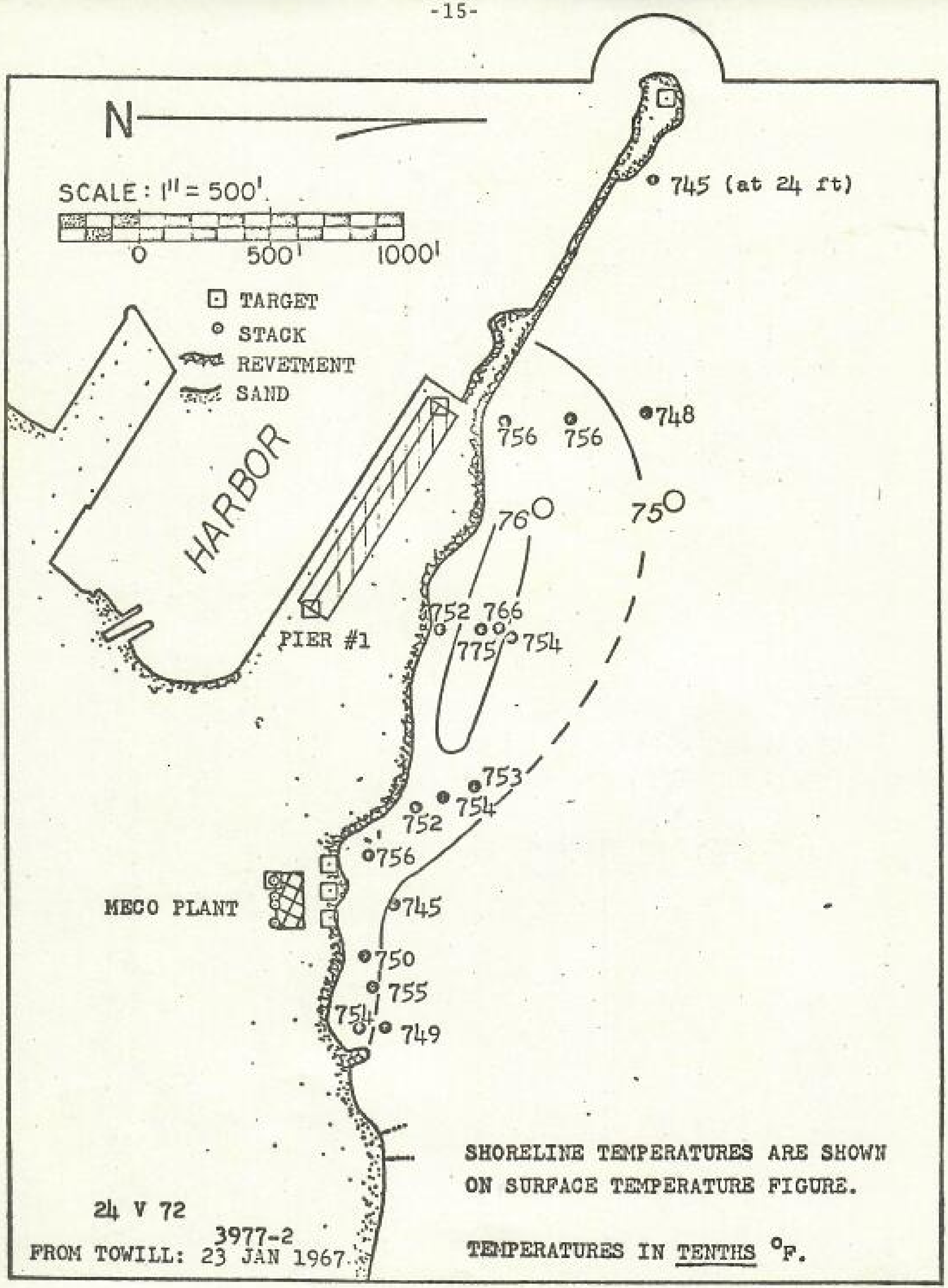

FIGURE 10. Bottom temperatures on 18 May 1972.

