APPENDIX A

ENVIRONMENTAL ASSESSMENT AND FINDING OF NO SIGNIFICANT IMPACT

FINAL

ENVIRONMENTAL ASSESSMENT
KAUMĀLAPAʻU HARBOR BREAKWATER REPAIR
Island Of Lānaʻi, Hawaiʻi

May 2002

US Army Corps of Engineers ®

Department of the Army
U.S. Army Engineer District, Honolulu

and

State of Hawaiʻi
Department of Transportation

FINDING OF NO SIGNIFICANT IMPACT (FONSI)
KAUMĀLAPAʻU HARBOR BREAKWATER REPAIR
ISLAND 0F LĀNAʻI, HAWAIʻI

1. Description of the Proposed Action. The proposed plan of improvement consists of repairing the existing breakwater at Kaumālapaʻu Harbor, Lānaʻi, to reduce wave action in the harbor and increase harbor safety and usability.

   The breakwater will be rebuilt on the footprint of the old rubblemound structure, with the existing structure serving as the core of the new breakwater. The new breakwater will have a crest length of 320 feet, and a crest elevation of +14.5 feet mllw. The existing rubblemound structure will be re-shaped to form the core of the breakwater, over which will be placed an underlayer of 2.5 to 4.5 ton stone and an armor layer of 35-ton Core-Loc concrete armor units. The breakwater crest and top row of Core-Loc units will be stabilized by a concrete crest cap. The new armor units will extend to a depth of 45 to 55 feet on the ocean side and 20 feet on the harbor side, and the toe of the armor layer will be stabilized by a stone buttress.

2. Basis for Finding. The following factors were considered in the Environmental Assessment (EA) in making a determination that an Environmental Impact Statement (EIS) is not required for the proposed project.

2.1 The project consists of the repair of an existing manmade structure, in an area which has previously been disturbed by breakwater construction and maintenance activities. Significant maintenance was required following a severe kona storm in 1980 and hurricane ʻIwa in 1982, and the breakwater was again severely damaged by hurricane ʻIniki in 1992. A well-engineered repair of the breakwater will essentially eliminate the requirement for maintenance in the future.

2.2 Construction of the project would not significantly alter the environmental setting of the area. Natural resources and human use of the surrounding area would not be noticeably affected. Failure to repair the damaged breakwater would result in continued hazardous berthing conditions in the islands only barge harbor. The project would benefit the economic welfare of the residents of Lānaʻi by facilitating the timely and consistent delivery of fuel and goods to the island, and would reduce the possibility of accidents.

2.3 The project site is not a wetland, special aquatic site, marine sanctuary or wildlife refuge. Coral cover on the existing breakwater will be destroyed by the project, however the new breakwater will consist of materials similar to the existing breakwater and coral is expected to re-colonize on the new structure. The larger new breakwater with more hard surface area should result in a long-term net increase in coral cover in the area. Care will be taken during construction to avoid damage to the natural reef areas adjacent to the breakwater. The larger breakwater will also increase fish habitat (shelter), with a resultant positive impact on fish abundance. The repairs will also reduce damage to corals caused by rock and concrete rubble movement during storm wave attack.

2.4 Endangered species coordination with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service concluded that the proposed project would not affect

endangered or protected species or their critical habitat, nor would the project affect an identified Essential Fish Habitat.

2.5 Construction would utilize large stone and pre-cast concrete units, no fine-grained sediment would be introduced into the water. Care will be exercised to insure that no contamination of the marine environment with petroleum products or other deleterious materials results from construction activity. Best Management Practices and an Environmental Protection Plan for construction operations will be developed to help minimize adverse impacts to coastal water quality and the marine ecosystem. While the new breakwater is designed to reduce surge at the wharf, it would not significantly alter circulation or flushing of the harbor, and no change in water quality at the project site is anticipated following completion of construction.

2.6 Exhaust gases from construction equipment may cause a temporary reduction of air quality at the project site during construction, and some temporary generation of dust in the construction area resulting from the transport and handling of construction materials. There would be temporary localized increases in ambient noise due to operation of heavy equipment during construction. There would not, however, be any long-term impacts to air or noise quality following completion of construction.

2.7 The project will not affect archaeological or cultural resources in the project area. Concurrence with the Corps "no effect" determination has been obtained from the State Historic Preservation Office.

2.8 The project will be undertaken in a manner consistent to the fullest extent practicable with the State Coastal Zone Management Program.

2.9 The project would not affect scenic vistas or viewplanes identified in county or state plans or studies.

2.10 The project would not result in secondary effects, such as population changes or infrastructure demands, or involve a commitment to larger actions.

2.11 The project would not require significant energy consumption, energy will only be required during construction. Repair of the breakwater would reduce future energy requirements associated with maintenance of the structure.

3. Findings. Based on the findings of the environmental assessment, the US Army Corps of Engineers finds that the proposed breakwater repair project does not constitute a major federal action significantly affecting the quality of the environment; therefore an EIS will not be prepared for this project.

Ronald N. Light

Ronald N. Light
Lieutenant Colonel, US Army
District Engineer

May 17, 2002
Date

FINAL
ENVIRONMENTAL ASSESSMENT
FOR
KAUMĀLAPAʻU HARBOR BREAKWATER REPAIR
ISLAND OF LĀNAʻI, HAWAIʻI

This Joint Document is Submitted Pursuant to 42 USC 4321,
40 CFR 1500-1508, 33 CFR 230, ER 1105-2-100, and Chapter 343, HRS

Federal Proponent:
U.S. Army Engineer District, Honolulu

State Proponent:
Department of Transportation, Harbors Division

May 2002

TABLE OF CONTENTS

1. INTRODUCTION AND SUMMARY 1

1.1 IDENTIFICATION OF AUTHORITY AND SCOPE OF DOCUMENT 1

1.2 SUMMARY DESCRIPTION OF THE PROPOSED ACTION 1

1.3 SUMMARY DESCRIPTION OF ALTERNATIVES 3

1.4 SUMMARY OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES 3

2. PURPOSE OF AND NEED FOR THE PROPOSED ACTION 5

2.1 PURPOSE OF THE PROPOSED ACTION 5

2.2 NEED FOR THE PROPOSED ACTION 5

3. DESCRIPTION OF THE PROPOSED ACTION 6

3.1 PROJECT LOCATION 6

3.2 SITE DESCRIPTION 6

3.3 PROJECT FEATURES 6

3.4 CONSTRUCTION OPERATIONS 7

3.5 CONSTRUCTION SCHEDULE AND COST 8

4. ALTERNATIVES INCLUDING THE PROPOSED ACTION 11

4.1 NO ACTION 11

4.2 OTHER IMPROVEMENT ALTERNATIVES CONSIDERED 11

5. ENVIRONMENTAL SETTING 13

5.1 THE NATURAL ENVIRONMENT 13

5.1.1 Physical Marine Environment 13

5.1.2 Air Quality 19

5.1.3 Noise 19

5.1.4 Water Quality 19

5.1.5 Marine Biology 20

5.1.6 Terrestrial Biological Resources 24

5.1.7 Threatened and Endangered Species 24

5.2 MAN-MADE ENVIRONMENT 25

5.2.1 Harbor Facilities 25

5.2.2 Hazardous Waste 25

5.3 THE SOCIO-ECONOMIC ENVIRONMENT 26

5.3.1 Ocean Activities 26

5.3.2 Harbor Operations 26

TABLE OF CONTENTS (continued)

5.4 HISTORIC AND CULTURAL RESOURCES 27

6. ENVIRONMENTAL CONSEQUENCES 28

6.1 THE NATURAL ENVIRONMENT 28

6.1.1 Physical Marine Environment 28

6.1.2 Air Quality 28

6.1.3 Noise 28

6.1.4 Water Quality 28

6.1.5 Marine Biological Resources 28

6.1.6 Terrestrial Biological Resources 29

6.1.7 Threatened and Endangered Species 29

6.2 THE MAN-MADE ENVIRONMENT 30

6.3 THE SOCIO-ECONOMIC ENVIRONMENT 30

6.4 HISTORIC AND CULTURAL RESOURCES 30

7. CONCLUSIONS 31

7.1 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY 31

7.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES 31

7.3 PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED 31

7.4 EVALUATION OF STATE OF HAWAIʻI IMPACT SIGNIFICANCE CRITERIA 32

7.5 MITIGATION MEASURES 34

7.6 UNRESOLVED ISSUES 35

8. LIST OF PREPARERS 36

9. PUBLIC AND AGENCY INVOLVEMENT, REVIEW AND CONSULTATION 37

9.1 PROJECT SCOPING MEETING 37

9.2 STATE AND FEDERAL AGENCY COORDINATION 37

9.3 DRAFT ENVIRONMENTAL ASSESSMENT COORDINATION 37

9.4 STATE AND FEDERAL AGENCY COORDINATION 38

10. REFERENCES 39

APPENDICES:

Appendix A: Assessment of Water Quality Pre-Construction Monitoring

Appendix B: Assessment of Marine Biological Community Structure

Appendix C: Final Fish and Wildlife Coordination Act Report

Appendix D: Coordination Letters

Appendix E: Section 404(B)(1) Evaluation

TABLE OF CONTENTS (continued)

Appendix F: Coastal Zone Management (CZM) Consistency Certification

Appendix G: Oral Historic Studies for the Determination of Traditional Cultural Places at Kaumālapaʻu Harbor, Lānaʻi Island, Hawaiʻi

Appendix H: DEA Review Comment and Response Letters

1. INTRODUCTION AND SUMMARY

1.1 Identification of Authority and Scope of Document

The proposed action involves modifications and repairs to the existing breakwater at Kaumālapaʻu Harbor, Island of Lānaʻi, Hawaiʻi. The authority for this study is provided in the Energy and Water Development Appropriations Acts of 1993 and 1994. The 1993 Act stated the following:

> "the Secretary of the Army, acting through the Chief of Engineers is directed to initiate pre-construction engineering and design; and environmental studies for the Kaumālapaʻu Harbor, Lānaʻi, Hawaiʻi, project."

A special design report was initiated with this act – Kaumālapaʻu Harbor Special Design Report, Island of Lāna`i, Hawai`i prepared, by the US Army Corps of Engineers, Pacific Ocean Division, 1996. The Act of 1994 continued these actions, stating:

> "to continue pre-construction engineering and design, including preparation of the special design report, initiation of National Environmental Policy Act document preparation and initiation of hydraulic model studies for the Kaumālapaʻu Harbor navigation study, Lānaʻi, Hawaiʻi."

This environmental assessment (EA) is prepared to address the effects of the breakwater repair on the environment, and is in accordance with both federal and state requirements. The EA conforms to the National Environmental Policy Act, Council of Environmental Quality (CEQ) regulations, Army Regulations (AR) 200-2-2, and Department of the Interior (DOI) Manual on Environmental Quality, Part 516. It also conforms to State of Hawaiʻi Revised Statutes, Chapter 343, on the preparation of environmental assessments.

1.2 Summary Description of the Proposed Action

Kaumālapaʻu Harbor is a small barge harbor located in a natural embayment on the southwest coast of Lānaʻi (Figure 1). The harbor has a 10-acre berthing area, and water depths between 20 and 60 feet. Shoreside facilities along the north side of the embayment consist of a 400-foot long wharf, a cargo shed and barge loading and unloading equipment. The harbor has no distinct entrance channel and has a 600-foot wide opening at the mouth of the bay. A breakwater extending to the south from the northwestern point of the embayment protects the harbor and wharf facilities. The breakwater was reportedly originally 400 feet long, but has been reduced by wave damage to a current length of approximately 200 to 250 feet. The remnants of the breakwater crest elevation are about 10 feet above mean lower low water (mllw).

The badly deteriorated breakwater allows increased wave energy to enter the harbor, thereby hindering safe berthing and cargo handling. The purpose of the proposed action is to repair the existing breakwater at Kaumālapaʻu Harbor to reduce wave action in the harbor and increase harbor safety and usability.

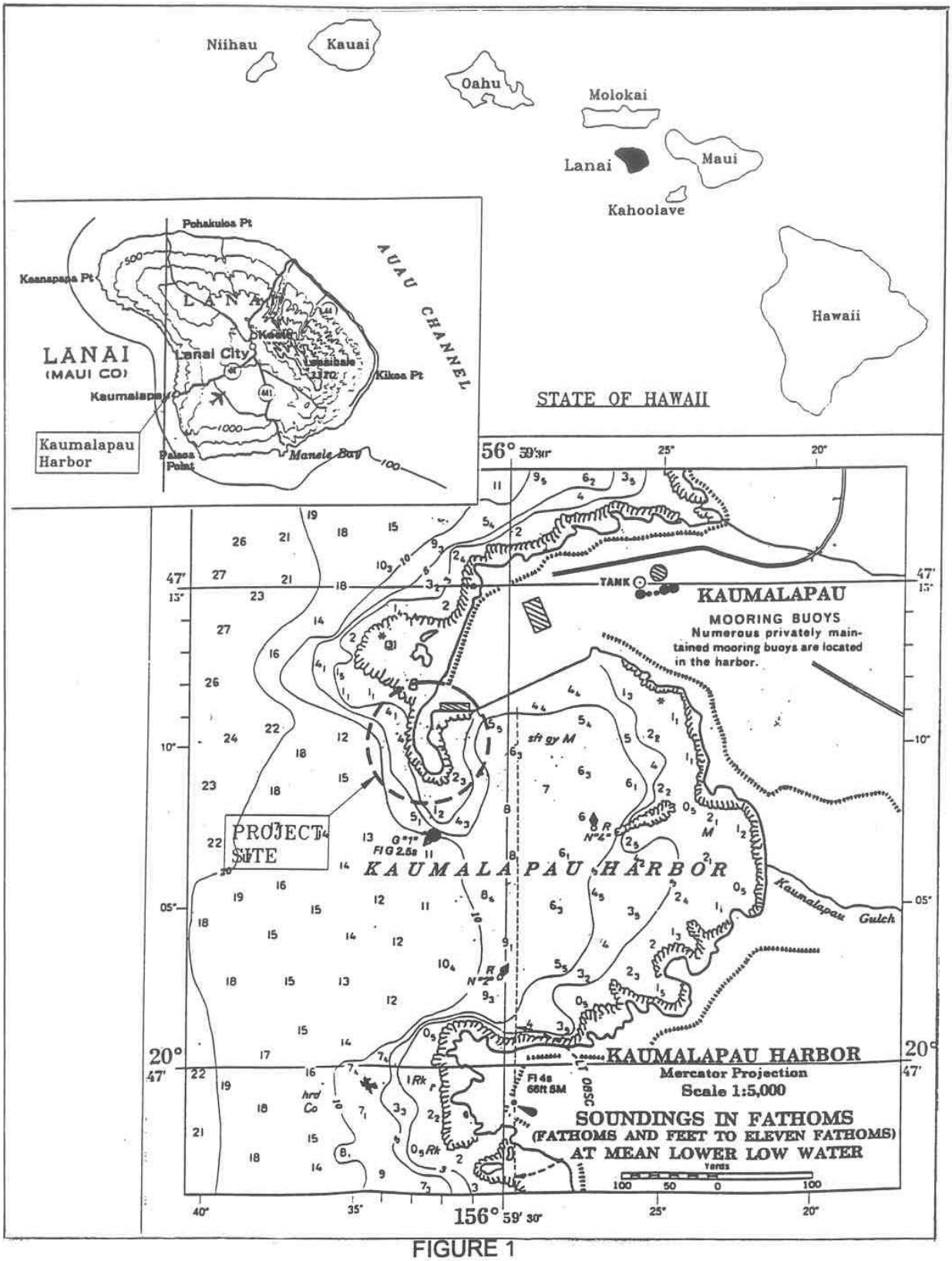

Niihau
Kauai
Oahu
Molokai
Lanai
Maui
Kahoolave
Hawaii
STATE OF HAWAII
Pohakuloa Pt
Kaanapapa Pt
LANAI
(MAUI CO)
Lanai City
Kaumalapau
Kaumalapau Harbor
Palaoa Point
Manele Bay
Kikoa Pt
AUAU CHANNEL
KAUMALAPAU
MOORING BUOYS
Numerous privately maintained mooring buoys are located in the harbor.
TANK
PROJECT SITE
KAUMALAPAU HARBOR
Kaumalapau Gulch
KAUMALAPAU HARBOR
Mercator Projection
Scale 1:5,000
SOUNDINGS IN FATHOMS
(FATHOMS AND FEET TO ELEVEN FATHOMS)
AT MEAN LOWER LOW WATER
Yards
156° 59' 30"
20° 47'

FIGURE 1

1.3 Summary Description of Alternatives

The alternatives to the proposed action include no action and several structural repairs that were evaluated using numerical and physical modeling techniques. No action entails leaving the harbor breakwater in its present badly deteriorated state. Hazardous berthing and cargo handling conditions would continue in the harbor. Severe storm events can be expected to continue to erode and damage the breakwater, and other harbor facilities. Additional damage to the wharf and vessels would be expected. Delays in shipping operations would continue and perhaps increase as the breakwater further deteriorates. Additional erosion of the existing breakwater material could damage surrounding coral areas. Also, spills of cargo into the water would be more likely due to hazardous wave conditions. Emergency and unauthorized repairs would likely also continue, resulting in more debris being placed on the breakwater.

The structural alternatives evaluated using numerical and physical modeling include the following:

Alternative 1 - a 200-foot long rubble mound breakwater, extending to the northwest from the southern corner of the harbor entrance.

Alternative 2 - wave absorbers along the southern and northeastern portion of the harbor shoreline.

Alternative 3 - rebuilding the existing breakwater and adding a 200-foot long straight extension to the end of the existing breakwater.

Alternative 4 - adding wave absorbers along the northeastern shore to the 200-foot straight extension of Alternative 3.

Alternative 5 - a dogleg extension of the existing breakwater. The first 350 feet of the existing breakwater would be re-built along the current alignment and the next 50 feet would be angled 30 degrees toward the inside of the harbor.

Alternatives 3 and 5 showed promising results in the numerical model studies. For some wave conditions, Alternative 3 showed reductions in wave heights of 29 to 55 percent along the wharf relative to existing conditions, and Alternative 5 resulted in reductions of 26 to 57 percent relative to existing conditions. These alternatives were further evaluated by physical modeling. Based on the physical modeling studies, Alternative 5 (the dogleg breakwater) provided significant improvements over the existing conditions and demonstrated better results than Alternative 3 (the straight breakwater). Alternative 5 was the recommended improvement plan.

The ongoing design study has recommended eliminating the dogleg and shifting the proposed alignment of the breakwater shoreward to center it above the existing rubblemound structure. In the present design, the new breakwater will have a total crest length of 320 feet, and a crest elevation of +14.5 feet above mean lower low water (mllw).

1.4 Summary of Environmental Impacts and Mitigation Measures

The proposed project is to repair and improve the breakwater to reduce wave energy entering the harbor. The new breakwater will be aligned and centered on the existing breakwater structure,

thereby minimizing impacts on the surrounding seafloor. It will extend approximately 50 feet further across the mouth of the harbor than the existing structure, and will occupy an additional 8,000 square feet of native sandy seafloor.

The modified breakwater is not expected to noticeably affect current and flushing throughout the harbor. Long-term impacts are not expected to the water quality in the harbor. Construction of the new breakwater will consist of placement of rock and concrete structures, which should be clean of any fine-grained sediment. With Best Management Practices (BMPs) in place to prevent drainage of materials from land into the harbor during construction, there are no apparent agents that could substantially, or permanently, alter water quality within the harbor.

The present deteriorated breakwater structure is characterized by high coral growth. The design of the new breakwater will involve coverage of the existing breakwater structure with new rock and concrete, resulting in loss of much of the existing coral cover on the old breakwater structure. Survey results, however, indicate that coral colonization is rapid in the area. The new breakwater will consist of materials similar to the existing breakwater, and will cover a larger footprint, and consist of a larger surface area of boulders and concrete. Coral colonization of these surfaces is expected, resulting over the long term in a net increase in coral cover in the Kaumālapaʻu area.

Survey results also indicate that the fish populations at Kaumālapaʻu appear to be substantially depleted by fishing pressure. None of the activities associated with construction of the new breakwater would appear to further impact fish populations. Rather, the increased complexity afforded by the new, larger breakwater should increase favorable fish habitat.

There are expected to be no significant impacts to air quality, noise or terrestrial resources or biology.

Project mitigation measures include:

- Best Management Practices and an Environmental Protection Plan for construction operation will be developed to help minimize adverse impacts to coastal water quality and the marine ecosystem.
- Excess coral encrusted boulders from the construction footprint will be placed on the sand bottom surrounding the breakwater toe. This would maintain in part the coral cover that presently populates the breakwater, and would add substrate complexity to the relatively featureless sand bottom that would increase fish habitat.

2. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

2.1 Purpose of the Proposed Action

The purpose of the proposed action is to repair the existing breakwater at Kaumālapaʻu Harbor, Island of Lānaʻi, Hawaiʻi to reduce wave action in the harbor and increase harbor usability. The existing breakwater has been heavily damaged and eroded from an original length of approximately 400 feet to its current length of approximately 200 to 250 feet. The badly deteriorated breakwater allows increased wave energy to enter the harbor, thereby decreasing safe berthing and cargo handling in the harbor.

2.2 Need for the Proposed Action

Kaumālapaʻu harbor was originally constructed in the late 1920's to serve pineapple operations on the island and facilitate shipments to O`ahu. The original breakwater was built and repaired over the years with available material on the island, such as armor stone, concrete jersey barriers, concrete "dolosse" armor units, large shipping containers filled with concrete and other discarded construction material. Storm waves from the south through northwest impact the harbor and the breakwater has been heavily damaged and deteriorated by the storm waves, particularly during Hurricanes ʻIwa (1982) and ʻIniki (1992).

Severe wave conditions close the harbor several times each winter season. During the winter of 1995, the breakwater had deteriorated to such an extent that the fuel barge refused to enter the harbor because of unsafe wave conditions at the wharf. The supply and availability of fuel on the island became a serious concern.

The increased wave action in the harbor also causes a constant maintenance problem because the fender system and the pier structure are continuously damaged and repaired. The fenders are replaced three to four times a year; they were replaced only once a year before Hurricane ʻIwa.

Kaumālapaʻu Harbor is the only commercial harbor on Lānaʻi , and is therefore essential to the welfare of the island's residents and visitors. Most of the consumer goods and food come into Lānaʻi via this harbor. Air transportation is the only alternative, but it is very expensive and has limited cargo capacity. Interruptions in barge service pose hardships to the people on the island and is costly to the carrier serving the island. Without adequate repair to the existing breakwater, the social and economic welfare of the people of Lānaʻi will be negatively impacted.

3. DESCRIPTION OF THE PROPOSED ACTION

3.1 Project Location

Lānaʻi, the sixth largest island in the state (Figure 1), is situated approximately 60 miles southeast of the island of O`ahu. It covers 141 square miles and includes about two percent of the state's land area. The 1990 estimated population was 2,426 residents within Lānaʻi City, the island's only town.

Kaumālapaʻu Harbor (Figure 1) is located on the southwest coast of Lānaʻi, approximately 6 miles from Lānaʻi City. It is a small barge harbor and the sole commercial harbor on the island.

3.2 Site Description

Lānaʻi is made of a single volcanic dome called Lānaʻihae, which rises 3,370 feet above sea level. The major crop producing area is located on a central plateau formed by two partially filled calderas. Most of the area below the 1,000-foot elevation slopes steeply. There is a narrow strip of flat, non-stony, alluvial land along the north to east coast. Steep marine cliffs exist along the west and south coast areas.

Kaumālapaʻu Harbor is a small barge harbor located in a natural embayment on the southwest coast of Lānaʻi. The harbor has a 10-acre berthing area, and water depths between 20 and 60 feet. Shoreside facilities along the north side of the embayment consist of a 400-foot long wharf, a cargo shed and barge loading and unloading equipment. The harbor has no distinct entrance channel and has a 600-foot wide opening at the mouth of the bay. A breakwater extending to the south from the northwestern point of the embayment protects the harbor and wharf facilities. The breakwater was reportedly originally 400 feet long, but has been reduced by wave damage to a current length of approximately 200-250 feet. The remaining breakwater crest elevation is about 10 feet above mean lower low water (mllw).

The topography of surrounding areas is either sheer cliffs or steep slopes. The area behind the existing pier consists of a narrow strip of land, wide enough to allow a truck or tractor with trailer to make a U-turn. Small offices and warehouses are located along the access road.

3.3 Project Features

The Kaumālapaʻu Harbor breakwater repair project will rebuild the badly damaged and deteriorated existing breakwater, in order to provide safe berthing conditions at the existing wharf for cargo and fuel delivery to the island. The breakwater will be rebuilt on the footprint of the old rubblemound structure, and will utilize the existing structure for the core of the new breakwater. The new structure has been designed based on standard coastal engineering criteria and methodology, and the design storm condition wave height and stillwater level rise is based on a hurricane approaching Hawai`i from the south. Core-Loc concrete armor units will be used to provide a stable armor layer capable of withstanding the design storm wave heights of 25 to 30 feet. The Core-Loc armor units are a recent development of the Corps of Engineers Waterways

Experiment Station, and testing has shown them to be extremely stable under wave attack. The project plan is shown on Figure 2, and typical breakwater sections are shown on Figure 3. The new breakwater will have a total length of 320 feet, and a crest elevation of +14.5 feet mllw. The existing rubblemound structure will be re-shaped to form the core of the breakwater, over which will be placed an underlayer of 2.5 to 4.5 ton stone, followed by 35-ton Core-Loc concrete armor units. The breakwater crest and top row of Core-Loc units will be stabilized by a concrete crest cap. The new armor units will extend to a depth of 45 to 55 feet on the ocean side and 20 feet on the harbor side, and the toe of the armor layer will be stabilized by a stone buttress.

Following coordination of the Draft EA minor revisions were made to the design of the breakwater repairs. The design revisions do not alter the basic scale or scope of the project, their primary purpose is to incorporate current Core-Loc concrete armor unit design practice and experience into the design. Design revisions include the following items.

1. The breakwater crest has been re-designed to increase Core-Loc stability during design storm wave conditions, and to improve constructability. Primary changes are: (a) widening the crest width to 40 feet at the top of the underlayer stone (+9.5' elevation), (b) adding a horizontal row of Core-Loc units on the ocean-side crest, and (c) replacement of the rib cap on the crest with a solid mass concrete crest cap.
2. A requirement for tremie concrete to be placed in the toe trench following placement of the Core-Loc units has been added to the design for the nearshore ocean-side where the toe trench will be excavated into hard rock bottom in very shallow water. The concrete will prevent Core-Loc movement and increase stability of the toe in this area.
3. The allowable stone size range for underlayer stone and bedding stone has been increased slightly for more efficient use of available quarry stone.

3.4 Construction Operations

The lack of level and clear space on the shoreline, and the need to maintain usability of the wharf and cargo handling area for fuel and freight service to the island, necessitate careful staging and coordination of the construction activities. An approximate 2-acre contractor work and storage area will be located approximately 2,000 feet inland of the harbor, at a site which has been previously graded. It is anticipated that the underlayer stone would come from existing operating quarries on Lānaʻi, Oʻahu or Maui, and that the core–loc armor units would be cast on Lānaʻi, or O`ahu and barged to Lānaʻi. Stone and Core-Loc placement will be accomplished by a crane positioned on the breakwater crest or by a barge-mounted crane. A small concrete batch plant will be located on Lānaʻi, near the project site, for construction of the cast-in-place concrete crest cap. The construction sequence would be to re-shape the existing rubblemound to form the trapezoidal core cross section, then the underlayer stone will be placed and the toe buttress formed, followed by placement of the Core-Loc armor layer, and finally construction of the concrete crest cap. Primary construction material quantities are estimated as follows:

Core-Loc Concrete Armor Units:	
Number of Units -	760
Volume of Concrete -	13,590 cy
Concrete Crest Cap:	2,060 cy
2.5 to 4.5-ton Stone:	25,440 cy
500 to 5,000 lb. Stone:	930 cy
50 to 500 lb. Stone:	3,040 cy
Geotextile Filter Fabric:	3,780 sy

3.5 Construction Schedule and Cost

The total construction period is estimated to be 24 months, with actual on-site and in-water work estimated to take approximately 18 months. The total construction cost is estimated to be $15 million, of which 80 percent ($12 million) will be federally funded and 20 percent ($3 million) will be cost shared by the State of Hawai‘i.

