Marine Fouling and Boring Organisms in Monterey Harbor
II. Second Year of Investigation

BY

E. C. HADERLIE

Department of Oceanography, Naval Postgraduate School, Monterey, California 93940

(2 Text figures; 2 Tables)

INTRODUCTION

Since October, 1966, continuous studies have been made on the fouling and boring organisms that attach to or drill into test panels exposed to the marine environment under Municipal Wharf No. 2 in Monterey Harbor. The results of the first year of study have been published (Haderlie, 1968a). The present paper will summarize progress in the work during the second year, which basically extended from October, 1967, to October, 1968, but continued through December, 1968, on certain exposed panels. In addition to these investigations in the harbor area, studies are also being conducted in the open water of Monterey Bay in water-depths of 50, 100 and 200 feet. Results of two years' work at the 50 foot level have been published (Haderlie, 1968b) and data from deeper levels are presently being analyzed. It is planned to continue all these investigations for several more years, for experience has indicated that the results obtained show great variability from year to year and data from many years must be collected before a reasonable idea of the nature of the fouling and boring community can be obtained.

When this project was initiated in 1966 the objectives were to obtain information on the kinds of marine organisms that settle on or burrow into test panels of a variety of types of material exposed in sea water at different depths under the wharf, to determine the season or seasons of settling, to note any correlation between settling of organisms and the temperature or salinity or both of the sea water, to determine any choice of substrate by individual organisms, to measure rate of growth of the dominant calcareous foulers, and to study evidence of seasonal progression or ecological succession over an extended period of time. Data from the first year's work gave partial answers to some of these problems, but experience also indicated ways in which the experimental procedure should be modified in order to get a more complete picture. These modifications in technique will be explained below.

The author wishes to acknowledge the following colleagues for help in the identifications of organisms: Mr. Jack Gougé (Foraminiferans), Dr. D. J. Reish (Polychaetes), Dr. D. P. Abbott (Ascidians), Dr. A. H. Cheetham (Bryozoans). Mr. Stephen V. Smith made mineralogical determinations of spirorbid tubes, and Mr. J. R. Lance again assisted in resolving nomenclatural problems with opisthobranchs. Mr. Barry Roth pointed out correctly that the bivalves identified as *Pecten* sp. in my earlier paper were in reality young specimens of *Hinnites multirugosus* (Gale, 1928). Acknowledgment is also due Mr. Jack C. Mellor for help in field work, to my wife, Mrs. A. E. Haderlie, for assistance in the laboratory, and to the Office of Naval Research for financial support.

AREA OF STUDY

As reported in the 1968 paper on fouling and boring organisms in the harbor, the site of the study is near the outer end of Monterey Municipal Wharf No. 2 where the water depth is approximately 21 feet at mean low tide. For a complete description of the site readers are referred to the earlier paper. As before, biweekly surface temperature and salinity measurements were made throughout the year (Figure 1).

METHODS

Techniques used during the period of study reported on here were similar to those used the previous year, with some modifications. During 1966-1967, collecting panels consisting of standardized 8 inch by 10 inch panels of

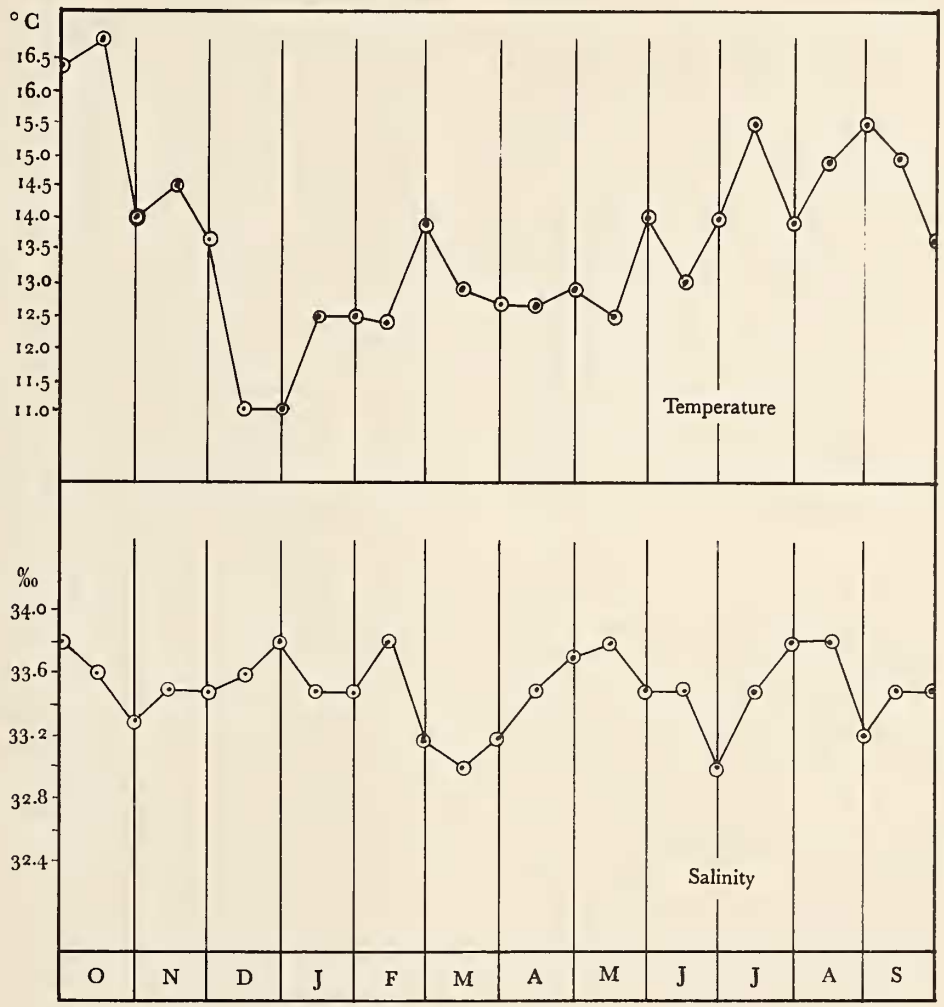

Figure 1

Biweekly morning temperatures and salinities at test site for the year October 1, 1967 to October 1, 1968