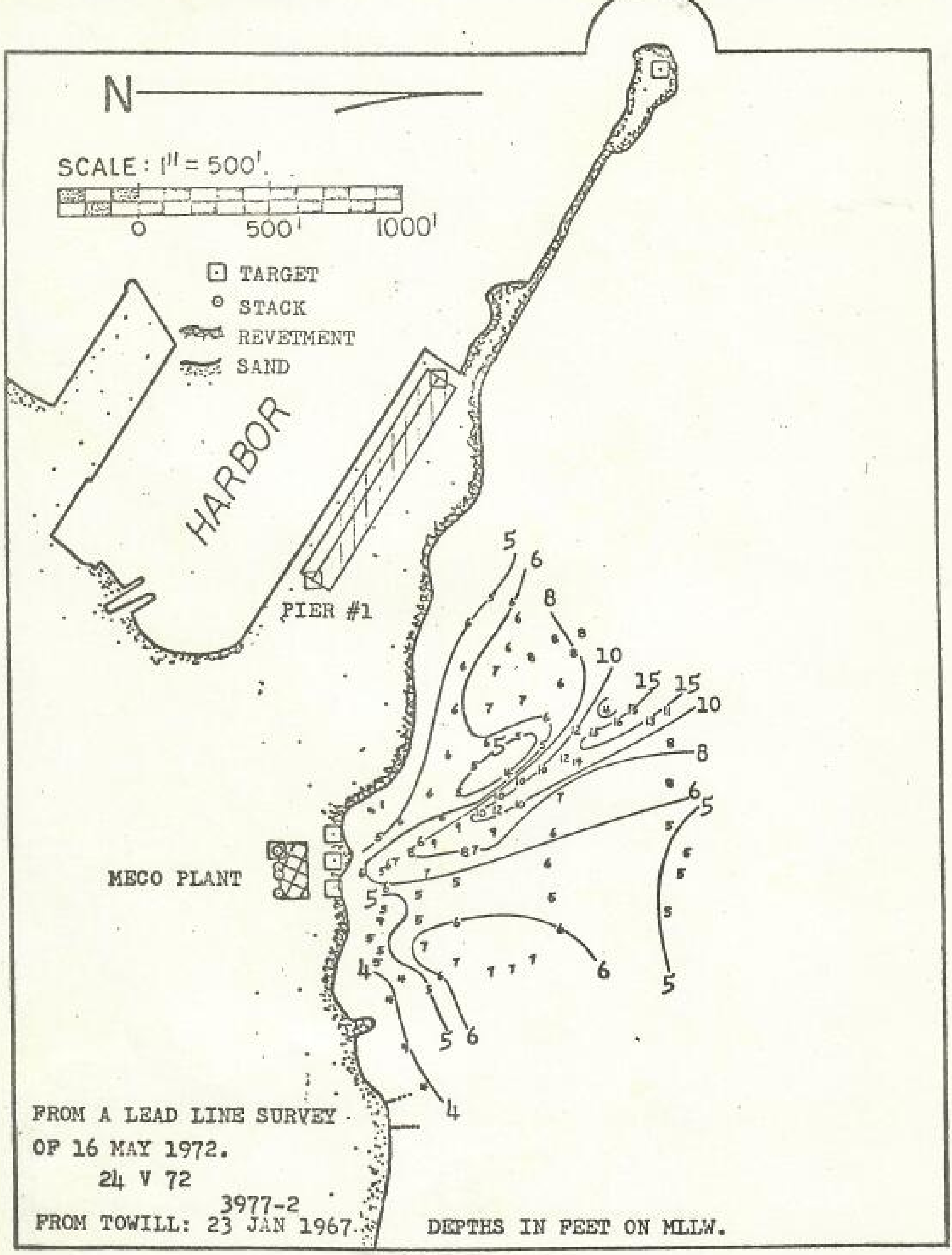

FIGURE 11. Bathymetry near the Kahului Generating Station.

shore. Buske estimated that waves in excess of 1.2 m (4 ft) occur at the station site less than 5% of the time, while waves less than 0.6 (2 ft) occur 82% of the time. Therefore, mixing of the effluent due to wave turbulence is restricted most of the year. Waves striking the harbor entrance breakwater are considerably larger than those reaching the station site.

E. LITERATURE REVIEW

In contrast to more extensive information available on the effects of thermal discharges on temperate marine and freshwater benthos (See reviews by Coutant 1970, 1971; and Bush et. al., 1974), comparatively few studies have been made of thermal effects in subtropical or tropical marine areas. Available information has been derived principally from studies conducted in Florida, Hawaii, Guam, and Puerto Rico. These studies have been predominantly concerned with thermal effects on two types of benthic communities: turtle grass-algal communities and coral reef communities.

Turtle grass (Thalassia testudinum) is the dominant organism providing both food and living habitat in nearshore areas of Florida and the Caribbean. Turtle grass communities in the shallow waters of Biscayne Bay and Card Sound, Florida, have been stressed by thermal effluent from an electrical generating station at Turkey Point, Florida, since 1968. The impact of the effluent on the benthic biota has been substantial and has been described by many authors (Roessler and Zieman, 1969; Ferguson Wood and Zieman, 1969; Roessler, 1971; Thorhaug et al., 1973). Temperatures of +4-5°C over ambient completely killed all turtle grass and macroalgae during summer months of 1968 and 1969. Within the +3°C isotherm, some Thalassia survived, but macroalgae were killed. However, growth of Thalassia in the +2°C isotherm was reported (Thorhaug, et al., 1973) to exceed growth in ambient temperature control areas, and regrowth of Thalassia occurred in the +3°C zone during cooler winter temperatures. The absolute temperature which produced mortality in these studies was, unfortunately, not precisely measured. Roessler and Zieman (1969) report summer, 1969, high effluent temperatures of 38-39°C, while ambient temperatures in mid-bay were 31-32°C. However, Thorhaug, et al. (1973) report that where the +3°C isotherm was maintained, macroalgae and turtlegrass populations fell markedly as temperatures exceeded 31°C. The total damaged area (+3°C or greater) in 1969 encompassed some 300 acres, with 50 acres of this area totally barren of macroflora. These changes were accompanied by growths of blue-green and filamentous green algal mats in the damaged area.

Changes in the macrofaunal populations were also noted to correlate with thermal effects on the macroflora. Stations within the +3-4°C isotherm had few animals in summer but showed some increases during winter. However, standing crops were less than at control stations. At +2-3°C, standing crops were lower in summer but higher in winter than at ambient temperatures. In this +3°C zone, macromollusks were apparently utilizing the dead macroalgae and Thalassia as food. At elevations of +2°C or less, no differences in macrofauna from controls were found. Predictive models based on field data indicated that maximum numbers of species and individuals of benthic macroinvertebrates and fishes occurred near 26°C and that half the species were excluded at 33°C.

A field study of effects of a thermal discharge in Hawaii (Jokiel and Coles, 1974) indicated similar thermal tolerance limits for Hawaiian reef corals. Nearly all corals in water of ambient +4-5°C were killed during late summer, while ambient +2-4°C produced sublethal loss of symbiotic zooxanthellae. Some recovery of these damaged corals occurred during cooler winter temperatures, but mortality of those having lost most of their zooxanthellae was high. The absolute temperatures producing coral mortality were 31-32°C, with sublethal effects imparted by 29-31°C. These results are in good agreement with laboratory measurement of thermal effects on survival and growth of Hawaiian corals (Jokiel and Coles, ms. submitted) which have indicated an optimum temperature of 27°C, approximately the annual ambient temperature maximum.