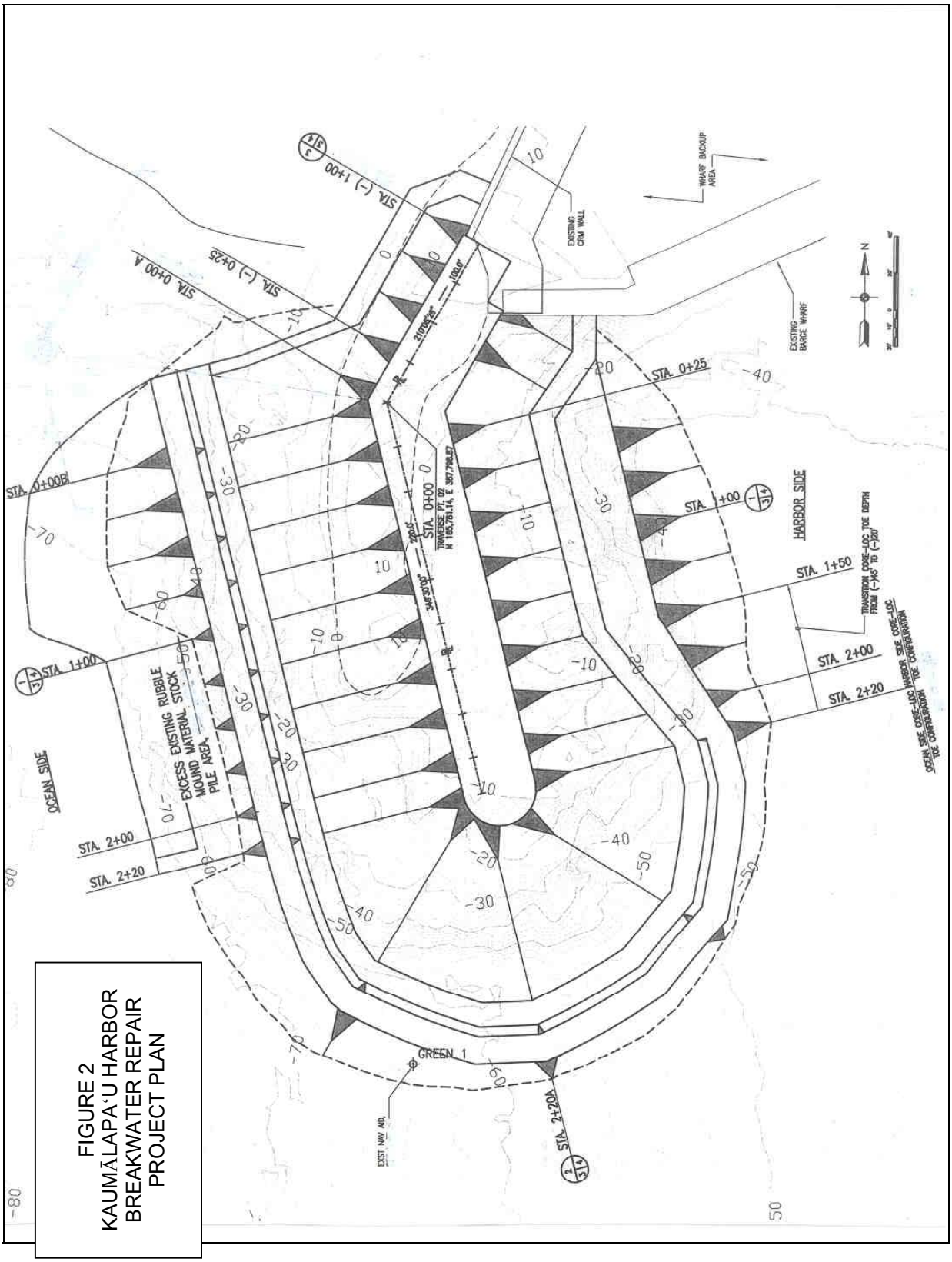


FIGURE 2
KAUMĀLAPA'U HARBOR
BREAKWATER REPAIR
PROJECT PLAN

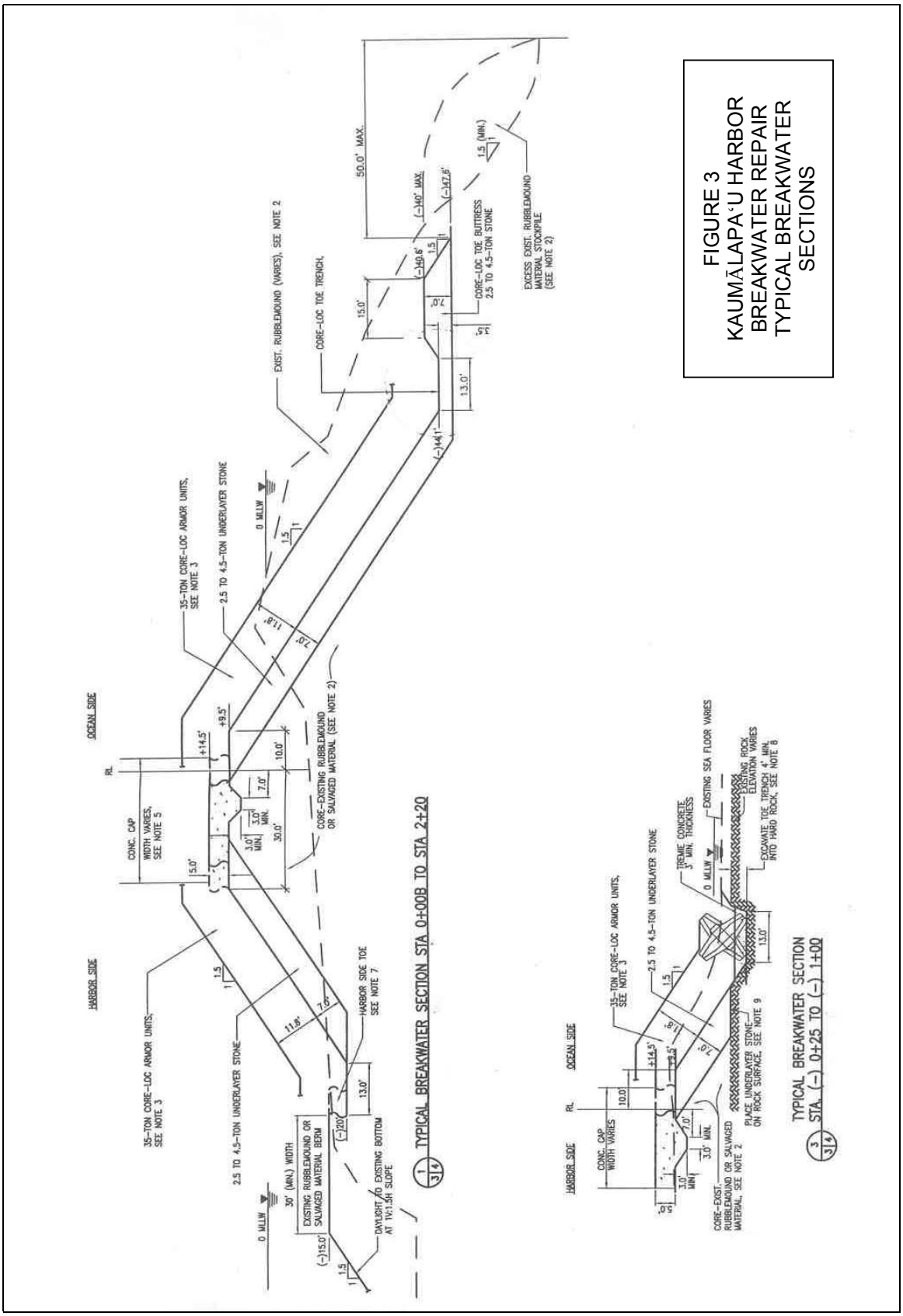


FIGURE 3
KAUMĀLAPA'U HARBOR
BREAKWATER REPAIR
TYPICAL BREAKWATER
SECTIONS
TYPICAL BREAKWATER SECTION STA 0+00B TO STA 2+20
TYPICAL BREAKWATER SECTION STA (–) 0+25 TO (–) 1+00
OCEAN SIDE
HARBOR SIDE
35-TON CORE-LOC ARMOR UNITS, SEE NOTE 3
2.5 TO 4.5-TON UNDERLAYER STONE
CONC. CAP WIDTH VARIES, SEE NOTE 5
EXIST. RUBBLEMOUND (VARIES), SEE NOTE 2
CORE-LOC TOE TRENCH
CORE-LOC TOE BUTTRESS 2.5 TO 4.5-TON STONE
EXCESS EXIST. RUBBLEMOUND MATERIAL STOCKPILE (SEE NOTE 2)
CORE-EXISTING RUBBLEMOUND OR SALVAGED MATERIAL (SEE NOTE 2)
HARBOR SIDE TOE SEE NOTE 7
EXISTING RUBBLEMOUND OR SALVAGED MATERIAL BERM
DAYLIGHT TO EXISTING BOTTOM AT 1V:1.5H SLOPE
0 MLLW
RL
50.0' MAX.
(–)140' MAX.
(–)147.6'
(–)149.6'
(–)141'
15.0'
13.0'
7.0'
11.8'
10.0'
30.0'
3.0' MIN.
5.0'
+14.5'
+9.5'
(–)20'
(–)15.0'
30' (MIN.) WIDTH
1.5 (MIN.)
1.5
1
TREMIE CONCRETE 3' MIN. THICKNESS
EXISTING SEA FLOOR VARIES
EXISTING ROCK ELEVATION VARIES
EXCAVATE TOE TRENCH 4' MIN. INTO HARD ROCK, SEE NOTE 8
PLACE UNDERLAYER STONE ON ROCK SURFACE, SEE NOTE 9
CORE-EXIST. RUBBLEMOUND OR SALVAGED MATERIAL, SEE NOTE 2

4. ALTERNATIVES INCLUDING THE PROPOSED ACTION

4.1 No Action

The alternative of no action entails leaving the harbor breakwater in its present badly deteriorated state. Hazardous berthing and cargo handling conditions would continue in the harbor. Severe storm events can be expected to continue to erode and damage the breakwater and other harbor facilities. Additional damage to the wharf and vessels would be expected. Delays in shipping operations would continue and perhaps increase as the breakwater further deteriorates.

No repair to the breakwater may also negatively impact the natural environment. Further erosion of the existing breakwater material could damage surrounding coral areas. Also spills of cargo into the water would be more likely during hazardous conditions. Emergency and unauthorized repairs would likely also continue, resulting in more debris being place on the breakwater. These unstable items are anticipated to breakup and to be distributed during severe storm events, possibly damaging development of the coral-reef community surrounding the existing breakwater.

4.2 Other Improvement Alternatives Considered

The US Army Corps of Engineers (1996), using numerical and physical modeling techniques, evaluated five alternatives for the harbor improvements.

Alternative 1 consisted of a 200-foot long rubble mound breakwater, extending to the northwest from the southern corner of the harbor entrance. Numerical model tests showed that the southern breakwater had little effect on wave conditions at the pier.

Alternative 2 consisted of wave absorbers along the southern and northeastern portion of the harbor shoreline. The modeling analysis showed the wave absorbers had little effect on wave heights at the wharf - the average reduction in wave height at the wharf was no more than 10 percent. Wave heights were only reduced in a very localized area immediately adjacent to the absorbing shore.

Alternative 3 consisted of rebuilding the existing breakwater and adding a 200-foot long straight extension to the end of the existing breakwater. For 10-second waves, approaching from the northwest, the addition of the breakwater extension resulted in a reduction in wave heights of 29 to 55 percent relative to existing conditions. Waves approaching from the southwest, however, resulted in wave heights between 61 and 113 percent of those without the extension.

Alternative 4 consisted of adding wave absorbers along the northeastern shore in addition to the 200-foot straight extension of Alternative 3. The average additional wave height reduction at the pier did not exceed 10 percent.

Alternative 5 consisted of a dogleg extension of the existing breakwater. The first 350 feet of the existing breakwater would be re-built along the current alignment and the next 50 feet would be angled 30 degrees toward the inside of the harbor. This alternative significantly reduced wave heights within the harbor. Waves with 10 second periods, approaching from the northwest were

particularly affected; wave heights were reduced 26 to 57% relative to those in the existing harbor. Waves approaching from the west and southwest were reduced to a lesser degrees, resulting in wave heights of 60 to 98 percent of those in the existing harbor.

Alternatives 3 and 5 were further evaluated in a physical hydraulic model. Based on the physical modeling studies, Alternative 5 (the dogleg breakwater) provided significant improvements over the existing conditions and demonstrated better results than Alternative 3 (the straight breakwater). Alternative 5 was the recommended improvement plan of the Special Design Report (1996). The ongoing design study has recommended eliminating the dogleg, and instead shifting the proposed alignment of the breakwater shoreward to center it above the existing rubblemound structure.

In the present design, the new breakwater will have a total length of 320 feet, and a crest elevation of +14.5 feet mllw.

5. ENVIRONMENTAL SETTING

5.1 The Natural Environment

5.1.1 Physical Marine Environment

Climate

The climate on Lānaʻi is subtropical, dominated by the surrounding ocean and persistent trade winds. Median annual rainfall varies from 35 inches at Lānaʻihale to ten inches along the arid leeward coast. Average temperatures at Kaumālapaʻu Harbor are not available. Average temperatures in Lānaʻi City, which is approximately six miles northwest of Kaumālapaʻu at elevation of 1,600 feet, range from 66 degrees Fahrenheit to 73 Fahrenheit during the year.

Winds

The prevailing winds in the Hawaiian Islands are the northeasterly trade winds. They occur approximately 90 to 95 percent of the time during the summer months of May through October and approximately 55 to 65 percent of the winter months of November through April. Typical wind speeds for the northeasterly trades average 10 to 20 miles per hour. Because of the sheltering effect of the island from the tradewinds, winds at the project site are frequently light and variable land/sea breezes due to the diurnal heating and cooling of the land.

Storms

Storm conditions in the Hawaiian Islands are relatively infrequent. Three classes of storms occur in Hawaiʻi: cold fronts, low-pressure passages and tropical cyclones (tropical storms or hurricanes). Cold fronts, which occur during the winter months, cause spotty rainfalls and gusty winds. The low-pressure passages bring heavy rains, sometimes with strong winds. The low-pressure storms known as Kona storms usually occur during the winter months. They are associated with strong and persistent southerly winds and intense rainfall on the south and western shores of the islands. In 1980, a severe Kona storm generated waves struck Kaumālapaʻu Harbor and damaged the breakwater. The deepwater height of these waves was hindcasted by Sea Engineering, Inc. to be 17 feet, with a 9-second period.

Hurricanes, which are classified as storms with wind speeds in excess of 74 miles per hour, are infrequent in Hawaiian waters. Tropical storms are relatively frequent, passing close to the Hawaiian Islands on an average of once in one or two years. Since 1950 eight hurricanes have either hit or come close enough to the islands to cause property damage, ranging from $100,000 to $1 billion. Hurricanes ʻIwa (1982) and ʻIniki (1992) with deepwater wave heights of 22 and 20 feet, respectively, offshore of the project site, caused major damage to Kaumālapaʻu Harbor.

Tides

The tides in Hawaiian waters are semi-diurnal with pronounced diurnal inequalities. Normal tidal fluctuations along the coasts of the main Hawaiian Islands generally do not exceed about 2.5 feet. There is relatively little difference in tidal range between the islands. At Kaumālapaʻu Harbor, the mean tidal range and diurnal tidal range are 1.5 feet and 2.2 feet with a mean tide of 0.9 feet above mean lower low water.

Waves

The wave climate of the Hawaiian Islands is characterized by four primary wave types. These are northeast tradewind waves, southern swell, Kona storm waves, and north Pacific swell. Hurricane generated waves, although infrequent, also affect the Hawaiian Islands. All but tradewind waves can affect the study area to some degree.

Southern swell is generated by storms in the Southern Hemisphere and is most prevalent during the summer months. These waves, after traveling long distances, arrive in the Hawaiian waters as low, long waves with typical periods of 12 to 22 seconds and deepwater wave heights of 1.5 to 6.5 feet. Kona storm waves are generated by intense winds associated with locally occurring Kona storms. These waves approach from the south to the west. The typical Kona storm waves have periods ranging from 6 seconds to 10 seconds and heights from 10 to 15 feet.

North Pacific swell is produced by severe winter storms in the Aleutian area of the North Pacific and by mid-latitude low-pressure systems. North swell may arrive in Hawai`i throughout the year, but is largest and most frequent during the winter months of October through March. The waves in North Pacific swell typically have periods of 10 to 20 seconds and heights of 5 to 15 feet or greater.

Kaumālapa‘u Harbor is exposed to waves approaching from a directional sector between south-southwest clockwise to north. Annual wave statistics for the site can be estimated using U.S. Army Corps of Engineers, Wave Information Study (WIS) data. The wave statistics for a directional sector from 206 to 310 degrees is shown on Table 1. The table indicates that the waves approach from this sector only about 5 percent of the time, and usually reflect storm conditions, with swell wave heights typically greater than 6 feet with a period longer than 11 seconds. Based on the WIS data, 95 percent of the time wave conditions in the vicinity of Kaumālapa‘u Harbor are small, local wind generated seas, less than about 6 feet in height.

TABLE 1. WIS DATA: NUMBER OF WAVE OCCURRENCES FROM THE DIRECTIONAL SECTOR AFFECTING KAUMĀLAPAʻU HARBOR
WAVE DIRECTION: 206 – 310 DEGRESS
TOTAL NUMBER OF DATA: 116,880

Wave Period (sec)	Significant Wave Height (feet)							Total
	<3.2	3.2-6.6	6.6-9.8	9.8-13.1	13.1-16.4	16.4-19.7	>19.7	
<7	9	0	24	1	0	0	0	34
7-9	0	6	58	62	30	2	0	158
9-11	0	94	163	39	8	13	3	320
11-13	0	7	948	435	33	1	0	1424
13-15	0	0	663	1902	994	175	8	3742
15-17	0	0	0	0	0	0	0	0
17-19	0	0	0	21	24	26	39	110
>19	0	0	0	0	0	0	0	0
Total	9	107	1856	2460	1089	217	50	5788 (5.0%)

Wave measurements were made at Kaumālapaʻu Harbor to calibrate the numerical and physical models of the harbor. Wave gages were placed off the toe of the breakwater head and along the wharf. Data was collected between January 16, 1994 and the end of September 1994. Wave conditions were not very energetic during the measurement period. The mean incident wave height was 1.6 feet, while the largest waves occurred in January, with a height of 4.9 feet and a period of 15 seconds.

Tsunamis

Tsunamis are very long period ocean waves generated by earthquakes, submarine landslides, and volcanic eruptions. Tsunamis are difficult to detect in the deep ocean, but they can significantly increase in height as they approach the shore. Based on methodology described by M & E Pacific, Inc. (1978), the runup elevation of a 100-year tsunami will be about 5 feet above mean lower low water along the Kaumālapaʻu shoreline. This indicates that the inundation zone from such a tsunami will be confined to the rocky shoreline near the coast.

Currents

The predominant ocean current flow near Kaumālapaʻu Harbor is generally toward the northwest. Under normal tradewind conditions, the speed of the current is typically less than one knot and is not strong enough to cause navigational problems. Tidal currents at Kaumālapaʻu Harbor, which do not reverse during ebb and flood tidal periods, are usually too weak to affect navigation (US Department of Interior 1995).

A current drogue study was conducted by Sea Engineering, Inc. in the harbor vicinity on January 14, 1999. Currents were measured during flood, high water slack and the beginning of ebb tide. Winds were west-southwest at 10 to 15 knots. Currents outside the harbor moved to the north during flood tide. In the harbor, surface currents were to the northeast during flood and slack tides, but during ebb tide the currents changed to southeast. Subsurface currents in the harbor consistently moved to the southeast through the tidal phases during the field study. The results of the drogue study also indicate no distinct tidal reversal during the field study. The current speeds were up to 0.1 knots inside the harbor; the speed outside the harbor ranged from 0.1 to 0.3 knots. Figure 4 illustrates the results of the drogue study.

Although the tidal currents are relatively weak, large waves and strong wave-generated currents may develop during Kona and southwesterly storms. The harbor is forced to close during these storm events.

Bottom Characteristics

Figure 1 shows the general bathymetry in the harbor area, while Figure 5 shows the detailed bathymetry around the breakwater. This bathymetry was collected in surveys conducted on October 13 and 14, 1998. The natural shoreline throughout the harbor, and to the north of the breakwater is relatively uniform in structure, consisting of steeply sloping vertical cliffs that also extend underwater. Off the northern end of the existing breakwater a finger reef extends perpendicular to the axis of the breakwater. The finger reef consists of a relatively flat upper surface and nearly vertical sides that extend to the sand floor of the outer harbor. The vertical faces of the natural shoreline are inhabited by high cover (>50%) of a variety of reef corals. The inner shoreline of the harbor also consists of sloping vertical basalt faces that terminate at the sand surface of the harbor floor. Coral cover is uniformly high throughout the margin of the harbor. The breakwater structure extends approximately 400 feet to the south of the finger reef, and is 300 to 350 feet wide. Only a 250-foot length of the breakwater, about 50 feet wide, lies above the water. The breakwater materials consist of large basalt boulders, and construction debris including pilings, concrete debris, conduit, scrap metal and other debris. The breakwater rises from a sand bottom at a depth of 70 feet on the seaward side and 50 feet on the harbor side. The bottom of the bay and harbor consists of gently sloping plain gray sand. The sand is heavily rippled and pocked with numerous burrows likely of either worms or shrimp.

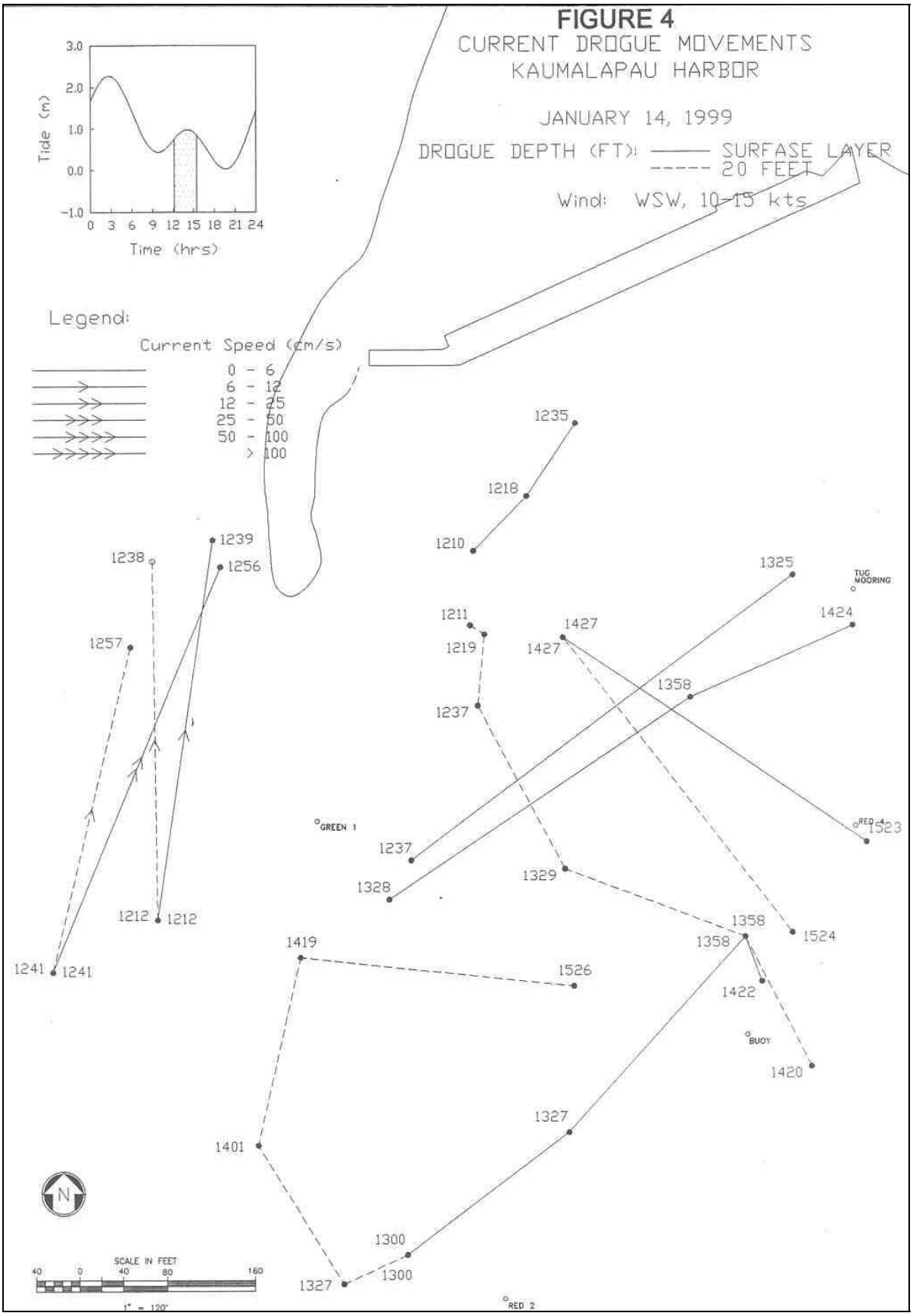


FIGURE 4
CURRENT DROGUE MOVEMENTS
KAUMALAPAU HARBOR
JANUARY 14, 1999
DROGUE DEPTH (FT): SURFASE LAYER
20 FEET
Wind: WSW, 10-15 kts
Tide (m)
Time (hrs)
Legend:
Current Speed (cm/s)
0 - 6
6 - 12
12 - 25
25 - 50
50 - 100
> 100
TUG MOORING
GREEN 1
RED 4
BUOY
RED 2
SCALE IN FEET
1" = 120'

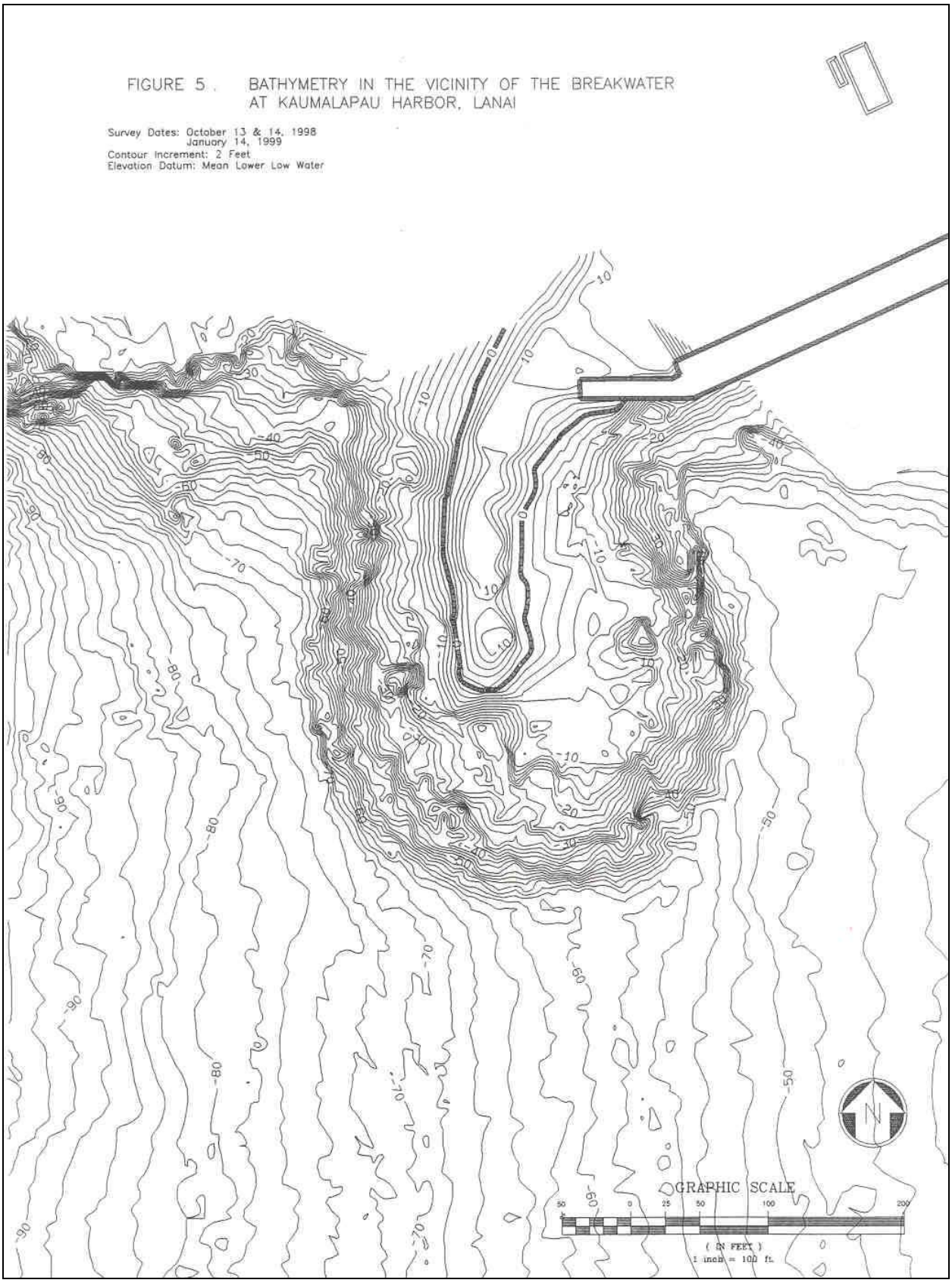


FIGURE 5. BATHYMETRY IN THE VICINITY OF THE BREAKWATER AT KAUMALAPAU HARBOR, LANAI
Survey Dates: October 13 & 14, 1998
January 14, 1999
Contour Increment: 2 Feet
Elevation Datum: Mean Lower Low Water
GRAPHIC SCALE
50 0 25 50 100 200
(IN FEET)
1 inch = 100 ft.
N

5.1.2 Air Quality

There are no known records or studies of air quality measurements in the Kaumālapaʻu vicinity. Air quality, however, can be considered good because of the limited activity occurring in the harbor, and the prevailing tradewinds that disperse any pollutants. Cars, trucks, ships and cargo equipment are the main sources of air pollution. They operate only sporadically in the area, and typically, the tradewinds blow their emissions offshore. Dust from agricultural activities on the island is another possible source of air pollution, although agriculture on the island has greatly diminished in recent years with the cessation of commercial pineapple production.