$\frac{1}{4}$ inch marine grade douglas fir plywood were used as the primary collecting surfaces. Panels were placed in stainless steel racks holding 6 panels vertically and 3 inches apart. To compare at least one other material that has been used in the past as a collecting surface for foulers, panels of $\frac{1}{4}$ inch asbestos board (Johns-Manville Colorlith) were also exposed in racks alongside those containing plywood. It was found that there was essentially no difference in the total number of species collected by plywood or asbestos board and in settling most foulers did not appear to distinguish between the two substrates. A few organisms settled in slightly greater numbers on plywood, whereas a few others were more abundant on asbestos board, but the differences were not considered significant. To simplify the procedure, during the 1967 to 1968-year reported on here the asbestos board panels were discarded and only plywood panels used. Plywood was selected over asbestos board, for wood panels also collected wood boring organisms of interest in this study.

In the 1966-1967 study, one series of panels was suspended in the water alongside the wharf where it was exposed to relatively strong sunlight during at least half

the day. These lighted panels collected a total of 5 species of benthic algae during the year, but otherwise the fouling and boring organisms collected by the lighted panels were very similar to those collected by panels at the same water depth in the dim-light conditions under the wharf. During this past year, therefore, the lighted series has been discontinued.

Again during the 1966-1967 year, one rack of panels designated "floating panels" was rigged so that the rack floated at the sea surface regardless of tidal level. This rack was difficult to keep in place and several panels were lost. During the 1967-1968 year the floating rack was continually lost during storms and was replaced many times. Ultimately this series of panels was abandoned. This lack of data is perhaps not serious, for during 1966 to 1967 the floating panels did not collect a population of foulers and borers much different from panels submerged some distance below the surface.

During 1967-1968, then, three series of panels in racks as used the previous year were continued as follows:

(1) Intertidal rack. Positioned about 4 feet above the lowest low tide level. The panels in this rack were submerged approximately one half the time and exposed to air the other half. Short Term and Cumulative Panels.

(2) Shallow rack. Located 1 foot below lowest low tide level. Panels always submerged. Short Term and Cumulative Panels.

(3) Deep rack. Positioned 14 feet below the lowest low tide level and about 7 feet off the bottom. Short Term and Cumulative Panels.

In addition to the above listed three racks a fourth one was added for reasons that will be explained below. This rack was designated as follows:

(4) Shallow Long-Term Rack. Positioned 1 foot below the lowest low tide level. Long Term Panels (3 month and 6 month exposure).

The basic period covered by the present study was from October 1, 1967, to October 1, 1968. In the case of the panels in the intertidal, shallow and deep racks the routine for placing and retrieving the collecting surfaces was the same as in 1966-1967. Of the 6 panels in each of the racks there were 4 that were left in place for 3 months (Panel C-1), 6 months (Panel C-2), 9 months (Panel C-3), and 12 months (Panel C-4) respectively. These were designated Cumulative Panels. The other 2 panels in each rack were designated Short Term Panels (S-1, S-2, etc.): one was put in the water on the first of each month and removed for analysis on the first of the following month; the second panel was put in on the 15th of each month and removed one month later.

During the 1966-1967 investigation it was found that the Cumulative Panels exposed for 3, 6, 9, and 12 months showed the most varied and extensive fouling communities. This was to be expected, for many benthic organisms settle only on surfaces that have been colonized by pioneering fouling organisms. All of the Cumulative Panels were placed in the water at the same time on October 1, 1966. During the course of the first year of this study it was wondered if a panel placed in the water for 3 months (or 6 months) beginning in October would ultimately collect the same fouling community as one placed in the water for 3 months (or 6 months) beginning in January, March, or any other month. To find an answer to this question a new rack was used during 1967-1968. The rack was designated "shallow, long term rack" and was positioned alongside the regular "shallow rack" at 1 foot below low tide. Panels that would remain in the water for 3 months (Panel 3-L) and for 6 months (Panel 6-L) were submerged in this rack. One 3-month panel was placed in the water on October 1, 1967, a second on November 1, 1967, and so on throughout the study period. Six-month panels were submerged every 3 months. The length of exposure of the various panels is shown diagrammatically in Figure 2.

As before, the panels were removed from the racks and transported to the laboratory in sea water containers to be examined under a stereoscopic microscope while the panels were submerged in a pan of sea water. After examination, one of the surfaces of each of the Long Term and Cumulative Panels (80 square inches or 512¾ cm^2) was scraped clean of attached organisms and the scrapings were oven dried at 100° C until the weight was constant. This provided a rough statistical measure of the relative amount of fouling growth accumulated in any one period (see bottom line, Table 2). Short Term Panels usually collected so little in terms of weight that they were not scraped and treated as above.

