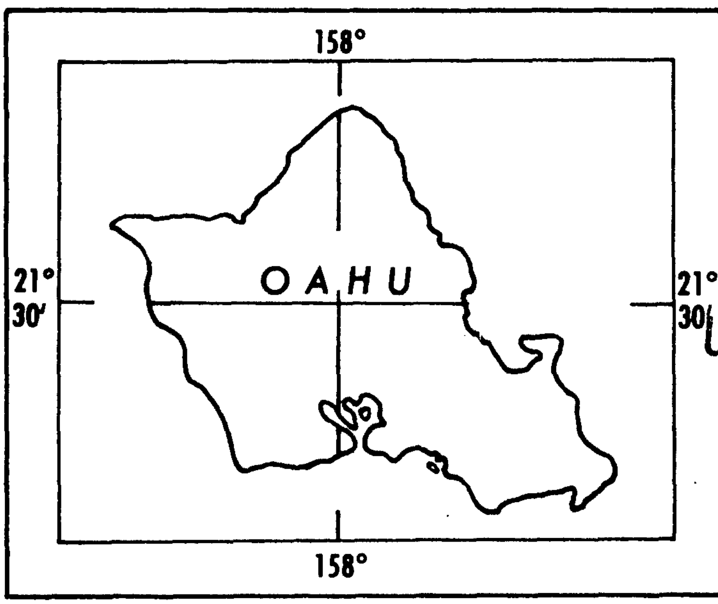
IR NO. 70-48

INFORMAL REPORT

OCEANOGRAPHIC CRUISE SUMMARY SECOND YEAR OF MARINE BIOFOULING STUDIES OFF OAHU, HAWAII



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NAVAL OCEANOGRAPHIC OFFICE
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INFORMAL REPORT

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ABSTRACT

The second year of marine biofouling studies off Oahu, Hawaii, was conducted by the Naval Oceanographic Office from March 1969 to March 1970. Biofouling data were collected by exposing 75 wood/asbestos fouling panels on racks suspended 50 and 100 feet deep at two nearshore sites.

Fouling was of average severity and lacked noticeable seasonality. *Balanus amphitrite*, *Ostrea equestris*, and *Hydroides norvegica* dominated the fouling community and consistently occurred together at both sites. The severity of fouling and the size of individual foulers were greater at 50 feet than at 100 feet. Fouling at the 50-foot level in Hawaiian waters will add a 1- to 2-centimeter coating on moored or bottom objects within 5 to 8 months. Objects placed 100 feet deep should accumulate fouling at a somewhat slower rate. Wood was attacked rapidly by borers; most wood boards were completely riddled after 4 to 6 months' exposure. Near the entrance to Pearl Harbor, the relative abundance of gammarid amphipods and the sparsity of the coral *Leptastrea purpurea* indicated that these organisms are sensitive to the silt and pollution carried out of the harbor. Hawaii biofouling studies are continuing.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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I. INTRODUCTION

In March 1969, the U.S. Naval Oceanographic Office (NAVOCEANO) began the second year of a marine biofouling sampling program in the offshore waters of Oahu, Hawaii (Operation No. 929025). The sampling program was conducted at the following two sites: site I at 21°17'10"N, 158°02'03"W, and site II at 21°19'02"N, 158°08'01"W (Fig. 1). At both sites, biofouling organisms were collected on standard NAVOCEANO fouling test panels exposed at approximately 50- and 100-foot depths. During the year-long test period, 75 panels were exposed and recovered from the two test sites. The site I panel array was lost in high seas in December when the buoy parted. Many of the panels were subsequently collected on 11 December from the broken racks lying on the bottom. The second year of study was completed in March 1970.

The data from the previous year of NAVOCEANO Hawaii fouling studies, conducted from February 1968 to February 1969, have previously been reported[1].

II. OBJECTIVES

The NAVOCEANO fouling study in the Hawaiian waters is one in a series of programs to determine the character and extent of the fouling communities in various faunal provinces. The objectives of this study were the following:

- to determine if fouling organisms attach in coastal regions in sufficient numbers to affect military operations.
- to determine growth rates, productivity, seasonality, and patterns of distribution of coastal fouling communities and the environmental parameters which control them.
- to develop the capability for tracing the life history of derelict objects recovered from the sea by examining the attached foulers.