5.1.3 Noise

Cars, trucks, ships, and cargo equipment are the principal sources of intrusive noise in the Kaumālapaʻu area. However, noises from these sources occur only intermittently when cargo is being offloaded or onloaded on ships at the wharf. In addition, airplane traffic of Lānaʻi Airport, which located 2.5 miles from Kaumālapaʻu Harbor, contributes to noise in the region.

5.1.4 Water Quality

Water quality in Kaumālapaʻu Harbor has been assessed with a one-year sampling program. Over the course of the calendar year 1999, water sampling was conducted about once every two months at twelve stations within, and just outside the harbor (Figure 6). Samples were collected at the surface and near the bottom at each station, and analyzed for constituents that could potentially be affected by activities associated with construction and operation of the new breakwater (turbidity, total suspended solids (TSS), salinity, pH). The purpose of the water quality sampling program is to obtain a set of baseline conditions that depict variability of water quality within the harbor on spatial and seasonal scales that can be used to determine changes that could result from construction activities. The pre-construction water quality monitoring program provides a baseline that can be continued during the construction and post-construction periods.

The detailed water quality baseline study results are presented in Appendix A. Overall, the results of the monitoring program indicate that water quality throughout the sampling area in the vicinity of Kaumālapaʻu Bay is remarkably clear of suspended material throughout the year. This observation appears to be a result of the arid nature of the western side of the island of Lānaʻi, which receives little rainfall, and hence there is little runoff of particulate materials. Table 2 summarizes the data by showing the geometric means, maxima and minima for the six sample periods and four parameters measured, for each of the twelve sampling stations. The generally excellent water clarity is illustrated by the turbidity geometric mean of 0.08 to 0.10 ntu. By comparison, State Department of Health water quality standards list the geometric mean limit for turbidity under dry conditions as 0.20 ntu. Statistical analysis of the data set shows no significant differences in any of the four water quality constituents between means of surface and deep samples, indicating that there is no vertical stratification of the water column. Analysis also shows no significant differences for any of the water quality constituents when all data from each of the twenty-four sampling stations is pooled, indicating that water throughout the sampling regime is essentially homogeneous at any time of the year. Statistical analysis does, however, show small differences between sampling times. In general, the highest means of all constituents

occurred in the winter season samplings (January, October, December), while the lowest means occurred during the summer (June, August).

5.1.5 Marine Biology

The marine biology in the area has been studied during a survey conducted for this project by Marine Research Consultants (Appendix B); during a reconnaissance site visit by the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the project environmental consultant in December 1999; and by the Fish and Wildlife Service beginning in 1994 and culminating in their Final Fish and Wildlife Coordination Act Report, April 1, 2001 (Appendix C).

The underwater physical environment of the existing breakwater consists of a steeply sloped aggregation of armor stones and various items of debris that extend from the emergent breakwater crest to the sand plain that comprises the natural floor of the harbor (depth of approximately 65 feet). Figure 7 is a typical view of the breakwater, showing boulders, debris and extensive coral coverage. The predominant marine biota inhabiting the present breakwater structure are stony corals, predominantly of the genera *Porites, Pocillopora, and Montipora.* Coral cover is lowest on the shallowest portions of the breakwater compared to the deeper areas, and on the harbor side face of the breakwater as compared to the seaward face. Coral cover peaks on the solid surfaces of debris (pipes, piles, dolos, pineapple boxes) off the end of the existing end of the breakwater and along the seaward face. Coral cover in this area is approximately 50% of bottom cover. As much of the debris was likely placed on site following the two hurricanes in 1982 and 1992, it appears that settlement and growth of corals on the surfaces has been rapid. Other invertebrate communities were restricted to sea urchins (primarily *Echinometra mathaei,* and *Heterocentrotus mammillatus)* observed primarily within the spaces between the boulders and debris.

The natural shoreline throughout the harbor, and to the north of the breakwater is relatively uniform in structure, consisting of steeply sloping vertical cliffs that extend underwater. Off the northern end of the existing breakwater a finger reef extends perpendicular to the axis of the breakwater. The finger reef consists of a relatively flat upper surface and nearly vertical sides that extend to the sand floor of the outer harbor. As with the solid surfaces of the breakwater, the vertical faces of the natural shoreline are inhabited by high cover (greater than 50%) of a variety of reef corals, predominantly of the three genera named above. The inner shoreline of the harbor also consists of sloping vertical basalt faces that terminate at the sand surface of the harbor floor. Coral cover is uniformly high throughout the margin of the harbor. In contrast, the floor of the harbor consists of a flat plain of gray sand. The sand is heavily rippled and pocked with numerous burrows likely of either worms or shrimp. Except for scattered debris that serves as settling surfaces, coral colonies or other macrobenthos do not occur on the sand flat.

Fish assemblages were typical of Hawaiian reef communities, with the exception that there appear to be very limited numbers of large individuals, and species recognized as preferred food fish. The observation of numerous spearfishermen that use the harbor as a point of entry to the ocean along the otherwise inaccessible coastline indicates a high degree of fishing pressure in the area.

Marine macroalgae (*limu*) were essentially absent from all of the areas surveyed within Kaumālapaʻu Harbor.

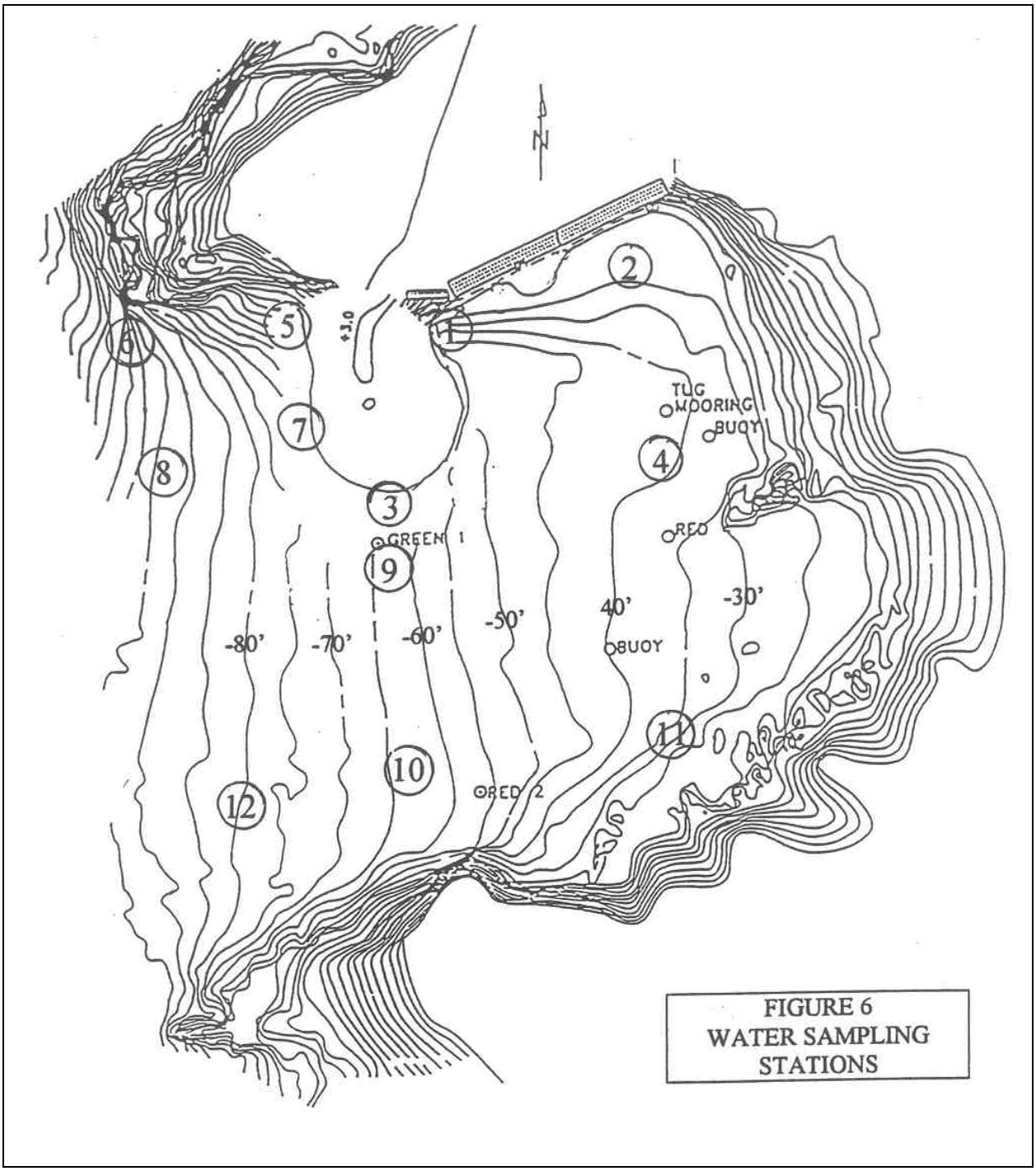


FIGURE 6
WATER SAMPLING
STATIONS

TABLE 2. SUMMARY OF GEOMETRIC MEANS, MAXIMA AND MINIMA FROM SAMPLING STATIONS COMBINED FOR SIX PRE-CONSTRUCTION SURVEYS AT KAUMALAPAU HARBOR. PEAK VALUES OF TSS AND TURBIDITY ARE IN BOLD TYPE FOR EACH PARAMETER.

GEOMETRIC MEANS

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	2.13	0.09	34.971	8.12
1-B	**2.22**	0.09	34.962	8.14
2-S	1.14	0.08	34.899	8.15
2-B	1.39	0.09	34.971	8.16
3-S	1.55	0.08	34.931	8.16
3-B	1.74	0.08	34.973	8.16
4-S	1.96	0.09	34.935	8.16
4-B	1.63	0.09	34.974	8.16
5-S	1.52	0.08	34.952	8.17
5-B	1.83	0.09	34.973	8.17
6-S	1.49	0.08	34.930	8.17
6-B	1.59	0.08	34.973	8.17
7-S	1.27	0.07	34.958	8.17
7-B	1.35	0.08	34.969	8.17
8-S	1.30	0.08	34.924	8.17
8-B	1.19	0.09	34.966	8.17
9-S	1.42	0.07	34.932	8.17
9-B	1.38	0.08	34.987	8.17
1-0-S	1.73	0.08	34.919	8.17
10-B	1.27	0.08	**34.980**	8.17
11-S	1.43	0.09	34.932	8.16
11-B	1.50	**0.10**	34.966	8.17
12-S	2.05	0.09	34.908	8.17
12-B	1.35	0.08	34.971	8.17

MAXIMA

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	4.71	0.12	35.057	8.15
1-B	3.40	0.14	35.054	8.17
2-S	3.87	0.12	35.074	8.18
2-B	5.40	0.17	35.071	8.19
3-S	3.80	0.12	35.051	8.19
3-B	3.93	0.13	35.053	8.18
4-S	5.01	0.12	35.080	8.19
4-B	3.47	0.13	35.034	8.19
5-S	4.27	0.13	35.060	8.19
5-B	3.80	0.16	35.059	8.19
6-S	3.87	0.11	35.055	8.20
6-B	2.07	0.09	35.072	8.20
7-S	2.20	0.11	35.088	8.20
7-B	2.80	0.11	35.073	8.19
8-S	4.87	0.15	35.074	8.20
8-B	4.00	0.30	35.064	8.20
9-S	3.20	0.09	35.072	8.20
9-B	2.40	0.13	35.071	8.19
1-0-S	2.80	0.10	35.078	8.20
10-B	3.27	0.10	35.106	8.18
11-S	2.20	0.18	35.069	8.20
11-B	2.93	**0.32**	35.063	8.18
12-S	**5.40**	0.12	35.076	8.19
12-B	1.80	0.16	35.080	8.19

MINIMA

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.20	**0.08**	34.844	8.09
1-B	**1.40**	0.06	34.860	8.10
2-S	0.08	0.07	34.631	8.12
2-B	0.27	0.07	34.878	8.14
3-S	0.80	0.06	34.777	8.13
3-B	1.27	0.05	34.845	8.14
4-S	0.87	0.07	34.737	8.14
4-B	0.87	0.05	34.872	8.14
5-S	0.47	0.06	34.824	8.15
5-B	0.87	0.06	34.849	8.15
6-S	0.80	0.06	34.740	8.15
6-B	1.00	0.06	34.869	8.16
7-S	0.47	0.05	34.815	8.15
7-B	0.67	0.05	34.861	8.15
8-S	0.60	0.06	34.718	8.15
8-B	0.47	0.05	34.864	8.16
9-S	0.87	0.06	34.803	8.15
9-B	0.80	0.05	34.877	8.16
1-0-S	1.03	0.06	34.753	8.16
10-B	0.27	0.06	34.870	8.16
11-S	0.87	0.07	34.770	8.15
11-B	0.80	0.06	34.879	8.16
12-S	1.27	0.06	34.679	8.16
12-B	0.93	0.05	34.875	8.16

FIGURE 7. Two views of concrete poles and pipes lying near inside end of underwater section of Kaumālapa‘u breakwater. Water depth is 8-10 m. Photos courtesy of J. Naughton, NMFS.

5.1.6 Terrestrial Biological Resources

The U.S. Fish and Wildlife Service (Appendix C) has evaluated terrestrial biological resources at the harbor site. They found no wetlands or sensitive upland habitats located within the harbor area. The terrestrial portion of the proposed project site has been altered by construction of the existing breakwater and ancillary harbor buildings, parking lot and wharf. The dominant terrestrial plants at the site include kiawe (Prosopis pallida) and bristly foxtail (Setaria verticillata). Other plants likely to be present in the area include pili grass (Heteropogon contortus), swollen fingergrass (Chloris barbata), false mallow (Malvastrum coromandelianum), hairy merremia (Merremia aegyptia), and partridge pea (Chamaecrista nictitans). All of these species except pili grass are considered exotic introductions to Hawai`i that have become naturalized.

Terrestrial animals at the site are limited to introduced species, including Axis deer (*Cervus axis*), gray francolin (*Francolinus pondicerianus*), and ring neck pheasant (*Phasianus colchicus*), northern cardinals (*Cardinalis cardinalis*), red-crested cardinals (*Paroaria coronata*), barred doves (*Geopilia striata*), spotted doves (*Streptopelia chinensis*), common myna birds (*Acridothetres tristis*), and seabirds are reported to be present within the vicinity of the site (Corps 1993). The domestic cat (*Felis catus)* and dog (C*anis familiaris)*, house mouse (*Mus musculus domesticus*), black roof rat (*Rattus rattus*), brown rat (*R. norvegicus)*, Polynesian rat (*R. exulans hawaiiensis*), and Indian mongoose (*Herpestes auropunctatus*) occur at the site. Introduced skinks (Scincidae) and geckos (Gekkonidae) are also present

5.1.7 Threatened and Endangered Species

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction. The threatened green sea turtle (*Chelonia mydas*) occurs commonly throughout the island chain, and is known to feed on selected species of macroalgae. The endangered hawksbill turtle (*Eretmochelys imbricata*) also occurs, but is considered rare compared to the green turtle. While turtles are known to exist in the waters surrounding Kaumālapaʻu Harbor, no turtle-nesting habitat occurs within Kaumālapaʻu Bay. The preferred types of resting habitat and food resources for these species were not observed during the survey (e.g. lack of *limu*). No turtles were observed during the fieldwork conducted for preparation of this environmental assessment.

Populations of the endangered humpback whale (*Megaptera novaeangliae*) are known to winter in the Hawaiian Islands from December to April. In November 1992, the Congress passed the Ocean Act of 1992, which established the Hawaiian Island Humpback Whale National Marine Sanctuary. Waters extending seaward from Kaumālapaʻu Harbor to the 100-fathom contour are included within the sanctuary's boundaries. Hawaiian monk seals (*Monachus schauinslandi*) also occur occasionally in waters off the high islands. The predominantly cliffed shorelines, and lack of beaches in the area indicate that the area would not be particularly suitable for seals to haul out (beach themselves to rest). No whales or monk seals were observed during the surveys in Kaumālapaʻu Harbor.

5.2 Man-Made Environment

5.2.1 Harbor Facilities

The harbor is located in a small natural embayment along the southwest coast of Lānaʻi. The entrance to the harbor is formed by a rocky point on the south side and the existing breakwater on the north side. Navigation lights are located on the tip of the breakwater and the point south of the harbor. The breakwater is currently about 250 feet long and is badly deteriorated, with only a portion of its crest still above water. A 400-foot-long wharf is located along the north shore of the harbor, in the lee of the breakwater. The wharf is concrete on top of a rock base. The wharf face is concrete to about the waterline, and is pile supported. Wharf facilities include a cargo shed, cargo loading and unloading equipment, and a derrick for lifting small craft up to 40 feet in length out of the water for repairs. A small office building is located on the slope behind the wharf. There are several privately maintained moorings within the harbor.

5.2.2 Hazardous Waste

Two investigations of environmental conditions in the Kaumālapaʻu Harbor vicinity with an emphasis on the potential for hazardous waste materials have been conducted. In August 1997 Brewer Environmental Services, under contract to the Lanai Company, Inc., conducted a site reconnaissance and assessment of environmental conditions at the proposed Kaumālapaʻu Land Acquisition parcels (harbor lands to be acquired by the State of Hawaiʻi, Department of Transportation, Harbors Division). They concluded, "There were no obvious hazardous waste disposal sites or environmental impairments at the Acquisition area." A Phase I Environmental Site Assessment was conducted by Clayton Environmental Consultants in November 1999, also under contract to the Lanai Company, Inc. and performed as part of the harbor land acquisition by the State. This assessment was performed in accord with ASTM E-1527-97, Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process. The objective of the assessment was to determine the presence or likely presence of any hazardous substances or petroleum products on the property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The assessment included 1) a walkthrough of the property, 2) review of records of present and historical use of the property, 3) interviews with owners and occupants, and 4) review of Federal and State databases for hazardous waste spills or problems. Other than an empty 300-gallon above ground storage tank and some empty 55-gallon drums, and possible PCB containing light fixtures, no evidence of hazardous waste problems in the harbor vicinity were noted by the site assessment.

Investigation of the project site during preparation of this EA to ascertain the likelihood of issues associated with hazardous wastes within the project boundaries or which might be affected by the project included 1) a review of past uses of the harbor, 2) visual observations of the site, and 3) review of the State Department of Health, Office of Hazard Evaluation and Emergency Response, database for known or reported spills or other evidence of possible contaminants or hazardous waste.

The project will consist of work only on the existing breakwater rubblemound structure, which is almost entirely submerged, and is composed of rock and concrete rubble. There is no known

reason to suspect hazardous waste material in the existing breakwater structure. The harbor was historically used to ship pineapples grown upland in the center of the island to Oahu, and for the importation of food, fuel, consumer goods, construction materials etc. to the island. With the demise of pineapple production about 10 years ago, the harbor is now used primarily for weekly cargo and fuel barge service. There are no known instances of significant fuel or other contaminant spills from the barge service operations.

Detailed engineering and environmental investigations of the project site have been made, and no visual evidence of contamination was noted (e.g. containers, discolored soil, seeping liquids, films on the water, suspect odors, dead-end pipes etc.). Existing aboveground fuel oil storage tanks owned by the Lanai Oil Company are located about 700 feet inland from the project site, however they are in good condition, show no visual signs of leakage, and are surrounded by containment structures. Lanai Oil Company operations include pumping of oil from a barge at the wharf to the storage tanks. No leaks have been reported either from the tanks or the pipelines. The contractor's work and storage area will be located approximately 2,000 feet inland from the harbor. This area was previously cleared and was the site of a rock quarry. It has been vacant for a number of years, and the surface is composed of grass, earth and rock. It shows no visual evidence of contamination.

The State of Hawai‘i, Department of Health, Office of Hazard Evaluation and Emergency Response (HEER) maintains a database of known or reported hazardous waste spills or evidence of possible contamination by hazardous substances. Review of this database showed no reporting of hazardous or toxic waste problems for the Kaumālapa‘u Harbor vicinity. The two previous studies discussed above are available for review at the HEER office.

5.3 The Socio-Economic Environment

5.3.1 Ocean Activities

Dominant fishing activities at Kaumālapa‘u Bay include hook and line fishing from the harbor breakwater and wharf, and spear fishing on the reefs inside and outside of the bay. The surrounding reefs, especially the fringing coral-reef shelf outside the harbor, are important SCUBA dive sites. Kaumālapa‘u Bay is also important to charter dive operators who use the harbor as a loading and unloading site.

5.3.2 Harbor Operations

Kaumālapa‘u Harbor is Lāna‘i's only commercial harbor, and provides the only deep draft vessel berthing for the island. Young Bros., Inc. inter-island cargo barge which serves Lāna‘i once a week, and the weekly fuel barge call, are the primary harbor users. The barge service, particularly the fuel barge, is limited by wave action at the wharf. The barges suspend heavy weights from the bow and stern to dampen vessel motion resulting from wave action and surge, but even with this the barges cannot berth at the wharf when wave heights exceed about 4 feet. In the past, fuel service was provided by Sause Brothers, using a large ocean-going 270-foot long barge and two tugs. Following damage to the breakwater during hurricane ‘Iniki, Sause Brothers stopped serving the island, citing the difficult and sometimes dangerous berthing conditions

which made it difficult to schedule the barge calls in advance. Fuel is now delivered by a smaller tug and barge operating from Maui.

5.4 Historic and Cultural Resources

No prehistoric archaeological resources have been identified in the areas to be affected by the proposed project, including the inland Contractor's Work and Storage Area. The work and storage area has been previously graded and thoroughly altered. This was verified during a site visit by State Historic Preservation District personnel in March 2001. Kaumālapaʻu Harbor, and presumably the breakwater itself, was constructed by the Hawaiian Pineapple Company ca. 1926. The original 425-foot-long (reportedly) breakwater was constructed of rock blasted from nearby cliffs, and hauled to the shore by railroad cars on a 4,000-foot-long track. A 400-foot-long dock was also built, and the harbor was dredged to a minimum depth of 27 feet. The harbor has been recommended for Reserve status on the Hawaiʻi Register of Historic Places based on its historical association with the pineapple industry on the island of Lānaʻi. Unfortunately, storm wave destruction and numerous repair efforts over the years have left virtually none of the original breakwater intact.

A study of Traditional Cultural Places (TCPs) at Kaumālapaʻu Harbor has been conducted by Social Resource Pacific, Inc. for this project. Their study report, Oral Historic Studies for the Determination of Traditional Cultural Places at Kaumālapaʻu Harbor, Lānaʻi Island, Hawaiʻi, is included in Appendix G. A summary of the study findings taken from Chapter 5 of the report is as follows:

> The oral histories done for this survey come about nearly 75 years after construction began on the harbor area. It is unclear the extent to which this area was used (for traditional purposes) prior to construction-related activities. There has always been some use of Kaumālapaʻu Harbor but how much of that has changed since prior to contact and in traditional ways, is difficult to ascertain. It is reasonable to assume that much of the "traditional uses" of the area was discontinued by the time pineapple farming became established on the island. Fishing is a traditional activity, and fishing is a modern activity. It's a practice that continues but has changed in technology as well as in the availability of resources, e.g. types of fish. So traditional uses of the ocean area have continued but all traditional activities are no longer known nor conducted. The area has lost that character. As a result, the Traditional Cultural Properties, those which meet the definition and guidelines of the National Register, and as well the cultural landscapes that hold traditional meaning to native Hawaiians, became nearly non-existent. Physically that is. What remain are the memories of the people who created or inherited the traditions that bring value and significance to these features and places.
>
> Kaumālapaʻu Harbor and the breakwater are now important for the more familiar, non-traditional, but historically significant activities. These speak to the importance of having this area as a resource that allows the people to sustain these historically significant activities. The harbor itself has become a place of importance for the current residents of Lānaʻi.

6. ENVIRONMENTAL CONSEQUENCES

6.1 The Natural Environment

6.1.1 Physical Marine Environment

The proposed project is to repair and improve the breakwater to reduce wave energy entering the harbor. It will therefore have a direct impact on waves and wave energy along the harbor wharf. The improved breakwater, however, will only extend 50 feet further across the harbor mouth and is therefore not expected to noticeably affect current and flushing throughout the harbor.

6.1.2 Air Quality

There are expected to be no long-term impacts of the proposed project on air quality in the area. Activities during construction of the breakwater will create dust and emit exhaust fumes.

6.1.3 Noise

There are expected to be no long-term impacts of the proposed project on noise in the area. Activities during construction of the breakwater will cause periods of elevated noise levels.

6.1.4 Water Quality

Results to date indicate that even though Kaumālapaʻu Harbor is a semi-enclosed basin, water quality throughout the area is essentially oceanic. Such conditions appear to be a result of the lack of drainage into the harbor owing to the arid nature of the terrestrial environment, and substantial exchange between the harbor basin and the open ocean. Construction of the new breakwater will consist of placement of rock and concrete structures, which would be clean of any fine-grained sediment. With Best Management Practices in place to prevent drainage of materials from land into the harbor during construction, there are no apparent agents that could substantially, or permanently, alter water quality within the harbor. While the new breakwater is designed to reduce surge within the inner harbor, it would not significantly alter circulation or flushing of the harbor, and no change in overall water quality at the project site is anticipated following completion of construction.

6.1.5 Marine Biological Resources

Survey results indicate that all of the existing solid surfaces in Kaumālapaʻu Harbor, whether natural or manmade, are highly suitable surfaces for reef coral settlement and growth. The apparent lack of sediment input owing to the arid climate of the area, sufficient circulation of seawater, and apparent lack of destructive wave stress during the course of the normal (i.e. non-hurricane) seasonal wave climate appear to provide an ideal habitat for coral growth. Of particular interest is the high coral cover on the armor stone and numerous pieces of debris comprising the submerged sections of the breakwater. Percentage coral cover on the breakwater is presently similar to percentage cover on neighboring natural surfaces. As much of the debris was likely placed on the breakwater following the two hurricanes that impacted Kaumālapaʻu (1982, 1992), the coral colonization and growth on these structures appear to be relatively rapid.

The present design of the new breakwater will unquestionably involve coverage of the existing breakwater structure with new rock and concrete, resulting in loss of much of the existing coral cover on the breakwater. Inspection of the breakwater and Kaumālapaʻu Harbor basin indicates that the floor of the harbor consists of sand. Thus, expanding the footprint of the breakwater would not substantially impact existing benthic biotic communities beyond the edge of the present breakwater. The new breakwater will consist of materials similar to the existing breakwater, and will cover a larger footprint, and consist of a larger surface area of boulders and concrete. As there is no reason to assume that the new breakwater structures would not colonize in a similar manner as the existing breakwater, it appears that over the long term (10-20 years), there is likely to be coral coverage on the new structure similar to what is present today.

Prolific coral communities also occur on the natural hard bottom adjacent to the breakwater, particularly on the fringing coral reef shelf projecting seaward near the landward terminous of the existing breakwater. While the proposed construction plan does not involve activity in this area, care will be taken to avoid impacts that might accompany construction, such as mooring of barges or stockpiling of materials.

Survey results also indicate that the fish populations at Kaumālapaʻu appear to be substantially depleted by fishing pressure. None of the activities associated with construction of the new breakwater would appear to further impact fish populations. The new breakwater with its large concrete armor units will provide increased interstitial space and complexity, which would replace and increase favorable fish habitat that would be lost by covering the existing structure. The National Marine Fisheries Service also concurs that the project will not impact an identified Essential Fish Habitat as delineated by the Magnuson-Stevens Fishery Conservation and Management Act.

6.1.6 Terrestrial Biological Resources

As the existing terrestrial habitat at Kaumālapaʻu is already highly affected by the present harbor infrastructure, the proposed work is not expected to impact terrestrial biological resources.

6.1.7 Threatened and Endangered Species

Kaumālapaʻu is not a turtle-nesting site, nor does it appear to be a favorable habitat for monk seals. While turtles undoubtedly occur in the area of the proposed construction, it does not appear that the locale is a unique or especially favorable habitat for turtles. A general paucity or lack of food preferred by green sea turtles and hawksbill sea turtles indicates that the area is not likely a feeding habitat for turtles. Nevertheless, it is recommended that a protocol be developed to mitigate disturbances to turtles or seals, should they be present in the area during construction. The construction activity is also restricted to an area not frequented by whales.

Fish and Wildlife Coordination Act and Endangered Species Act (1973), Section 7 coordination has been conducted with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Both of these agencies concurred that the proposed project is not likely to adversely affect listed endangered species, and that formal consultation under Section 7 of the Endangered Species Act is not required.

6.2 The Man-Made Environment

There are expected to be no adverse impacts of the proposed project on the man-made environment in the harbor vicinity. The proposed project will benefit all harbor operations by reducing wave energy entering the harbor, and minimizing hazardous berthing conditions.

6.3 The Socio-Economic Environment

Kaumālapaʻu Harbor was constructed in 1926, and for 75 years it has been a functioning port. Repair of the breakwater will not change the harbor size, wharf space or services provided. Up until about the past decade, when the island's economy was based on agriculture, the harbor chiefly was used for the export of pineapple. As the economic base has changed from agriculture to tourism, the primary function of the harbor is also changing from export to the import of supplies and materials to support the new economic environment. Repair of the harbor breakwater will not of itself result in an increase in tourism and visitor arrivals to the island, the fundamental change in economic base is fueling any expansion in resident population and visitors. Repair of the breakwater will, however, facilitate the safe, timely and consistent delivery of fuel and goods to the island, a benefit to both the social and economic welfare of the residents as well as visitors. The new breakwater will also reduce the possibility of accidents that may introduce pollutants into the water.