THE FOULING COMMUNITY

I. DISCUSSION OF ORGANISMS SETTLING ON SHORT TERM PANELS

Table 1 presents a list of organisms and their relative numbers that settled on panels exposed for 1 month during the period October 1, 1967, to October 15, 1968. A total of 66 different animal species identified at least to genus were recorded. During the previous year, a total of 70 different kinds of organisms was found on similar panels, but this number included 4 species of algae. None of the panels submerged under the wharf during 1967

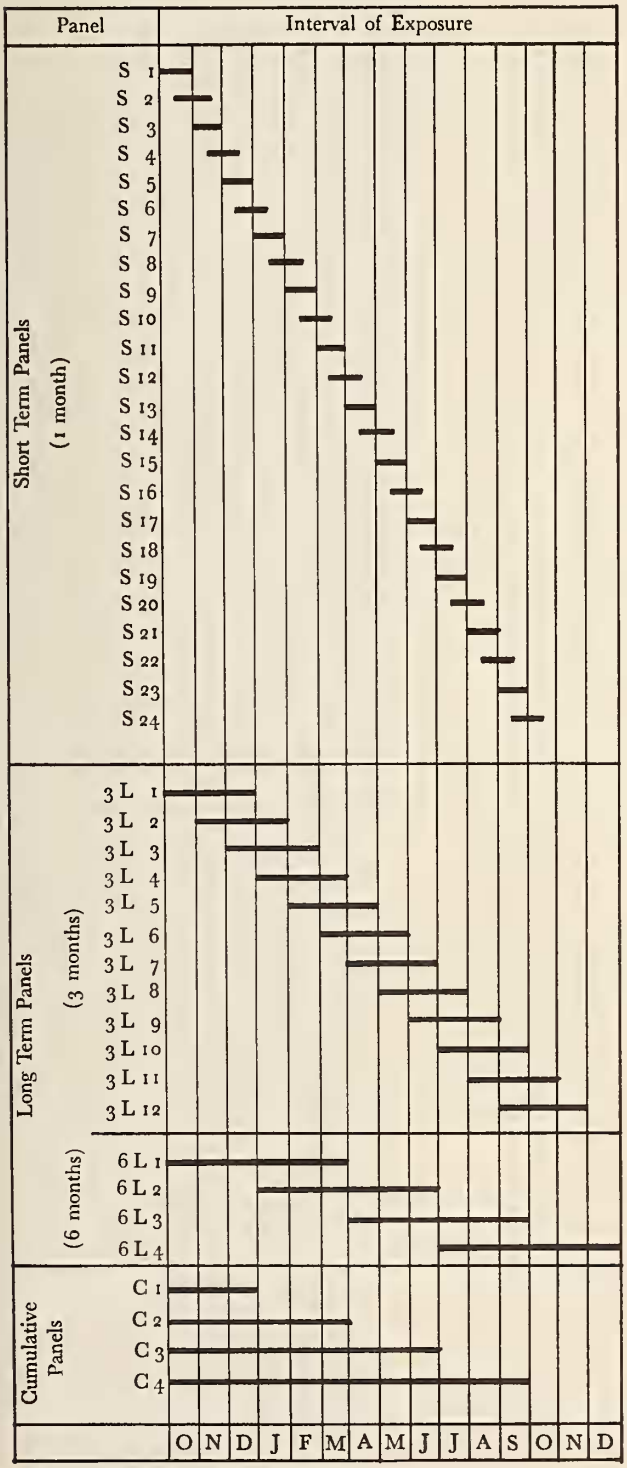

Figure 2

Diagram illustrating period of exposure for test panels from October 1, 1967 to January 1, 1969

to 1968 collected any green, brown, or red algae for, as explained above, none of the racks was placed in water receiving direct sunlight. All panels when first placed in the water collected a surface film of bacteria and benthic diatoms, but none of these was identified.

During each of the past 2 years, then, Short Term Panels have collected 66 different kinds of animals. This identical total seems to be merely a coincidence for, although the totals were the same, the lists of organisms are not identical for each of the two years. During each year the dominant fouling organisms were the same: encrusting cheilostomate and cyclostomate bryozoans, calcareous-tubed serpulid worms and acorn barnacles. The most common boring organism was the gribble *Limnoria,* and these and other wood borers will be considered later. The following discussion will briefly review the occurrence of the most common organisms of each major group listed in Table 1.

Protozoa:

Eight different kinds of benthic foraminiferans were observed on the Short Term Panels. *Cornuspira lajollensis* and *Rosalina columbiensis* were the only species regularly encountered, but the former was often found in great numbers. The reason that more species of foraminiferans were found during 1967-1968 than in the previous year was due in part to a more determined effort to locate them, but principally because Mr. Jack Gougé examined many of the panels when fresh and picked up forms that had been overlooked previously. The ciliate *Folliculina* sp. was perhaps the most abundant single protozoan encountered, and it settled on panels at all depths throughout the year. The suctorian *Ephelota gemmipara* often formed fuzzy forests over the panel surface and attached to hydroids such as *Obelia.* The colonial ciliate *Zoothamnium* sp. again was found to be common during the summer and fall months.

Porifera:

Two species of sponges settled on the Short Term Panels, but of these only *Leucosolenia eleanor* was found regularly.

Coelenterata:

The only coelenterate that settled on the panels with any regularity was the hydroid *Obelia* sp. which settled during most months of the year. *Syncoryne mirabilis,* a second hydroid, was encountered only rarely and in small numbers.

Platyhelminthes:

Four different species of flatworms were recorded on Short Term Panels during 1967-1968. The commonest form encountered was *Thysanozoon californicum* which occurred only on those panels with a population of the bryozoan *Celleporaria brunnea*.

Nemertea:

Nemertean worms were rarely seen on the panels, but two species were observed, each on one occasion, on the intertidal panels only.