Effects of thermal loading under truly tropical conditions are described by Jones and Randall (1973) for both algal and coral communities in Guam. Ambient ocean water temperatures of the area range ca. 27-29°C, although temperatures on the reef flat areas generally range about 2°C higher and can approach 34° during mid-day low tides. Effluent from a power-generating station which commenced operation in 1972 elevates temperatures an average of 6.2°C above oceanic and 4.5°C above reef flat mean temperatures. Maximum temperature for the effluent in 1972 was 37.8°C and averaged 33.1°C.

These temperatures reduced the number of macroalgae species in the path of the effluent by 60% (from 39 to 12 species) with a simultaneous increase in abundances of blue-green algae and of two green macroalgae, Enteromorpha and Cladophoropsis. Similarly, all species of fish disappeared from the plume area on the reef flat, and the number of species at the reef margin was reduced by 44%. However, evidence indicated this departure of fish to be more related to use of chlorine in station condensers than to thermal effects.

Substantial mortality of corals occurred at the reef margin in the path of the station effluent. Of a total 61 species, 17 were killed and 37 showed loss of pigment. At the end of the first year of station operation all corals were dead in a core area of 4320 m^2 (ca. 1 acre), while the total area affected approximated 10,000 m^2. Laboratory determinations of thermal tolerances of representative coral species suggest an upper thermal tolerance of 31-32°, similar to results for Hawaiian corals (Jokiel and Coles, 1974).

These studies suggest that an upper lethal temperature of approximately 31°C applies for a variety of benthic organisms from distant areas of the world. Such results are surprising, considering the quite different ranges and normal upper limits of temperature of these three regions. Some evidence exists, however, that upper thermal tolerances are more variable than implied by these studies. Glynn (1968) found Thalassia communities to live on Puerto Rican reef flats where temperature often exceeded 32°C. Damage was imparted to the eel grass by temperatures approaching 40°C on two occasions, but plants possessing well developed rhizomes recovered. Various species of echinoids on these reefs were found by Glynn (1968) to survive temperatures of 35°-38° for up to 4 hours, but combinations of high temperatures and dessication during low tides were lethal to substantial percentages of the echinoid populations. Biebl (1962; cited in Glynn, 1968) found the heat tolerance of a variety of macroalgae to range 35-40°C in Puerto Rico, and that similar tolerances applied to a variety of benthic invertebrates. Orr and Moorhouse (1933) described coral growing in tide pools on the Great Barrier Reef in 37°C, while Gardiner (cited in Orr and Moorhouse; 1933) reported coral to live at 56°C at Minikoi. Kinsmann (1964) describes abundant coral growth in waters of the Persian Gulf where summer temperatures exceed 40°C and average in excess of 30°C. Recent experiments in Eniwetok (Coles and Jokiel, ms.) have indicated that genera previously proposed to be thermally sensitive (*Acropora* and *Pocillopora*) can tolerate continuous exposure to 32.5°C and three-hour exposures to 34°C every six hours for up to three days.

F. Acknowledgments

This report consists of a compilation of data and analytical inputs from numerous sources. Dr. Dennis Devaney of the Bernice P. Bishop Museum conducted the macrobenthic investigations. His primary concern has been the collecting, sorting and determination of the invertebrates, exclusive of the micromollusks. He was assisted in the identification of the Crustacea by Mr. Richard Muffley (Brachyura) and Mrs. Dora M. Banner (Alpheidae).

Mrs. Danielle Fellows in association with Dr. Devaney conducted the micromollusk sorting and identification portions of this survey and were further assisted in sorting by Mrs. Sari Lassiter Astro.

Dr. Stephen V. Smith and Mr. D. T. O. Kam of the Hawaii Coastal Zone Data Bank, University of Hawaii, contributed the factor analysis portion of this study. Mr. Kam assisted in the computer analysis of all data.

Dr. John C. McCain, Dr. Stephen L. Coles, and James M. Peck, Jr., of Hawaiian Electric Company assisted in the collection of samples. Drs. McCain and Devaney collaborated to compile this manuscript, thereby reducing a large mass of benthic data into a somewhat more intelligible mass. Dr. Stephen L. Coles contributed the literature review. Mr. Donn Fukuda of Hawaiian Electric Company assisted in the collection of the algae samples reported herein and has been responsible for their identification.

II. MATERIALS AND METHODS

The analysis of the effects of pollution on natural assemblages of organisms can be extremely time-consuming and thereby, quite costly if complete documentation of physical factors in the environment is required in addition to the elucidation of multitudinous taxa. Practical constraints such as time and money generally cause the environmental assayer to reconcile the intensity of sampling physical factors and to the level of taxonomic discrimination of biological components with his budget. Obviously, some loss of information occurs if the intensity of either portion is reduced.

Physical factors in the marine environment must be monitored over long periods of time and under various climatic and circulatory conditions if one is to obtain a reasonably accurate representation.

The biota themselves, represent an integrated measure of the physical factors affecting an area. The sessile benthos would reflect long-term environmental conditions since they are not at liberty to move away from stressful factors, whereas, in contrast many motile can move from an area of stress. Thus, without a measure of the physical conditions occurring at a particular site, some idea of these conditions may be gained by looking at the composition of the biota.

A point-source of pollution such as a power generating station will cause a change in one or more physical factor (thermal, chemical, etc.), the magnitude of change decreasing away from the source. Thus, an environmental gradient radiating from the source will be established. Such a gradient should be evident from an analysis of the patterns of distribution and abundance of the biota in the region of a source.