Data from these studies will supplement published information and, together with the data from other geographical regions being studied, will ultimately result in a worldwide atlas of biofouling communities.

III. METHODS OF COLLECTION AND ANALYSIS

The standard NAVOCEANO test panels used in this study are composed of 6- x 12-inch sections of 1/4-inch asbestos attached to 3/4-inch

[1] Edward R. Long. 1969. Oceanographic Cruise Summary, Marine Biofouling Studies off Oahu, Hawaii. IR No. 69-86. UNPUBLISHED MANUSCRIPT. U.S. Naval Oceanographic Office, Washington, D.C.

pine wood blocks. The panels were secured on a vertical array as shown in Figure 2.

Each month, Explosive Ordnance Disposal Training and Evaluation Unit - Pacific (EODTEUPAC) divers retrieved two panels from each 50- and 100-foot rack, replacing one of the panels with a new one to accumulate the next month's fouling. Thus, data were collected on settlement and community development for monthly and cumulatively longer periods up to 12 months. After retrieval of the panels, the divers took temperature readings and water samples at panel depths. The water samples were forwarded to NAVOCEANO for salinity determinations.

After the exposed panels were retrieved, they were soaked in ethyl alcohol for 2 days, packaged, and then shipped to NAVOCEANO for analysis. X-radiographs of the wood portion of the panel were taken and the panels then were forwarded by NAVOCEANO to Harvard University for analysis of borers by Dr. Ruth Turner. Analyses of the panels included identification of the various organisms, determination of the number and size of each species present, determination of relative importance of each species to the community, estimation of the percent of the panel covered by each species, and measurement of the depth of penetration of the wood borers.

After the above analyses, the asbestos panels were scraped clean of foulers for dry weight determinations. The scraped biomass was heated in an oven until dry and then weighed.

IV. DISPOSITION OF DATA

A reference collection of fouling organisms, dried biomass scrapings, and data summary sheets are retained on file in NAVOCEANO under Operation No. 929025.

V. DISCUSSION

A. General.

The marine fouling community is defined as the assemblage of plants and animals that adhere to, or foul, manmade objects. Fouling provinces are described as arctic, boreal, temperate, or tropical according to their geographic distribution, and each of these provinces is formed by communities composed of certain characteristic species of fauna and flora. Most species of foulers are able to tolerate certain ranges of environmental parameters such as temperature and salinity. Species having similar environmental tolerances tend to occur together and characterize the fouling community for a given environmental regime. However, some organisms apparently are capable of withstanding great environmental changes. They are called cosmopolitan and are found virtually worldwide.

Each community of foulers is dominated by only a few species. The species that consistently are the largest and occupy the most space, thereby influencing other fouling species, are termed DOMINANT. Dominants are also most important because they present the greatest problems from a marine bioengineering viewpoint. The majority of community members occur in either moderate numbers or are relatively small in size and are termed INFLUENT. Finally, those species that occur rarely or which occupy very little substrate are termed TRACE.

B. Analysis.

The fouling community off Oahu, Hawaii, can be characterized as a Balanus amphitrite/Ostrea equestris/Hydroides norvegica community. These macroscopic fouling organisms consistently occurred together during both years of the study. Several influents were important members of the community: Ostrea sandwichensis, Pinctada galtsoffi, Aetea truncata, Dictyota divaricata, Padina japonica, and numerous diatoms (Table I). Although Aetea truncata and the diatoms are listed in Table I as dominants, their extreme small size and negligible effects on marine hardware qualify them as influents rather than dominants. The basic Hawaiian community, as characterized by the three dominant species and the six relatively abundant influents, was observed often enough to serve in the future as a diagnostic tool in the determination of the origin and life history of marine derelicts.

Fouling accumulated rapidly on panels at both sites and at both depths. A stable, well-developed Balanus/Ostrea/Hydroides community was established within 2 and 4 months at the site I/50- and 100-foot depths, respectively; and within 3 and 5 months at the site II/50- and 100-foot depths, respectively.

