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TITLE

MARINE FOULING RESEARCH, A STATE-OF-THE-ART REPORT

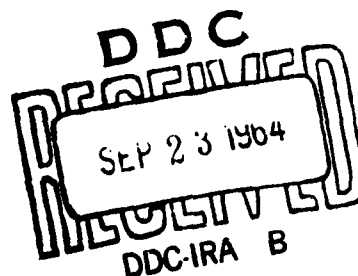
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MARINE SCIENCES DEPARTMENT
U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

ABSTRACT

This report is concerned with the present state of research on the ecology of marine fouling communities and the effects of fouling attachment on the performance of underwater equipment. An assessment is made of the amount and types of data in existence, the adequacy of these data, and the research methods involved in collecting and analyzing these data. An annotated listing of references is provided to show the extent and variety of fouling intelligence presently in existence and to provide a basic source of information directly related to practical fouling problems.

BACKGROUND

One of the most serious of the biological activities currently presenting problems to naval operations is the fouling and deterioration of submerged equipment and structures. Biological fouling is the assemblage of marine organisms that attaches to and grows upon underwater objects. The term fouling is generally limited to situations in which the results of the attachment may be considered harmful although there are recognized beneficial aspects as well.

Marine fouling is one of the oldest biological problems known to mariners and is the subject of written records dating to the fifth century B.C. (135). However, modern scientific investigation of sessile organisms did not begin until the mid-19th century when Edward Forbes and C. G. J. Peterson began designating marine biotopes by indigenous species of plants and animals. During this period, Kirchenpauer (62) performed what probably was the first comprehensive study of the fouling community when he compiled a list of 84 species from navigation buoys in the Elbe River. The use of test panels was introduced a short time later when Dahl (21) exposed wooden blocks in the Elbe to determine the time and rate of settling of fouling organisms.

FOULING EFFECTS

While the problems of fouling on ships' bottoms are well documented, the impairment of operation or the destruction of other kinds of military hardware by marine organisms only recently has been considered and is less well understood. Fouling will affect the hydrodynamic characteristics of sonar domes, resulting in an increase in water noise (24). Fouling is known to have an acoustic damping effect on underwater transducers, often reducing their sensitivity by as much as 10 db (36, 109, 119). Barham (6) reported that fouling on sound projectors and receivers will cause serious acoustic energy losses. More recently, oceanographic sensors have been affected by fouling organisms. Texas A and M University (107) noted that coelenterate fouling affected the movement of current meter rotors after 63 days of operation in the Gulf of Mexico. The U. S. Naval Oceanographic Office (112) found that after 120 days of unattended exposure in Penobscot Bay, Maine, electrical conductivity cells were desensitized by fouling organisms, resulting in salinity errors in excess of 4.0 parts per thousand.

Fouling has been shown to be damaging to protective coatings intended to reduce corrosion (37, 135). Some fouling organisms increase the corrosion rate of unprotected metal by the creation of oxygen concentration cells at points of adhesion. This has been shown to cause penetration of 1/16th inch stainless steel (tenslon) panels after only 111 days of marine exposure (125). The increase in acid metabolic products caused by dying members of the fouling community create a condition favorable to corrosion (106). Exposed moving parts may cease to function properly if appreciably fouled (116, 119), and it has been shown that moored mines will dip below

their intended depth after only 6 months because of the increase in resistance to water movement created by fouling growth (72, 110, 117).

While antifouling coatings adequately protect ships' hulls during the periods between drydockings, there are situations where this protection is entirely lacking or short term at best. Windows, sensor covers, moving parts, wire rope and cable, hydrofoil and other high speed surfaces (9), and conduits and water mains (98) are particularly difficult or impossible to protect effectively. A maintenance-free life of from 5 to 10 years required for underwater surveillance systems cannot be guaranteed by the present state of antifouling technology. A knowledge of the fouling community is required, therefore, for the proper design and maintenance of underwater installations.