It is this pattern in the distribution and abundance of the biota that is examined in this report. Numerous reference is made to the distance from shore or the outfalls and a comparison of these distances is often made. Obviously, physical factors may be aligned along an inshore-offshore gradient and this gradient must be particialed out from the gradient established by the pollution source.

The sampling program described below was designed to establish if such an environmental gradient exists in the area offshore of the Kahului Generating Station outfalls and, if so, what is its magnitude. It is felt that this approach is reasonable in that it is thrifty and results in the loss of only a small amount of information concerning the nature and extent of the marine effects of the power station.

Four types of sampling were employed in order to survey the macrobenthos in the vicinity of the Kahului Generating Station as follows:

A. Quadrants of 1/10 m^2 were scraped from the sublittoral hard substratum to survey reef-dwelling invertebrates and algae.

B. Sediment samples of approximately 25 cc were taken in the sand patches and channels between reef patches to survey the micromollusks.

C. Chain-link counts were made of the algae occurring on the hard substratum.

D. A qualitative survey was made of the intertidal algae occurring along the eastern Kahului Harbor breakwater.

While SCUBA diving, a frame with an area of 1/10 m^2 was placed on the reef and the living material including corals was removed as much as possible using a geology hammer to break the hard substratum. The organisms along with as much rubble and sediment as possible were then placed in a plastic bag, which was frozen until sorting could be done in the laboratory. Quadrants were taken at each end and at the mid-point of 25 meter transect lines located at the stations shown on Figure 12. The dates of collection of reef quadrants are as follows:

January 16, 1973: T-1 to T-8

January 17, 1973: T-9 to T-12

March 13, 1973: T-13 to T-14

March 14, 1973: T-15

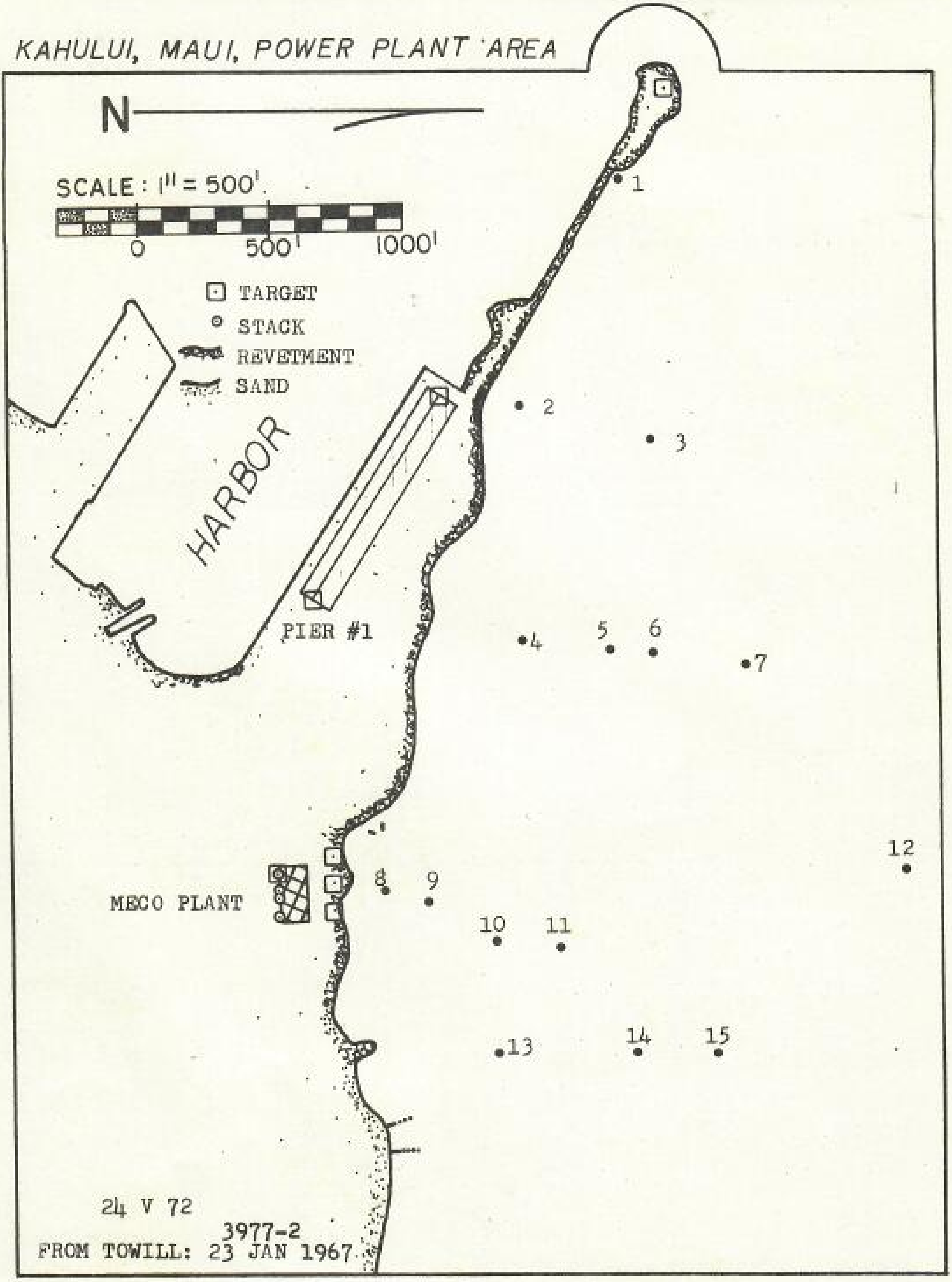

FIGURE 12. Reef quadrants, station locations.