Fishing and SCUBA diving at the project site would be restricted during the construction period. After construction, fisheries may be locally enhanced around the breakwater since the concrete armor units would provide new habitat for some algae, benthic invertebrates, and reef fishes.

6.4 Historic and Cultural Resources

The proposed project has been coordinated with the State Historic Preservation Officer (SHPO) under the provisions of Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulations 36 CFR Part 800. The SHPO has recommended the implementation of two historic mitigation measures: 1) installing a fence along the edge of the gulch bordering the Contractor Work and Storage Area, and 2) photographically documenting the existing breakwater using Historic American Building Survey standards. With the implementation of the recommended mitigation measures, the SHPO has concurred that there will be no historic properties affected by the proposed project (see coordination letter in Appendix D).

Repair of the breakwater will not affect any existing cultural properties at the site. The harbor itself will remain basically as is following completion of construction, and its use by the current residents of Lānaʻi will be unchanged.

7. CONCLUSIONS

7.1 Relationship Between Local Short-term Uses of the Environment and Maintenance and Enhancement of Long-term Productivity

The short-term uses of the environment for this project are associated with the construction of the breakwater. This includes reshaping the existing rubblemound to form a suitable base for the new material, and then placing the new armor material to form the breakwater. The on-site construction work is expected to take approximately 18 months. Short-term uses of the environment will be minimal, and should result in long-term benefits and enhancement of productivity. These include the following: enhanced fish and coral populations in the area by providing increase surface area and habitat; reduction in coral damage caused by dumping debris for emergency protection and by movement of debris during storms; reducing the risk of fuel and cargo spills at the wharf by improving berthing conditions; and more consistent, and regular supply of goods to the island.

7.2 Irreversible and Irretrievable Commitments of Resources

The proposed project entails repairing the existing breakwater. The new breakwater will extend about 50 feet further across the harbor mouth than the existing structure, and therefore, will occupy about 8,000 square feet of new sandy seafloor. The breakwater is designed for stability during hurricanes, and can be considered irreversible and irretrievable. This small sandy area is characterized by very limited macrobiota and will be permanently lost as habitat. However, the few bottom dwelling organisms that might occur in this sand should be a very minor component of the community; sand is extensive within and offshore of the harbor.

The proposed action will not make use of non-renewable resources and will not irreversibly curtail the range of potential uses of the environment. To the contrary, the project will increase the range of potential uses of the area by providing improved vessel berthing opportunities.

Environmental accidents that may occur in this project include the following:

- The unforeseen release of pollutants into the water during construction – best management practices, and a containment plan will be in place to counter the unforeseen release of pollutants into the water.
- Damage to coral during construction – construction activities and stockpiles will be carefully located to avoid natural reef environments, such as the finger reef north of the breakwater.

7.3 Probable Adverse Environmental Effects Which Cannot Be Avoided

Coral growth on the man-made structure that comprises the present breakwater is comparable to natural surfaces. While construction of the new breakwater is expected to cover much, or all, of the existing coral, the new breakwater should be colonized in a similar manner within a relatively short time span. As the new breakwater will result in an increase in settlement surfaces compared

to the present, and if some replacement of existing coral encrusted debris is undertaken, the net result of the project could be an increase in coral community abundance. An adverse environmental effect of this project that cannot be avoided is the loss of a small area of sandy seafloor that may serve as habitat for bottom dwelling organisms. This area averages only 40 feet wide and 200 feet long, curving around the head of the breakwater. The few bottom dwelling organisms that may occur in this area represent a very minor portion of the community. Sand bottom is extensive within and offshore of the harbor.

Minor unavoidable impacts may also include the temporary disruption of boating traffic and ocean activities during the construction activities.

7.4 Evaluation of State of Hawai‘i Impact Significance Criteria

The "significance criteria" defined in the State of Hawai‘i Environmental Impact Statement Rules (Section 11-200-12(a)(11)) are applied during the EA process to support a finding of no significant impact (FONSI) for the project. The following evaluation of the significance criteria indicates that the proposed project is not expected to have significant environmental impact.

(1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.

The breakwater repair will result in the loss of much of the existing coral and other benthic organisms presently colonizing the existing deteriorated breakwater structure. The new breakwater will consist of materials similar to the existing breakwater, and will cover a larger footprint and will thus have a larger surface area of boulders and concrete on which coral can colonize. As there is no apparent reason why the new breakwater structure would not colonize in a manner similar to the existing breakwater, it is reasonable to assume that over the long term (10-20 years) there is likely to be coral coverage on the new structure similar to what is present today. The proposed project is not likely to adversely impact listed threatened or endangered species, nor will it impact an identified essential fish habitat.

There will be no historic properties affected by the proposed project, nor will the project affect traditional cultural resources or practices of the community.

(2) Curtails the range of beneficial uses of the environment.

Kaumālapa‘u Harbor and the breakwater have been in existence and serving as a commercial port for 75 years. Local residents also use the harbor area for fishing, diving and boating. The proposed breakwater repair will not alter the general harbor configuration or increase the size of the port area, either in the water or on the land. While there will be some curtailment of recreational use of the harbor during the construction period, there would be no permanent reduction of harbor area use by residents as a result of the proposed project.

(3) Conflicts with the State's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS.

The proposed project is consistent with the Environmental Policies established in Chapter 344, HRS, and the National Environmental Policy Act. The project is also consistent with the State's policy to create opportunities for the residents of Hawai‘i to improve their quality of life through diverse economic activities that are in balance with the physical and social environment.

(4) Substantially affects the economic or social welfare of the community or state.

The proposed project will provide a significant contribution to Lānaʻi's present and future population by providing residents with a safer commercial harbor. Repair of the breakwater is important to the welfare of the residents and economy of Lānaʻi because it would facilitate timely and consistent delivery of fuel and goods to the island.

(5) Substantially affects public health.

No impact to public health is anticipated to result from the project.

(6) Involves substantial secondary impacts, such as population changes or effects on public facilities.

Repair of the breakwater is not expected to of itself result in significant impacts on the population of Lānaʻi. Up until about the past decade, when the island's economy was based on agriculture, the harbor was primarily used for the export of pineapple. As the economic base has changed from agriculture to tourism, the principal function of the harbor has also changed from export to the import of supplies and materials to support the new economic environment. Repair of the breakwater will not impact the resident population or number of visitor arrivals to the island, the fundamental change in economic base is fueling any population changes. Repair of the breakwater will, however, render the harbor, an essential public facility, safer and more useable.

(7) Involves a substantial degradation of environmental quality.

The project site is not a wetland, special aquatic site, marine sanctuary or wildlife refuge. Coral cover on the existing breakwater will be destroyed by the project, however the new breakwater will consist of materials similar to the existing breakwater and coral is expected to re-colonize on the new structure. Best Management Practices during construction will be used to avoid damage to the natural reef areas adjacent to the project site, and a Water Quality Monitoring Plan will be used to control impacts to coastal water quality. The new breakwater with its large concrete armor units will provide increased interstitial space and complexity, which would replace and increase favorable fish habitat lost by covering the existing structure. Construction of a stable breakwater will also reduce damage to corals caused by rock and concrete rubble movement during storm wave attack.

(8) Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions.

Repair of the breakwater is a stand-alone project, with neither an attachment to additional projects which could have cumulative impacts or any commitment for larger actions.

(9) Substantially affects a rare, threatened, or endangered species, or its habitat

Three species of marine animals that occur in Hawaiian waters have been declared threatened or endangered by Federal jurisdiction: green and hawksbill sea turtles, humpback whales and Hawaiian monk seals. Kaumālapaʻu Harbor is not a turtle nesting site, nor is it a favorable habitat for monk seals. While turtles undoubtedly occur in the area of the proposed construction, the locale is not a unique or especially favorable habitat for turtles. The construction activity is also restricted to an area not frequented by whales. Nevertheless, the construction plan will include a protocol to mitigate disturbances to endangered species should they enter the area during construction. Endangered Species Act coordination has been conducted with the U.S. Fish

and Wildlife Service and the National Marine Fisheries Service, and these agencies have concurred that the proposed project is not likely to adversely affect listed endangered species. The National Marine Fisheries Service also concurs that the project will not impact an identified Essential Fish Habitat.

(10) Detrimentally affects air or water quality of ambient noise levels.

Construction of the new breakwater will consist of placement of rock and concrete armor units. All material would be inert and free of earth or fine sediment, and would not have any significant effect on water chemistry, salinity, temperature, dissolved oxygen, nutrients, nor contain any contaminants. No water quality impacts are expected other that temporary turbidity and suspended solids production from on-site sediment during re- shaping of the existing breakwater and placement of the new breakwater stone. Water quality monitoring in the vicinity of construction activities will be required as part of the construction contract. The monitoring program will be prepared in accordance with State water quality regulations (RDOH, Chapter 11-54) and the General Monitoring Guideline for Section 401 Water Quality Certification Projects (HDOH, 2000). While the new breakwater is designed to reduce surge within the harbor, it would not significantly after circulation or flushing of the harbor, and no change in overall water quality is anticipated following completion of construction.

(11) Affects or is likely to suffer damage by being in an environmentally sensitive area such as a floodplain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal water.

Kaumālapaʻu Harbor breakwater is directly exposed to severe storm wave attack. Both hurricane ʻIwa (1982) and ʻIniki (1992) storm waves severely damaged the existing breakwater, and were in large part responsible for the current need for repair. The breakwater repairs have been designed for hurricane wave conditions using standard coastal engineering design criteria and methodology, and the proposed repair has been extensively tested by hydraulic model studies to help insure its ability to perform without significant damage under the design wave conditions. Kaumālapaʻu Harbor is a rocky embayment, and there are no breaches or erosion-prone areas in the vicinity of the project.

(12) Substantially affects scenic vistas and viewplanes identified in county or state plans or studies.

The repaired breakwater crest would be larger than presently exists, and would reduce somewhat the seaward ground level view from the immediate harbor area. However, there are no identified scenic vistas or viewplanes that would be significantly altered by the project.

(13) Requires substantial energy consumption.

Other than energy expended during construction operations, the project involves no energy consumption or long-term commitment to energy use.

7.5 Mitigation Measures

Best Management Practices (BMPs) for construction operations will be developed to help minimize adverse impacts to coastal water quality and the marine ecosystem.

The project specifications will require the Construction Contractor to adhere to environmental protection measures, including, but not limited to, the following.

- The Contractor shall perform the work in a manner that minimizes environmental pollution and damage as a result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of the construction period.
- The Contractor shall submit an environmental protection plan for approval prior to initiation of construction.
- The Contractor shall confine all construction activities to areas defined by the drawings and specifications. No construction materials shall be stockpiled in the marine environment outside of the immediate area of construction.
- The Contractor shall keep construction activities under surveillance, management and control to avoid pollution of surface or marine waters. Construction related turbidity at the project site shall be controlled so as to meet Hawai‘i State Water Quality Standards. All water areas affected by construction activities shall be monitored by the Contractor. If monitoring indicates that the turbidity standards are being exceeded due to construction activities, the Contractor shall suspend the operations causing excessive turbidity levels until the condition is corrected. Effective silt containment devices shall be deployed where practicable to isolate the construction activity, and to avoid degradation of marine water quality and impacts to the marine ecosystem. In-water construction shall be curtailed during sea conditions that are sufficiently adverse to render the silt containment devices ineffective.
- All construction materials shall be free of dirt, sediment and possible pollutants.
- Waste materials and waste waters directly derived from construction activities shall not be allowed to leak, leach or otherwise enter marine waters.

Transplanting corals from the existing breakwater structure to another area is not feasible. However, excess coral encrusted boulders and concrete from the construction footprint

will be placed on the sand bottom immediately seaward of the breakwater toe. This would maintain in part the coral cover that presently populates the material, and would add substrate complexity to the relatively featureless bottom that would increase fish habitat and the opportunity for additional coral growth.

7.6 Unresolved Issues

There are presently no unresolved issues for this project.

8. LIST OF PREPARERS

Scott P. Sullivan, MS, Ocean Engineering
Marc Ericksen, MS, Coastal Geology and Geoscience
Sea Engineering, Inc.
Makai Research Pier
Waimānalo, Hawai`i 96795-1820
Phone: 808/259-7966
Fax: 808/259-8143
E-mail: sei@seaengineering.com
Website: www.seaengineering.com

Steve Dollar, Ph. D., Oceanography
Marine Research Consultants
4467 Sierra Drive
Honolulu, Hawai‘i 96816
Phone: 808/734-4009
Fax: 808/732-1813

9. PUBLIC AND AGENCY INVOLVEMENT, REVIEW AND CONSULTATION

9.1 Project Scoping Meeting

An environmental scoping meeting was held at the U.S. Army Corps of Engineers, Honolulu Engineer District offices on December 16, 1998, to discuss issues concerning the preparation of an environmental assessment and water quality monitoring plan for the proposed Kaumālapaʻu Harbor breakwater modifications. Attendees included the following:

Steve Dollar, Marine Biological Consultants, 734-4009

Michael Molina, U.S. Fish and Wildlife Service, 541-3441

Ed Chen, State DOH, Clean Water Branch, 586-4309

Randal Leong, State DOT-HAR, 587-1883

Stanley Boc, USACOE, 438-9526

Helen Stupplebeen, USACOE, 438-0430

Marc Ericksen, Sea Engineering, Inc., 259-7966

Scott P. Sullivan, Sea Engineering, Inc., 259-7966

9.2 State and Federal Agency Coordination

Environmental coordination has been accomplished with the following agencies:

U.S. Fish and Wildlife Service:	Endangered Species Act, Section 7 Coordination Fish and Wildlife Coordination Act Report
National Marine Fisheries Service:	Endangered Species Act, Section 7 Coordination Marine Mammal Protection Act Fish and Wildlife Coordination Act Magnuson-Stevens Fishery Conservation and Management Act
State Historical Preservation Office:	National Historic Preservation Act, Section 106 Review

9.3 Draft Environmental Assessment Coordination

Notice of the availability of the Draft Environmental Assessment (DEA) was published in The Environmental Notice, State Office of Environmental Quality Control, in the May 23, 2001 issue. The DEA was also sent to concerned Federal, State and County agencies. A public meeting was held on July 9, 2001, on the island of Lānaʻi, to present the project plan and solicit public comment. DEA review comment letters have been received from the following agencies and interested public:

Federal Agencies:	U.S. Fish and Wildlife Service
State Agencies:	Office of Environmental Quality Control State Historic Preservation Officer Office of Hawaiian Affairs
Public:	Hawai‘i Chapter, Sierra Club

The comment letters and responses to them are contained in Appendix G.

9.4 State and Federal Agency Coordination

The project will require the following permits and approvals.

Section 401 Water Quality Certification, State of Hawai‘i, Department of Health, Clean Water Branch (pending).

Hawai‘i Coastal Zone Management (CZM) Program Federal Consistency Determination, State of Hawai‘i, Department of Business, Economic Development & Tourism, Office of Planning (concurrence received by letter dated July 13, 2001, see Appendix F).

10. REFERENCES

Brewer Environmental Services. Environmental Site Reconnaissance, Kaumālapaʻu Land Acquisition. August 1997. Prepared for Lanai Company, Inc.

Clayton Environmental Consultants. Phase I Environmental Site Assessment, 2.3 Acres at Kaumālapaʻu Harbor, Lānaʻi Hawaiʻi.

Department of Army Pacific Ocean Division, Corps of Engineers. Manual for Determining Tsunami Runup Profiles on Coastal Areas of Hawaiʻi 1978

U.S. Army Corps of Engineers, Pacific Ocean Division. Kaumālapaʻu Harbor Special Design Report, Island of Lānaʻi, Hawaiʻi. September 1996

U.S. Army Corps of Engineers, Waterways Experimental Station. Wave Response of Kaumālapaʻu Harbor Lānaʻi, Hawaiʻi. July 1997. Prepared for U.S. Army Engineer Division, Pacific Ocean.

U. S. Department of the Interior, Fish and Wildlife Service. Final Fish and Wildlife Coordination Act Report, Kaumālapaʻu Harbor Navigation Improvements, Lānaʻi, Hawaiʻi. April 2001. Prepared for U.S. Army Corps of Engineers, Honolulu Engineer District, Fort Shafter, Hawaiʻi.

APPENDIX A: ASSESSMENT OF WATER QALITY PRE-CONSTRUCTION MONITORING

ASSESSMENT OF WATER QUALITY
PRE-CONSTRUCTION MONITORING

KAUMALAPAU HARBOR BREAKWATER MODIFICATIONS
ISLAND OF LANAI, HAWAII

Prepared for:

SEA ENGINEERING, INC.
Makai Research Pier
41-202 Kalanianaole Hwy.
Waimanalo HI 96795

Prepared by:

MARINE RESEARCH CONSULTANTS
4467 Sierra Dr.
Honolulu, HI 96816

April 1, 2000

EXECUTIVE SUMMARY

Planning is underway to improve the existing breakwater at Kaumalapau Harbor on the west coast of the Island of Lanai, Hawaii, in order to provide safe docking conditions for cargo and fuel barges calling at the harbor. One component of the planning process is establishing the existing character of water quality in the area. The purpose of such a characterization is to provide an early indication if there are concerns that need to be specifically addressed in the planning and permitting process to ensure maintenance of water quality, and also to serve as a baseline for future monitoring programs that will be required during and after construction.

To meet these objectives, a water quality monitoring program was carried out in 1999. Six surveys were conducted at approximately bimonthly intervals in which water was sampled from the surface and bottom at twelve stations within and outside of Kaumalapa Harbor. Constituents that were analyzed included turbidity, total suspended solids (TSS), salinity and pH. These constituents were deemed to be the most appropriate suite of parameters that could be affected by the proposed construction activity.

Results of the program indicate that the lack of substantial sediment input, owing to the arid climate of the Kaumalapau area, sufficient circulation of seawater, and lack of destructive wave stress during the normal (i.e., non-hurricane or severe storm) seasonal wave climate result in very clear (low turbidity) waterconditions. Results of the study indicate that water quality throughout Kaumalapau Bay can be considered essentially pristine open coastal waters with little impact from loading of suspended materials from land. Statistical treatment of the data indicate that there is essentially no surface layer of low salinity water that typically occurs in areas where groundwater or surface water enters the ocean from land. In addition, at any particular time, there is no difference in water quality at any of the survey stations which ranged in location from the inner portions of the Bay to the open ocean. The only statistically significant difference in the data occurred as a function of season, indicating a small increase in all constituents during the winter months.

The proposed project to modify and improve the breakwater separating the Bay from the open ocean will consist of placement of rock and concrete armor units over the existing deteriorated breakwater. Such construction activity should have minimal effect on water quality as long as placed material is clean and devoid of dirt, mud, or silt. None of the probable construction activities should affect dissolved nutrient concentrations or organic compounds within the Bay.

The pristine nature of water quality within Kaumalapau Bay is likely a key component in the prolific reef coral growth, and associated biotic communities that inhabit the area. Should Best Management Practices (BMP's) for construction operations employ methods that minimize the addition of suspended sediment to the water column, and avoid disturbance of the naturally occurring reef adjacent to the breakwater, it appears that the proposed project will not have a deleterious effect to water quality or marine community structure.

The present program was designed to serve as an initial phase of construction monitoring, and provides a good representation of the spatial and temporal aspects of water quality in the area of proposed construction. Follow-up surveys using the same methodologies during and after the construction process should provide unambiguous documentation of the effects of the action that should fulfill all regulatory requirements stipulated for the project.

1.0 INTRODUCTION

Kaumalapau Harbor is a small barge harbor located in a natural embayment (Kaumalapau Bay) on the southwest coast of the Island of Lanai, Hawaii. It is the sole harbor serving the island. The harbor has a 10-acre berthing area, 10 to 20 meters (m) deep. A boulder breakwater that extends from the northwestern shoreline southward across the mouth of the bay protects the harbor and wharf facilities (Figure 1).

Kaumalapau Bay is exposed to storm waves from the west and south. The water depth across the mouth of the embayment is about 20 to 25 m deep. The breakwater was originally about 125 m long, but has been reduced by damage from storm waves to a length of approximately 60 m. Damage to the breakwater occurred during both Hurricane Iwa in 1982 and Hurricane Iniki in 1992. The shortened breakwater presently allows for increased wave energy within the harbor during periods of large waves, resulting in hazardous conditions for berthing and cargo handling.

The Kaumalapau Harbor breakwater repair project will rebuild the badly damaged and deteriorated existing breakwater, in order to provide safe berthing conditions at the existing wharf for cargo and fuel delivery to the island. The breakwater will be rebuilt on the footprint of the old rubblemound structure, and will utilize the existing structure for the core of the new breakwater. Construction will consist of shaping the existing rubblemound to provide a core, placing an underlayer of 3 to 4 ton stone, and placing an armor layer of 35 ton Core-Loc concrete armor units. The new breakwater will have a total length of 98 m (320 feet), and a crest elevation of 4.4 m (14.5 feet) above mean lower low water.

An Environmental Assessment (EA) is necessary to address possible impacts of the proposed modification of the harbor. One of the components of the assessment is to evaluate the potential effects to water quality from the construction and operation of the new facility. One requirement of the project will be the issuance of a Section 401 Water Quality Certification; conditions of the certification are the design and implementation of a Best Management Practices (BMP's) and a Water Quality Monitoring Plan. The intents of the Water Quality Monitoring Plan are: 1) to ascertain that the specified BMP's are adequate to comply with State Water Quality Standards (HAR 11-56) and to preserve water quality in State Waters; 2) in the event that the BMP's prove inadequate, to promptly determine such, so that modifications of the BMP's can be implemented in a timely fashion to bring the activity into compliance, so that quality of State waters will be preserved; and 3) to serve as a basis for self-compliance, so that activities associated with the proposed action can proceed within the parameters defined under State water quality standards.

In this vein, it will be necessary that a monitoring program is established to evaluate the extent of changes to water quality during these activities. Typically such monitoring programs involve a three phase approach; 1) an initial pre-construction phase delineates the conditions prior to the commencement of any work. The pre-construction program establishes a set of conditions that can be used as a baseline from which changes can be discerned. Ideally the pre-construction baseline encompasses such factors as seasonal variations and anomalous events (e.g., storms) that are natural phenomena, yet cause extreme excursions in the magnitude of typical natural conditions. As such, the purpose of the pre-construction monitoring program is to define an envelope of natural variability that provides a sound scientific and statistical basis capable of differentiating changes from natural factors and the anthropogenic (construction) activity that is taking place.

It follows that the second phase of monitoring occurs during the period of construction, and is designed to mesh with the pre-construction phase in order to identify changes to the environment that result from the activity in question. It is important that the design of the construction phases is such that potentially harmful conditions can be identified at an early enough point in time that effective mitigation measures can be employed prior to a point where damage to the biotic marine communities that populate the area occur. The third, and final phase of the monitoring program is the post-construction phase. This follow-up monitoring ensures that an effects from the construction activity have completely been completely eliminated, and that no unforseen problems have arisen as a result of the project. The following report presents the methods, results and conclusions of the pre-construction phase of the water quality monitoring for the proposed modifications of Kaumalapau Harbor.

II. SAMPLING AND ANALYTICAL METHODS

A. MONITORING CONSTITUENTS

Chemical constituents that were assessed included turbidity, total suspended solids (TSS), salinity, and pH. Dissolved nutrients, pesticides, heavy metals, etc. were not considered as monitoring constituents as there appears to be little potential for changes in these materials as a result of the proposed construction of the breakwater.

A. SAMPLING STATIONS

A total of twelve sampling stations were established to monitor effects of project activities on water quality (shown in figure 1). Four stations (1, 3, 5, 7) were located in the vicinity of the existing breakwater. Stations 2, 4 and 11 were located in the interior of Kaumalapau Bay; Stations 9 and 10 were located at the mouth of the bay parallel to the existing breakwater, and Stations 6, 8, and 12 were located seaward of the margin of the inner bay.

C. SAMPLING FREQUENCY

During the pre-construction phase, samples were collected on six occasions at approximately 2 month intervals during the calendar year 1999. This sampling schedule was designed to encompass any seasonal variability that may occur in the region. Sampling was conducted randomly with no consideration for any particular sea or weather conditions. During all six of the samplings, conditions were similar with no wind or rain, and small surf of 1-3 feet breaking along the outer shorelines of the Bay. Contingencies were in place to conduct a seventh monitoring during a period of heavy rainfall and surface drainage into Kaumalapau Bay.

D. FIELD SAMPLING METHODS

All water samples were collected using a small boat. At each of the twelve sampling stations, two water samples were collected. Grab samples were collected at the surface (within the upper one meter of the water column), and near the ocean bottom. Samples were collected using 2-liter Niskin oceanographic sampling bottles. These bottles contain spring-loaded end-caps which are cocked in an open position allowing free flow-through as the bottle is lowered to the desired sampling depth. At the desired depth, a weighted messenger is released from the surface which trips the end-caps to close, isolating a volume of water. Following collection, sub-samples were transferred from the Niskin bottles to triple-rinsed 1-liter polyethylene bottles. Samples were immediately analyzed for pH at ambient temperature using a field meter calibrated with 7 and 10 buffers. Following measurement of pH, all samples were stored on ice in insulated coolers from the time of collection until delivery to the analytical laboratory. Appropriate chain of custody transfers were executed between the field sampler and the laboratories.

E. ANALYTICAL METHODOLOGY

Turbidity was determined on 60-ml subsamples using a Turner Designs 90° laboratory nephelometer (EPA method 180.1). TSS was measured gravimetrically using a laboratory grade electrobalance (EPA method 160.2). Salinity was measured using a AGE laboratory grade salinometer calibrated with Copenhagen standards. All laboratory analyses of turbidity, TSS and salinity were performed by Marine Analytical Specialists, located in Honolulu (EPA Lab. No. HI00009).

II. RESULTS

Overall, the results of the monitoring program indicated that water quality throughout the sampling area in the vicinity of Kaumalapau Bay was remarkably clear of suspended material throughout the year. This observation appears to be a result of the arid nature of the western side of the Island of Lanai, which receives little rainfall, and hence little runoff of particulate materials.

Tables 1-6 show the results of each of the six separate samplings for each constituent at each sampling station, along with the geometric means, maxima, minima, and standard deviations for data set. The total range of individual measurements of TSS for all surveys was 0.08 to 5.40 mg/L, while the range in geometric means of TSS from the six samplings was 0.94 to 3.07 mg/L. Similarly, the range of individual measurements of turbidity was 0.05 to 0.32 ntu, while the range of geometric means of turbidity was 0.07 to 0.12 ntu. By comparison, Department of Health (DOH) water quality standards list the geometric mean limit for turbidity under dry conditions as 0.20 ntu. Hence, the highest mean turbidity for any of the sampling dates was approximately one-half of the most stringent DOH limit. Similarly, over the sampling regime salinity shows only slight variation with a range of individual measurements from 34.631 to 35. 051 (Tables 1-6).

Table 7 shows water quality data for each station during each of the sampling periods. Table 8 summarizes this information by showing only the geometric means, maxima and minima from each station at each sampling period. One-way ANOVA performed on the entire data set showed no significant differences ($p = 0.01$) in any of the four water quality constituents between means of surface and deep samples, indicating that there is no vertical stratification of the water column. One-way ANOVA also showed no significant differences ($p = 0.01$) for any of the water quality constituents when all data from each of the twenty-four sampling stations was pooled. This result indicates that water throughout the sampling regime is essentially homogeneous at any time of the year.

One-way ANOVA, however, did reveal significant differences ($p = 0.01$) when the data was pooled by sampling period (e.g., data from all 24 stations in march was pooled). Table 9 shows results of these analyses in terms of ranked means and associations (significant differences are shown by different association letters). In general, the highest means of all constituents occurred in the winter samplings (January, October, December), while the lowest means occurred during the summer (June, August). This result may indicate that even though the region as a whole is dry throughout the year, there is a small, but significant effect of rainfall and runoff that affects water quality.

IV. CONCLUSIONS AND RECOMMENDATIONS

Results of the program indicate that the lack of substantial sediment input, owing to the arid climate of the Kaumalapau area, sufficient circulation of seawater, and apparent lack of destructive wave stress during the normal (i.e. non-hurricane) seasonal wave climate result in very clear waterconditions. Results of the study indicate that water quality throughout Kaumalapau Bay can be considered essentially pristine open coastal waters with little impact from loading of suspended materials from land. Statistical treatment of the data indicate that there is essentially no surface layer of low salinity water that typically occurs in areas where groundwater or surface water enters the ocean from land. In addition, at any particular time, there is no difference in water quality at any of the survey stations which ranged in location from the inner portions of the Bay to the open ocean. The only statistically significant difference in the

data occurred as a function of season, indicating a small increase in all constituents during the winter months.

The proposed project to modify and improve the breakwater separating the Bay from the open ocean is likely to consist of placement of rock or concrete structures over the existing breakwater. Such construction activity should have minimal effect on water quality as long as placed material is clean and devoid of dirt, mud, or silt. None of the probable construction activities should affect dissolved nutrient concentrations or organic compounds within the Bay.