The thickness of the fouling accumulation, as determined by the height of the Balanus amphitrite barnacles, the tallest hard fouler, reached 0.5 to 1.0cm after 3 months' exposure and remained constant until approximately the ninth month. At site II after 9 months, the growth of Leptastrea purpurea and Pteria lobeni increased the fouling thickness to 2.0cm. At both sites, the fouling accumulation at 50 feet was consistently slightly higher than that at 100 feet.

Growth of individual organisms and the development of the total community were more rapid at both 50-foot levels than at the 100-foot levels, probably due to the greater abundance and availability of planktonic food. For example, Balanus amphitrite specimens reached a diameter of 1.5cm 2 months sooner at the 50-foot level than at the 100-foot level. Also, the year-long average of the diameters of the largest B. amphitrite specimens observed each month on cumulative panels was noticeably smaller at 100 feet than at 50 feet. These values were 1.10cm at site I/100 feet and 1.00cm at site II/100 feet, as compared to 1.50cm at site I/50 feet and 1.40cm at site II/50 feet.

Hard-shelled or calcareous foulers constituted the greatest percentage of the fouling communities at all four sampling racks. Fouling organisms considered to be hard were the various species of barnacles, tubeworms, molluscs, encrusting bryozoans, calcareous algae, and corals. Soft foulers (hydroids, algae, sponges, and tunicates) did not make up an appreciable percentage of the total community except in the early stages of the community's development at site II. There, numerous hydroids developed more quickly than the hard foulers, but the hydroids were later replaced by the dominant molluscs, barnacles, and tubeworms. Hard fouling organisms constituted an average of 72 percent of the total, cumulative fouling community as sampled at the two sites. This percentage was relatively stable after the community had existed for approximately 3 months.

Balanus amphitrite was one of the early foulers to encrust the panels and reached a maximum diameter of 0.4cm within 1 month of exposure. B. amphitrite ultimately grew to a diameter of 1.8cm, the species maximum size, within approximately 5 months. Hydroides norvegica and Ostrea equestris, also early foulers, reached their maximum specific size relatively quickly, a length of 3.0cm within 4 months and a diameter of 4.0cm within 5 months, respectively. The alga Padina japonica, however, reached a maximum diameter of 9.0cm after 9 months' exposure even though it did not appear on the panels until August, 4 months after the panels were exposed. Padina japonica then grew rapidly, and in so doing, smothered numerous other mature foulers, namely, Hydroides norvegica and Balanus amphitrite.

Yet another late-starting fouler, the coral Leptastrea purpurea, actively competed against other established foulers after settling. At site II/50 feet, it appeared as though Leptastrea purpurea would eventually take over the entire panel if given enough time. After 9 months' exposure, 15 percent of these panels were encrusted by this spreading, hard coral. This species did not appear on sites I and II panels until after 7 and 5 months, respectively.

Dry weight productivity of fouling after various periods of time is presented in Table II. The data show that more fouling generally accumulated at the 50-foot level than at the 100-foot level. Also, after a certain amount of time, generally 5 to 8 months, the community seemed to reach a plateau in productivity. That is, for various reasons new larvae failed to settle on the remaining open spaces on the panels. New larvae were present all the time, as consistent attachment was noted on all monthly panels. Perhaps the diatom scum which covered the foulers and panels, or some other organisms on the panels, had a biocidal effect on larvae and prevented new settlement. In addition to the paucity of new foulers, the existing organisms simultaneously reached their maximum specific size and failed to continue growth. Consequently, after 5 to 8 months, as in the previous year of study, the community stabilized in severity (productivity) and remained relatively stable for the remainder of the study. As opposed to the previous year of the project, however, two late-starting foulers, *Padina japonica* and *Leptastrea purpurea*, began exerting an increasingly greater influence on the community and, given enough time, presumably would completely dominate the Hawaiian community.

Numerous gammarid amphipods were found on many short-term panels at site I/50 feet and sometimes covered over 90 percent of the monthly panels. These animals were found only rarely on site II panels. Gammarids normally inhabit areas where suspended matter or fine silt is available in the water. Site I is located near the mouth of Pearl Harbor, the waters of which carry much silt and pollutants out to sea.