Mollusks were sorted from the sediment collected with the reef quadrants; however, this approach yielded far from satisfactory quantitative results. Therefore, a separate series of twelve 25 cc samples were collected in the sand patches and channels adjacent to the reefs, and nine 25 cc sand samples were collected from areas near the reef quadrants. These quantitative micromollusk (less than 1/8 inch) samples are shown in Figure 13. The date of collection of these samples are as follows:

January 17, 1973: 2D, 7

May 10, 1973: 1-12 (sand channel samples)

November 2, 1973: 8E, 8W, 9E, 10A, 11E, 11W, no number

McCain (1972) reports on the effects which the discharge from the Kahului Generating Station had upon horizontal zonation of intertidal algae. Using similar methods this survey was repeated on December 26-27, 1972, and August 8, 1973. This intertidal survey consisted of careful examination of the revetment at the sampling sites indicated in Figure 14 for all species of algae present. An attempt at quantification of this data failed, due to the irregularities of the revetment, the vertical zonation of algae on the revetment, and the wave conditions encountered.

A quantitative survey of the sublittoral algae on the reef was made by laying a 100-link chain and then counting the number of links touched by the various species of algae. No attempt was

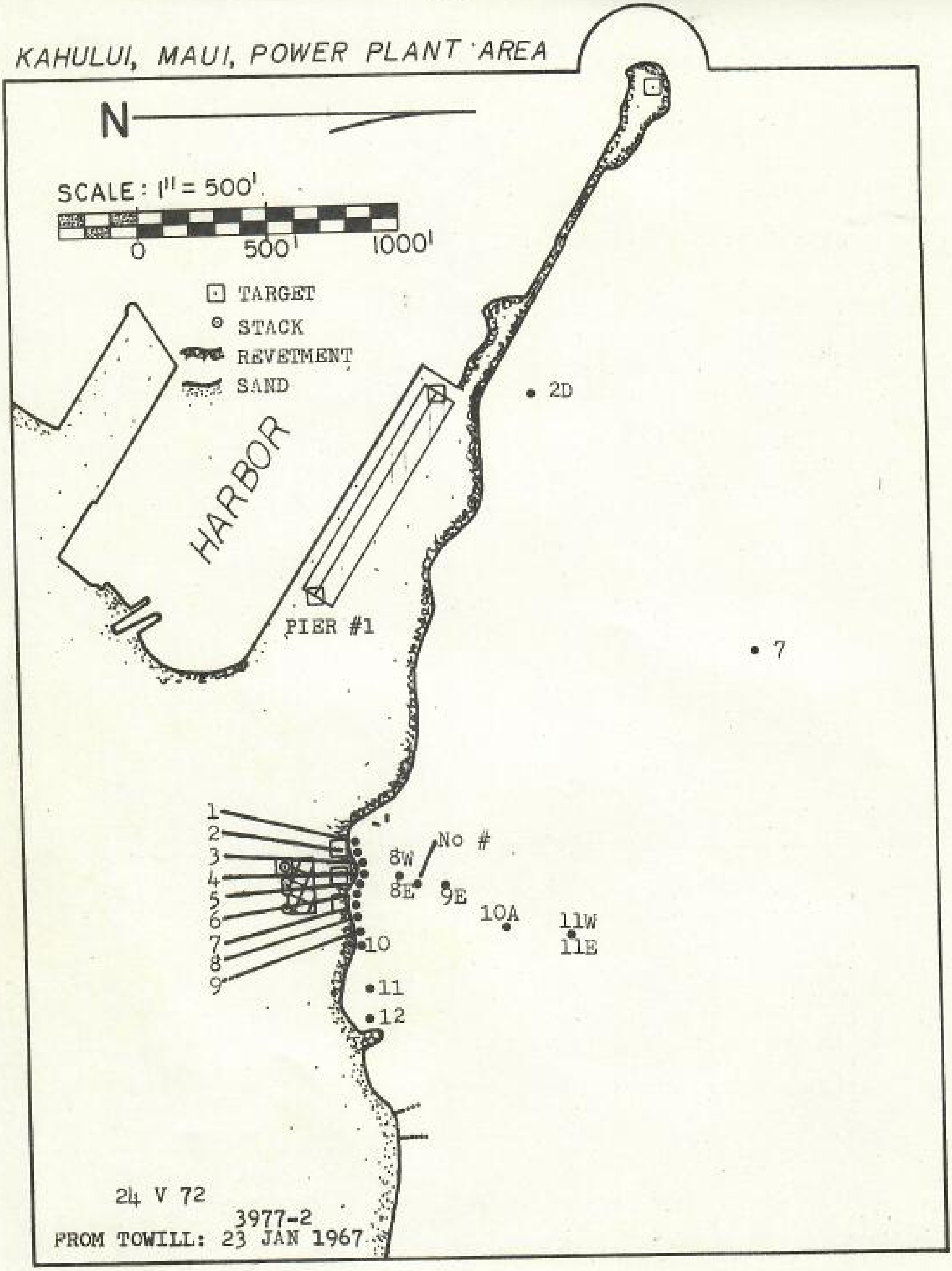

FIGURE 13. Quantitative micromollusk station locations.