FOULING RESEARCH ASSESSMENT

Extensive field studies have been performed and considerable information on the nature of the fouling community in various parts of the world has been published. These studies generally are fact-finding surveys at single locations to determine such fundamental information as seasonal succession, growth rates, and dominant organisms. These data are sometimes inadequate for the solution of practical fouling problems, however, because of the following serious shortcomings:

1. Insufficient areal coverage - The bulk of fouling investigations have been conducted in the temperate waters of the world. Data from tropical areas are less abundant and data from boreal areas are restricted almost exclusively to the Caspian and White Seas. Fouling data from deep water are almost non-existent; Dr. Sidney Galler of the Office of Naval Research has postulated, "the amount of data available on biological conditions in the ocean is inversely proportional to the depth of water".
2. Sites not representative - Fouling investigations traditionally are conducted off the ends of piers where the collected data often reflect local extremes of turbidity, pollution, temperature, and fresh water dilution. These harbor areas are not necessarily representative of the biological provinces in which they occur (Fig. 1).
3. Measurements not uniform - There has been no overall plan of research. For example, fouling data have been collected on wood, glass, slate, bakelite, concrete, steel, asbestos, plastics, and calcareous plates exposed vertically, horizontally, under rafts, or on permanent platforms. Experience has shown, however, that the tendency of different materials to foul is dependent on such variables as surface contour (20,73), texture and composition (7, 14, 91, 100, 132), color (124), and previous history (15). Fouling organisms also are influenced to attach by varying conditions of light (49, 71, 122, 126), water currents (18, 19, 32, 71, 102), gravity (53), stage of tide (38, 126), presence of other sessile organisms (22, 64, 80, 127), and angle of inclination of the surface (53,90). The collected data have been expressed as weight in water, wet weight in air, dry weight in air, alcohol wet weight, ash weight,

volumetric displacement, total volume, percent coverage, thickness, relative abundance, and combinations of the above. Critical evaluation is difficult when comparing investigations performed with different collectors or with non-standard techniques of exposure or analysis.

4. Investigations mostly short term - Most investigations have been carried out for only one season or one year, which may result in an atypical picture of the biological conditions for that locality. Coe and Allen (15), in summarizing 9 years of observations on the growth of sedentary organisms at a pier in LaJolla, California remarked that "each of the nine years has shown certain peculiarities both in the periodicity and in the abundance of some of the organisms found on the experimental blocks and plates." Loosanoff and Romejko (67) also noted that in 2 of 15 years studied, oyster set was as much as 40 times greater than in preceding years. Research must extend over a considerable number of years before normal or mean fouling conditions can be determined.

5. Environmental data lacking - Supplementary environmental data are lacking in some investigations. A meaningful fouling program should provide not only data concerning the composition, areal distribution, and seasonal accumulation of the biomass but observations of the chemical and physical environment as well. With the establishment of a productive basic ecological program in the various biological provinces, trends will appear in the occurrence and distribution of various foulers. As parallel trends in the environment become apparent, relationships can be postulated which will facilitate prediction of the type and degree of fouling in areas where no fouling data are available.

6. Qualitative information on the effects of fouling limited - Very little qualitative information is available on the effects of fouling and biological deterioration on sensors and other underwater equipment. A program to determine these effects is required in order to effectively relate fouling conditions to equipment performance.

FOULING COMMUNITY INDEX

An annotated listing of marine fouling community studies is provided in Appendix I. The term "marine fouling community studies" is defined here as one in which data, primarily concerned with the ecology of the fouling community, are obtained from test panels exposed at depths below mean low water. Presented in Appendix II is a representative selection of fouling investigations in which the ecology of the fouling community was of secondary concern or where surfaces other than test panels were employed. These appendices, plus the references in the text of this report, show the extent and variety of fouling community intelligence presently in existence and provide a basic source of information directly related to practical fouling problems. Not included are references to tidal zone investigations (which are concerned with a separate and distinct biotope) and basic studies of the biology and behavior of individual organisms (which are the subject of an extensive literature and beyond the scope of this report). Bibliographic information on these subjects is available in the Prevention of Deterioration Center bibliographies (92,93,94) and in "Marine Fouling and its Prevention" (135).