Ectoprocta (Bryozoa):

{Dr. Cheetham of the U. S. National Museum has examined the cheilostomate bryozoans on the panels and has found that the bryozoan identified as *Lyrula hippocrepis* (Hincks, 1882) in my earlier papers (Haderlie, 1968a, 1968b) is in reality *Cryptosula pallasiana*. In addition, *Hippothoa hyalina* should be called *Celleporella hyalina* and *Holoporella brunnea* should be called *Celleporaria brunnea*.}

During the present study the same 4 encrusting bryozoans dominated the Short Term Panels as they did in 1966-1967. *Celleporella hyalina, Cryptosula pallasiana, Tubulipora pacifica* and *Celleporaria brunnea* were found on nearly all panels at all depths. During this past year *Celleporaria* seemed to be much more abundant, and *Celleporella* less abundant than during the year before. Erect bryozoans were also very common. These were dominated by the soft fuzzy *Bowerbankia gracilis* and by *Bugula neritina* and *B. californica*. On a shallow panel submerged from June 15 to July 15, 1968, dozens of tiny *Bugula neritina* were found, indicating the period of maximum settlement. During most months of the year only one or two specimens of *B. neritina* were found on any panel. From mid-summer through the fall *Crisulipora occidentalis* settled on panels in the shallow and deep racks.

Annelida:

During 1966-1967 spirorbid worms were encountered on the Short Term Panels in abundance second only to encrusting bryozoans. These forms were identified as *Spirorbis spirillum* and they settled on the panels at all depths throughout the year. During 1967-1968 spirorbids were again encountered, often in great numbers, and on most Short Term Panels throughout the year. The most intense settling was from mid-April through June when hundreds of small worm tubes were found, particularly on the deep panels. A more careful examination of the tubes of these spirorbids has shown that at least 4 distinct morphological types are present. The largest tubes and most commonly encountered forms are distinctly sculptured, coiled counter-clockwise, and faintly resemble the tubes of *Spirorbis nipponicus* Okuda, 1934, as figured in Ushakov (1955). Mineralogical analysis of the tubes by Stephen V. Smith has shown these to be composed of aragonite. A second morphological type (and second in abundance on the panels) coils clockwise and has a tube strongly ringed resembling the horn of an antelope such as the sable or oryx. These tubes are composed of calcite with 12% Mg substitution for Ca in the $CaCO_3$ lattice. A third form has a very smooth shell and coils clockwise. It is composed of aragonite. The fourth form was only rarely encountered. It is smooth and coils counter-clockwise and also seems to be composed of aragonite. When removed from the tubes the worms all look remarkably alike. The identity of these spirorbids is therefore in doubt. It is possible that these forms represent 3 or 4 distinct species. Until the systematics is worked out it seems wise to refer to them as *Spirorbis* spp.

A second common serpulid that has been found not only in Monterey Harbor but at depths to 100 feet in open water has been referred to previously only as *Serpula* sp. (Haderlie, 1968a, 1968b). A more critical examination of these worms during recent months has shown them to be *Chitinopoma occidentalis*. On deeper panels *Chitinopoma* was more abundant than *Spirorbis*.

Arthropoda:

As in the earlier study in the harbor, the most commonly encountered arthropod on the fouling panels was the acorn barnacle *Balanus crenatus*. On the Short Term Panels this barnacle settled in small numbers during most months of the year. There were usually 10 animals or fewer per panel side, and the greatest number seen was 20 per panel side during August, 1968. These results obtained during the 1967-1968 year contrast sharply with

Explanation to Table 1 (foldout, facing this page ⟶)

[1] Symbols used at head of columns indicate:
- S-1, S-2, etc. = Short term panel number as designated in Figure 2
- I = Intertidal panels
- S = Shallow panels
- D = Deep panels

[2] Symbols used in columns indicate:
- 1 = species present in numbers from 1 to 10 individuals or colonies per panel side
- 2 = species present in numbers from 11 to 20 individuals or colonies per panel side
- 3 = species present in numbers upward from 20 individuals or colonies per panel side