Reef corals are normally very sensitive to siltation and pollution. The encrusting coral *Leptastrea purpurea* was found on panels from both sites. However, the colonies found at site II were much larger (average size 1.50cm) than those observed at site I (average size 0.40cm). Also, nearly 3 times as many colonies were found at site II than at site I. From the preceding data, it appears that *Leptastrea purpurea* and the unidentified gammarid amphipods may serve as indicators of pollution and siltation in Hawaiian waters.

The fouling was noticeably less severe at site I/100 feet than at site II/100 feet (Table II). The low productivity values for site I/100 feet match those for the previous year of study and may reflect the effects of pollution on fouling severity.

The water salinity and temperature varied only an insignificant amount between the two sites throughout the year. Generally, at both sites, temperatures were slightly warmer and less saline at 50 feet than at 100 feet. The average temperature was 74°F (78°F - 70°F) and the average salinity was 34.7 o/oo (35.00 - 34.4 o/oo). The water appears to be well mixed in this area.

C. Operational Guidelines.

The fouling in the Hawaii region is of average severity in comparison with other Pacific Ocean locations studied by NAVOCEANO, e.g., Monterey Bay, California, Puget Sound, Washington, and Kodiak, Alaska. Fouling at the 50-foot level in Hawaiian waters will add a 1- to 2-centimeter coating on moored or bottom objects within 5 to 8 months. Objects placed 100 feet deep should accumulate fouling somewhat slower. At the 100-foot level, fouling accumulation is noticeably less severe near the mouth of Pearl Harbor. Since fouling in Hawaiian waters seems to lack seasonality, there does not appear to be a specific optimum season for implanting marine hardware.

Untreated pine remains free of borers for at least 1 month, but numerous borers penetrate around the edges after 1 to 2 months. After

4 to 6 months' exposure, wood is totally riddled with borers (molluscan) and structurally destroyed (Figs. 3, 4, 5, and 6). After approximately 9 months, wood panels crumble and fall apart. Boring molluscs attack wood at a slightly slower rate at 100 feet than at 50 feet.

VI. ADDITIONAL WORK NEEDED IN THE REGION

Supplementary data are needed to clarify patterns in settlement, community succession, seasonality, depth distribution, and local distribution. An additional year of study will be started at site II, and a new, smaller rack will be established inside the entrance to Pearl Harbor. Both arrays will be serviced by EODTEUPAC divers at Pearl Harbor.

VII. ACKNOWLEDGEMENTS

Advice and assistance in identification of foulers were provided by John R. DePalma of NAVOCEANO. The EODTEUPAC divers, supervised by LDCR M.K. Heinz, provided local diver support by retrieving and replacing the test panels. Mr. Carey Ross of NAVOCEANO made x-radiographs of the wood panels.