In summary, the pristine nature of water quality within Kaumalapau Bay is likely a key component in the prolific reef coral growth, and associated biotic communities that inhabit the area. Should Best Management Practices (BMP's) for construction operations employ methods that minimize the addition of suspended sediment to the water column, and avoid disturbance of the naturally occurring reef adjacent to the breakwater, it appears that the proposed project will not have a deleterious effect to marine community structure.

The present program was designed to serve as an initial phase of construction monitoring, and provides a good representation of the spatial and temporal aspects of water quality in the area of proposed construction. Follow-up surveys using the same methodologies during and after the construction process should provide unambiguous documentation of the effects of the action that should fulfill all regulatory requirements stipulated for the project.

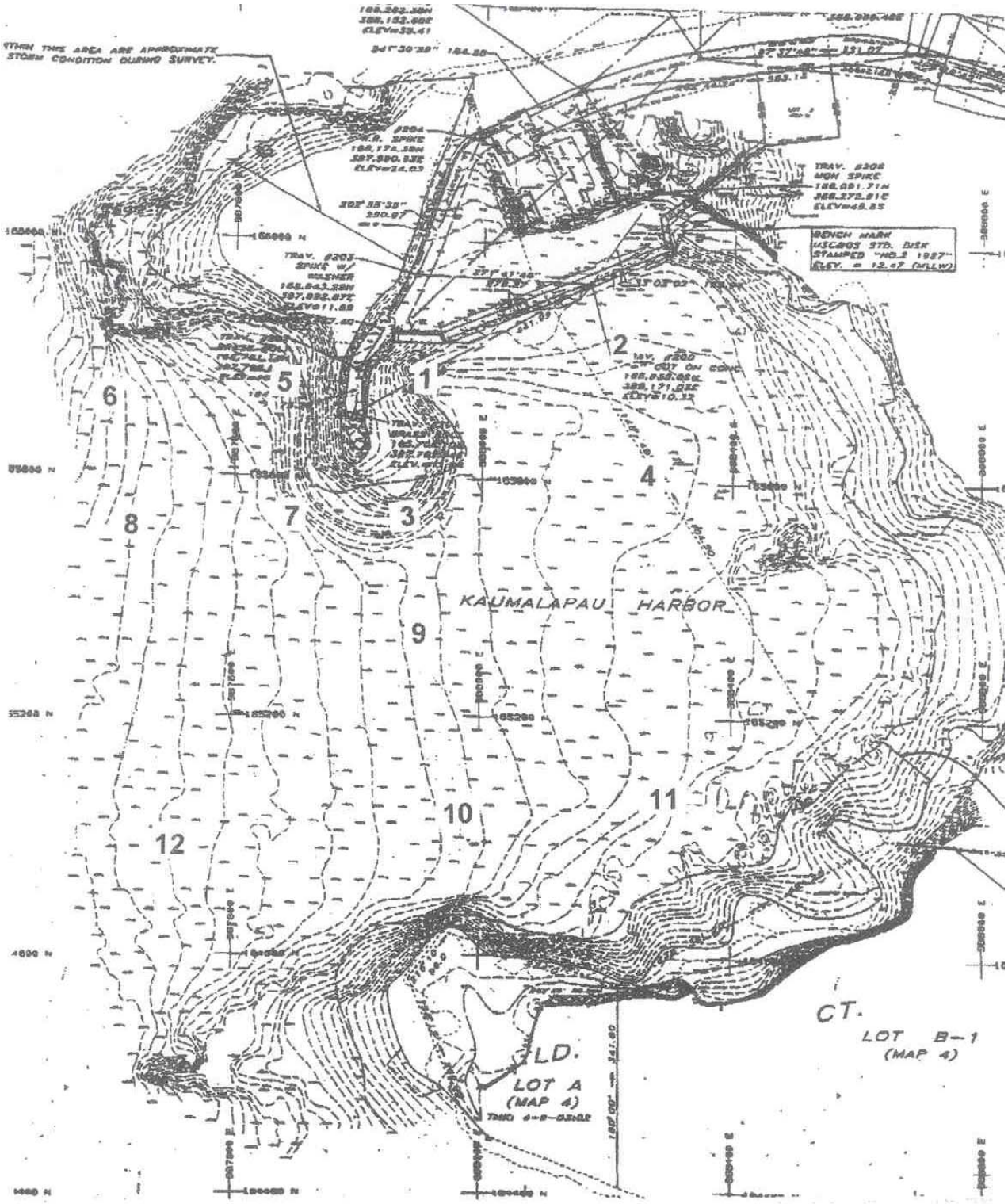


FIGURE 1. Map of Kaumalapau Bay showing locations of twelve water quality sampling stations.

TABLE 1. Water quality monitoring results from stations in Kaumalapau Harbor collected on January 5, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.73	0.12	35.040	8.154
1-B	1.67	0.10	35.043	8.174
2-S	0.93	0.08	35.025	8.178
2-B	0.87	0.07	35.046	8.186
3-S	0.80	0.06	35.044	8.193
3-B	1.60	0.08	35.043	8.178
4-S	0.87	0.07	35.034	8.191
4-B	1.03	0.08	35.034	8.185
5-S	1.20	0.08	35.031	8.191
5-B	1.27	0.07	35.013	8.190
6-S	0.93	0.07	35.025	8.197
6-B	1.00	0.06	35.014	8.200
7-S	1.20	0.06	35.020	8.200
7-B	1.47	0.09	34.999	8.185
8-S	1.80	0.06	34.997	8.200
8-B	1.47	0.07	35.016	8.198
9-S	1.40	0.06	35.006	8.195
9-B	1.27	0.08	35.016	8.186
10-S	1.03	0.06	34.999	8.195
10-B	0.87	0.07	35.015	8.183
11-S	1.20	0.07	35.009	8.197
11-B	1.03	0.08	35.008	8.181
12-S	1.27	0.06	35.015	8.193
12-B	1.60	0.07	35.006	8.188
GEO.MEAN	1.19	0.07	35.021	8.188
MAXIMA	1.80	0.12	35.05	8.20
MINIMUM	0.80	0.06	35.00	8.15
STD. DEV.	0.30	0.01	0.02	0.01

TABLE 2. Water quality monitoring results from stations in Kaumalapau Harbor collected on March 4, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.47	0.09	34.968	8.126
1-B	1.40	0.09	34.940	8.155
2-S	0.93	0.07	34.631	8.162
2-B	0.27	0.07	34.934	8.159
3-S	0.87	0.09	34.814	8.171
3-B	1.27	0.08	34.993	8.166
4-S	1.00	0.08	34.827	8.160
4-B	0.93	0.08	34.974	8.166
5-S	0.80	0.08	34.824	8.172
5-B	0.87	0.07	35.009	8.171
6-S	0.80	0.08	34.740	8.174
6-B	1.27	0.07	34.966	8.172
7-S	1.20	0.07	34.869	8.171
7-B	1.00	0.08	34.938	8.172
8-S	0.87	0.07	34.718	8.174
8-B	0.47	0.07	34.942	8.172
9-S	1.40	0.09	34.819	8.166
9-B	1.20	0.09	34.955	8.172
10-S	2.27	0.08	34.753	8.176
10-B	0.27	0.08	34.986	8.167
11-S	0.87	0.09	34.834	8.159
11-B	0.93	0.07	34.948	8.171
12-S	1.47	0.09	34.679	8.162
12-B	0.93	0.07	34.933	8.172
GEO.MEAN	0.94	0.08	34.875	8.166
MAXIMA	2.27	0.09	35.01	8.18
MINIMUM	0.27	0.07	34.63	8.13
STD. DEV.	0.42	0.01	0.11	0.01

TABLE 3. Water quality monitoring results from stations in Kaumalapau Harbor collected on June 7, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.20	0.08	34.844	8.092
1-B	1.87	0.07	34.860	8.104
2-S	0.08	0.07	34.760	8.123
2-B	0.93	0.07	34.878	8.138
3-S	1.27	0.07	34.777	8.128
3-B	1.40	0.08	34.845	8.142
4-S	1.47	0.09	34.737	8.140
4-B	1.87	0.10	34.872	8.150
5-S	0.47	0.07	34.865	8.159
5-B	2.20	0.10	34.849	8.150
6-S	1.20	0.10	34.854	8.152
6-B	2.07	0.09	34.869	8.161
7-S	0.47	0.07	34.815	8.149
7-B	0.93	0.06	34.861	8.159
8-S	0.87	0.06	34.837	8.152
8-B	0.93	0.05	34.864	8.159
9-S	1.20	0.06	34.803	8.150
9-B	0.80	0.05	35.007	8.169
10-S	1.47	0.08	34.775	8.159
10-B	1.20	0.06	34.870	8.179
11-S	2.07	0.09	34.770	8.159
11-B	0.80	0.07	34.879	8.176
12-S	1.40	0.08	34.803	8.159
12-B	1.27	0.07	34.875	8.176
GEO.MEAN	1.06	0.07	34.840	8.149
MAXIMA	2.20	0.10	35.01	8.18
MINIMUM	0.08	0.05	34.74	8.09
STD. DEV.	0.54	0.01	0.06	0.02

TABLE 4. Water quality monitoring results from stations in Kaumalapau Harbor collected on August 14, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	3.47	0.09	34.909	8.126
1-B	2.40	0.06	34.881	8.129
2-S	3.87	0.07	34.923	8.126
2-B	1.80	0.07	34.907	8.148
3-S	1.40	0.06	34.884	8.146
3-B	1.27	0.05	34.919	8.150
4-S	3.20	0.08	34.893	8.141
4-B	0.87	0.05	34.929	8.158
5-S	2.20	0.06	34.932	8.172
5-B	1.20	0.06	34.907	8.167
6-S	1.93	0.06	34.906	8.168
6-B	1.80	0.07	34.917	8.170
7-S	1.47	0.05	34.953	8.168
7-B	0.67	0.05	34.943	8.172
8-S	0.60	0.06	34.901	8.179
8-B	0.80	0.06	34.912	8.192
9-S	0.87	0.06	34.894	8.174
9-B	1.20	0.05	34.877	8.172
10-S	1.27	0.06	34.903	8.167
10-B	3.27	0.07	34.894	8.165
11-S	0.93	0.07	34.871	8.151
11-B	1.87	0.06	34.893	8.175
12-S	5.40	0.11	34.865	8.177
12-B	1.40	0.05	34.922	8.177
GEO.MEAN	1.59	0.06	34.906	8.161
MAXIMA	5.40	0.11	34.95	8.19
MINIMUM	0.60	0.05	34.87	8.13
STD. DEV.	1.19	0.01	0.02	0.02

TABLE 5. Water quality monitoring results from stations in Kaumalapau Harbor collected on October 16, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	4.71	0.09	35.006	8.111
1-B	3.40	0.09	34.997	8.150
2-S	2.87	0.11	34.984	8.155
2-B	5.40	0.17	34.991	8.164
3-S	3.80	0.12	35.017	8.157
3-B	3.93	0.13	34.983	8.160
4-S	5.01	0.12	35.041	8.152
4-B	3.47	0.10	35.003	8.157
5-S	4.27	0.13	35.002	8.150
5-B	3.80	0.11	34.999	8.154
6-S	3.87	0.11	35.000	8.159
6-B	1.87	0.09	35.002	8.164
7-S	2.20	0.11	35.005	8.159
7-B	2.40	0.11	35.002	8.157
8-S	4.87	0.15	35.018	8.159
8-B	4.00	0.30	35.001	8.160
9-S	3.20	0.09	34.997	8.166
9-B	1.93	0.08	34.999	8.171
10-S	2.80	0.10	35.006	8.166
10-B	2.47	0.10	35.008	8.167
11-S	1.93	0.10	35.041	8.164
11-B	2.71	0.32	35.004	8.157
12-S	2.20	0.12	35.013	8.164
12-B	1.29	0.16	35.012	8.167
GEO.MEAN	3.07	0.12	35.005	8.158
MAXIMA	5.40	0.32	35.04	8.17
MINIMUM	1.29	0.08	34.98	8.11
STD. DEV.	1.12	0.06	0.01	0.01

TABLE 6. Water quality monitoring results from stations in Kaumalapau Harbor collected on December 22, 1999. See Figure 1 for locations of sampling stations.

Sample Station	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.87	0.10	35.057	8.108
1-B	3.40	0.14	35.054	8.119
2-S	2.80	0.12	35.074	8.143
2-B	3.40	0.10	35.071	8.146
3-S	2.93	0.11	35.051	8.139
3-B	1.93	0.10	35.053	8.143
4-S	2.80	0.10	35.080	8.155
4-B	3.47	0.13	35.033	8.144
5-S	2.87	0.10	35.060	8.158
5-B	3.40	0.16	35.059	8.160
6-S	1.67	0.09	35.055	8.166
6-B	1.80	0.08	35.072	8.170
7-S	1.93	0.08	35.088	8.151
7-B	2.80	0.11	35.073	8.149
8-S	1.20	0.10	35.074	8.165
8-B	1.40	0.11	35.064	8.166
9-S	1.27	0.09	35.072	8.160
9-B	2.40	0.13	35.071	8.156
10-S	2.20	0.09	35.078	8.160
10-B	1.80	0.10	35.106	8.158
11-S	2.20	0.18	35.069	8.156
11-B	2.93	0.10	35.063	8.156
12-S	2.40	0.11	35.076	8.158
12-B	1.80	0.08	35.080	8.158
GEO.MEAN	2.25	0.11	35.068	8.152
MAXIMA	3.47	0.18	35.11	8.17
MINIMUM	1.20	0.08	35.03	8.11
STD. DEV.	0.71	0.02	0.01	0.01

TABLE 7. Water quality monitoring results by station collected in the vicinity of Kamalapau Harbor during six pre-construction bi-monthly monitoring surveys in 1999.

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	Jan	1.73	0.12	35.040	8.15
1-S	Mar	1.47	0.09	34.968	8.13
1-S	June	1.20	0.08	34.844	8.09
1-S	Aug	3.47	0.09	34.909	8.13
1-S	Oct	4.71	0.09	35.006	8.11
1-S	Dec	1.87	0.10	35.057	8.11
GEO.MEAN		2.13	0.09	34.971	8.12
MAXIMUM		4.71	0.12	35.057	8.15
MINIMUM		1.20	0.08	34.844	8.09
1-B	Jan	1.67	0.10	35.043	8.17
1-B	Mar	1.40	0.09	34.940	8.16
1-B	June	1.87	0.07	34.860	8.10
1-B	Aug	2.40	0.06	34.881	8.13
1-B	Oct	3.40	0.09	34.997	8.15
1-B	Dec	3.40	0.14	35.054	8.12
GEO.MEAN		2.22	0.09	34.962	8.14
MAXIMUM		3.40	0.14	35.054	8.17
MINIMUM		1.40	0.06	34.860	8.10
2-S	Jan	0.93	0.08	35.025	8.18
2-S	Mar	0.93	0.07	34.631	8.16
2-S	June	0.08	0.07	34.760	8.12
2-S	Aug	3.87	0.07	34.923	8.13
2-S	Oct	2.87	0.11	34.984	8.16
2-S	Dec	2.80	0.12	35.074	8.14
GEO.MEAN		1.14	0.08	34.899	8.15
MAXIMUM		3.87	0.12	35.074	8.18
MINIMUM		0.08	0.07	34.631	8.12
2-B	Jan	0.87	0.07	35.046	8.19
2-B	Mar	0.27	0.07	34.934	8.16
2-B	June	0.93	0.07	34.878	8.14
2-B	Aug	1.80	0.07	34.907	8.15
2-B	Oct	5.40	0.17	34.991	8.16
2-B	Dec	3.40	0.10	35.071	8.15
GEO.MEAN		1.39	0.09	34.971	8.16
MAXIMUM		5.40	0.17	35.071	8.19
MINIMUM		0.27	0.07	34.878	8.14

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
3-S	Jan	0.80	0.06	35.044	8.19
3-S	Mar	0.87	0.09	34.814	8.17
3-S	June	1.27	0.07	34.777	8.13
3-S	Aug	1.40	0.06	34.884	8.15
3-S	Oct	3.80	0.12	35.017	8.16
3-S	Dec	2.93	0.11	35.051	8.14
GEO.MEAN		1.55	0.08	34.931	8.16
MAXIMUM		3.80	0.12	35.051	8.19
MINIMUM		0.80	0.06	34.777	8.13
3-B	Jan	1.60	0.08	35.043	8.18
3-B	Mar	1.27	0.08	34.993	8.17
3-B	June	1.40	0.08	34.845	8.14
3-B	Aug	1.27	0.05	34.919	8.15
3-B	Oct	3.93	0.13	34.983	8.16
3-B	Dec	1.93	0.10	35.053	8.14
GEO.MEAN		1.74	0.08	34.973	8.16
MAXIMUM		3.93	0.13	35.053	8.18
MINIMUM		1.27	0.05	34.845	8.14
4-S	Jan	0.87	0.07	35.034	8.19
4-S	Mar	1.00	0.08	34.827	8.16
4-S	June	1.47	0.09	34.737	8.14
4-S	Aug	3.20	0.08	34.893	8.14
4-S	Oct	5.01	0.12	35.041	8.15
4-S	Dec	2.80	0.10	35.080	8.16
GEO.MEAN		1.96	0.09	34.935	8.16
MAXIMUM		5.01	0.12	35.080	8.19
MINIMUM		0.87	0.07	34.737	8.14
4-B	Jan	1.03	0.08	35.034	8.19
4-B	Mar	0.93	0.08	34.974	8.17
4-B	June	1.87	0.10	34.872	8.15
4-B	Aug	0.87	0.05	34.929	8.16
4-B	Oct	3.47	0.10	35.003	8.16
4-B	Dec	3.47	0.13	35.033	8.14
GEO.MEAN		1.63	0.09	34.974	8.16
MAXIMUM		3.47	0.13	35.034	8.19
MINIMUM		0.87	0.05	34.872	8.14

TABLE 7. Conitinued.

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
5-S	Jan	1.20	0.08	35.031	8.19
5-S	Mar	0.80	0.08	34.824	8.17
5-S	June	0.47	0.07	34.865	8.16
5-S	Aug	2.20	0.06	34.932	8.17
5-S	Oct	4.27	0.13	35.002	8.15
5-S	Dec	2.87	0.10	35.060	8.16
GEO.MEAN		1.52	0.08	34.952	8.17
MAXIMUM		4.27	0.13	35.060	8.19
MINIMUM		0.47	0.06	34.824	8.15
5-B	Jan	1.27	0.07	35.013	8.19
5-B	Mar	0.87	0.07	35.009	8.17
5-B	June	2.20	0.10	34.849	8.15
5-B	Aug	1.20	0.06	34.907	8.17
5-B	Oct	3.80	0.11	34.999	8.15
5-B	Dec	3.40	0.16	35.059	8.16
GEO.MEAN		1.83	0.09	34.973	8.17
MAXIMUM		3.80	0.16	35.059	8.19
MINIMUM		0.87	0.06	34.849	8.15
6-S	Jan	0.93	0.07	35.025	8.20
6-S	Mar	0.80	0.08	34.740	8.17
6-S	June	1.20	0.10	34.854	8.15
6-S	Aug	1.93	0.06	34.906	8.17
6-S	Oct	3.87	0.11	35.000	8.16
6-S	Dec	1.67	0.09	35.055	8.17
GEO.MEAN		1.49	0.08	34.930	8.17
MAXIMUM		3.87	0.11	35.055	8.20
MINIMUM		0.80	0.06	34.740	8.15
6-B	Jan	1.00	0.06	35.014	8.20
6-B	Mar	1.27	0.07	34.966	8.17
6-B	June	2.07	0.09	34.869	8.16
6-B	Aug	1.80	0.07	34.917	8.17
6-B	Oct	1.87	0.09	35.002	8.16
6-B	Dec	1.80	0.08	35.072	8.17
GEO.MEAN		1.59	0.08	34.973	8.17
MAXIMUM		2.07	0.09	35.072	8.20
MINIMUM		1.00	0.06	34.869	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
7-S	Jan	1.20	0.06	35.020	8.20
7-S	Mar	1.20	0.07	34.869	8.17
7-S	June	0.47	0.07	34.815	8.15
7-S	Aug	1.47	0.05	34.953	8.17
7-S	Oct	2.20	0.11	35.005	8.16
7-S	Dec	1.93	0.08	35.088	8.15
GEO.MEAN		1.27	0.07	34.958	8.17
MAXIMUM		2.20	0.11	35.088	8.20
MINIMUM		0.47	0.05	34.815	8.15
7-B	Jan	1.47	0.09	34.999	8.19
7-B	Mar	1.00	0.08	34.938	8.17
7-B	June	0.93	0.06	34.861	8.16
7-B	Aug	0.67	0.05	34.943	8.17
7-B	Oct	2.40	0.11	35.002	8.16
7-B	Dec	2.80	0.11	35.073	8.15
GEO.MEAN		1.35	0.08	34.969	8.17
MAXIMUM		2.80	0.11	35.073	8.19
MINIMUM		0.67	0.05	34.861	8.15
8-S	Jan	1.80	0.06	34.997	8.20
8-S	Mar	0.87	0.07	34.718	8.17
8-S	June	0.87	0.06	34.837	8.15
8-S	Aug	0.60	0.06	34.901	8.18
8-S	Oct	4.87	0.15	35.018	8.16
8-S	Dec	1.20	0.10	35.074	8.17
GEO.MEAN		1.30	0.08	34.924	8.17
MAXIMUM		4.87	0.15	35.074	8.20
MINIMUM		0.60	0.06	34.718	8.15
8-B	Jan	1.47	0.07	35.016	8.20
8-B	Mar	0.47	0.07	34.942	8.17
8-B	June	0.93	0.05	34.864	8.16
8-B	Aug	0.80	0.06	34.912	8.19
8-B	Oct	4.00	0.30	35.001	8.16
8-B	Dec	1.40	0.11	35.064	8.17
GEO.MEAN		1.19	0.09	34.966	8.17
MAXIMUM		4.00	0.30	35.064	8.20
MINIMUM		0.47	0.05	34.864	8.16

TABLE 7. Conitinued.

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
9-S	Jan	1.40	0.06	35.006	8.20
9-S	Mar	1.40	0.09	34.819	8.17
9-S	June	1.20	0.06	34.803	8.15
9-S	Aug	0.87	0.06	34.894	8.17
9-S	Oct	3.20	0.09	34.997	8.17
9-S	Dec	1.27	0.09	35.072	8.16
GEO.MEAN		1.42	0.07	34.932	8.17
MAXIMUM		3.20	0.09	35.072	8.20
MINIMUM		0.87	0.06	34.803	8.15

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
9-B	Jan	1.27	0.08	35.016	8.19
9-B	Mar	1.20	0.09	34.955	8.17
9-B	June	0.80	0.05	35.007	8.17
9-B	Aug	1.20	0.05	34.877	8.17
9-B	Oct	1.93	0.08	34.999	8.17
9-B	Dec	2.40	0.13	35.071	8.16
GEO.MEAN		1.38	0.08	34.987	8.17
MAXIMUM		2.40	0.13	35.071	8.19
MINIMUM		0.80	0.05	34.877	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
10-S	Jan	1.03	0.06	34.999	8.20
10-S	Mar	2.27	0.08	34.753	8.18
10-S	June	1.47	0.08	34.775	8.16
10-S	Aug	1.27	0.06	34.903	8.17
10-S	Oct	2.80	0.10	35.006	8.17
10-S	Dec	2.20	0.09	35.078	8.16
GEO.MEAN		1.73	0.08	34.919	8.17
MAXIMUM		2.80	0.10	35.078	8.20
MINIMUM		1.03	0.06	34.753	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
10-B	Jan	0.87	0.07	35.015	8.18
10-B	Mar	0.27	0.08	34.986	8.17
10-B	June	1.20	0.06	34.870	8.18
10-B	Aug	3.27	0.07	34.894	8.17
10-B	Oct	2.47	0.10	35.008	8.17
10-B	Dec	1.80	0.10	35.106	8.16
GEO.MEAN		1.27	0.08	34.980	8.17
MAXIMUM		3.27	0.10	35.106	8.18
MINIMUM		0.27	0.06	34.870	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
11-S	Jan	1.20	0.07	35.009	8.20
11-S	Mar	0.87	0.09	34.834	8.16
11-S	June	2.07	0.09	34.770	8.16
11-S	Aug	0.93	0.07	34.871	8.15
11-S	Oct	1.93	0.10	35.041	8.16
11-S	Dec	2.20	0.18	35.069	8.16
GEO.MEAN		1.43	0.09	34.932	8.16
MAXIMUM		2.20	0.18	35.069	8.20
MINIMUM		0.87	0.07	34.770	8.15

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
11-B	Jan	1.03	0.08	35.008	8.18
11-B	Mar	0.93	0.07	34.948	8.17
11-B	June	0.80	0.07	34.879	8.18
11-B	Aug	1.87	0.06	34.893	8.18
11-B	Oct	2.71	0.32	35.004	8.16
11-B	Dec	2.93	0.10	35.063	8.16
GEO.MEAN		1.50	0.10	34.966	8.17
MAXIMUM		2.93	0.32	35.063	8.18
MINIMUM		0.80	0.06	34.879	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
12-S	Jan	1.27	0.06	35.015	8.19
12-S	Mar	1.47	0.09	34.679	8.16
12-S	June	1.40	0.08	34.803	8.16
12-S	Aug	5.40	0.11	34.865	8.18
12-S	Oct	2.20	0.12	35.013	8.16
12-S	Dec	2.40	0.11	35.076	8.16
GEO.MEAN		2.05	0.09	34.908	8.17
MAXIMUM		5.40	0.12	35.076	8.19
MINIMUM		1.27	0.06	34.679	8.16

Sample Station	Sample Month	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
12-B	Jan	1.60	0.07	35.006	8.19
12-B	Mar	0.93	0.07	34.933	8.17
12-B	June	1.27	0.07	34.875	8.18
12-B	Aug	1.40	0.05	34.922	8.18
12-B	Oct	1.29	0.16	35.012	8.17
12-B	Dec	1.80	0.08	35.080	8.16
GEO.MEAN		1.35	0.08	34.971	8.17
MAXIMUM		1.80	0.16	35.080	8.19
MINIMUM		0.93	0.05	34.875	8.16

TABLE 8. Summary of geometric means, maxima and minima from sampling stations combined for six pre-construction surveys at Kaumalapau Harbor. Peak values of TSS and turbidity are in bold type for each parameter.

GEOMETRIC MEANS

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	2.13	0.09	34.971	8.12
1-B	**2.22**	0.09	34.962	8.14
2-S	1.14	0.08	34.899	8.15
2-B	1.39	0.09	34.971	8.16
3-S	1.55	0.08	34.931	8.16
3-B	1.74	0.08	34.973	8.16
4-S	1.96	0.09	34.935	8.16
4-B	1.63	0.09	34.974	8.16
5-S	1.52	0.08	34.952	8.17
5-B	1.83	0.09	34.973	8.17
6-S	1.49	0.08	34.930	8.17
6-B	1.59	0.08	34.973	8.17
7-S	1.27	0.07	34.958	8.17
7-B	1.35	0.08	34.969	8.17
8-S	1.30	0.08	34.924	8.17
8-B	1.19	0.09	34.966	8.17
9-S	1.42	0.07	34.932	8.17
9-B	1.38	0.08	34.987	8.17
1-0-S	1.73	0.08	34.919	8.17
10-B	1.27	0.08	**34.980**	8.17
11-S	1.43	0.09	34.932	8.16
11-B	1.50	**0.10**	34.966	8.17
12-S	2.05	0.09	34.908	8.17
12-B	1.35	0.08	34.971	8.17

MAXIMA

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	4.71	0.12	35.057	8.15
1-B	3.40	0.14	35.054	8.17
2-S	3.87	0.12	35.074	8.18
2-B	5.40	0.17	35.071	8.19
3-S	3.80	0.12	35.051	8.19
3-B	3.93	0.13	35.053	8.18
4-S	5.01	0.12	35.080	8.19
4-B	3.47	0.13	35.034	8.19
5-S	4.27	0.13	35.060	8.19
5-B	3.80	0.16	35.059	8.19
6-S	3.87	0.11	35.055	8.20
6-B	2.07	0.09	35.072	8.20
7-S	2.20	0.11	35.088	8.20
7-B	2.80	0.11	35.073	8.19
8-S	4.87	0.15	35.074	8.20
8-B	4.00	0.30	35.064	8.20
9-S	3.20	0.09	35.072	8.20
9-B	2.40	0.13	35.071	8.19
1-0-S	2.80	0.10	35.078	8.20
10-B	3.27	0.10	35.106	8.18
11-S	2.20	0.18	35.069	8.20
11-B	2.93	**0.32**	35.063	8.18
12-S	**5.40**	0.12	35.076	8.19
12-B	1.80	0.16	35.080	8.19

MINIMA

STATION	TSS (mg/l)	Turb (ntu)	SALT (o/oo)	pH (rel)
1-S	1.20	**0.08**	34.844	8.09
1-B	**1.40**	0.06	34.860	8.10
2-S	0.08	0.07	34.631	8.12
2-B	0.27	0.07	34.878	8.14
3-S	0.80	0.06	34.777	8.13
3-B	1.27	0.05	34.845	8.14
4-S	0.87	0.07	34.737	8.14
4-B	0.87	0.05	34.872	8.14
5-S	0.47	0.06	34.824	8.15
5-B	0.87	0.06	34.849	8.15
6-S	0.80	0.06	34.740	8.15
6-B	1.00	0.06	34.869	8.16
7-S	0.47	0.05	34.815	8.15
7-B	0.67	0.05	34.861	8.15
8-S	0.60	0.06	34.718	8.15
8-B	0.47	0.05	34.864	8.16
9-S	0.87	0.06	34.803	8.15
9-B	0.80	0.05	34.877	8.16
1-0-S	1.03	0.06	34.753	8.16
10-B	0.27	0.06	34.870	8.16
11-S	0.87	0.07	34.770	8.15
11-B	0.80	0.06	34.879	8.16
12-S	1.27	0.06	34.679	8.16
12-B	0.93	0.05	34.875	8.16

TABLE 9. Ranked means of combined sampling from six individual dates at Kaumalapau Harbor. Means followed by the same association letter are not significantly different (p = 0.01).