Table 1

List of Species, and of Panels where Organisms Settled in Short Term Series

Species	S-1 I	S-1 S	S-1 D	S-2 I	S-2 S	S-2 D	S-3 I	S-3 S	S-3 D	S-4 I	S-4 S	S-4 D	S-5 I	S-5 S	S-5 D	S-6 I	S-6 S	S-6 D	S-7 I	S-7 S	S-7 D	S-8 I	S-8 S	S-8 D
Protozoa:															NO DATA									
Iridia lucida LeGalley, 1936																								
Cornuspira lajollaensis Uchio, 1960	3	3		2	3	3			3			1		1				3						3
Rosalina columbiensis (Cushman, 1925)		2					1				1													
Spirillina revertens (Rhumbler, 1906)		2							3															
Spirillina vivipara (Rhumbler, 1906)																								
Patellina corrugata Williamson, 1858																								
Tubinella funalis (Brady, 1884)																								
Entosolenia sp.																								
Ephelota gemmipara (Hartwig, 1876)				3	3							3	3							3				2
Zoothamnium sp.												3												
Folliculina sp.		3	3		3	3	1		3	2	2	2						1			2		3	2
Stentor sp.					3																			
Carchesium sp.					1																			
Porifera:															N. D.									
Leuconia heathi (Urban, 1905)			1																					
Leucosolenia eleanor Urban, 1905																		1			1			1
Coelenterata:															NO DATA									
Obelia sp.	3			1														1	1	1		3	1	
Syncoryne mirabilis (Agassiz, 1862)									1	1		1											1	
Metridium senile (Linnaeus, 1767)																								
Platyhelminthes:															NO DATA									
Stylochoplana gracilis Heath & McGregor, 1912																					1			
Notoplana acticola (Boone, 1929)																								
Thysanozoon californicum Hyman, 1953																								
Pseudocerous sp.																								
Nemertea:															N. D.									
Tubulanus sexlineatus (Griffin, 1898)																								
Tetrastemma nigrifrons Coe, 1904																								
Entoprocta:															N. D.									
Barentsia gracilis (Lomax, 1886)																								
Ectoprocta (Bryozoa):															NO DATA									
Bowerbankia gracilis O'Donoghue, 1926	1																					1		1
Filicrisia franciscana (Robertson, 1910)					1	1																		1
Crisia sp.																								
Crisulipora occidentalis Robertson, 1910																								
Tubulipora pacifica Robertson, 1910	2	3	3		3	1		2	3		2	2								2	3		2	3
Bugula neritina (Linnaeus, 1758)	1	1				1			1			1												
Bugula californica Robertson, 1905									1															
Celleporella hyalina (Linnaeus, 1767)	3	1			3			1	1			1						1					2	2
Cryptosula pallasiana (Moll, 1803)	1	2		1	3			1	1	1														
Scrupocellaria californica Trask, 1857																								
Scruparia ambigua (d'Orbigny, 1841)					1																		1	1
Celleporaria brunnea (Hincks, 1884)	1	1	1		2	1		1	1	1	1	1		1				1					1	
Annelida:															NO DATA									
Platynereis agassizi (Ehlers, 1868)						1																		
Pseudopotamilla ocellata Moore, 1905																								
Spirorbis spp.		3	3		3	3	1	3	2	1	1	2		1		1	1			1	3			2
Chitinopoma occidentalis (Bush, 1904)	1	1	1		1	2								1										
Arthropoda:															NO DATA									
Balanus crenatus Bruguière, 1789	3			1										1							1		1	1
Balanus glandula Darwin, 1854																								
Balanus tintinnabulum (Linnaeus, 1758)																								
Chthamalus dalli Pilsbry, 1916				1																		1		
Lepas anatifera (Linnaeus, 1758)				1																				
Caprella californica Stimpson, 1857	1	1			1																			
Corophium insidiosum Crawford, 1937																								
Limnoria quadripunctata Holthuis, 1949	1	3		1	1	1	1	3		1	1	1		1		1	1	1	1	1		1	1	1
Loxorhynchus crispatus Stimpson, 1875																								
Mollusca:															NO DATA									
Pododesmus cepio (Gray, 1850)						1					1										1			
Hinnites multirugosus (Gale, 1928)																								
Mytilus edulis Linnaeus, 1758																								
Hiatella arctica (Linnaeus, 1771)			1															1		3	3	3	3	3
Bankia setacea (Tryon, 1863)			1							1								1						
Coryphella trilineata O'Donoghue, 1921																								
Hermissenda crassicornis (Eschscholtz, 1831)	1	1		1						1												1		
Dendronotus frondosus (Ascanius, 1774)	1	1																						
Dendronotus subramosus MacFarland, 1966																								
Doto kya Marcus, 1961																								
Triopha grandis MacFarland, 1905																								
Trinchesia albocrusta (MacFarland, 1966)				1																				
Polycera atra MacFarland, 1905																						1		
Aegires albopunctatus MacFarland, 1905																						1		
Echinodermata:															NO DATA									
Strongylocentrotus sp.					1					1						1	1	1		1	1	1	1	1
Ophiothrix spiculata LeConte, 1851																								