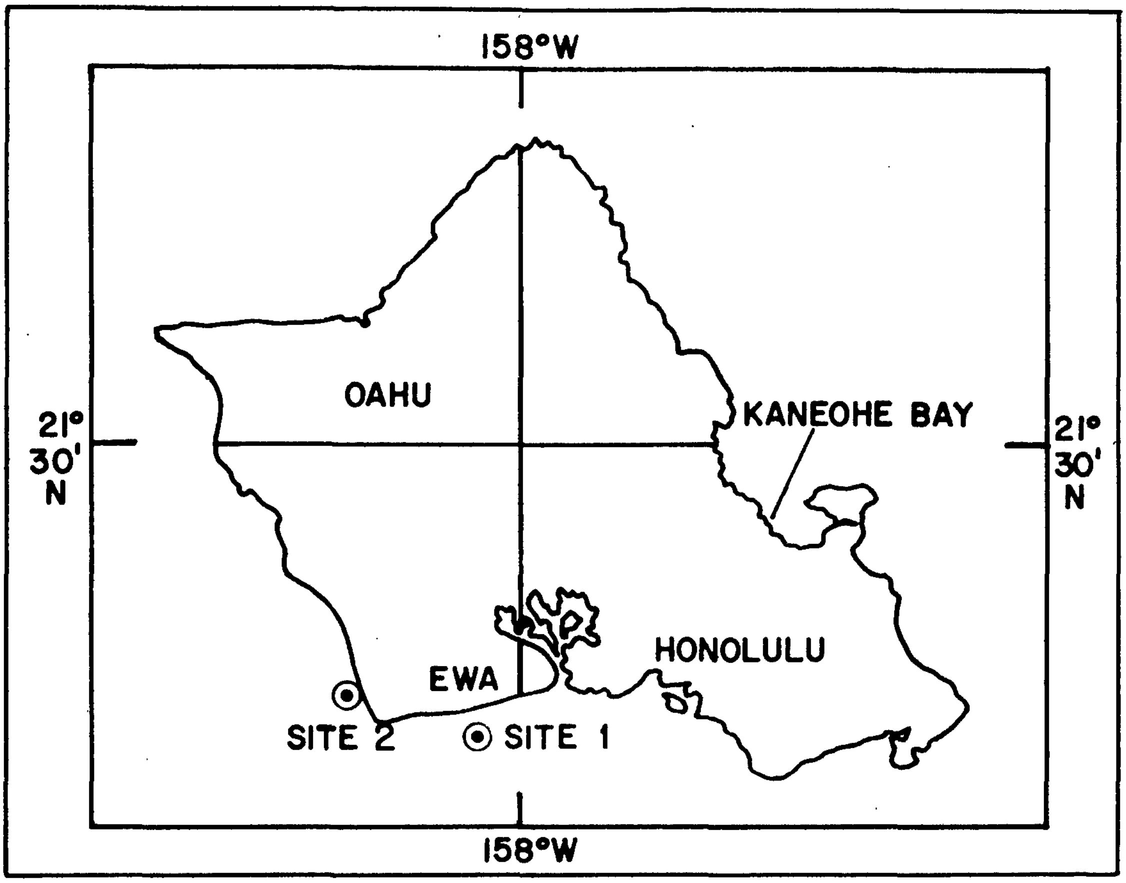

FIGURE 1. Test Site Locations.