TSS			TURBIDITY		
Sampling Month	Ranked Mean	Association letter	Sampling Month	Ranked Mean	Association letter
MAR	1.032	A	JAN	0.0737	A
AUG	1.226	A	AUG	0.0745	A
JUN	1.226	A	JUN	0.0745	A
JAN	1.229	A	MAR	0.0792	A
DEC	2.361	B	DEC	0.1097	B
OCT	3.266	C	OCT	0.1295	B

SALINITY			pH		
Sampling Month	Ranked Mean	Association letter	Sampling Month	Ranked Mean	Association letter
AUG	34.8404	A	AUG	8.14937	A
JUN	34.8404	A	JUN	8.14937	A
MAR	34.8747	A	DEC	8.15183	A
OCT	35.0055	B	OCT	8.1579	AB
JAN	35.0208	BC	MAR	8.1666	BC
DEC	35.068	D	JAN	8.1888	D

APPENDIX B: ASSESSMENT OF MARINE BIOLOGICAL COMMUNITY STRUCTURE

ASSESSMENT OF MARINE BIOLOGICAL COMMUNITY STRUCTURE

KAUMALAPAU HARBOR BREAKWATER MODIFICATIONS
ISLAND OF LANAI, HAWAII

DRAFT

Prepared for:

SEA ENGINEERING
Makai Research Pier
41-202 Kalanianaole Hwy.
Waimanalo HI 96795

Prepared by:

MARINE RESEARCH CONSULTANTS
4467 Sierra Dr.
Honolulu, HI 96816

March 15, 1999

INTRODUCTION

Kaumalapau Harbor is a small barge harbor located in a natural embayment (Kaumalapau Bay) on the southwest coast of the Island of Lanai, Hawaii. It is the sole harbor serving the island. The harbor has a 10-acre berthing area, 10 to 20 meters (m) deep. A boulder breakwater that extends from the northwestern shoreline southward across the mouth of the bay protects the harbor and wharf facilities (Figure 1).

Kaumalapau Bay is exposed to storm waves from the west and south. The water depth across the mouth of the embayment is about 20 to 25 m deep. Large waves close the harbor several times a year. The breakwater was originally about 125 m long, but has been reduced by damage from storm waves to a length of approximately 60 m. Damage to the breakwater occurred during both Hurricane Iwa in 1982 and Hurricane Iniki in 1993. The shortened breakwater presently allows for increased wave energy within the harbor during periods of large waves, resulting in hazardous conditions for docking vessels.

In order to restore a protected docking environment for barges, a design report, completed by the Corps of Engineers in September 1996 recommends construction of a dog-leg extension of the existing breakwater. The extension includes rebuilding the first 100 m of the breakwater on the existing alignment, with the final 15 m constructed along an alignment shifted slightly toward the inside of the harbor in order to reduce wave heights in the berthing area. Construction would entail placement of a core consisting of stones capped by an armor layer consisting of concrete core-loc units. The proposed structure would cover a footprint area of xxx m^2 on the floor of the bay compared to the present footprint of yyym^2.

An Environmental Assessment (EA) is necessary to address possible impacts of the proposed modification of the harbor. One of the components of the assessment is to evaluate the potential effects to the marine communities that presently populate the area. The following report presents the methods, results and conclusions of the field investigations of the marine community structure at Kaumalapau.

METHODS

Corps of Engineers diving regulations preclude all but commercially certified divers from conducting underwater work. As a result, scientific investigators were restricted from carrying out any underwater surveys to characterized biotic community structure at Kaumalapau. Owing to this restriction, surveys were carried out in total using

underwater video equipment. A small video camera (Sub-Sea Video System 100) housed within a protective metal frame attached to a tow sled was lowered by winch from a small boat to a location near the bottom. Real time images of the underwater video were observed on a monitor on the boat. The camera sled was towed slowly along pre-determined transect line throughout the harbor and neighboring areas, recording on video tape. Interfaces between the clock on the camera and shipboard GPS recorded the position of each of the transect tows.

Following the fieldwork, the video tapes were viewed by a marine biologist (S. Dollar) to semi-quantitatively assess the biotic community structure. At periods of 5 seconds, the tape was "paused" and the approximate coverage of identifiable biota (primarily reef corals) was estimated. Following the completion of the transect, average cover on each transect was calculated.

The remote video method employed for this investigation has both advantages and disadvantages over conventional diver-conducted surveys. The advantages are that the method results in a permanent record of the habitat and community structure that can be viewed repeatedly, and can be seen by viewers (e.g., regulators) that cannot conduct site visits. In addition, the video images often provide a more comprehensive picture of the environment than can be conveyed through still photographs.

A disadvantage with the method is that it precludes the accurate quantification of biotic community composition. Differentiation of species, and even genera, is often not possible by the video images. Small benthic organisms, and those that occur within interstitial spaces or on the undersides of exposed surfaces are not visible. Because of avoidance of the camera, estimation of motile species, especially fish, is also extremely limited. In addition, because of the steep topography of the bottom within much of the the study area at Kaumalapau, maintaining a constant field of view (distance from the bottom) is not possible, so scaling of the area of coverage was constantly changing.

With these considerations, however, it appears that the remote video method provided adequate information to address the questions at hand regarding the marine environmental assessment for the Kaumalapau Breakwater Modifications. Because the marine survey was not intended to provide a quantitative assessment of community structure to serve as a pre-construction baseline for follow-up surveys, the lack of collection of such numerical data does not appear deleterious to the overall goals required for the EA. Similarly, while the identification of organisms to genus or species would be preferred, the lack of such ability does not appear to limit or invalidate any of the conclusions. In a sum, while diving surveys would provide more specific detailed data, the method employed appears to be sufficient to address the questions regarding potential environmental impacts from the project.

RESULTS

Figure 1 is a map of Kaumalapau Harbor and adjacent areas. Also shown on the map are the numbered video transect lines. Below is a discussion of the physical structure and biotic composition along each of the transect lines.

Line 1. This transect runs parallel to the inside upper face of the existing breakwater, beginning at the innermost accessible area of the northern corner of the harbor basin and extending to the sand bottom off the seaward end of the breakwater. Bottom composition of the area consists of large boulder armor stones that slope from the emergent rocks of the breakwater to the sand plain that comprises the natural harbor floor. With distance southward (toward the end of the breakwater), bottom composition at depths below approximately 5 m is made up of progressively larger amounts of concrete rip-rap, including poles, pipes and dolos as well as old machinery and even a vehicle. All of this debris material appears to have been intentionally deposited to subsidize and stabilize the breakwater structure.

Biotic composition in the shallower area (upper 3 m) of the breakwater consists of thin veneers of encrusting red algae (*Porolithon spp.*) covering large portions of the boulder armor stones. Corals in this area are rare (<2% of bottom cover) and consist primarily of small (10-20 cm in diameter) hemispherical colonies of the branching coral *Pocillopora meandrina*, and small flat encrustations of what appears to be *Porites lobata* (Figures 2 and 3). Below a depth of approximately 3 m, benthic biotic composition consists primarily of corals that have settled and proliferated on both the armor stones and the deposited debris. The dominant corals visible in the videos are *P. meandrina*, and flat encrustations of *Porites spp.* and *Montipora spp* (Figures 4 and 5). Coral cover increases both with depth and distance southward toward the end of the breakwater, peaking on the hard surfaces at the end of the breakwater (Figures 6 and 7). Average coral coverage along the entire transect was estimated at about 10% of bottom cover for *Pocillopora* and 26% for the encrusting *Porites-Montipora* growth form.

Line 2. This transect runs parallel to and below Line 1 along the inside face of the existing breakwater, beginning at the innermost accessible area of the northern corner of the harbor basin and extending to the sand bottom off the end of the breakwater. As on Line 1, bottom composition consists of a steep slope comprised of boulder armor stones and a variety of deposited rip-rap. This line encompasses the juncture of the inside edge of the breakwater structure and the sand bottom. Along most of the transect, there is a very distinct edge where the boulder and rip-rap intersects the sand; in other words rock and concrete structures do not appear to have moved much laterally from the base of the breakwater over the sand flat. The exception is the

presence of several large tires observed on the sand flat that might have slid from the sloping rock face onto the sand flat.

Biotic composition along Line 2 consists primarily of abundant encrustations of flat coral colonies *(Porites-Montipora*) and colonies of *Pocillopora*. As on Line 1, coral cover increased with distance from the inner harbor, peaking on the solid surfaces off the end of the emergent breakwater. Average coral cover along the transect was 15% *Pocillopora* and 32% for encrusting *Porites-Montipora* growth form. Coral occurrence essentially ceased at the juncture of the breakwater slope and the sand bottom, with only occasional corals growing on rubble or debris fragments laying on the sand bed. It was readily apparent from the underwater video transects that the armor stones, concrete rip-rap, and other metal debris that form the breakwater serve as suitable substratum for coral settlement as some surfaces were completely covered with living corals (Figures 6 and 7).

Line 3. This transect begins at the submerged seaward end of the breakwater structure and proceeds northward along the upper portion of the outer face of the breakwater. As on the inner face of the breakwater slope, the outer face is also covered with a variety of concrete structures, predominantly consisting of pipes, poles and dolos. In addition, numerous large metal boxes, which appear to have formerly been used to ship pineapples, are embedded in the outer face of the breakwater. At the northerly end of the outside face of the breakwater, the video transect takes a 90° turn westward and proceeds along the top of a natural finger of reef that extends seaward from the juncture of the breakwater and the wharf for approximately 100 m. The top of the finger lies at a depth of approximately 5 m, with vertical sides that extend to the sand bottom at a depth of approximately 20 m. Within the vertical walls of the finger are numerous undercut ledges and holes providing substantial substratum complexity.

Coral cover appears to reach peak values on the boulder and rip-rap surfaces on the seaward side of the existing breakwater, near the origin of line 3 (Figures 8 and 9). In particular, the cover of *Pocillopora meandrina* off the seaward end and the outer side of the breakwater is substantially greater than observed on the inside edge (Lines 1 and 2). Colonies of *P. meandrina* are extremely abundant on all concrete surfaces, particularly on the flat upper surfaces of the pineapple boxes (Figures 10 and 11). Overall estimates of coral cover revealed approximately 35% *P. meandrina* and 24% encrusting corals on the outer face of the breakwater. The predominance of living coral colonies on the outer seaward face of the breakwater indicates that prevailing oceanographic conditions are extremely suitable for coral settlement and growth.

Biotic composition on the natural finger reef extending perpendicular from the breakwater consists of similar assemblages as observed on the breakwater. The upper

flat surface of the finger is populated primarily with hemispherical colonies of *P. meandrina* (estimated at 40% coral cover). The vertical undercut sides of the finger are primarily covered with both *P. meandrina* and flat encrusting species that appeared to be predominantly *Porites lobata* and several species of *Montipora* (cover estimated at 30%) (Figure 12).

Line 4. This transect runs parallel to line 3 at the juncture of the breakwater structure and the sand bottom, and also takes a 90° turn at the juncture of the breakwater and the finger reef. Physical structure and coral community structure on the breakwater and cliff face of line 4 were similar to that described above for line 3. At the base of the cliff, bottom topography slopes gently toward the sand plain that extends seaward and toward the harbor mouth. Corals occurring on the natural bottom at the base of the cliff include the branching species *Pocillopora meandrina* and *Porites compressa*, as well as the encrusting species *Porites lobata* and *Montipora spp.* (Figure 13). Coral cover at the base of the cliff was estimated at 60%.

Line 5. This transect runs along the outer, seaward facing reef edge beginning at the outer terminus of the finger reef and extending in a northeasterly direction. The physical structure of the area is similar to the finger reef, with a narrow reef top extending to the rocky shoreline that drops in a near vertical face to a sand plain. Examination of the shoreline north of the harbor indicates that such structure is the typical shoreline topography for at least several kilometers. Coral cover along the entire shoreline ridge consists primarily of large colonies of *P. lobata* and heads of *P. meandrina,* with an overall cover of 50-60%.

Line 6. This line bisects Kaumalapau Bay, originating at the berthing wharf and terminating at the southern edge of the harbor. Overall, the harbor floor consists of coarse-grained grey sand. Numerous burrows, likely from burrowing shrimp or worms occur throughout the sand plain. Abundant debris, including tires, cables and machinery occurs on the sand bed. Occasional small outcrops of limestone also occur throughout the sand plain. Living coral colonies occupy the outcrops which extend above the level of the sand plain. In total, however, coral cover within the harbor basin is less than 1%.

Line 7. This line traced the boundary of the shoreline around the circumference of the harbor basin originating at the inner corner of the wharf, and terminating at the southern point of the harbor mouth opposite from the breakwater. Throughout the transect, bottom topography consisted of a rocky nearshore ledge that slopes to the sand plain of the harbor floor. Numerous sand-filled grooves and spurs characterize the nearshore ledge. In the approximate center of the harbor, a rocky outcrop protrudes approximately 50 m outward from the shoreline. Near the southern edge of the harbor mouth, the shoreline ridge becomes a nearly vertical face approximately 3 m in height

that terminates on a boulder-strewn sand plain. The entire shoreline ledge was populated by a high percentage (70%)of living corals of the species *Pocillopora meandrina, Porites compressa* and *P. lobata,* and *Montipora spp.* One conspicuous difference in the coral assemblages between the inner harbor ridge, and the outer harbor reef described above is the greater abundance of *Porites compressa* in the inner areas. *P. compressa*, known commonly as "finger coral" consists of mats of relatively delicate branches that are susceptible to breakage from wave energy. The presence of high levels of cover of this species within the inner harbor suggests that while water circulation within the harbor is sufficient to result in ideal conditions of coral growth, wave energy is minimal. On the contrary, on the outer reefs and on the breakwater, the lack of P. compressa suggests the occurrence of periodic episodes of high wave energy.

Other Observations of Marine Biota at Kaumalapau

Because of the limitations of the video methods in terms of identifying organisms, it is fortunate to have other resources to consider. In August 1995, the U.S. Fish and Wildlife Service (FWS) prepared a Draft Report entitled "Fish and Wildlife Coordination Act Report; Kaumalapau Harbor Navigation Improvements, Lanai, Hawaii." The report contains an assessment of the terrestrial and marine biota of the area based on field surveys conducted by Service personnel.

In general, the descriptions of the coral community structure in the vicinity of the existing breakwater and harbor presented in the FWS report is similar to the results of the present report. However, the FWS report also describes the presence of other common reef invertebrates not visible in the videos, including the sea urchins *Heterocentrotus mammillatus*, *Echinometra matheai*, *Colobocentrotus atra*, and the sea cucumber *Holothuria atra*.

The FWS report also describes the fish communities of the area. On the seaward facing area of the breakwater, the fish community was described as being fairly diverse with 56 species in 26 families identified. On the inner side of the breakwater, fish communities were less diverse with 40 species from 15 families observed. Throughout the entire region, however, overall fish abundance appeared to be relatively low, and fish species were generally represented by individuals belonging to small size classes. The near absence of larger individuals of common food fishes was noticeable. During the surveys conducted for the present report, several groups of spearfishermen were observed working in the harbor. Such observations, as well as the documentation of lack of larger fish, indicate that this area sustains a high level of fishing pressure.

The FWS report also states that the only marine plant observed was an unidentified filamentous turf algae on the finger reef west of the breakwater. The lack of algae in the video transects appears to be consistent with this observation.

The FWS report states that although federally protected green sea turtles (*Chelonia mydas*), and endangered hawksbill turtles (*Eretmochelys imbricata*) are known to exist in the waters surrounding the harbor, no turtle nesting habitat occurs within Kaumalapau Bay. The FWS report also states that the preferred types of resting habitat and food resources for these species were not observed during the survey. No turtles were observed during the field periods when the video transecting was conducted.

CONCLUSIONS AND RECOMMENDATIONS

Results of the present study as well as the draft report prepared by the FWS indicate that all of the existing solid surfaces, whether natural or manmade, are highly suitable surfaces for reef coral settlement and growth. The apparent lack of sediment input owing to the arid climate of the area, sufficient circulation of seawater, and apparent lack of destructive wave stress during the course of the normal (i.e. non-hurricane) seasonal wave climate appear to provide an ideal habitat for coral growth. Of particular interest is the high coral cover on the armor stone and numerous pieces of debris comprising the submerged sections of the breakwater. Percentage coral cover on the breakwater is presently similar to percentage cover on neighboring natural surfaces. As much of the debris was likely placed on the breakwater following the two hurricanes that impacted Kaumalapau (1982, 1993), the coral colonization and growth on these structures appears to be relatively rapid.

The present design of the new breakwater will unquestionably involve coverage of the existing breakwater structure with new rock and concrete, resulting in loss of much of the existing coral cover. Inspection of the breakwater and Kaumalapau Harbor basin indicates that the floor of the harbor consists of sand. Thus, expanding the footprint of the breakwater should not substantially impact existing benthic biotic communities beyond the edge of the present breakwater. The new breakwater will consist of materials similar to the existing breakwater, and will cover a larger footprint, and consist of a larger surface area of boulders and concrete. As there is no reason to assume that the new breakwater structures would not colonize in a similar manner as the existing breakwater, it appears that over the long term (10-20 years), there is likely to be a net increase in coral cover in the Kaumalapau area.

While transplanting existing corals that presently occur on the armor stone and breakwater debris appears unfeasible, a partial method of mitigating loss of existing coral resources might involve moving some of the rip-rapdebris (poles, pipes and boxes) from

the breakwater to the sand plain of the harbor floor. Moving these structures out of the footprint of the new breakwater may be required for stable placement of the new construction materials. Movement of debris to the harbor floor would maintain in part the coral cover that presently populates the debris, and would also add substrate complexity to the relatively featureless harbor floor that could promote fish habitat in the manner of an artificial reef. The depth of the harbor floor appears substantial enough that movement of materials from the breakwater to the harbor floor would not result in hazards to navigation. In addition, the design purpose of the new breakwater is to reduce wave action within the harbor; hence, material within the harbor should not be subject to forces sufficient to move them from the areas of placement. Such a measure could result in an overall net increase in coral abundance when considering both colonization of newly placed materials and maintenance of a portion of corals that presently occur on existing structures.

Survey results also reveal prolific coral communities on the naturally occurring bottom adjacent to the breakwater, particularly on the finger reef that projects westward from the wharf. While the proposed construction plan does not involve activity in this area, care should be taken to avoid impacts that might accompany construction, such as mooring of barges or stockpiling of materials.

Survey results also indicate that the fish populations at Kaumalapau appear to substantially depleted by fishing pressure. None of the activities associated with construction of the new breakwater would appear to further impact fish populations. Rather, the increased complexity afforded by the new, larger breakwater should increase favorable fish habitat.

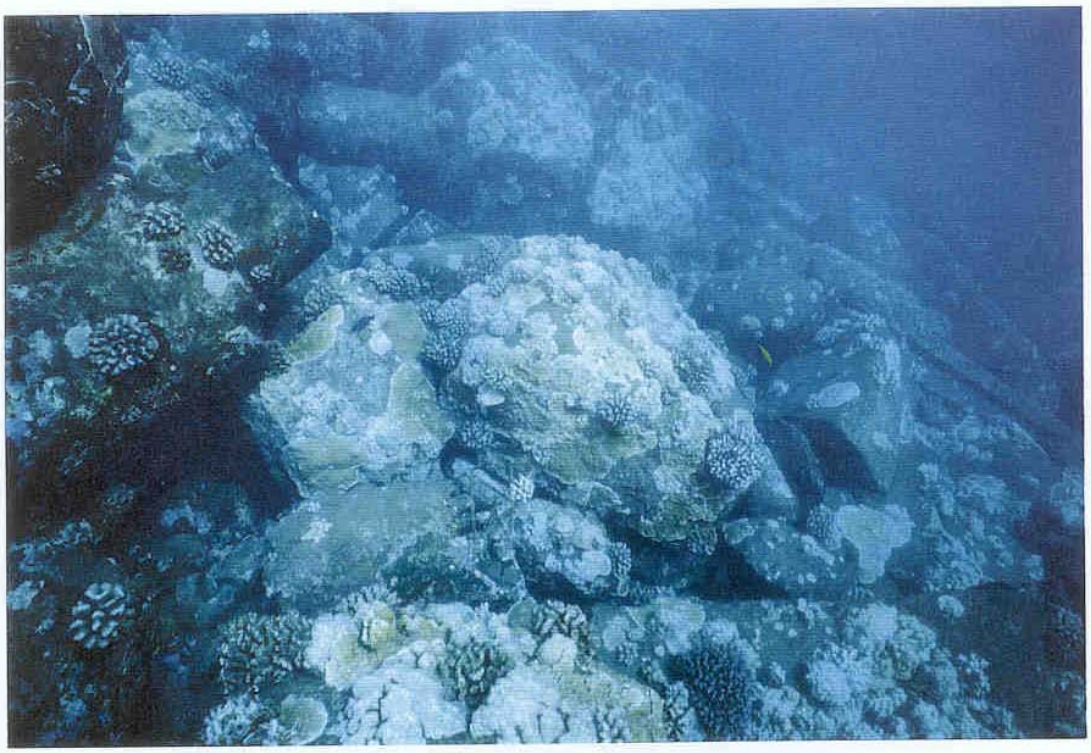
The FWS report also states that Kaumalapau is not a turtle nesting site. While turtles undoubtedly occur in the area of the proposed construction, it does not appear that the locale is a unique or especially favorable habitat for turtles. The lack of filamentous algae also indicates that the area is not likely a preferred feeding habitat for turtles. Nevertheless, it is recommended that a protocol be developed to mitigate disturbances to turtles, should they be present in the area during construction.

In summary, the marine resources in the vicinity of Kaumalapau Harbor consist of prolific reef coral growth, and associated communities. Coral growth on the man-made structures that comprise the present breakwater is comparable to natural surfaces. While construction of the new breakwater is expected to cover much of the existing coral, there is no reason to believe that the new breakwater will not be colonized in a similar manner within a relatively short time span. As the new breakwater will result in an increase in settlement surfaces compared to the present, and if some replacement of existing coral encrusted debris is undertaken, the net result of the project could be an

increase in coral community abundance. Should Best Management Practices (BMP's) for construction operations employ methods that minimize the addition of suspended sediment to the water column, and avoid disturbance of the naturally occurring reef adjacent to the breakwater, it appears that the proposed project will not have a deleterious effect to marine community structure.

Figure 1. Map of Kaumalapau Harbor showing location of existing breakwater and numbered tracks of video transects used to assess marine community structure.

Figures 2 and 3. Two views of boulders located on inside edge of existing breakwater at Kaumalapau Harbor. Water depth is 1-2 meters. Photos courtesy of J. Naughton, NMFS.



Figures 4 and 5. Two views of boulders on inside sloping side of breakwater at Kaumalapau Harbor, Lanai. Hemispherical branched corals are *Pocillopora meandrina*; flat encrusting species are predominantly *Porites lobata* and *Montipora spp.* Water depth is approximately 8-10 m. Photos courtesy of J. Naughton, NMFS.

Figures 6 and 7. Two views of concrete poles and pipes lying near inside end of underwater section of Kaumalapau breakwater. Water depth is 8-10 m. Photos courtesy of J. Naughton, NMFS.

Figures 8 and 9. Two views of concrete dolos off seaward facing edge of submerged Kaumalapau breakwater. Note high percentage of coral cover on all exposed surfaces. Water depth is 5 to 8 m. Photos courtesy of J. Naughton, NMFS.

Figures 10 and 11. Two views of metal boxes lying off the seaward end of the submerged Kaumalapau breakwater. Note high coverage of Pocillopora meandrina on tops of boxes. Water depth is 5 to 8 m. Photos courtesy of J. Naughton, NMFS.

Figure 12. View of natural finger reef that extends seaward from juncture of Kaumalapau breakwater and wharf. Photo shows flat top of reef and nearly vertical face on left. Photos courtesy of J. Naughton, NMFS.

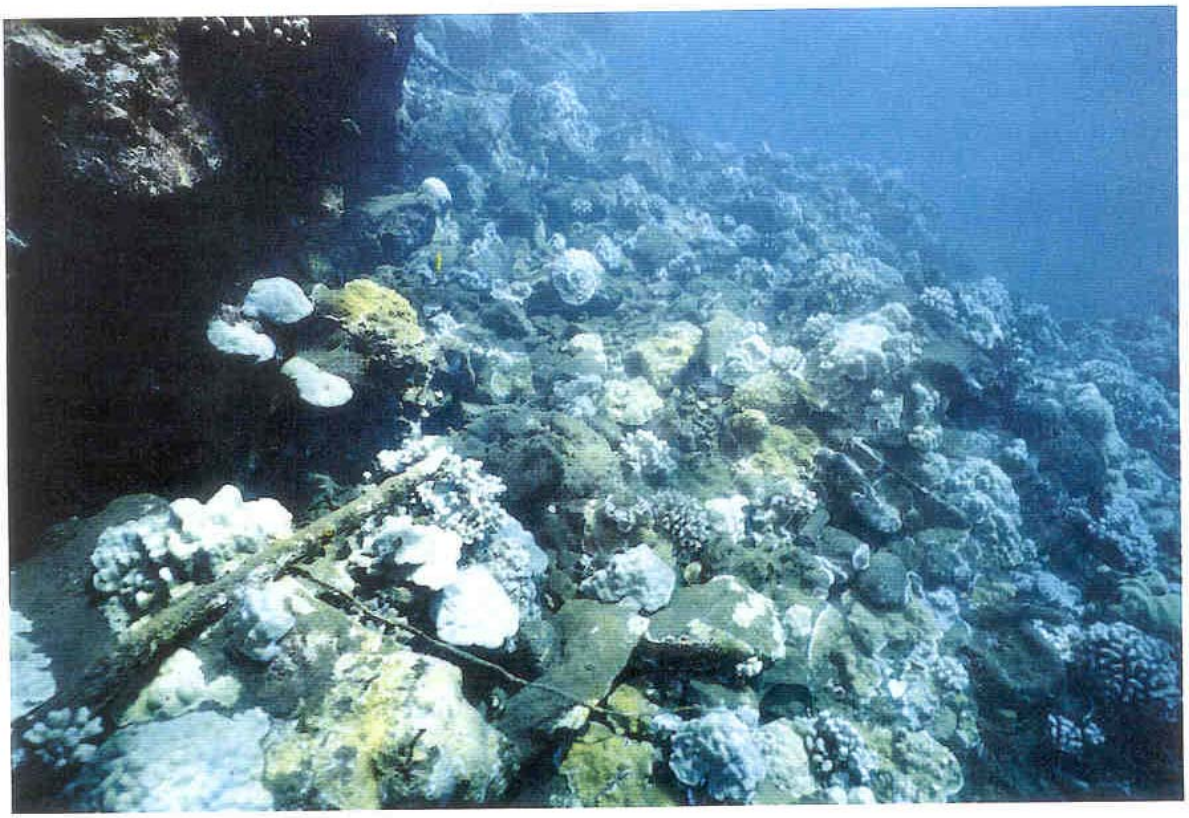


Figure 13. View of gently sloping reef edge at base of cliff shown in Figure 12. Water depth is approximately 12 m. Photos courtesy of J. Naughton, NMFS.