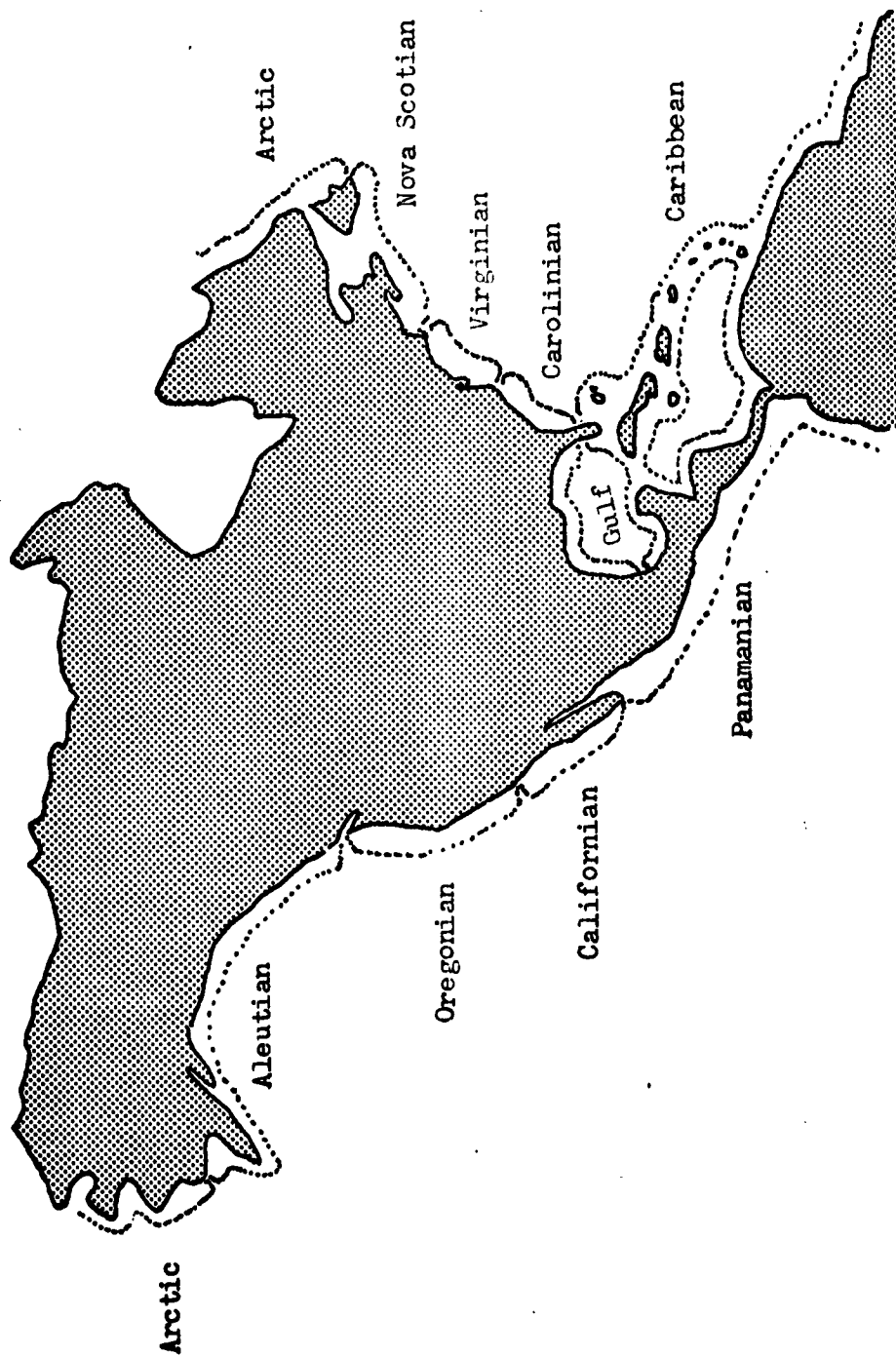


FIGURE 1 - MAJOR DIVISIONS OF THE COASTAL WATERS OF NORTH AND CENTRAL AMERICA
(Principally according to Valentine)