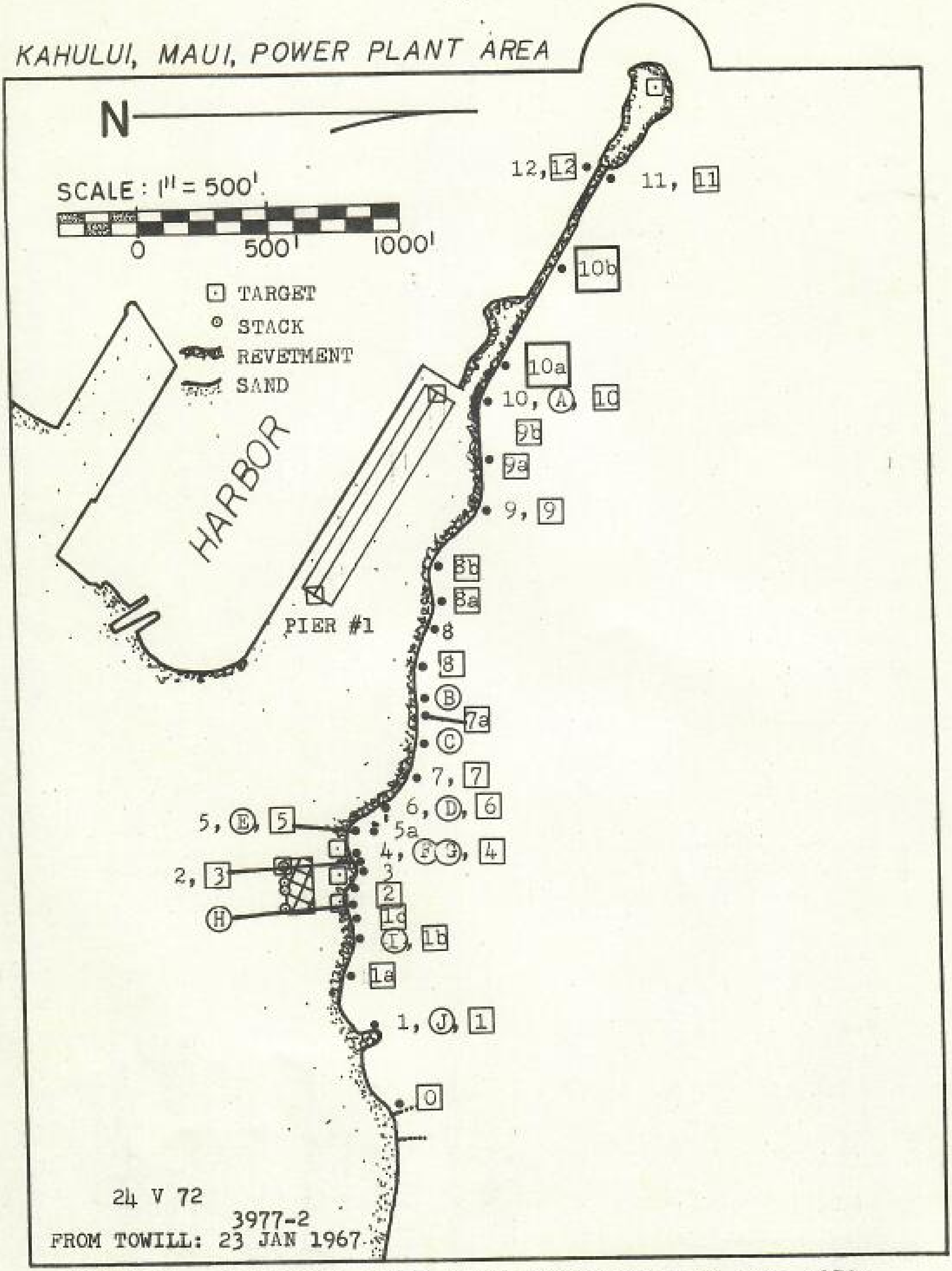

FIGURE 14. Intertidal algae survey stations: 1-12, May, 1972; (A) - (J), August, 1973; [0] - [12], December, 1972.

made to randomize the positioning of the chain; rather, it was laid along a path which was felt to be representative of the sampling site. This survey was conducted on August 9, 1973, at the stations indicated on Figure 15.