APPENDIX C: FINAL FISH AND WILDLIFE COORDINATION ACT REPORT

FINAL
FISH AND WILDLIFE COORDINATION ACT REPORT
KAUMALAPAU HARBOR NAVIGATION IMPROVEMENTS
LANAI, HAWAII

prepared by

U.S. Department of the Interior
Fish and Wildlife Service
Pacific Islands Ecoregion
Honolulu, Hawaii

prepared for

U.S. Army Corps of Engineers
Pacific Ocean Division
Honolulu Engineer District
Fort Shafter, Hawaii

April 2001

TABLE OF CONTENTS

LIST OF FIGURES i

LIST OF TABLES ii

INTRODUCTION 1
- Authority, Purpose, and Scope 1
- Coordination with Federal and State Resource Agencies 1
- Prior Fish and Wildlife Studies and Reports 2

DESCRIPTION OF THE PROJECT AREA 2

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES 4

EVALUATION METHODOLOGY 5

DESCRIPTION OF FISH AND WILDLIFE RESOURCES 6
- Existing Conditions 6
- Future Without the Project 9

DESCRIPTION OF ALTERNATIVES EVALUATED 10

PROJECT IMPACTS 11

FISH AND WILDLIFE SERVICE RECOMMENDATIONS 12

SUMMARY AND FISH AND WILDLIFE SERVICE POSITION 14

REFERENCES CITED 15

LIST OF FIGURES

Figure 1. The proposed project site at Kaumalapau Harbor on the island of Lanai, Hawaii (Source: Corps 2000)..... 16

Figure 2. Recommended Plan of Improvement (final Alternative 5) for breakwater repair at Kaumalapau Harbor, Lanai, Hawaii (Source: Corps 2000)..... 17

Figure 3. Typical breakwater cross sections for the Recommended Plan of Improvement at Kaumalapau Harbor, Lanai, Hawaii (Source: Corps 2000)..... 18

LIST OF TABLES

Table 1. Coral-reef fishes observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994 19

Table 2. Reef corals observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994 21

Table 3. Marine molluscs observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994 23

Table 4. Marine coelenterates, crustaceans, and echinoderms observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994 24

INTRODUCTION

Authority, Purpose and Scope

This is the U.S. Fish and Wildlife Service's (Service) final report on plans developed by the U.S. Army Corps of Engineers (Corps) for navigation improvements at Kaumalapau Harbor on the island of Lanai in the State of Hawaii. This report has been prepared under the authority of the Fish and Wildlife Coordination Act of 1934 [16 U.S.C. 661 et seq.; 48 Stat. 401], as amended (FWCA), and other authorities mandating Department of the Interior (DOI) concern for environmental values. This report is also consistent with the National Environmental Policy Act of 1969 [42 U.S.C. 4321 et seq.; 83 Stat. 852], as amended (NEPA). The purpose of this report is to document the existing fish and wildlife resources at the proposed project site and to insure that fish and wildlife conservation receives equal consideration with other proposed project objectives as required under the FWCA. The report includes an assessment of the significant fish and wildlife resources at the proposed project site, an evaluation of potential impacts associated with the proposed project design alternatives, and recommendations for fish and wildlife mitigation measures.

The proposed Kaumalapau Harbor project was originally authorized under the Energy and Water Development Appropriations Act of 1993 (PL 102-337). In this act, Congress directed the Corps to initiate preconstruction engineering and design work to repair the breakwater that protects the harbor basin. Congress released funds for the Corps to initiate a reconnaissance study of the harbor and compile a Special Report with technical appendices. Additional funding was provided through the Energy and Water Development Appropriations Act of 1994 for the Corps to continue the pre-engineering and design work.

Kaumalapau Harbor is forced closed several times each winter by wave assault associated with storms approaching from the west and south. In 1980, 1982, 1985, 1992, and 1993, storm waves severely damaged the harbor's breakwater. Concrete dolosse, pilings and conduit and scrap metal and other debris were placed on the breakwater to reinforce it after many of these events. Much of this material was displaced after the 1992 and 1993 storms, which also scattered the breakwater's crest stones, broke a hole through the middle of the breakwater, and left most of the seaward 23 m (75 ft) of the breakwater reduced to a submerged, low rubble mound. The breakwater, which has not been repaired since the 1993 event, has continued to deteriorate. In 1995, the captain of the fuel barge servicing Lanai refused to enter the harbor because of unsafe wave conditions near the existing wharf, and the supply and availability of fuel on the island became a serious concern.

Kaumalapau Harbor is important to the public welfare in Lanai because it serves as the only commercial harbor and the receiving site for most of the consumer goods, food, and mail that come into the island. The purpose of the proposed project is to repair and lengthen the existing, damaged breakwater. The existing rubble mound would be slightly reshaped to form the core of the new breakwater. A new underlayer of stones would be placed over the core, and a layer of core-loc concrete armor units would be placed over the stone underlayer. Finally, a cast-in-place concrete rib cap would be constructed to stabilize the crest of the breakwater.

Coordination with Federal and State Resource Agencies

Service biologists have discussed the proposed project with staff of the National Marine Fisheries Service (NMFS) of the U.S. Department of Commerce (DOC), the Division of Aquatic Resources (DAR) of the Hawaii Department of Land and Natural Resources, and the Coastal

Zone Management Program (CZMP) of the Hawaii Office of State Planning. Concerns relative to the protection and conservation of important fish and wildlife resources at Kaumalapau Harbor expressed by the Hawaii DAR and CZMP were incorporated into this draft FWCA report. Copies of this report are being provided to the U.S. Environmental Protection Agency (EPA), the Clean Water Branch (CWB) of the Hawaii Department of Health, the NMFS, the DAR, and the CZMP.

Prior Fish and Wildlife Studies and Reports

In October 1994, the Service conducted a field investigation of the proposed project site, which was documented in a draft FWCA report to the Corps that was released in August 1995. The report included brief descriptions of the major habitats existing within the project site and data on the composition of conspicuous species observed in each habitat. In the report, the Service identified the coral reefs within Kaumalapau Bay and immediately outside the existing breakwater as the habitats of major concern. Several conservation measures to minimize the degradation of coastal water quality and impacts to marine fish and wildlife resources and habitats were recommended for incorporation into the project design. From a resource conservation perspective, the Service supported either of the two project breakwater design alternatives under consideration at that time.

In December 1998, the Service attended a scoping meeting on issues concerning the proposed project. The meeting participants also included representatives of the Corps, the CWB, the Harbors Division of the Hawaii Department of Transportation, and two project environmental consulting companies. The meeting focused primarily on a potential modification of the original design for the repaired breakwater, avoidance of the coral reef shelf immediately seaward and north of the existing breakwater, and proposed project mitigation measures. Based on this meeting, a site visit was scheduled to assess the potential impacts anticipated to result from the modified breakwater design.

In January 1999, the Service participated in the site visit with representatives of the NMFS and two project environmental consulting companies. Observations indicated that the status of the coral reef habitat at the proposed project site had changed very little since the 1994 FWCA investigation. The major change was that many of the small, newly recruited coral colonies seen on the breakwater stones in 1994 had grown in size. Based on the site visit, it was determined that additional FWCA resource surveys and a revised draft FWCA report for the proposed project would not be required.

DESCRIPTION OF THE PROJECT AREA

The proposed project area is the island of Lanai (20° 50' N and 156° 55' W) in the State of Hawaii (Figure 1). With approximately 84 kilometers (km) [52 miles (mi)] of shoreline encompassing approximately 361 square km (km^2) [139.5 square mi (mi^2)] of land, Lanai is the sixth largest island in the Hawaiian archipelago. The island was created by the eruptions of a single shield volcano. Lanai's highest point of land, Lanaihale, reaches an elevation of 914 m (3000 ft) roughly in the center of the island. Almost the entire island is privately owned by Castle & Cook, Incorporated. Until recently, the Dole Company, a subsidiary of Castle & Cook, used the island primarily for the production of pineapple (University of Hawaii, 1983).

Kaumalapau Harbor is located in Kaumalapau Bay on the arid, high-cliffed, volcanic southwestern coast of Lanai (Figure 1). Kaumalapau Harbor was completed in 1926 by the Hawaiian Pineapple Company (later the Dole Company) to provide small barge facilities for exporting locally grown pineapples and importing various goods from Oahu. The harbor has since become the principal seaport for the island. Aside from its commercial port facilities, the harbor contains numerous privately maintained mooring buoys. Although the harbor lacks a boat launching ramp, a derrick is present for lifting small craft up to 12 m (40 ft) in length out of the water and onto a concrete wharf for repairs. The nearest small boat launching ramp exists at Manele Bay, which is approximately eight nautical miles away (Balder, 1992).

Existing features at Kaumalapau Harbor include a west rubble-mound breakwater that is approximately 76 m (250 ft) long with an existing crest elevation of approximately 3 m (10 ft). A concrete wharf approximately 122 m (400 ft) in length lies along the harbor's north side adjacent to cargo sheds, the derrick, and other barge loading and unloading equipment. Gasoline, diesel fuel, and water are available at the wharf. Although there is no distinct harbor entrance channel, an opening approximately 182 m (600 ft) wide leads into a turning and mooring basin that is four hectares (ha) [10 acres (ac)] in size and from 9 m (30 ft) to 15 m (50 ft) in depth. Navigational markers are located on both sides of the harbor opening and on a shallow reef that extends along the eastern and southern sides of the harbor.

Although the average daytime high temperature at Kaumalapau Harbor is not available, this temperature calculated for Lanai City, which is approximately 10 km (6 mi) northwest of Kaumalapau at an elevation of 494 m (1620 ft), is 24° C (75° F). Rainfall on Lanai is relatively low due to the shielding effects of rain-producing tradewinds by the islands of Molokai and Maui. Average annual precipitation recorded in the vicinity of Kaumalapau is approximately 25 cm (10 in), although Lanaihale near the center of the island receives over 89 cm (35 in) of rainfall per year. The majority of the rainfall at Kaumalapau occurs between October and April, but intermittent rainfall may be expected in any month of the year, including the summer months, which are generally drier (University of Hawaii, 1983).

Northeast tradewinds with an average velocity of 10-20 knots (kts) [11-23 miles per hour (mph)] blow fairly consistently across Lanai from May through September. Average wind velocities at Kaumalapau on the leeward coast are approximately 8-10 kts (9-11 mph). Between October and April, winds may decrease in velocity and shift direction in response to the northerly winds that follow or the southwesterly winds that precede cold fronts and southerly winds of "Kona" storms. Thus, winter is the season of more frequent cloudiness and rain (University of Hawaii, 1983).

The predominant ocean current flow near Kaumalapau Harbor is generally toward the northwest. Under normal tradewind conditions, the speed of this current is typically less than 1 kt (1.2 mph) and is not strong enough to cause navigational problems. However, during Kona and southwesterly storms, large waves may close the harbor, and strong wave-generated currents may develop. Tidal currents at Kaumalapau Harbor are usually too weak to affect navigation and do not reverse during ebb and flow periods.

The Hawaii DAR has indicated that the dominant fishing activities occurring at Kaumalapau Bay include hook & line fishing from the harbor breakwater and wharf and spear fishing on the reefs inside and outside of the bay (S. Hau and B. Puleloa, Pers. Comm.). Targeted organisms include reef fishes, octopuses, lobsters, crabs, molluscs, and algae. Fishing effort at the harbor is currently unquantified. Also, Kaumalapau Bay is important to charter dive operators who use the harbor as a loading and unloading site and the surrounding reefs, especially the fringing coral-reef shelf outside the harbor, as a scuba dive site.

In November 1992, the U.S. Congress passed the Oceans Act of 1992 (P.L. 102-587), which established the Hawaiian Islands Humpback Whale National Marine Sanctuary. Waters extending seaward from Kaumalapau Harbor to the 100-fathom isobath are included within the sanctuary's boundaries.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The Service's primary concerns with the proposed project include potential impacts to endangered species and other fish and wildlife resources and their habitats from dredging and filling in the marine environment. Specific Service planning objectives are to maintain and enhance the existing significant habitat values at the proposed project site by (1) obtaining basic biological data for the proposed project site, (2) evaluating and analyzing the impacts of proposed-project alternatives on fish and wildlife resources and their habitats, (3) identifying the proposed-project alternative least damaging to fish and wildlife resources, and (4) recommending mitigation for unavoidable project-related habitat losses consistent with the FWCA and the Service's Mitigation Policy.

Under the authority of the ESA, the DOI and the DOC share responsibility for the conservation, protection and recovery of federally-listed endangered and threatened species. Authority to conduct consultations has been delegated by the Secretary of the Interior to the Director of the Service and by the Secretary of Commerce to the Assistant Administrator for Fisheries of the NOAA. Section 7(a)(2) of the ESA requires federal agencies, in consultation with and with the assistance of the Service or NMFS, to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitats. The Biological Opinion is the document that states the opinion of the Service or the NMFS as to whether the Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

The Service's Mitigation Policy (Service, 1981) outlines internal guidance for evaluating project impacts affecting fish and wildlife resources. The Mitigation Policy complements the Service's participation under the NEPA and the FWCA. The Service's Mitigation Policy was formulated with the intent of protecting and conserving the most important fish and wildlife resources while facilitating balanced development of this nation's natural resources. The policy focuses primarily on habitat values and identifies four resource categories and mitigation guidelines. The resource categories are the following:

a. Resource Category 1: Habitat to be impacted is of high value for the evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.

b. Resource Category 2: Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

c. Resource Category 3: Habitat to be impacted is of high to medium value for the evaluation species and is relatively abundant on a national basis.

d. Resource Category 4: Habitat to be impacted is of medium to low value for the evaluation species.

The coral reefs fronting Kaumalapau Harbor and within Kaumalapau Bay comprise the habitat of major concern. Although corals are very small and sensitive organisms, healthy coral colonies are fundamentally important in providing the basic foundation for habitat that supports diverse communities of other highly-specialized aquatic organisms. Corals contribute the bulk of the calcareous raw material that forms and maintains the basic structural framework of the reef. Coral colonies add significantly to the submarine topographic relief in which a large number of fish and invertebrate species find shelter and food. Coral polyps themselves are an important food source for some fishes and other marine life. The institutional significance of U.S. coral reefs has been established through their formal designation as Special Aquatic Sites [40 CFR Part 230 §230.44 / FR v.45 n.249] and as a Federal Trust Resource [Executive Order (E.O.) 13089 on Coral Reef Protection]. Such sites possess special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values and contribute to the general overall environmental health or vitality of an entire ecosystem of a region.

Coral reefs are relatively scarce on a national basis and are currently in a world-wide state of decline (Crosby *et al.* 1995; U.S. Coral Reef Task Force 2000). In the main Hawaiian Islands, coral reefs are subjected to relatively frequent adverse impacts, and the extent of healthy and productive coral reefs may be declining on a local basis. The Service considers coral reef habitats to be Resource Category 2 habitats. The Service's resource goal for Category 2 habitat is no net loss of in-kind habitat values. Under this designation, the Service will recommend ways to avoid or minimize the losses. If losses are unavoidable, mitigation measures to immediately rectify, reduce, or eliminate these losses over time will be recommended. As necessary, compensation by replacement of the in-kind habitat values may be incorporated as integral project features.

Corals and reef fishes have been selected as the evaluation species for the reef habitats that may be affected by the proposed project. Reef fishes were selected because of their potential importance as sources of food and recreation for humans. The harbor area supports subsistence and sport fisheries for reef fishes, lobsters, crabs, octopi, and algae. Hook and line fishing from the existing breakwater and spear fishing on the reef slope are commonly practiced. Also, reef fishes are among the marine resources most important to resident and visiting recreational skin and SCUBA divers.

EVALUATION METHODOLOGY

In 1994, the Service conducted a reconnaissance survey at Kaumalapau Bay to evaluate potential impacts on fish and wildlife resources based on the proposed project design criteria in effect at the time. A brief reconnaissance of the terrestrial flora and fauna around the harbor was also conducted. Observations on the distribution and relative abundances of marine fishes, corals,

other macroinvertebrates, and algae were compiled during random swims over substrates both inside and outside of the bay.

Within the bay, marine surveys were conducted adjacent to the harbor side of the existing breakwater and commercial dock, adjacent to the shore of the bay between the commercial dock and the point at the south end of the bay, and over the turning basin and middle portion of the bay. Outside the bay, marine surveys were conducted adjacent to the seaward side of the existing breakwater, over the fringing reef shelf west of the breakwater, and on the submarine terrace between the shelf and the harbor opening to a maximum depth of 25 m (82 ft). Substrate coverage data collected every 0.6 m (2 ft) along 46-m (150-ft) transects were used to assess the potential value of the existing reef habitat.

A brief site visit was made in 1999 to assess whether a potential modified breakwater design (*i.e.*, dogleg extension off the existing breakwater) would result in greater potential coral reef impacts than those anticipated to result from the original two alternative designs. Potential mitigation measures for the proposed project were also discussed. The complete results of these surveys are contained in this final report.

DESCRIPTION OF FISH AND WILDLIFE RESOURCES

Existing Conditions:

Terrestrial:

The arid, terrestrial portion of the proposed project site has been altered by construction of the existing breakwater and ancillary harbor buildings, parking lot, and wharf. There are no wetlands or sensitive upland habitats located within the harbor area.

A type of mesquite known locally as kiawe (*Prosopis pallida*) and bristly foxtail (*Setaria verticillata*) are among the dominant terrestrial plants present at the harbor site. Pili grass (*Heteropogon contortus*), swollen fingergrass (*Chloris barbata*), false mallow (*Malvastrum coromandelianum*), hairy merremia (*Merremia aegyptia*), and partridge pea (*Chamaecrista nictitans*) are also likely to be present (Corps, 1993). All of these species except *H. contortus*, which is considered indigenous, are exotic introductions to Hawaii that have become naturalized (Wagner *et al.*, 1990).

Terrestrial animals at the site are limited to introduced species, including Axis deer (*Cervus axis*), gray francolin (*Francolinus pondicerianus*), and ring neck pheasant (*Phasianus colchicus*), which were originally introduced as game species. House sparrows (*Passer domesticus*), northern cardinals (*Cardinalis cardinalis*), red-crested cardinals (*Paroaria coronata*), barred doves (*Geopilia striata*), spotted doves (*Streptopelia chinensis*), common myna birds (*Acridothetres tristis*), and seabirds are reported to be present within the vicinity of the site (Corps, 1993). The domestic cat (*Felis catus*) and dog (*Canis familiaris*), house mouse (*Mus musculus domesticus*), roof or black rat (*Rattus rattus*), brown rat (*R. norvegicus*), Polynesian rat (*R. exulans hawaiiensis*), and Indian mongoose (*Herpestes auropunctatus*) occur at the site. Introduced skinks (Scincidae) and gekkos (Gekkonidae) are also present.

Marine:

A fringing, coral-reef shelf extends approximately 200 m westward from the point at which the existing breakwater at Kaumalapau Harbor is connected to shore (Figure 2). The end of this shelf descends to approximately 35 m (115 ft) where it meets a submarine terrace that extends seaward from the existing breakwater and across the mouth of Kaumalapau Bay. The top of the shelf is relatively shallow with high spots that are exposed at low tide. The southwest side of the shelf is a nearly vertical wall that contains ledges and small caves to an approximate depth of 24 m (80 ft). A narrow zone of calcareous rubble lies adjacent to the base of the wall on the southern side of the shelf.

Over the top central portion of the shelf, coral coverage is approximately 90%. Between the central portion and southwest edge of the shelf above the wall, coral coverage is 100%. *Pocillopora meandrina* is the dominant coral species on the shelf, followed by *Porites lobata*. Black coral (*Cirrhipathes anguina*) was recorded on the wall near its western end below 21 m (70 ft). A school of approximately 75 spotted unicornfishes (*Naso brevirostris*) was seen swimming northward past the end of the shelf between depths of 6 and 8 m (20 and 26 ft). An aggregation of approximately 100 pyramid butterflyfishes (*Hemitaurichthys polylepis*) was seen feeding on plankton off the end of the shelf between depths of 8 and 12 m (25 and 40 ft).

In the area adjacent to the southwest side of the shelf and the landward third of the breakwater, the submarine terrace is covered with patches of coral (47%), basalt boulders (25%), calcareous rubble (15%), reef pavement (10%), and unconsolidated calcareous sand (3%). *P. meandrina* is the most abundant coral occurring on the terrace within this area. As the terrace deepens toward the seaward end of the breakwater, the coral *P. lobata* appears to be more abundant. The corals *Montipora verrucosa* and *Pocillopora eudouxi* are common on the terrace, and the coral *Montipora flabellata* is present but relatively rare. Near the mouth of the bay, the terrace becomes progressively covered by greater amounts of unconsolidated, calcareous sand and eventually grades into a sand flat fronting the harbor entrance.

The fish community between the shelf and the seaward end of the breakwater is fairly diverse, with 56 species in 26 families having been observed during the survey. Common food-fishes eaten by humans include 16 (29%) of these species. Overall fish abundance, however, appears to be relatively low, and fish species are generally represented by individuals belonging to small size classes. The absence of larger individuals of common food-fish species is notable. The most abundant fishes observed include round herrings (*Sprateloides delicatulus*), halfbeaks (*Hyporhamphus acutus pacificus*), jacks (*Caranx melampygus*), fusiliers (*Caesio caerulaurea*), goatfishes (*Mulloides vanicolensis*), damselfishes (*Chromis agilis* and *C. vanderbilti*), surgeonfishes (*Acanthurus guttatus, A. triostegus, Ctenochaetus strigosus,* and *Zebrasoma flavescens*), and Moorish idols (*Zanclus cornutus*).

A large number of basalt boulders lie near the base of the existing breakwater, apparently having tumbled down during periods of severe storm-wave assault. In addition, numerous pieces of concrete (*eg.*, dolosse, pilings, and conduit), scrap metal, and other debris are scattered among and on top of these boulders, especially over the submerged, low rubble mound adjacent to the seaward half of the breakwater. Off the seaward end of the breakwater, this material is present to a depth of at least 27 m (90 ft). Along the western side of the breakwater, corals have colonized the boulders and concrete material between depths of 6 and 12 m (20 and 40 ft). This coral zone widens to a depth of approximately 20 m (65 ft) near the seaward end of the breakwater. Coral coverage within this zone is approximately 80%, with *P. lobata* and *M. verrucosa* being the most abundant species.

Other conspicuous macroinvertebrates present on the western side of the breakwater include cowrie snails (*Cypraea caputserpentis*), cone snails (*Conus flavidus*), slate-pencil sea urchins (*Heterocentrotus mammillatus*), boring sea urchins (*Echinometra mathaei*), and sea cucumbers (*Holothuria atra*). In shallower water, helmet sea urchins (*Colobocentrotus atratus*) are present on the breakwater just below the intertidal zone. Rock crabs (*Grapsus grapsus tenuicrustatus*), moon snails (*Polinices melanostomus*), and nerites (*Nerita picea*) are common within the intertidal and splash zones on the breakwater.

Within the harbor, a very large rubble mound of basalt boulders, concrete material, and other debris lies adjacent to the eastern side of the breakwater. Along the seaward half of the breakwater, this mound extends approximately 46 m (140 ft) into the harbor turning basin and is relatively level within the first 30 m (100 ft) before descending to the basin floor. Corals have colonized this material within a zone that is approximately 15 m (50 ft) wide between depths of 5 m (15 ft) and 11 m (35 ft). *P. meandrina* and *P. lobata* are the dominant corals present within this zone. Beyond the submerged rubble mound, the turning basin floor is covered by a layer of unconsolidated, calcareous sand and terrigenous silt, in which a wide variety of metal, plastic, and rubber debris items are embedded.

Adjacent to the landward half of the breakwater, the boulder/debris mound inside the harbor is less extensive. Scattered, small colonies of *P. lobata* are present on the basalt boulders and cement pilings comprising the mound. Within the portion of the harbor immediately bounded by the breakwater and the wharf, coral cover is greatest in the corner where the breakwater meets the wharf. Along an oblique line extending approximately 46 m (150 ft) into the turning basin from this corner, the harbor floor is covered with corals (24%), basalt boulders (25%), and sand/silt (51%). *P. lobata* is the dominant coral on the lower portion of the wharf face and on natural rock outcrops near the wharf on the turning basin floor. *P. meandrina*, *M. verrucosa*, and *Porites compressa* are also present, especially on the wharf face. Away from the breakwater and wharf the relatively flat harbor basin substrate is widely covered by deposits of sand and silt.

The dominant feature in the eastern portion of the bay is Kaumalapau Gulch. Between the wharf and the gulch, the substrate immediately seaward of the shoreline changes from predominantly sand/silt near the wharf to basalt with outcrops colonized by corals. Immediately north of the gulch, a shallow basalt ridge extends across the basalt substrate and into the sand/silt area toward the center of the bay. The predominant coral species present on the ridge include *P. compressa*, *P. lobata*, *P. meandrina*, and *M. verrucosa*. The top of the ridge is 90-100% covered by corals, although overall coral coverage on the ridge is approximately 50%. A field of basalt rocks lines the shore immediately in front of the gulch. Directly offshore, many larger basalt boulders are spread over the substrate. Seaward of these boulders, scattered, low-relief outcrops colonized by corals are present. *P. compressa* and *P. lobata* are dominant on the boulders and the outcrops. Seaward of these outcrops, the substrate within the center of the bay is predominantly covered by sand and silt.

South of the gulch and the submerged tract of larger boulders, 90-100% of the hard basalt substrate between the shoreline and the sand/silt bay floor is covered by corals. Reef outcrops in this area are more abundant and of higher relief than they are north of the gulch. Between the gulch and the southern point of the bay near the harbor entrance, several basalt ridges, which are separated by sand/silt-covered channels, extend from shore toward the center of the bay. The tops of these ridges are 100% covered by corals, however, overall coral coverage on the ridges is approximately 50%. *P. meandrina* is the dominant coral on the ridges, which slope downward and grade into lower relief coral beds as they approach the sand/silt substrate in the center of the bay. *P. lobata*, *P. compressa*, *and M. verrucosa* are also present, with *P. compressa* being more

abundant toward the south point of the bay. Immediately inside of the south point, the reef is a nearly vertical wall along the shoreline. Basalt boulders lie scattered on the substrate near the base of the wall. Coral coverage is 90-100% on the wall, boulders, and basalt substrate between the shoreline and the sand/silt harbor floor.

The fish community within Kaumalapau Bay is less diverse than it is outside of the bay. A total of 40 species representing 15 families were observed inside the bay during the survey. Despite the excellent, high-relief coral habitat present within the shoreward portions of much of the bay, reef fishes are not very abundant. Common food-fishes eaten by humans include nine (23%) of these species. As is the case outside of the bay, the absence of larger individuals of common food-fish species is notable. The most abundant fishes observed in the bay include round herrings (*S. delicatulus*) in the corner of the harbor where the breakwater meets the wharf, goatfishes (*M. vanicolensis*) over the sand/silt harbor substrate, and damselfishes (*C. agilis* and *C. vanderbilti*) and surgeonfishes (*C. strigosus* and *Z. flavescens*) over the coral reef areas.

Excluding corals, conspicuous macroinvertebrates present within the bay include collector sea urchins (*Pseudoboletia indiana*), slate-pencil sea urchins (*H. mammillatus*), and cowrie snails (*C. caputserpentis*) within coral reef areas; and rock crabs (*Grapsus grapsus tenuicrustatus*), moon snails (*P. melanostomus*), and nerites (*Nerita picea*) within intertidal and splash zones on the breakwater and along rocky shorelines. Spiny lobsters (*Panulirus pennicilatus*) are also present in reef areas in the south and southwestern parts of the bay.

Lists of the marine organisms observed during the 1994 surveys are presented in Tables 1-4. A total of 68 species of marine fishes (Table 1), nine species of reef corals (Table 2), 25 species of marine molluscs (Table 3), and 13 species of other macroinvertebrates, including nine species of echinoderms, (Table 4) were recorded. The only algae observed during the surveys was an unidentified filamentous turf, primarily on the shelf west of the breakwater. Although federally threatened Green sea turtles (*Chelonia mydas*) and endangered Hawksbill sea turtles (*Eretmochelys imbricata*) are known to exist in the waters surrounding the harbor, no turtle nesting habitat occurs within Kaumalapau Bay. Furthermore, preferred types of resting habitat and food resources for these species were not observed during the survey.

Future Without the Project:

Kaumalapau Harbor is important to the public welfare in Lanai because it serves as the only commercial harbor and the receiving site for most of the consumer goods, food, and mail that come into the island. A majority of the items leaving Lanai also go through the harbor. Due to its location, however, the existing breakwater and wharf at Kaumalapau Harbor are susceptible to being damaged by storm-generated waves. As a result of periodic damage, loading and unloading operations at the harbor have been adversely affected. Without repairs to the breakwater, rough sea conditions in the harbor are expected to continue. Accordingly, additional damage to the wharf and vessels in the harbor and delays in ship operations are anticipated. These rough sea conditions also increase the risk of catastrophic releases of petroleum products and other chemicals from vessels and vessel groundings.

Without the project, emergency strengthening of the breakwater after major storm events will continue to be necessary. It is likely that such temporary repair measures will continue to involve the piling of boulders, concrete, and debris items on the damaged areas of the breakwater. It is obvious that development of the coral-reef community surrounding the existing breakwater has been hampered by the recurring storm-related breakup and distribution of these items. Although

the degree of this impact cannot be quantified by available data, it is anticipated that future storm events will continue to redistribute these unstable items and adversely affect the development of the existing coral-reef community.

DESCRIPTION OF ALTERNATIVES EVALUATED

Only two alternatives were under consideration at the time of the draft FWCA report (Service 1995). In 2000, the Corps released revised and expanded information on alternatives for the proposed project. This revision was based on model test analyses and additional field investigations. Six alternative actions are currently being considered by the Corps (Corps 2000). One of the proposed actions is a No Action Alternative that would leave the existing harbor as it is with no action taken to install any of the proposed federal improvements. The other five alternatives would result in the construction of a new breakwater to replace the old deteriorated structure. Details of the five alternative breakwater designs under consideration are summarized below.

Alternative 1:

This alternative includes construction of a new 200-foot rubble mound breakwater, extending to the northwest from the southern corner of the harbor entrance. Numerical model tests showed that the southern breakwater had little effect on wave conditions at the pier.

Alternative 2:

This alternative includes installation of new wave absorbers along the southern and northeastern portions of the harbor shoreline. Model analysis showed that wave heights were reduced in localized areas immediately adjacent to the wave absorbers but resulted in no more than a 10% average wave height reduction at the wharf where the reduction is most needed.

Alternative 3:

This alternative includes rebuilding the existing breakwater and adding a 200-foot straight extension to the end of the existing breakwater. Test results showed 29-55% wave height reductions for northwest swells but 61-113% wave height changes for southwest swells.