REFERENCES

1. ALEEM, ANWAR ABDEL. Succession of marine fouling organisms on test panels immersed in deep water at La Jolla, Calif. *Hydrobiologia* 11(1): 40-58, 1957.
2. ALEXANDER, A. L., B. W. FORGESON, H. W. MUNDT, C. R. SOUTHWELL, and L. J. THOMPSON. Corrosion of metals in tropical environments. Part 1 - Test methods etc. NRL Report 4929. U. S. Naval Research Laboratory. Wash. D. C. 1957.
3. ANDREWS, J. D. Fouling organisms of Chesapeake Bay, Interim report #17 on the Inshore Survey Program (Ref #53-3). Chesapeake Bay Institute, Johns Hopkins Univ. 1953.
4. AYERS, J. C. The average rate of fouling of surface and submerged objects in the waters adjacent to New York harbor. Status report #66 Cornell Univ. 1951.
5. BALAKRISHNAN, NAIR N. Ecology of marine fouling and boring organisms of Western Norway. *Sarsia* 8, 1-88. 1962.
6. BARHAM, E. G. Effects of marine biological environment on compliant grating acoustic lenses. Research Report 1018, U. S. Navy Electronics Laboratory, San Diego, California. 6 March 1961.
7. BARNES, H., and H. T. POWELL. Some observations on the effect of fibrous glass surfaces upon the settlement of certain sedentary marine organisms. *Jour. Mar. Biol. Assoc. U. K.* Vol. 29(2): 299-302. 1950.
8. BENGOUGH, G. D., and V. G. SHEPHEARD. The corrosion and fouling of ships. The Iron and Steel Institute, Marine Corrosion Subcommittee. Paper #1, 15 April 1943.
9. BUKZIN, ELLIOT. U. S. Navy Bureau of Ships, Personal communication. 1964.
10. BUSH, JAMES. General Electric Company, Rochester, N. Y. Personal communication. 1961.
11. CAREY, A. G. Jr. Oregon State Univ. Corvallis, Oregon. Personal communication, 25 Sept. 1962.
12. CASTLE, E. S. Electrical control of marine fouling. *Industrial and Engineering Chemistry*, Vol. 43, 901-904. 1951.
13. CHADWICKE, W. L., F. S. CLARKE, and D. L. FOX. Thermal control of fouling at Redondo. Scripps Institution of Oceanography Contribution #425. La Jolla, California. 1949.

14. COE, W. R. Season of attachment and rate of growth of sedentary marine organisms at the pier of Scripps Institute of Oceanography, LaJolla, California. Bull. SIO Tech ser 3, #3, 37-86. 1932.
15. COE, W. R. and W. E. ALLEN. Growth of sedentary organisms on experimental blocks and plates for nine years at Scripps pier, Bull. SIO Tech ser. 4. #4. 1937.
16. CORLETT, J. Rates of settlement and growth of pile fauna of the Mersey estuary. Proc. Trans. Liverpool Biol. Soc. Vol. 56, 3-28. 1948.
17. CORY, ROBERT L. Environmental factors affecting attached macro-organisms, Patuxent River estuary, Maryland. Art. 165 In U. S. Geol. Survey Prof. Paper 475-D, pages D194-D197. 1964.
18. CRISP, D. J. Changes in orientation of barnacles of certain species in relation to water currents. Journal of Animal Ecology Vol. 22, 331-343. 1953.
19. CRISP, D. J. The behavior of barnacle cyprids in relation to water movement over a surface. Journal Exp. Biol. Vol. 32, 569-590. 1955.
20. CRISP, D. J., and H. BARNES. The orientation and distribution of of barnacles at settlement with particular reference to surface contour. Journal of Animal Ecology Vol. 23, 142-162. 1954.
21. DAHL, FRIEDRICH. Untersuchungen uber die Thierwelt der unterelbe. Jahresb. comm. wiss. unters. deuts. Meere Kiel Vol. 6(1887-1891) 151-185. 1893.
22. DANIEL, A. Gregarious attraction as a factor influencing the settlement of barnacle cyprids. Madras Univ. Journal Vol. 25B, 99-107. April 1955.
23. DAUGHERTY, F. M. Jr. Marine Biological Fouling in the approaches to Chesapeake Bay. Technical Report #96, U. S. Navy Hydrographic Office, Washington, D. C. 1961.
24. DEFENSE RESEARCH BOARD OF CANADA. The effect of fouling on frigate class A/S vessels. 1950.
25. DE PALMA, JOHN R. Field results of the first year of a bottom fouling study in Penobscot Bay, Maine. IMR #0-34-62. U. S. Navy Hydrographic Office, Washington, D. C. June 1962(a).