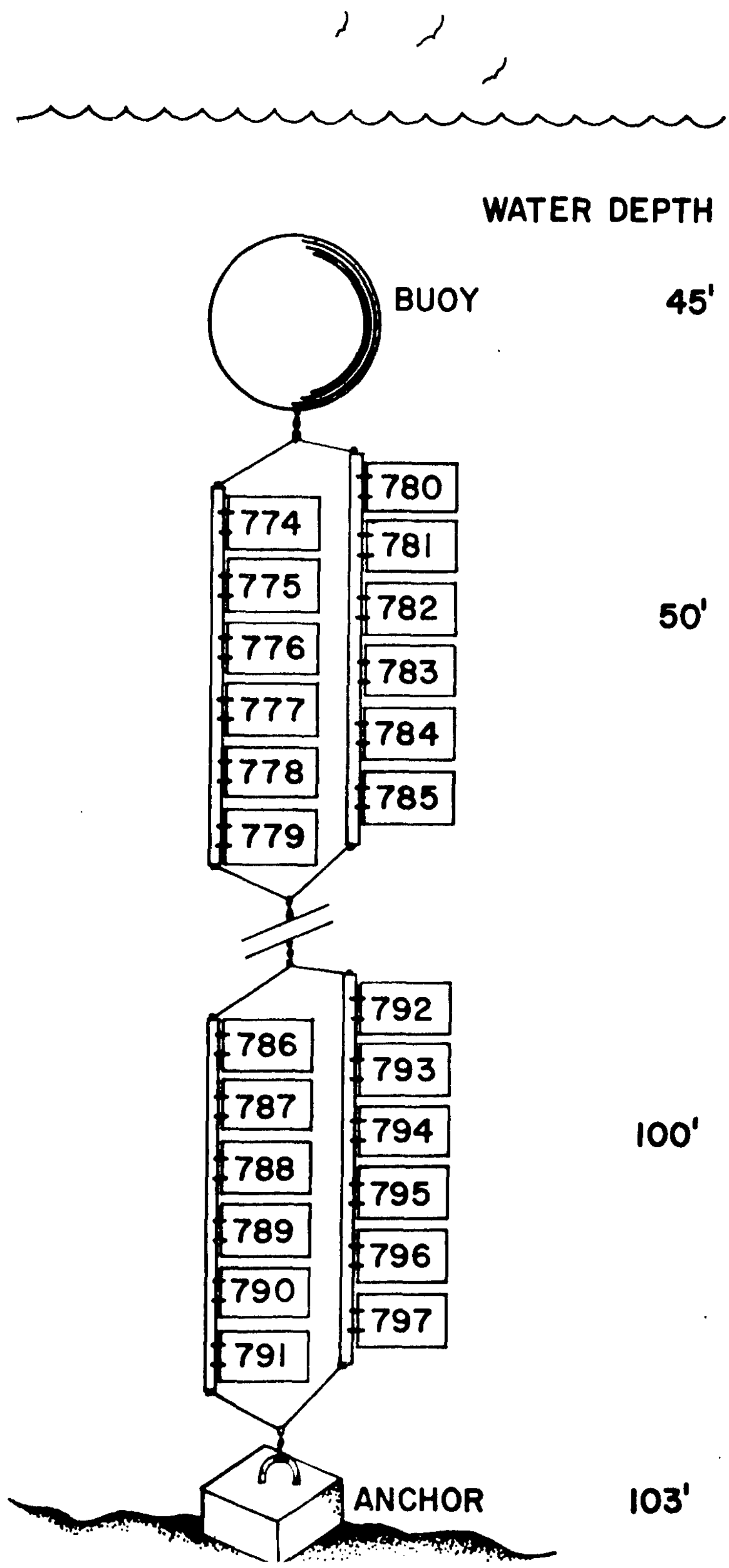

FIGURE 2. Configuration of Test Panel Array.

FIGURE 3. Marine Borer Attack After 1 Month's Exposure at Site II/100 Feet.

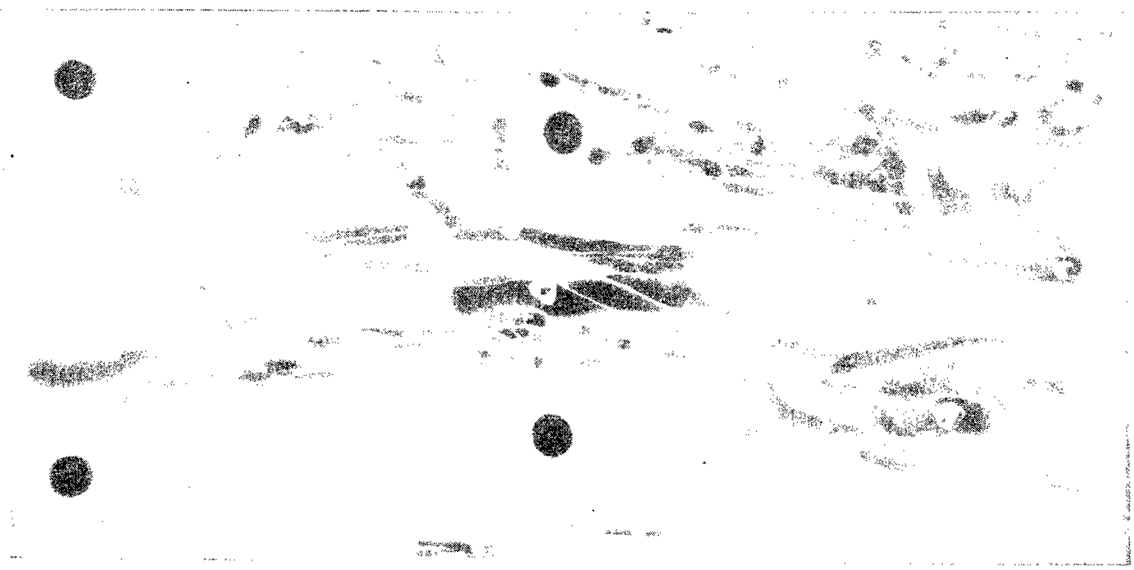

FIGURE 4. Marine Borer Attack After 2 Months' Exposure at Site II/100 Feet.