Species	S-9 I	S-9 S	S-9 D	S-10 I	S-10 S	S-10 D	S-11 I	S-11 S	S-11 D	S-12 I	S-12 S	S-12 D	S-13 I	S-13 S	S-13 D	S-14 I	S-14 S	S-14 D	S-15 I	S-15 S	S-15 D	S-16 I	S-16 S	S-16 D
Protozoa:																								
Iridia lucida LeGalley, 1936																								
Cornuspira lajollaensis Uchio, 1960	3	3					2		3			3	3	3					3	3	2		3	
Rosalina columbiensis (Cushman, 1925)										1									1		1			
Spirillina revertens (Rhumbler, 1906)																								
Spirillina vivipara (Rhumbler, 1906)																								
Patellina corrugata Williamson, 1858																			1					
Tubinella funalis (Brady, 1884)																				1				
Entosolenia sp.																								
Ephelota gemmipara (Hartwig, 1876)				3			3																	
Zoothamnium sp.																	3			3	3		3	
Folliculina sp.			3			3			3	3	2	1			3	2	1	1		1	1		3	1
Stentor sp.																								
Carchesium sp.																								
Porifera:																								
Leuconia heathi (Urban, 1905)																				1				
Leucosolenia eleanor Urban, 1905		1	1			1					1			2	2			2	1	1	1			1
Coelenterata:																								
Obelia sp.	1	1		1			1			1			1	1			2					3	3	
Syncoryne mirabilis (Agassiz, 1862)																								
Metridium senile (Linnaeus, 1767)																								
Platyhelminthes:																								
Stylochoplana gracilis Heath & McGregor, 1912		1																			1			
Notoplana acticola (Boone, 1929)																								
Thysanozoon californicum Hyman, 1953	1							1			1	1	1		1									1
Pseudocerous sp.								1																
Nemertea:																								
Tubulanus sexlineatus (Griffin, 1898)																			1					
Tetrastemma nigrifrons Coe, 1904	1																							
Entoprocta:																								
Barentsia gracilis (Lomax, 1886)												1												
Ectoprocta (Bryozoa):																								
Bowerbankia gracilis O'Donoghue, 1926				2						3		1	1			1	1		1	1	2	2	3	3
Filicrisia franciscana (Robertson, 1910)									1						1			1						1
Crisia sp.																							1	
Crisulipora occidentalis Robertson, 1910																					1		1	1
Tubulipora pacifica Robertson, 1910		3	3		3	3		3	3		2	3		3	3		1	3		3	2		3	2
Bugula neritina (Linnaeus, 1758)									1		1			1	1		1		1	1	1		1	1
Bugula californica Robertson, 1905			1			1		1	1		2	1						1		1	1		1	1
Celleporella hyalina (Linnaeus, 1767)		1	2		3	3		2	2		3	1		1	2	1	1	1	1	1	2		2	1
Cryptosula pallasiana (Moll, 1803)		1	1			1						1		1			1	1	1	1	1	2	1	
Scrupocellaria californica Trask, 1857																							1	
Scruparia ambigua (d'Orbigny, 1841)						1			1			1	1		1			1			1			
Celleporaria brunnea (Hincks, 1884)		2	1		1	1		3	3		3	3	2	3	1		1	3	1	3	2	1	3	2
Annelida:																								
Platynereis agassizi (Ehlers, 1868)																								
Pseudopotamilla ocellata Moore, 1905																					1			
Spirorbis spp.		3	3		3	3		3	3		3	3		1	3		1	3	3	3	3	1	3	3
Chitinopoma occidentalis (Bush, 1904)																					1			1
Arthropoda:																								
Balanus crenatus Bruguière, 1789		1			1	1	1	1	1	1			2		1	1			1			1	1	1
Balanus glandula Darwin, 1854																						2		
Balanus tintinnabulum (Linnaeus, 1758)																								
Chthamalus dalli Pilsbry, 1916				3			3			1			1						2			2		
Lepas anatifera (Linnaeus, 1758)																								
Caprella californica Stimpson, 1857	1																						2	
Corophium insidiosum Crawford, 1937																					1			
Limnoria quadripunctata Holthuis, 1949	1	1		1	1				1	1		1	1			1	1	1	1	1		2	1	
Loxorhynchus crispatus Stimpson, 1875			1																					
Mollusca:																								
Pododesmus cepio (Gray, 1850)																								1
Hinnites multirugosus (Gale, 1928)																								
Mytilus edulis Linnaeus, 1758																1			1					
Hiatella arctica (Linnaeus, 1771)	1	3	3		3	3				1		1			1				1		1			1
Bankia setacea (Tryon, 1863)		1												1										
Coryphella trilineata O'Donoghue, 1921												1												
Hermissenda crassicornis (Eschscholtz, 1831)	1	1	1						1		1	1	2	1							1		1	1
Dendronotus frondosus (Ascanius, 1774)																								
Dendronotus subramosus MacFarland, 1966																								
Doto kya Marcus, 1961																								
Triopha grandis MacFarland, 1905																								1
Trinchesia albocrusta (MacFarland, 1966)	1								1		1													
Polycera atra MacFarland, 1905											1				1				1					1
Aegires albopunctatus MacFarland, 1905																								
Echinodermata:																								
Strongylocentrotus sp.		1			1			1	1				1	1							1		1	1
Ophiothrix spiculata LeConte, 1851														1	1								1	