26. DE PALMA, JOHN R. Field results - Panama Canal Zone Fouling Project O-11, 1957-1959. IMR #O-33-62. U. S. Navy Hydrographic Office, Washington, D. C. June 1962(b).
27. DE PALMA, JOHN R. Results of a Deep-Sea fouling and corrosion pretest in the Tongue-of-the-Ocean. IOM #13-62. U. S. Navy Hydrographic Office, Washington, D. C. March 1962(c).
28. DE PALMA, JOHN R. Marine fouling and boring organisms in the Tongue-of-the-Ocean, Bahamas. IMR #O-64-62. U. S. Naval Oceanographic Office, Washington, D. C. October 1962(d).
29. DE PALMA, JOHN R. Marine fouling and boring organisms off Fort Lauderdale, Florida. IMR #O-70-63. U. S. Naval Oceanographic Office, Washington, D. C. April 1963(a).
30. DE PALMA, JOHN R. Marine fouling and boring organisms off Southern Sardinia. IMR #O-57-63. U. S. Naval Oceanographic Office, Washington, D. C. December 1963(b).
31. DEXTER, RALPH, W. Fouling organisms attached to the American lobster in Connecticut waters. Ecology Vol. 36, #1, 159-160. 1950.
32. DOOCHIN, H and F. G. W. SMITH. Marine boring and fouling in relation to velocity of water current. Bull. Mar. Sci. Gulf and Carib. Vol. 1, #3, 196-208. 1951.
33. EBERHARDT, ROBERT. Lockheed-California Co., Burbank. California. Personal communication. 1964.
34. EDMONDSON, C. H. Incidence of fouling in Pearl Harbor, Honolulu, Hawaii. Bernice P. Bishop Museum Occasional Papers Vol. 18, #1. 1944.
35. EDMONDSON, C. H. and W. M. INGRAM. Fouling organisms in Hawaii. Bernice P. Bishop Museum occasional papers Vol. 14, 251-300. 1940.
36. FITZGERALD, J. W., M. S. DAVIS and B. G. HURDLE. Corrosion and fouling of sonar equipment. Part I. NOL Report #82477. U. S. Naval Ordnance Laboratory. Washington, D. C. 1947.
37. FORGESON, B. J. Marine Corrosion Section, U. S. Naval Research Laboratory. Washington, D. C. Personal communication. 1963.