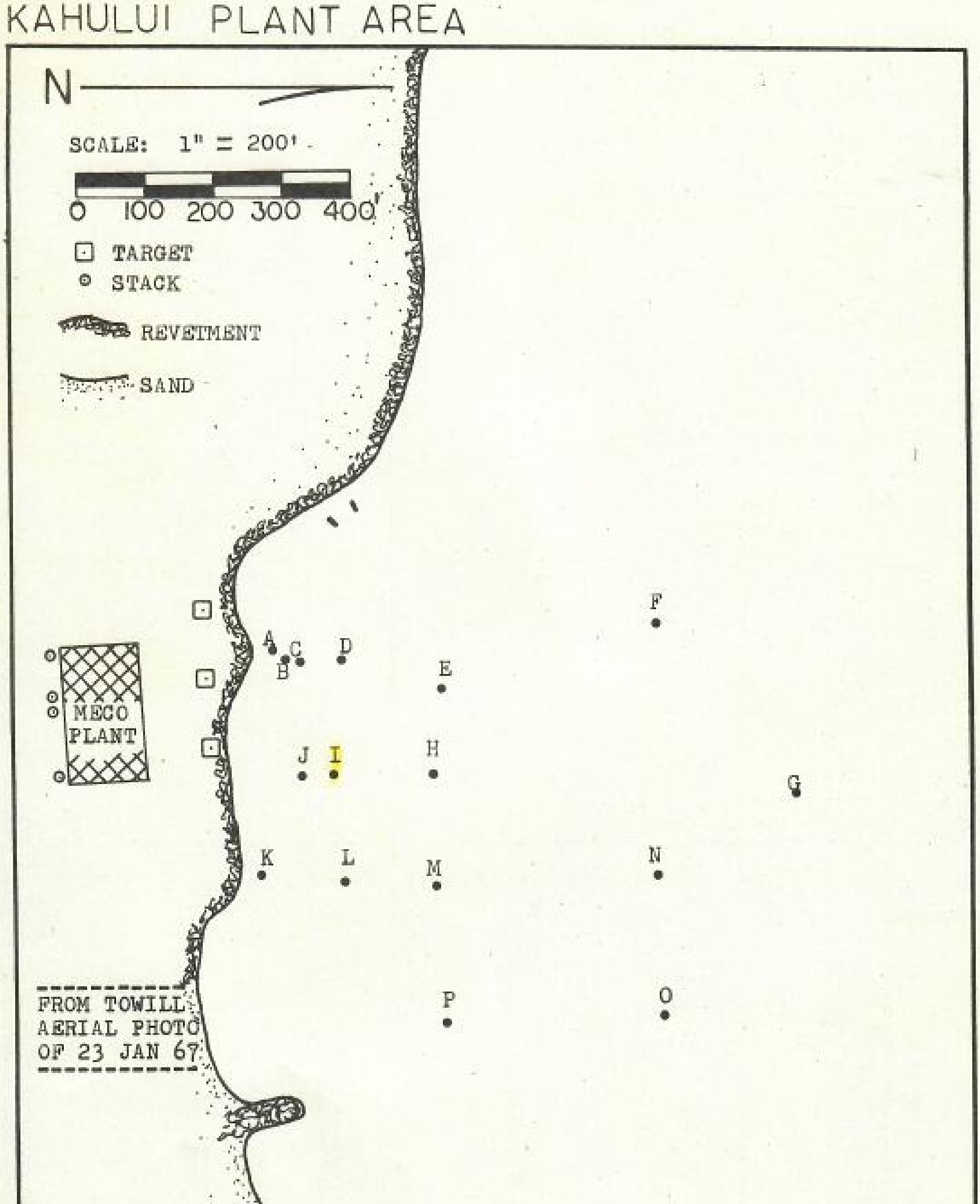

FIGURE 15. Sublittoral algae survey stations.

III. BIOLOGICAL RESULTS AND DISCUSSION

A. ALGAE

The results of the qualitative survey of intertidal algae near the Kahului Generating Station are presented in Table 2. A total of 55 species were recorded from this intertidal area.

In order to compare stations as to algal composition a series of analyses were made using Sørensen's Quotient of Similarity (QS) (Sørensen, 1948):

$$QS = \frac{2\ (\text{taxa in common between stations A and B})}{\text{taxa at each station (A+B)}}$$

A total of 46 stations were surveyed during the three sampling periods. The 46x46 matrix of QS values is not presented due to its large size. Instead, dendrographs were prepared for each sampling period and for all periods combined. These dendrographs were prepared using the procedure given by McCammon and Wenninger (1970) whereby a hierarchial arrangement is arrived at based on clustering, using the unweighted pair-group method which reflects both the within-group and the between-group similarities. Figures 16-18 depict the relationship of stations surveyed for each sampling period, and Figure 19 depicts the relationship for all stations which were surveyed. McCain (1972) based his survey on the May 1972 stations. He concluded that the effect of the thermal discharges from the generating station was limited to an area within 7.6 m (25 ft) of the discharges, since the algal

Table 2: Intertidal algae observed at Kahului, Maui.

STATIONS

MAY 17, 1972

	1	2	3	4	5	6	7	8	9	10	11	12
CHLOROPHYTA												
Bryopsis hypnoides												
B. pennata var. secunda												
B. sp.												
Caulerpa racemosa						X	X					
Chaetomorpha antennina		X	X									
C. Indicus												
Cladophora hemisphaerica												
Cladophoropsis sp.												
Derbesia minima												
Enteromorpha clathrata												
E. lingulata												
E. tubulosa		X	X									
Monostroma oxyspermum												
Pseudochlorodesmis parva	X	X	X	X	X	X	X	X	X	X		
Rhizoclonium riparium												
Siphonocladus tropicus												
Struvea sp.												
Ulva fasciata	X	X	X	X	X	X	X	X	X	X	X	X
U. Reticulata												
Chrysophyta (diatom)												
Melosira sp.		X	X									

DECEMBER 26-27 1974

	0	1	1a	1b	2a	2	3	4	5	5a	6	7	7a	8	8a	8b	9	9a	9b	10	10a	10b	11	12
CHLOROPHYTA																								
Bryopsis hypnoides																								
B. pennata var. secunda																								
B. sp.																								
Caulerpa racemosa										X		X		X										
Chaetomorpha antennina	X				X	X	X	X	X	X	X	X	X	X		X	X				X			
C. Indicus																	X							X
Cladophora hemisphaerica										X														
Cladophoropsis sp.																								
Derbesia minima																								
Enteromorpha clathrata																								
E. lingulata	X				X		X																	
E. tubulosa	X	X			X		X	X				X	X			X				X			X	X
Monostroma oxyspermum						X											X							
Pseudochlorodesmis parva			X	X						X	X	X	X	X							X	X		
Rhizoclonium riparium						X	X																	
Siphonocladus tropicus			X	X						X	X	X	X	X							X			
Struvea sp.																								
Ulva fasciata	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
U. Reticulata																								
Chrysophyta (diatom)																								
Melosira sp.																								

AUGUST 8 1973

	A	B	C	D	E	F	G	H	I	J
CHLOROPHYTA										
Bryopsis hypnoides								X		
B. pennata var. secunda									X	
B. sp.							X			
Caulerpa racemosa		X	X	X						
Chaetomorpha antennina	X		X	X	X		X	X		X
C. Indicus										
Cladophora hemisphaerica			X							
Cladophoropsis sp.										X
Derbesia minima		X	X	X						
Enteromorpha clathrata						X	X			
E. lingulata						X	X			
E. tubulosa								X		X
Monostroma oxyspermum										
Pseudochlorodesmis parva							X			
Rhizoclonium riparium										
Siphonocladus tropicus										
Struvea sp.				X						
Ulva fasciata				X	X		X			
U. Reticulata	X	X	X	X	X		X		X	X
Chrysophyta (diatom)										
Melosira sp.										