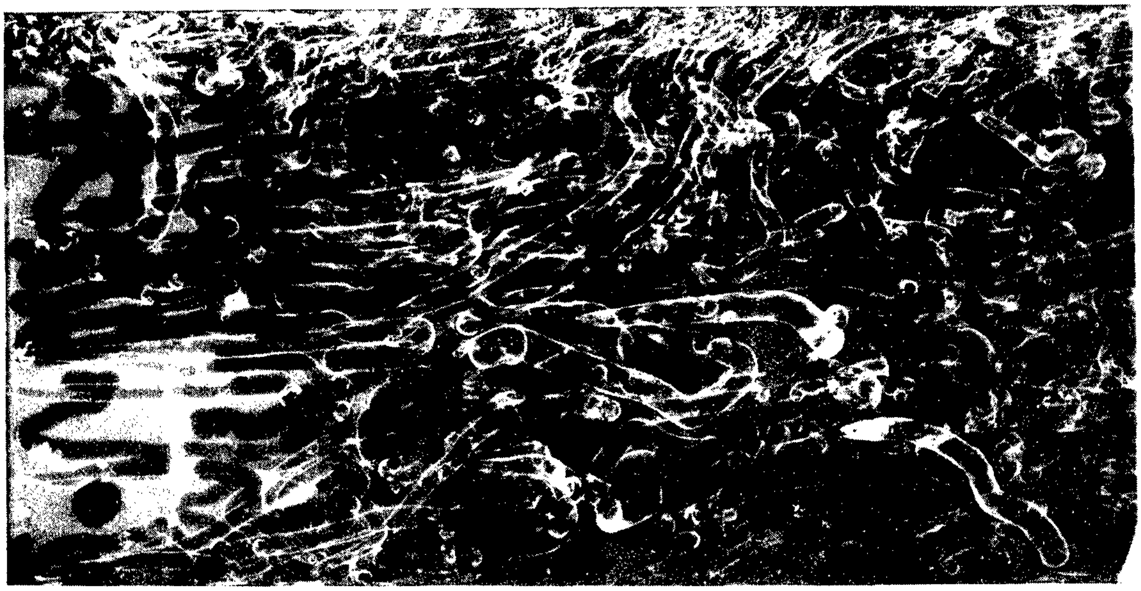

FIGURE 5. Marine Borer Attack After 4 Months' Exposure at Site II/100 Feet.

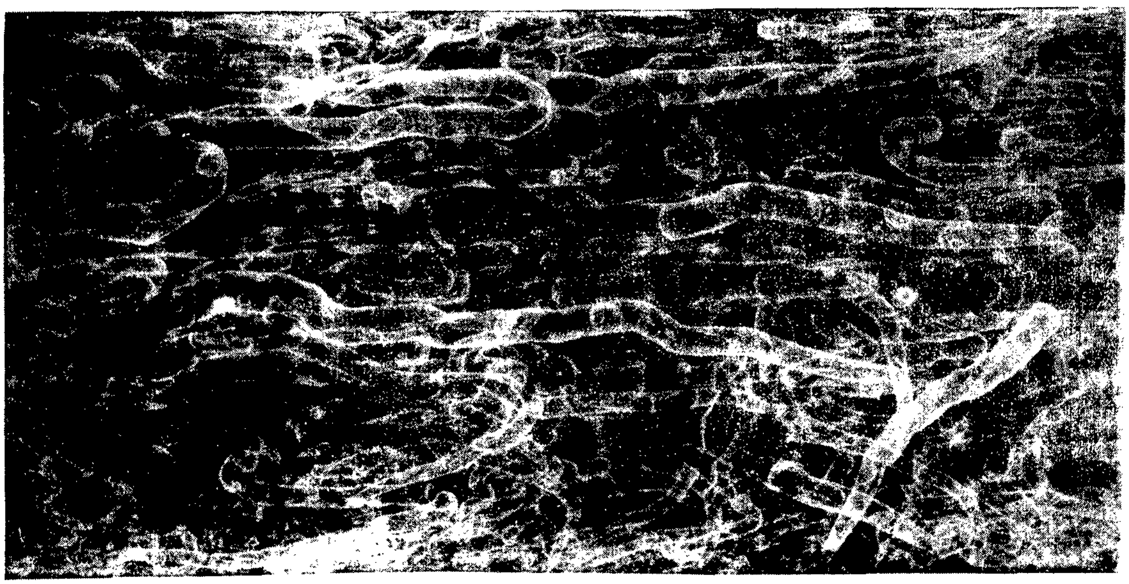

FIGURE 6. Marine Borer Attack After 6 Months' Exposure at Site II/100 Feet.