38. FRASER, J. H. The fauna of fixed and floating structures in the Mersey estuary and Liverpool Bay. Proc. Trans. Liverpool Biol. Soc. Vol. 51. 1-21. 1938.
39. FULLER, J. L. Season of attachment and growth of sedentary marine organisms at Lamoine, Maine. Ecology Vol. 27, 150-158. 1946.
40. GANAPATI, P. N., M. V. LAKSHMANA RAO, and R. NAGABHUSHANAM. Biology of fouling in Visakhapatnam harbour, Andhra. Univ. Mem. Ocean. ser #62, Vol. 2, 193-209. 1958.
41. GOODBODY I. Inhibition of the development of a marine sessile community. Nature Vol. 190, 282-283. April 1961.
42. GOODBODY, I. The development of a tropical marine sessile community. Paper presented at AIBS meeting, Amherst, Mass. August 1963.
43. GRAHAM, H. W. and H. GAY. Season of attachment and growth of sedentary marine organisms at Oakland, California. Ecology Vol. 26, #4, 375-386. 1945.
44. GRAVE, B. H. Rate of growth, age at sexual maturity, and duration of life of certain sessile organisms, at Woods Hole, Mass. Biol. Bull. Vol. 65, #3, 375-386. 1933.
45. GRAY, G. M. Buoy collecting 1937-1940. Unpublished manuscript, Marine Biological Laboratory, Woods Hole, Mass. 1940.
46. GRAY, KENNETH O. Effects of the deep-ocean environment on materials - A progress report. Technical note N-446, U. S. Naval Civil Engineering Laboratory, Port Hueneme, California. 1962.
47. GREAT BRITAIN ADMIRALTY CORROSION COMMITTEE. Fouling in Deep waters - H.M.S. AFFRAY. Report #ACC/F21/52. 1952.
48. GREAT BRITAIN ADMIRALTY CORROSION COMMITTEE. Season of settlement of sedentary marine organisms at Kuwait, Persian Gulf. Report #ACC/F42/54. 1954.
49. GREGG, J. H. Background illumination as a factor in the attachment of barnacle cyprids. Biol. Bull. Vol. 88, 44-49. 1945.
50. GUNTER, GORDON, and R. A. GEYER. Studies on fouling organisms of the Northwest Gulf of Mexico. Publ. Inst. Mar. Science Vol., 4. (1):37-87. 1955.

51. HOSHIAI, TAKAO. On the forming process of the marine sedentary community. Ecol. Review. Vol. 14(2): 191-197. 1956,
52. HIRANO, REIJIRO, and JUN OKUSHI. Studies on sedentary marine organisms. 1. Seasonal variations in the attachment and growth rates of barnacle cyprids in Aburatsubo Bay, near Misaki. Japan Soc. Sci. Fisheries Bull. 18, 639-644. 1952.
53. HOPKINS, A. E. Attachment of larvae of Olympia oyster (Ostrea lurida) to plane surfaces. Ecology Vol. 16:82-87. 1931.
54. HUDSON, J. Raft tests. Iron and Steel Institute Journal. Vol. 147. 1943.
55. HUTCHINS, L. W. and E. S. DEEVEY Jr. Estimation and prediction of the weight and thickness of mussel fouling on buoys. WHOI Interim Report #1, Woods Hole, Mass. 1944.
56. IREDALE, T., R. A. JOHNSON. Destruction of timber by marine organisms in the port of Sydney. Sydney Harbor Trust, Sydney Australia. 1934.
57. ITO, TAKEO. Marine sedentary communities with special references to the succession in the Inland Sea of Japan. Bull. Mar. Biol. Sta. Asamushi, Tohoku Univ. Vol. 9(4); 161-165. 1959.
58. IZUPUCHI, T. Increase in hull resistance through shipbottom fouling. Zosen Kikokai, Vol. 55. December 1934.
59. JEFFREYS, J. C. Submarine cable fauna. Annals and Magazine of Natural History, Vol. 15, (4):169-176. March 1875.
60. JOHNSON, M. W. and R. C. MILLER. The seasonal settlement of shipworms, barnacles, and other wharf-pile organisms at Friday Harbor, Washington. Univ. of Wash. Publ. in Oceanography, #2-5-18. 1935.
61. KETCHUM, B. H., C. M. WEISS, and G. KELLY. The seasonal incidence of fouling at various locations along the Atlantic coastline 1940-41. Fifth semiannual report to BUSHIPS, paper #6 Woods Hole Oceanographic Institution, Woods Hole, Mass. 1942.
62. KIRCHENPAUER, J. U. Die seetonnen der Elbmerndung. Abhandl. a.d. Gebiete d. Naturwiss. her. v.d. naturwiss. Ver. in Hamburg Vol. 4(4): 1-59. 1862.