Species	S-17 I	S-17 S	S-17 D	S-18 I	S-18 S	S-18 D	S-19 I	S-19 S	S-19 D	S-20 I	S-20 S	S-20 D	S-21 I	S-21 S	S-21 D	S-22 I	S-22 S	S-22 D	S-23 I	S-23 S	S-23 D	S-24 I	S-24 S	S-24 D
Protozoa:																								
Iridia lucida LeGalley, 1936																				1	1			
Cornuspira lajollaensis Uchio, 1960	3	3	1			3	2	1		2	2	3	3	3	3	3		3	3	3	3	2	3	3
Rosalina columbiensis (Cushman, 1925)	1	1	1		1	1			2			2			1		1	1	1	1	1		1	
Spirillina revertens (Rhumbler, 1906)																								
Spirillina vivipara (Rhumbler, 1906)											1													
Patellina corrugata Williamson, 1858																								
Tubinella funalis (Brady, 1884)																								
Entosolenia sp.															1									
Ephelota gemmipara (Hartwig, 1876)																						3	3	
Zoothamnium sp.						3			3	3	3	3	3		3								3	
Folliculina sp.					1	1		3	2	2	2	2	2	3	2	2	2	3	2					
Stentor sp.																							1	
Carchesium sp.																								
Porifera:																								
Leuconia heathi (Urban, 1905)																								
Leucosolenia eleanor Urban, 1905			1		1			1		1					1	2							1	
Coelenterata:																								
Obelia sp.		1					1			2			1			1			3			3	1	1
Syncoryne mirabilis (Agassiz, 1862)																1								
Metridium senile (Linnaeus, 1767)											1													
Platyhelminthes:																								
Stylochoplana gracilis Heath & McGregor, 1912																								
Notoplana acticola (Boone, 1929)														1										
Thysanozoon californicum Hyman, 1953																								
Pseudocerous sp.																								
Nemertea:																								
Tubulanus sexlineatus (Griffin, 1898)																								
Tetrastemma nigrifrons Coe, 1904																								
Entoprocta:																								
Barentsia gracilis (Lomax, 1886)											1													
Ectoprocta (Bryozoa):																								
Bowerbankia gracilis O'Donoghue, 1926	2	1	1	2	2		1		1	1	2		3	2	2	2	2	3	2			1	1	
Filicrisia franciscana (Robertson, 1910)																	1							
Crisia sp.																								
Crisulipora occidentalis Robertson, 1910					1			3	2		3	3					3	3					2	
Tubulipora pacifica Robertson, 1910					1	1		3			3							1					1	1
Bugula neritina (Linnaeus, 1758)		1	1		3	1		1	1		1		1	1	1		1	1					1	
Bugula californica Robertson, 1905								1	1		1	1	1			1	1						1	
Celleporella hyalina (Linnaeus, 1767)					1	1		2	3	1	3	1	1		1		3		1			1		
Cryptosula pallasiana (Moll, 1803)	1			1	1		2	1	1	1	1	1		1	1	1	2			1	1	1	1	
Scrupocellaria californica Trask, 1857								1																
Scruparia ambigua (d'Orbigny, 1841)																								
Celleporaria brunnea (Hincks, 1884)		1	1	1	3	3	1	3	3	1	3	1	1	2	1		3	3		3		1	3	1
Annelida:																								
Platynereis agassizi (Ehlers, 1868)															1	1								
Pseudopotamilla ocellata Moore, 1905																								
Spirorbis spp.		3	3		3	3		3	3		2	2	1	1	1	3	3	3	1	3	1	1	1	3
Chitinopoma occidentalis (Bush, 1904)						1			1	1	1		1	1	1	2	1	3			1	1	1	1
Arthropoda:																								
Balanus crenatus Bruguière, 1789							1	1		1			2	1	3		1	1	1	1	1	1	1	1
Balanus glandula Darwin, 1854				2												1								
Balanus tintinnabulum (Linnaeus, 1758)																1								
Chthamalus dalli Pilsbry, 1916	1			1									1			1			1					
Lepas anatifera (Linnaeus, 1758)																								
Caprella californica Stimpson, 1857											1		1	1	3		1		1		1	2	3	1
Corophium insidiosum Crawford, 1937																								
Limnoria quadripunctata Holthuis, 1949	1			1	1	1	1	1			1		1	1		1	2							
Loxorhynchus crispatus Stimpson, 1875																								
Mollusca:																								
Pododesmus cepio (Gray, 1850)								1					1	1	1		1	1					1	1
Hinnites multirugosus (Gale, 1928)														1							1			
Mytilus edulis Linnaeus, 1758	1												1											
Hiatella arctica (Linnaeus, 1771)		1				1	1			1			2	1	1		1	3	1	1	3	1	1	1
Bankia setacea (Tryon, 1863)						1																		
Coryphella trilineata O'Donoghue, 1921																								
Hermissenda crassicornis (Eschscholtz, 1831)			1			1	1			1	1		1	1	1	1	1	1	1	1	1	1	1	
Dendronotus frondosus (Ascanius, 1774)																								
Dendronotus subramosus MacFarland, 1966																						1		
Doto kya Marcus, 1961																				1				
Triopha grandis MacFarland, 1905																								
Trinchesia albocrusta (MacFarland, 1966)																	1							
Polycera atra MacFarland, 1905																								
Aegires albopunctatus MacFarland, 1905	1																							
Echinodermata:																								
Strongylocentrotus sp.												1												
Ophiothrix spiculata LeConte, 1851															1									

the former year where during certain months such as March, June and August there were massive setlements of up to 25 barnacles per square inch of panel surface. During the present study there was no one period when *B. crenatus* settled in great numbers. On panels in deeper water in the open bay, where massive settlement of *B. crenatus* occurred in March and August, 1967, no such peak in settling was recorded in the same months of 1968 (Haderlie, 1968b). Thus the data from the harbor and from open water are in agreement; no major seasonal settlement of *B. crenatus* occurred in 1968. The reason for this is not obvious. The water temperature and salinity recorded in 1968 was not much different from the previous year (Figure 1). This shows again that one must make observations over a number of years before one can generalize regarding season of settling of fouling organisms.

The small acorn barnacle *Chthamalus dalli* was recorded fairly regularly from panels exposed in the intertidal rack. The peak period of settlement was between February 15 and March 15, 1968, when over 100 barnacles settled on each side of a wooden intertidal panel. It was interesting to note that the barnacles settled only on the dark areas of the wood and on pencilled letters used for marking the panels. Perhaps a very dark board or a panel of asbestos board would have collected many more of these.

Other barnacles recorded from Short Term Panels were a few specimens of *Balanus glandulus,* one of *B. tintinnabulum* and one of *Lepas anatifera.*

Mollusca:

The nestling clam *Hiatella arctica* was commonly found on Short Term Panels as a tiny, freely-moving organism. In the spring months there were often dozens of these on every panel. *Pododesmus cepio* was also found fairly regularly throughout the year, but only in small numbers. *Mytilus edulis,* a dominant animal on the pilings of the Wharf, settled only occasionally on Short Term Panels. Many nudibranchs were found but of these only *Hermissenda crassicornis* was of regular occurrence.

Echinodermata:

Small green sea urchins were recorded on most panels during the spring and summer months. These were invariably so small as to make specific identification impossible.

Chordata (Tunicata):

As was true in the previous year, during 1967-1968 no tunicates settled on the Short Term Panels, yet, as will be seen, did settle on the Long Term and Cumulative Panels. This again confirms what Scheer (1945) and others have found, namely, that tunicates settle only on surfaces that have been colonized by earlier foulers such as bryozoans.