TABLE I. Local Abundance of Hawaii Foulers at Each Sampling Depth. Occurrence denoted: XXX-Dominant XX-Influent X-Trace.

SPECIES	SITE I 50 ft.	SITE I 100 ft.	SITE II 50 ft.	SITE II 100 ft.
Barnacles:				
Balanus amphitrite hawaiiensis	XX	XX	XX	XX
Balanus eburneus	X	--	--	--
Molluscs:				
Pinctada galtsoffi	X	X	XX	XX
Ostrea equestris	XX	XX	XXX	XXX
Ostrea sandwichensis	XX	X	XX	XX
Spondylus gloriosus	--	X	X	X
Pinna semicostata	X	--	XX	X
Pteria lobeni	--	--	X	X
Dendropoma platypus	--	X	--	X
Septifer bryanae	X	--	X	X
Tubeworms:				
Hydroides norvegica	XX	XX	XXX	XXX
Hydroides crucigera	--	--	X	--
Hydroides lunulifera	X	--	X	--
Spirobranchus tricornis	X	--	X	--
Salmacina dysteri	X	X	X	--
Hydroids:				
Pennaria tiarella	XX	X	X	--
Obelia sp.	X	X	X	X
Bryozoans:				
Aetea truncata	XXX	XXX	XXX	XXX
Thalamoporella hawaiiana	--	--	X	X
Bugula neritina	--	--	X	--
Scrupocellaria sinuosa	--	--	X	--
Vittaticella sp.	--	--	X	--
Watersipora edmondsoni	X	--	--	--
Reteporellina denticulata	--	--	--	X
Amathia sp.	--	--	X	--
Algae:				
Diatoms	XXX	XXX	XXX	XXX
Dictyota divaricata	XX	XXX	XX	--
Padina japonica	X	XX	XX	X
Codium tomentosum	X	--	X	--
Red, filamentous alga	X	--	X	--
Chrysonephos lewissi	X	X	X	--
Enteromorpha intestinalis	X	--	X	--
Encrusting, white alga	--	X	--	--
Stringy, green alga	X	--	--	--
Sponges:				
Sycon sp.	X	X	X	X
Encrusting, branching	--	X	--	--
Tunicates:				
Grey, solitary	X	--	X	--
Corals:				
Leptastrea purpurea	X	X	XX	X

TABLE II. Dry Weight Production of Marine Fouling Organisms on Test Panels from Site I and Site II.

Date of Retrieval	Dry Weight in Grams Per Panel Site I 50 ft.	Site I 100 ft.	Site II 50 ft.	Site II 100 ft.
1 May	--	--	0.3	0.3
29 May	0.8	0.01	1.9	0.5
1 July	10.1	--	--	--
3 Aug	17.7	3.5	14.6	7.2
5 Sept	--	5.1	31.6	8.9
1 Oct	17.9	6.9	15.1	11.0
30 Oct	33.1	9.0	24.2	13.3
11 Dec	14.5	9.3	31.3	22.4
30 Dec	--	--	21.1	18.0
1 Feb	--	--	24.5	21.6
27 Feb	--	--	27.7	33.2

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13. ABSTRACT

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Fouling was of average severity and lacked noticeable seasonality. Balanus amphitrite, Ostrea equestris, and Hydroides norvegica dominated the fouling community and consistently occurred together at both sites. The severity of fouling and the size of individual foulers were greater at 50 feet than at 100 feet. Fouling at the 50-foot level in Hawaiian waters will add a 1- to 2-centimeter coating on moored or bottom objects within 5 to 8 months. Objects placed 100 feet deep should accumulate fouling at a somewhat slower rate. Wood was attacked rapidly by borers; most wood boards were completely riddled after 4 to 6 months' exposure. Near the entrance to Pearl Harbor, the relative abundance of gammarid amphipods and the sparsity of the coral Leptastrea purpurea indicated that these organisms are sensitive to the silt and pollution carried out of the harbor. Hawaii biofouling studies are continuing.

14. KEY WORDS	LINK A		LINK B		LINK C	
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OAHU, HAWAII						