63. KOMAROVSKY, B., and L. SCHWARZ. History and progress of research in ship fouling, Israel. Unpublished paper, U. S. Naval Attache Tel Aviv. 1958.
64. KNIGHT-JONES, E. W., and D. J. CRISP. Gregariousness in barnacles in relation to the fouling of ships and to antifouling research. Nature Vol. 171, 1109-1110. 1953.
65. KURIYAN, O. K. Biology of the fouling in the Gulf of Mannar (India): a preliminary account. Ecology Vol. 34(4): 689-692. 1953.
66. LEBEDEV, E. M. Marine fouling on vessels cruising the Sea of Azov and Kerch' Strait. Trudy Instituta Okeanologii, Vol XLIX, 118-136, Moscow. 1961.
67. LOOSANOFF, V. L., and C. A. ROMEJKO. Relative intensity of oyster setting in different years in the same areas of Long Island Sound. Biol. Bull. Vol. 3(3): 387-392. 1956.
68. LUNZ, C. ROBERT JR. Periodicity of fouling growths at Cavite, Philippine Islands and at Guantanamo Bay, Cuba. Report to the Bureau of Construction and Repair. S19-1(3), 2. 13 June 1940.
69. LUNZ, G. ROBERT JR. Report on damage to floating drydock in Charleston Harbor, S. C., due to fouling organisms. Report to the Bureau of Construction and Repair. 1945.
70. MALONEY, WILLIAM F. A study of types, seasons of attachment and growth of fouling organisms in the approaches to Norfolk, Virginia. Technical Report #47. U. S. Navy Hydrographic Office. May 1958.
71. MCDOUGALL, K. D. Sessile marine invertebrates of Beaufort, N. C., a study of settlement, growth and seasonal fluctuations among pile dwelling organisms. Ecol. Monographs Vol. 13(3): 321-374. 1943.
72. MCMAHON, JAMES P. Steady and oscillatory flow forces on a mark 6 moored mine. Masters thesis, U. S. Naval Post Graduate School, Monterey, California. 1956.
73. MESSINEVA, M. A. and V. I. USPENSKAYA. Development of fouling communities in relation to the quality and form of the artificial surface. Biotsenozy obrastaniya v kachestve biopoglotitelya 181-197. 1961.

74. MILLARD, N. Observations and experiments on fouling organisms in Table Bay Harbour, South Africa. Trans. Roy. Soc. South Africa. Vol. 33(4). 1952.
75. MILLIGAN, SYDNEY, and R. S. AUSTIN. Observations of environmental effects on a deep-sea acoustic array. TM #319, U. S. Naval Underwater Ordnance Station, Newport, Rhode Island. April 1964.
76. MILNE, A. The ecology of the Tamar Estuary. IV. The distribution of the fauna on buoys. Jour. Mar. Biol. Assoc. U. K. Vol. 24, 69-87. 1940.
77. MIYAZAKI, I. On fouling organisms in the oyster farm. Bull. Jap. Soc. Sci. Fisheries, Vol. 6. 223-232. 1938.
78. MOSHER, L. M. Marine borers and fouling organisms and their prevalence in the vicinity of Bethlehem Shipyard properties. Bethlehem Steel Co., Shipbuilding Division, Quincy, Mass. Research Report #22, 21 May 1945.
79. MOTT, J. C. Report on the seasonal settlement of fouling at various exposure stations. Corrosion Committee Report N17/44, British Iron and Steel Institute. October 1944.
80. NAGABHUSHANAM, R. A note on the inhibition of marine woodboring molluscs by heavy fouling accumulation. Sci. and Culture Vol. 26. 127-128. Sept. 1960.
81. NARRAGANSETT MARINE LABORATORY. Biology of marine fouling growths on and adjacent to the bottom. Fouling Project Progress Report by Donald J. Zimm, Richard Wood, and H. Berkowitz. Kingston, Rhode Island. 1957.
82. NARRAGANSETT MARINE LABORATORY. Final Report - Acoustical fouling project, by Harold Berkowitz, W. Birch and others. Kingston, Rhode Island. 1957.
83. ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT. Hydrological and biological conditions in testing stations in Europe. Vol. I. by M. Romanovsky, Director of Oceanographic Study and Research Center, Paris, France. 1961.
84. ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT. Hydrological and biological conditions in testing stations outside of Europe. Vol. II. by M. Romanovsky, Director of Oceanographic study and research center, Paris, France. 1961.
85. ORTON, J. H. Some experiments on the rate of growth in a Polar region (Spitzbergen), and in England. Nature Vol. CXI, 1933.