II. DEPTH PREFERENCE

As can be seen from Table 1, most of the organisms encountered in this survey showed little preference for panels at different depths, and any one organism could be found on panels at all depths at one time or another. Exceptions to this generalization, however, were found among certain of the encrusting bryozoa. *Tubulipora pacifica,* for example, was exceedingly common on the continually submerged panels, but was found on only one occasion on an intertidal panel. *Celleporaria brunnea* was also common on submerged panels, especially the shallow panels, but rare on the intertidal ones. *Crisulipora occidentalis* definitely preferred the deep panels. On the other hand, the barnacles *Balanus glandula* and *Chthamalus dalli* were found only on intertidal panels.

III. DISCUSSION of ORGANISMS SETTLING on LONG TERM and CUMULATIVE PANELS

Table 2 presents data collected from Long Term and Cumulative Panels during 1967-1968. As indicated in Figure 2 and discussed earlier in this paper, the panels designated Long Term Panels were those that were immersed in racks suspended one foot below low tide level. Most of these panels were exposed for 3 month periods, one being submerged on the first of every month throughout the year and removed for analysis 3 months later. A second group of 4 Long Term Panels in the same rack remained in the water for 6 months; one panel was immersed on October 1, a second on January 1, a third on April 1 and the fourth on July 1.

Cumulative Panels, on the other hand, were submerged at the 3 depths discussed earlier in connection with Short Term Panels, namely in intertidal, shallow and deep racks. All the Cumulative Panels were submerged at the same time on October 1, 1967. From each of 3 racks one panel was removed at the end of 3 months, 6 months, 9 months and finally at the end of 12 months. The data from these panels are given in Table 2, right side. The reason there is no column for data from shallow panels at 3 and 6 months is that these data were incorporated into the

appropriate 3 or 6 month columns under Long Term Panels.

On these Long Term and Cumulative Panels a total of 88 different animals identified at least to genus were recorded. This was about the same total number as found in 1966-1967, but the list does include several animals not recorded earlier, particularly foraminiferans. And because none of the panels was exposed to bright light, no benthic algae were found on the 1967-1968 series.

In the discussion that follows, the dominant animals of each major group that settled in any numbers on the Long Term and Cumulative Panels will be discussed briefly.

Protozoa:

A total of 15 different kinds of benthic foraminiferans were recorded during the year. Many of these were found on only one or two occasions, but *Cornuspira lajollensis* was found regularly throughout the year and often was present in great numbers.

The ciliate *Folliculina* sp. was also exceedingly common throughout most of the year. On Cumulative Panels in the deep rack removed after 3, 6, 9, and 12 months, this large ciliate was often one of the dominant foulers in terms of numbers of animals present. On the deep panel removed on January 1, 1968, after 3 months exposure, *Folliculina* was present in thousands and blackened the surface of the panel. The same was true of a shallow panel removed April 1, 1968.

Porifera:

The sponge *Leucosolenia eleanor* was encountered on nearly all of the panels except the Cumulative Panels exposed in the intertidal. The anastomosing tubes often formed large clusters 5 cm or more in diameter on panels in the water for 3 months or more. Large globular specimens of *Leuconia heathi* up to 3 cm in diameter were present in fair numbers on deep panels in the water for 6 months, and on the 9-month panel it was second only to the bryozoan *Crisulipora occidentalis* as the dominant organism.

Coelenterata:

No coelenterates were common on the panels. *Obelia* sp. was found sporadically, but only on an intertidal panel in the water 6 months was it ever abundant. *Metridium senile* was recorded only twice: on an intertidal and a deep panel exposed 3 months beginning October 1, 1967. On each panel there was a single anemone 1 cm in diameter. It is surprising that more individuals of *Metridium* did not settle on the panels, for this anemone along with *Corynactis californica* Carlgren, 1936, is among the dominant fouling organisms on the wharf pilings near the position where the collecting panels were exposed. It is possible that a new surface must be in the water for a period much greater than 12 months before it is suitable for settlement of these anemones. In the 1966-1967 survey, *Corynactis* was encountered a few times on panels in the water 9 months or more, but this past year none were recorded.

Platyhelminthes:

Six species of flatworms were found on the Long Term and Cumulative Panels but of these only *Thysanozoon californicum* was common. This very unusual flatworm is papillated on the dorsal surface and in color and texture closely matches the encrusting bryozoan *Celleporaria brunnea* on which it lives. The worm is elliptical in outline and the largest individuals seen were 10 mm long. *Thysanozoon* was encountered regularly, especially on the 3 and 6 month Long Term Panels, and throughout the year except for late spring and early summer. Never was *Thysanozoon* found on a panel unless *Celleporaria* was established there, and in all cases the flatworm was found pressed tightly against the bryozoan colony. It was found to be very sluggish and moved only when prodded. When the flatworm was loosened and turned over it was often seen to have the pharynx extended and pressed over the zooids and in many cases the zooecium had turned white in color and the living zooids were gone. This indicates strongly that *Thysanozoon* feeds directly on the zooids of *Celleporaria*.

Ectoprocta (Bryozoa):

As can be seen in Table 2, the bryozoans were clearly the dominant fouling animals on the Long Term and Cumulative panels during the 1967-1968 year as they had

Explanation to Table 2 (foldout, facing this page ⟶)

[1] Symbols used at head of columns indicate:
- 3L1, 3L2, ... 6L1, 6L2, etc. = Panel numbers as designated in Figure 2
- I = Intertidal panels
- S = Shallow panels
- D = Deep panels

[2] Symbols used in columns indicate:
- 1 = species present in numbers from 1 to 10 individuals or colonies per panel side
- 2 = species present in numbers from 11 to 20 individuals or colonies per panel side
- 3 = species present in numbers upward from 20 individuals or colonies per panel side