Alternative 4:

This alternative includes the same design as in Alternative 3 with the addition of wave absorbers along the northeastern portion of the harbor shoreline. Analysis showed that this design resulted in an average additional wave height reduction at the wharf of less than 10%.

Alternative 5:

This alternative includes addition of a dog-leg extension to the existing breakwater. The first 350 feet of the existing breakwater would be rebuilt along its current alignment and the next 50 feet would be angled 30 degrees toward the inside of the harbor. Model tests showed wave height reductions of 26-57% for northwest swells and reductions of 60-98% for southwest swells.

After further evaluation, it was determined that Alternative 5 provided significant improvements over the existing conditions and demonstrated better results than Alternative 3. In the Corps' 1996 Special Design Report, Alternative 5 was the Recommended Plan of Improvement. Subsequent study has led to the recommendation that the dog-leg be eliminated and that the proposed breakwater alignment be repositioned shoreward to center it above the existing rubble mound. This final design for the Recommended Plan of Improvement would result in a new breakwater with a total length of 320 feet and a crest elevation of +14.5 feet above mean low low water (Figures 3 and 4).

PROJECT IMPACTS

Terrestrial Resources:

Construction activities associated with the proposed project are not expected to adversely impact terrestrial biological resources at the harbor. Stone for the breakwater's underlayer would come from existing quarries on Lanai, Oahu, or Maui, and the core-loc concrete armor units would be cast on Lanai or Oahu and barged to Lanai. A small concrete batch plant would be located in a currently disturbed area near the project site for construction of the cast-in-place concrete rib cap. An approximate two-acre contractor work and storage area would be located approximately 2,000 feet inland of the harbor, at the site of an old stone quarry operation. Any upland disposal of debris removed from the existing harbor bottom would be at an approved landfill site.

Marine Resources:

Excluding the No Action Alternative, all other actions currently under consideration would each result in direct and secondary adverse impacts to marine fish and wildlife resources. Alternative 1 is anticipated to result in the direct and permanent elimination of approximately 1.1 acre of undisturbed, marine benthic habitat from filling for the new breakwater. This structure would cover natural wall, boulder, and basalt substrate near shore that is 90-100% covered with corals. The seaward end of the breakwater would partially extend across the existing harbor entrance floor where the existing infauna residing in substrate sediments would be lost.

Alternative 2 is anticipated to result in the loss of an unestimated amount of undisturbed, reef substrate adjacent to the northeastern and southern shorelines of the bay from filling for the wave absorbers. Coral cover on the substrate in these areas is 50-100%, with coral cover as high as 100% on reef outcrops and ridge tops.

Alternative 3 is anticipated to result in the loss of approximately 2.5 acres of disturbed, benthic habitat comprised mostly of basalt boulders, concrete dolosse units, and other debris on the existing rubble mound at the site. The substantial amount of corals that have become established on these features would be lost. The seaward end of the breakwater would bury an estimated 0.3 acre of the harbor entrance floor where the existing infauna residing in substrate sediments would be lost.

Alternative 4 is anticipated to result in the same losses of marine benthic habitat and corals and soft-bottom infauna as alternatives 2 and 3 combined.

Alternative 5 (Recommended Plan) is anticipated to result in the loss of approximately 1.75 acres of disturbed, benthic habitat, comprised primarily of the basalt boulders, concrete dolosse units, and other debris on the existing rubble mound. The seaward end of the breakwater would bury an estimated 0.3 acre of the harbor entrance floor where the existing infauna residing in substrate sediments would be lost.

All alternatives would secondarily impact nearby corals and other filter-feeding organisms and algae by temporarily degrading nearshore water quality as a result of increased levels of suspended sediments and turbidity generated by project-related debris movement, boulder redistribution, and core-loc unit placement. Secondary impacts may include smothering of reef corals and other filter-feeders from excessive sediment deposition, abrasion of coral polyps by current-driven suspended sediments, and reduced primary productivity of benthic algae, zooxanthellae, and phytoplankton from decreased light levels.

The coral reefs that are present outside the harbor and along the eastern through southwestern shoreline within the bay are the habitats of major concern for the proposed project, and the degraded, marine benthic habitats within the harbor basin are considered to be important but of lesser value. During construction, it will be important to minimize adverse project-related impacts to these coral reefs. After construction, the new breakwater extension is not expected to cause the deflection of longshore currents or the creation of eddies, which could disperse suspended sediments over areas of productive reef and spread adverse impacts to a greater amount of corals and other sediment-sensitive marine organisms.

Project-related boulder and debris redistribution at the harbor may attract fish to the site to feed on benthic organisms exposed by these actions. However, high turbidity caused by these actions may limit or preclude this from happening. The harvest of marine resources from the site would have to be restricted for safety reasons during any implemented construction period, but overall fishing effort is expected to return to existing levels following project completion. After construction, fisheries may be locally enhanced near the concrete core-loc units, which would provide new habitat for some algae, benthic invertebrates, and reef fishes. Based on this and other studies at the proposed project site, it is expected that coral recruitment to the new breakwater surfaces will be relatively high and that new coral colonies will ultimately establish and grow on the new structure at densities similar to current levels. The repaired breakwater, however, is not expected to duplicate the physical heterogeneity, interstitial complexity, and vertical relief of the existing coral-reef habitat within the bay or on the terrace and shelf outside of the bay.

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The Service shares jurisdiction with the NMFS over federally listed threatened green sea turtles and endangered hawksbill sea turtles. The Service has sole jurisdiction over these species when they are on shore, and the NMFS has sole jurisdiction over the species when they are in the water. Although these sea turtles do not nest at Kaumalapau Bay, they are known to occur in waters surrounding the site. The Service is concerned that measures to protect these species be included within the scope of the proposed project. Therefore, the Service recommends that any NMFS recommendations for the protection and conservation of sea turtles at Kaumalapau be made part of the project.

The natural, fringing coral-reef shelf projecting seaward of the base of the existing breakwater should be protected as much as possible from project-related impacts. No construction-related materials should be placed on this reef. Coral colonies currently living on this reef should also be protected from runoff contaminated by project-related activities.

Coral colonies currently living on the boulders, concrete, and debris on the existing rubble mound would be lost by breakwater construction. Transplantation of these existing corals out of the footprint of the proposed breakwater is not feasible. However, relocation of some of the coral-covered debris from the rubble mound prior to filling is possible, especially since removal of this debris would be required for stable placement of new construction materials. The harbor basin is deep enough to accept these items without causing navigation problems, and coral growth on these items should be promoted by the protection afforded by the new breakwater and the overall relatively light use of the harbor by vessels.

Finally, the Service recommends that the following measures to minimize the degradation of coastal water quality and impacts to fish and wildlife resources and habitats be incorporated into the project:

a. No construction materials (other than basalt boulders currently displaced from the existing breakwater) should be stockpiled in the marine environment;

b. Underlayer fills for the repaired breakwater should be protected from erosion with core-loc units as soon after placement as practicable;

c. All construction-related materials should be placed on upland and properly contained to avoid or minimize disturbance to the natural reef;

d. All construction-related materials should be free of pollutants;

e. No contamination (trash or debris disposal etc) of the marine environment should result from construction activities;

f. A contingency plan to control accidental spills of petroleum products at the construction site should be developed. Absorbent pads and containment booms should be stored on-site to facilitate the clean-up of petroleum spills;

g. Turbidity and siltation from boulder/debris removal/redistribution and placement of fills should be minimized and confined to the immediate vicinity of the activity through the use of effective silt containment devices and the curtailment of these activities during adverse sea conditions;

h. No debris extracted from harbor sediments should be stockpiled in the marine environment; and

i. All debris removed from the harbor should be disposed of at an approved upland disposal site.

SUMMARY AND FISH AND WILDLIFE SERVICE POSITION

The coral colonies within Kaumalapau Bay and on the natural, fringing coral-reef shelf projecting seaward of the base of the existing breakwater have been identified as the habitats of major concern for the proposed project because of their value to reef-fish resources. Coral-reef habitats are relatively scarce on a national basis, and because they are currently subjected to relatively frequent adverse impacts in the main Hawaiian Islands, the extent of healthy and productive coral reefs on a local basis may be declining. Coral reefs have been designated as Special Aquatic Sites [40 CFR Part 230 §230.44 / FR v.45 n.249] and given special status as a Federal Trust Resource [E.O. 13089]. Such sites possess special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values and contribute to the general overall environmental health or vitality of an entire ecosystem of a region. The Service has recommended that limited relocation of coral-covered debris from the footprint of the proposed breakwater be conducted to the extent practicable. The disturbed marine benthic habitat within the harbor basin is considered to be important but of lesser value, and anticipated project-related losses of this habitat are minimal.

Although federally listed, threatened and endangered sea turtles are known to exist in waters surrounding Lanai, the Service does not expect losses of sea turtle nesting habitat to occur as a result of the proposed project. The maintenance of good water quality within the harbor is of great importance since cumulative adverse impacts to water quality could lead to the degradation of coral-reef biota and habitats at Kaumalapau Bay. Implementation of measures to control sedimentation from boulder/debris removal/redistribution and from stone and core-loc unit placement would minimize water quality degradation and subsequent adverse effects on coral-reef habitats. The Service has recommended that several conservation measures to minimize the degradation of coastal water quality and impacts to fish and wildlife resources and habitats be incorporated into the project design.

The Service believes that the proposed project cannot be avoided because of the need for the island of Lanai to have an adequately protected commercial harbor upon which all of the island's residents and visitors depend either directly or indirectly. Implementation of the proposed project at an alternative site is not possible since the project is meant to solve a specific problem at Kaumalapau Harbor. From a resource conservation perspective, the selection of Alternative 5 (*i.e.*, the final design for the Recommended Plan of Improvement) would result in the least amount of anticipated adverse impacts to fish and wildlife. The Service supports implementation of this plan provided the recommendations included in this report are incorporated into and made part of the project.

REFERENCES CITED

Balder, A. 1992. *Marine Atlas of the Hawaiian Islands*. University of Hawaii Press Honolulu. 120 pp.

Coleman, N. 1991. *Encyclopedia of Marine Animals*. Harper Collins Publishers, New York. 324 pp.

Crosby, M., S. Drake, C. Eakin, N. Fanning, A. Patterson, P. Taylor, and J. Wilson. 1995. *The United States Coral Reef Initiative: an overview of the first steps*. Coral Reefs (1995) 14: 1-3.

University of Hawaii. 1983. *Atlas of Hawaii (2nd ed.)*. University of Hawaii Press, Honolulu. 238 pp.

U.S. Army Corps of Engineers. 2000. *Draft Environmental Assessment for Kaumalapau Harbor Breakwater Repair, Island of Lanai, Hawaii*. Pacific Ocean Division, Fort Shafter, Hawaii. 36 pp + Appendices.

U.S. Army Corps of Engineers. 1993. *Kaumalapau Harbor Navigation Improvements, Island of Lanai, Hawaii: Reconnaissance Report*. Pacific Ocean Division, Fort Shafter, Hawaii. 29 pp + Appendices.

U.S. Coral Reef Task Force. 2000. *The National Action Plan to Conserve Coral Reefs*. U.S. Coral Reef Task Force, Washington DC. 34 pp + Appendices.

U.S. Fish and Wildlife Service. 1981. *U.S. Fish and Wildlife Service Mitigation Policy*. Federal Register (46) 15: 7644-7663.

U.S. Fish and Wildlife Service. 1995. *Draft Fish and Wildlife Coordination Act Report, Kaumalapau Harbor Navigation Improvements, Lanai, Hawaii*. U.S. Fish and Wildlife Service, Pacific Islands Ecoregion, Honolulu, Hawaii. 33 pp.

Wagner, W., D. Herbst, and S. Sohmer. 1990. *Manual of the Flowering Plants of Hawaii*. University of Hawaii Press and Bishop Museum Press, Honolulu. 1853 pp.

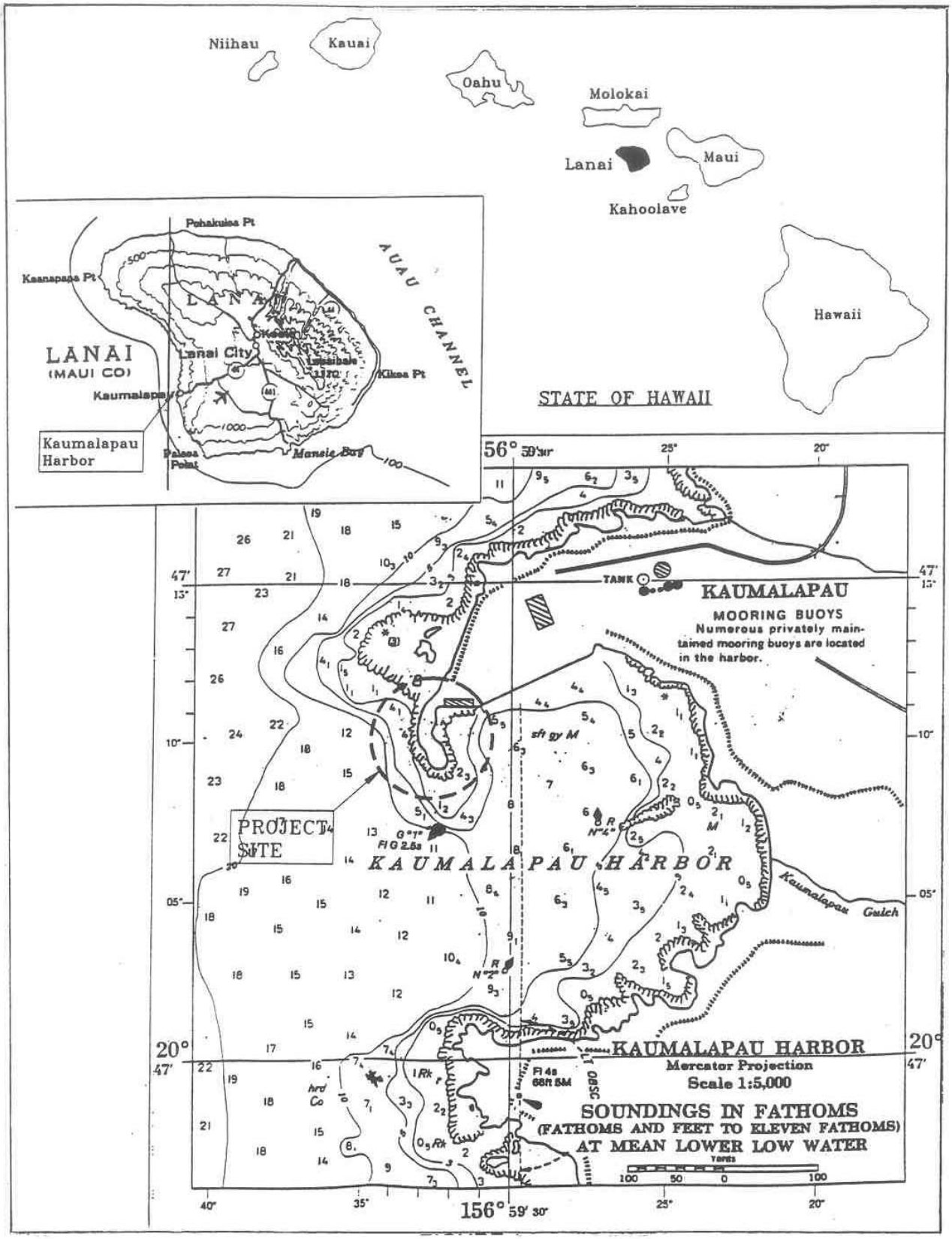


Figure 1. The proposed project site at Kaumalapau Harbor on the island of Lanai, Hawaii (Source: Corps 2000)

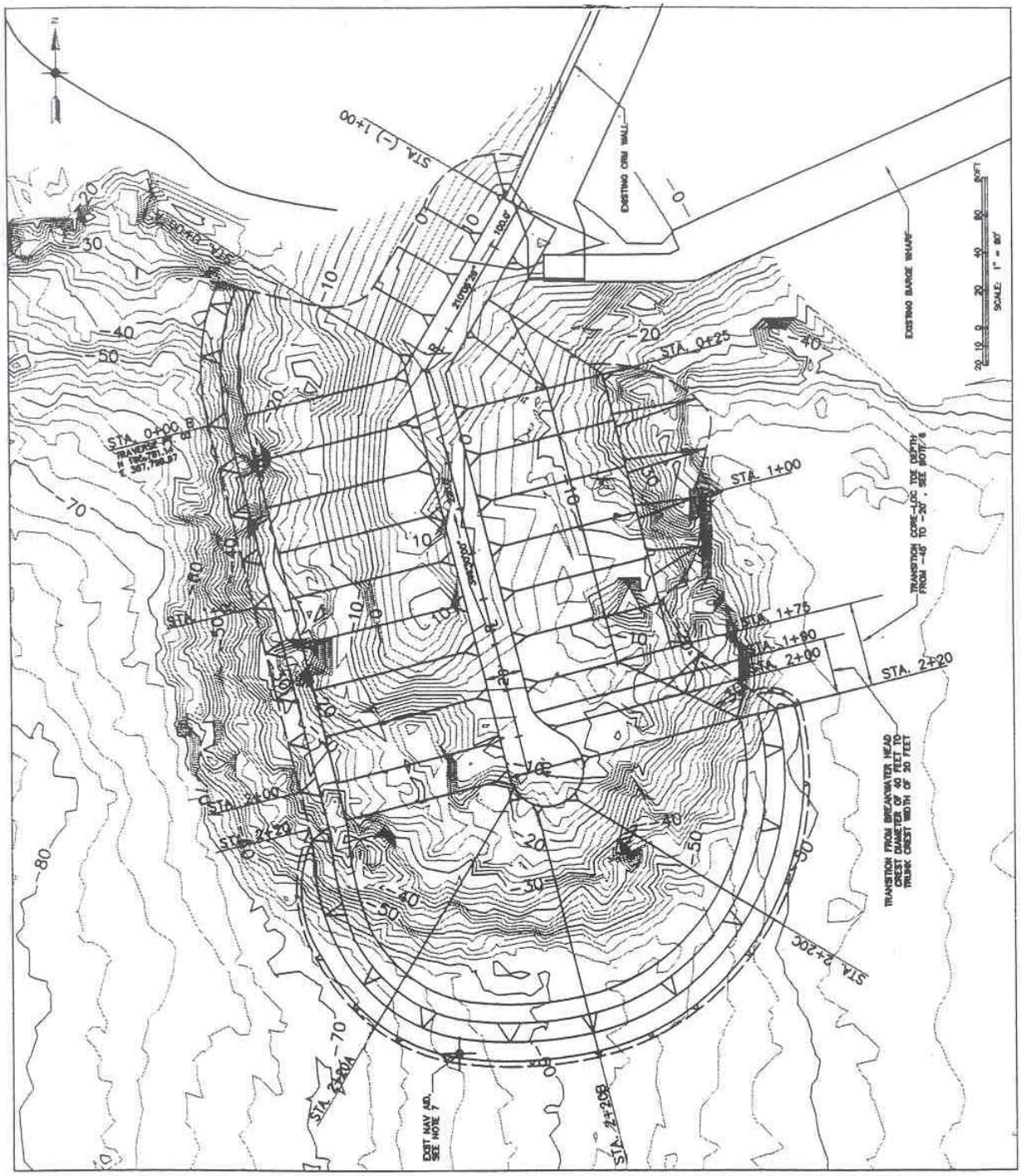


Figure 2. Recommended Plan of Improvement (final Alternative 5) for breakwater repair at Kaumalapau Harbor, Lanai, Hawaii (Source: Corps 2000)

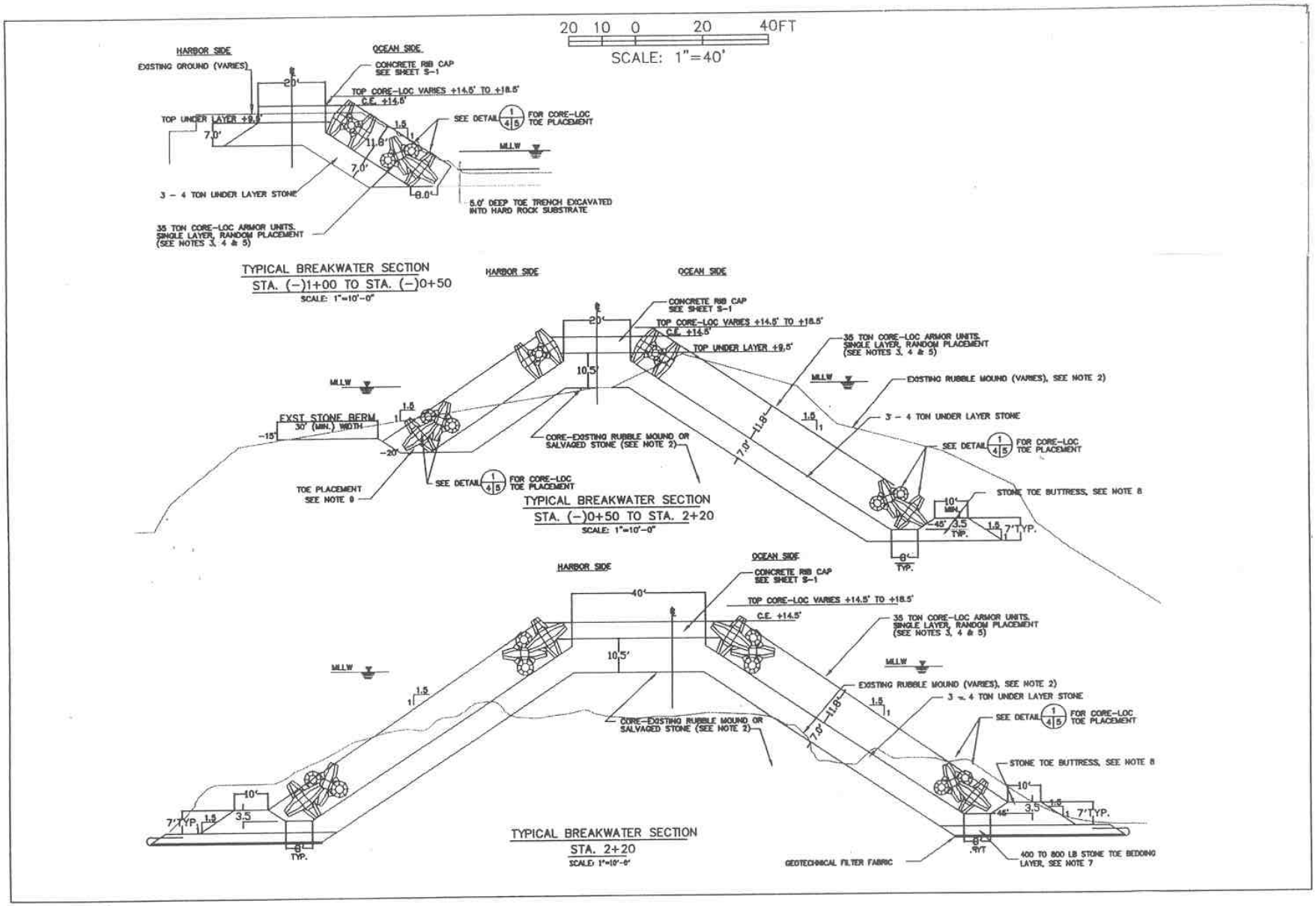


Figure 3. Typical breakwater cross sections for the Recommended Plan of Improvement at Kaumalapau Harbor, Lanai, Hawaii (Source: Corps 2000)

Table 1. Coral-reef fishes observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994.

FAMILY *Species*
MURAENIDAE (Moray Eels)
Gymnothorax meleagris
CLUPEIDAE (Herrings, Sardines)
Spratelloides delicatulus
SYNODONTIDAE (Lizardfishes)
Synodus variegatus
HEMIRAMPHIDAE (Halfbeaks)
Hyporhamphus acutus pacificus
AULOSTOMIDAE (Trumpetfishes)
Aulostomus chinensis
CARANGIDAE (Jacks, Trevallies)
Caranx melampygus
LUTJANIDAE (Snappers)
Aphareus furca
Lutjanus fulvus
L. kasmira
Monotaxis grandoculis
CAESIONIDAE (Fusiliers)
Caesio caerulaurea
MULLIDAE (Goatfishes)
Mulloides vanicolensis
Parupenus bifasciatus
P. multifasciatus
KYPHOSIDAE (Rudderfishes)
Kyphosus bigibbus

Table 1. (Continued)

FAMILY *Species*
CHAETODONTIDAE (Butterflyfishes)
Chaetodon auriga
C. fremblii
C. kleinii
C. lunula
C. miliaris
C. multicinctus
C. ornatissimus
C. quadrimaculatus
C. reticulatus
C. trifasciatus
C. unimaculatus
Forcipiger favissimus
F. longirostris
POMACANTHIDAE (Angelfishes)
Centropyge loriculus
POMACENTRIDAE (Damselfishes)
Chromis agilis
C. margaritifer
C. vanderbilti
P. johnstonianus
Pomacentrus vaiuli
Stegastes fasciolatus
CIRRHITIDAE (Hawkfishes)
Paracirrhites arcatus
LABRIDAE (Wrasses)
Bodianus bilunulatus
Coris gaimard
Gomphosus varius
Halichoeres marginatus
Pseudojuloides cerasinus
Thalassoma duperrey
SCARIDAE (Parrotfishes)
Scarus dubius
S. psittacus
S. sordidus

Table 1. (Continued)

FAMILY *Species*
BLENNIIDAE (Blennies)
Plagiotremus ewaensis
ACANTHURIDAE (Surgeonfishes)
Acanthurus achilles
A. blochii
A. guttatus
A. nigrofuscus
A. olivaceus
A. triostegus
Ctenochaetus hawaiiensis
C. strigosus
Hemitaurichthys polylepis
Naso brevirostris
N. lituratus
N. unicornis
Zebrasoma flavescens
ZANCLIDAE (Moorish Idols)
Zanclus cornutus
BALISTIDAE (Triggerfishes)
Rhinecanthus rectangulus
Sufflamen bursa
MONACANTHIDAE (Filefishes)
Cantherhines sandwichiensis
Melichthys niger
OSTRACIONTIDAE (Boxfishes)
Ostracion meleagris
TETRAODONTIDAE (Smooth Puffers)
Arothron meleagris
Canthigaster amboinensis
C. jactator

TOTAL NUMBER OF SPECIES OBSERVED: 59

Table 2. Reef corals observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994.

FAMILY *Species*
ANTIPATHIDAE
Cirrhipathes anguina
PORITIDAE
Porites compressa
P. lobata
P. rus
POCILLOPORIDAE
Pocillopora damicornis
P. eudouxi
P. meandrina
ACROPORIDAE
Montipora flabellata
M. verrucosa

TOTAL NUMBER OF SPECIES OBSERVED: 9

Table 3. Marine molluscs observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994.

FAMILY *Species*
PATELLIDAE (Limpets)
Cellana sandwicensis
TROCHIDAE (Top shells)
Trochus intextus
TURBINIDAE (Turbans)
Turbo sandwicensis
NERITIDAE (Nerites)
Nerita picea
VERMETIDAE (Vermetids)
Dendropoma gregaria
Vermetus alii
PLANAXIDAE (Cluster winks)
Planaxis labiosa
HIPPONICIDAE (Hipponicids)
Hipponix imbrcatus
CYPRAEIDAE (Cowries)
Cypraea caputserpentis
C. isabella
C. maculifera
C. moneta
NATICIDAE (Moon snails)
Polinices melanostomus
CYMATIIDAE (Trumpets)
Cymatium intermedius
THAIDIDAE (Thaidids)
Drupa ricina
Morula granulata
MITRIDAE (Miters)
Mitra fastigium
COSTELLARIIDAE (Costellarids)
Vexillum lautum

Table 3. (Continued)

FAMILY *Species*
CONIDAE (Cones)
Conus flavidus
C. lividus
C. pennaceus
PTERIIDAE (Pearl Oysters)
Pinctada margaritifera
ISOGNOMONIDAE (Toothed Pearl Shells)
Isognomon incisum
OSTREIDAE (True Oysters)
Ostrea sandvicensis
TELLINIDAE (Tellens)
Macoma dispar

TOTAL NUMBER OF SPECIES OBSERVED: 25

Table 4. Marine coelenterates, crustaceans, and echinoderms observed at Kaumalapau Harbor, Lanai, Hawaii, during October 24-25, 1994.

PHYLUM
FAMILY
Species

COELENTERATA

CARYBDEIDAE (Cuboid Medusae)
Carybdea alata

ZOANTHIDAE (Zoanthids)
Zoanthus pacificus

CRUSTACEA

PALINURIDAE (Spiny Lobsters)
Panulirus pennicilatus

GRAPSIDAE (Rock Crabs)
Grapsus grapsus tenuicrustatus

ECHINODERMATA

OPHIDIASTERIDAE (Sea Stars)
Linckia multifora

DIADEMATIDAE (Sea Urchins)
Diadema paucispinum
Echinothrix calamaris
E. diadema

TOXOPNEUSTIDAE (Collector Urchins)
Pseudoboletia indiana

ECHINOMETRIDAE (Sea Urchins)
Colobocentrotus atrata
Echinometra mathaei
Heterocentrotus mammillatus

HOLOTHURIDAE (Sea Cucumbers)
Holothuria atra

TOTAL NUMBER OF SPECIES OBSERVED: 13