Table 2 (continued): Intertidal algae observed at Kahului, Maui

STATION

RHODOPHYTA

MAY 17, 1972

	1	2	3	4	5	6	7	8	9	10	11	12
Acanthophora spicifera	X	X			X	X	X	X				
Ahnfeltia plicata						X	X					
A. sp. (plicata?)	X	X		X	X	X	X	X		X	X	
A. sp. (?)												
Amansia glomerata	X											
Centroceras clavulatum	X											
Ceramium gracillimum												
Gelidiella sp.												
Gelidiopsis sp. (intricata?)	X	X										
Gelidium sp. (?)												
Gigartina sp. (?)												
Goniotrichum sp. (?)												
Gracilaria sp.												
Grateloupia filicina		X	X		X							
G. hawaiiensis	X				X	X	X	X		X		
Grateloupia (or Ahnfeltia?) sp.			X			X	X	X		X	X	
Griffithsia ovalis												
G. sp.												
Hemitrema fragilis												
Hypnea cornuta												
H. esperi								X				
H. sp.												
Laurencia sp.	X											
Lophosiphonia sp.												

DECEMBER 26-27, 1972

	0	1	1A	1B	1C	2	3	4	5	5A	6	7	7A	8	8A	8B	9	9A	9B	10	10A	10B	11	12
Acanthophora spicifera			X	X	X	X				X	X		X	X	X	X	X	X			X			
Ahnfeltia plicata																								
A. sp. (plicata?)		X	X	X	X			X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
A. sp. (?)																								
Amansia glomerata																								
Centroceras clavulatum										X														
Ceramium gracillimum																								
Gelidiella sp.																								X
Gelidiopsis sp. (intricata?)						X	X	X	X	X														
Gelidium sp. (?)	X																							
Gigartina sp. (?)																								
Goniotrichum sp. (?)																	X							X
Gracilaria sp.								X		X														
Grateloupia filicina																								
G. hawaiiensis	X	X	X	X	X			X	X	X	X			X			X	X			X			
Grateloupia (or Ahnfeltia?) sp.																								
Griffithsia ovalis																								
G. sp.																								
Hemitrema fragilis																	X							
Hypnea cornuta																								
H. esperi						X			X															
H. sp.																								
Laurencia sp.																								
Lophosiphonia sp.																								

AUGUST 8, 1973

	A	B	C	D	E	F	G	H	I	J
Acanthophora spicifera	X	X	X	X	X		X		X	X
Ahnfeltia plicata	X	X	X	X	X				X	
A. sp. (plicata?)										
A. sp. (?)					X		X			X
Amansia glomerata	X			X						
Centroceras clavulatum				X					X	
Ceramium gracillimum			X	X	X					
Gelidiella sp.							X			
Gelidiopsis sp. (intricata?)										
Gelidium sp. (?)				X	X			X		
Gigartina sp. (?)								X		
Goniotrichum sp. (?)										
Gracilaria sp.										
Grateloupia filicina					X		X			
G. hawaiiensis		X	X	X					X	
Grateloupia (or Ahnfeltia?) sp.					X					
Griffithsia ovalis									X	
G. sp.									X	
Hemitrema fragilis										
Hypnea cornuta		X								
H. esperi	X	X			X				X	
H. sp.	X		X	X					X	
Laurencia sp.	X						X			X
Lophosiphonia sp.		X								

Table 2 (continued): Intertidal algae observed at Kahului, Maui

STATIONS

	MAY 17 1962											
	1	2	3	4	5	6	7	8	9	10	11	12
RHODOPHYTA (cont.)												
Polysiphonia sp.				X	X	X	X	X		X		
Porphyra sp.											X	
Pterocladia capillacea											*X	X
Rhodoglossum (or *Chondrus*?) sp.											X	
Taenioma perpusillum												
PHAEOPHYTA												
Ectocarpus indicus	X										X	
Ralfsia occidentalis												
Sargassum echinocarpum												
CYANOPHYTA												
Brachytrichia sp. (?)												
Lyngbya spp.		X	X						X			
Oscillatoria sp.												

	DECEMBER 26-27, 1972																							
	0	1	1A	1B	1C	2	3	4	5	5A	6	7	7A	7B	8A	8B	9	9A	9B	10	10A	10C	11	12
RHODOPHYTA (cont.)																								
Polysiphonia sp.			X	X	X		X			X	X	X	X			X		X	X		X	X		
Porphyra sp.																							X	
Pterocladia capillacea																								X
Rhodoglossum (or *Chondrus*?) sp.			X	X						X	X	X	X	X							X	X		
Taenioma perpusillum																								
PHAEOPHYTA																								
Ectocarpus indicus												X		X					X					
Ralfsia occidentalis																X								X
Sargassum echinocarpum																								
CYANOPHYTA																								
Brachytrichia sp. (?)																								X
Lyngbya spp.			X			X	X	X	X	X	X	X	X		X						X	X	X	X
Oscillatoria sp.																	X							

	AUGUST 8, 1973									
	A	B	C	D	E	F	G	H	I	J
RHODOPHYTA (cont.)										
Polysiphonia sp.	X	X	X	X	X		X		X	
Porphyra sp.										
Pterocladia capillacea	X		X						X	
Rhodoglossum (or *Chondrus*?) sp.	X	X							X	
Taenioma perpusillum										
PHAEOPHYTA										
Ectocarpus indicus								X		X
Ralfsia occidentalis									X	
Sargassum echinocarpum										
CYANOPHYTA										
Brachytrichia sp. (?)										
Lyngbya spp.						X	X	X		X
Oscillatoria sp.										