86. PARKER, G. H. The growth of marine animals on submerged metals. Biol. Bull., Woods Hole, Vol. 47, 127-142. 1924.
87. PAUL, M. D. Studies on the growth and breeding of certain sedentary organisms in the Madras Harbour. Proc. Indian Acad. Science, Sec. B. Vol. 15, 1-24. 1942.
88. PETERSON, C.G.J. Valuation of the sea. II. The animal communities of the sea bottom and their importance for marine zoogeography. Rept. Danish Biol. Sta. #21, 1-68. 1914.
89. PHELPS, A. Observations on fouling on test panels at Port Aransas Texas. Report to BUSHIPS, S19-1-(3), 1941.
90. POMERAT, C. M. and E. R. REINER. The influence of surface angle and light on the attachment of barnacles and other sedentary organisms. Biol. Bull. Woods Hole, Vol. 82 (1): 14-25. 1942.
91. POMERAT, C. M. and C. M. WEISS. The influence of texture and composition of surface on the attachment of sedentary marine organisms. Biol. Bull. Woods Hole, Vol. 91, 57-65. 1946.
92. PREVENTION OF DETERIORATION CENTER. Marine Deterioration and fouling, an introductory bibliography. PDC Search #58-034. National Academy of Sciences, Washington, D. C. December 1958.
93. PREVENTION OF DETERIORATION CENTER. Fouling by marine animals and antifouling methods. PDC Search #62-049 prepared by Richard W. H. Lee, National Academy of Sciences, Washington, D. C. October 1962.
94. PREVENTION OF DETERIORATION CENTER. References pertaining to Deep-sea corrosion and marine fouling. PDC Search #62-008 prepared by Robert G. Lyle. National Academy of Sciences, Washington, D. C. April 1962.
95. RICHARDS, A. P. William F. Clapp Laboratories, Duxbury, Massachusetts. Personal communication. 1963.
96. RICHARDS, B. R. and WILLIAM F. CLAPP. A preliminary report on fouling characteristics at Ponce de Leon Inlet, Daytona Beach, Florida. Journal of Marine Research Vol. 5 (3): 189. 1944.
97. RICHARDS, B. R. A study of the marine borers and fouling organisms at Wilmington, N. C. William F. Clapp Laboratories Bulletin #12, 28 May 1943.
98. RUSSELL, HAROLD JR. U. S. Navy Bureau of Yards and Docks, Washington, D. C. Personal communication. 1964.

99. SAITO, T. Research in fouling organisms of the ships bottoms.
Journal Jap. Soc. Naval Arch. Vol. 47, 13-64. 1931.
100. SCHEER, B. T. and D. L. FOX. Attachment of sedentary marine
organisms to petrolatum surfaces. Proc. Soc. Exp. Biol. and
Med. Vol. 65, 92-95. 1947.
101. SKADOVSKII, S. N., M. A. MERSINEVA, and V. I. USPENSKAYA.
Seasonal quantitative fluctuations in fouling communities.
Biotsenozy obrostanii v kachestve biopoglotitelya, 143-180. 1961.
102. SKERMAN, T. M. Marine fouling at the Port of Lyttelton. New
Zealand Journal Sci. Vol. 1 (2): 224-257. 1958.
103. SMITH, C. H. Goodyear Aerospace Co., Akron, Ohio. Personal
communication. 1961.
104. SMITH, F. G. WALTON. The effects of water currents upon the attach-
ment and growth of barnacles. Biol. Bull. Woods Hole, Vol. 90
(1): 51-70. 1946.
105. SMITH, F. G. WALTON, R. H. WILLIAMS, and C. C. DAVIS. An ecological
survey of the sub-tropical inshore waters adjacent to Miami.
Ecology Vol. 31 (1): 119-146. 1950.
106. SNOKE, L. R. Resistance of organic materials and cable structures
to marine biological attack. The Bell System Technical Journal
Vol. 36, 1095-1127. 1957.
107. TEXAS A and M UNIVERSITY. Status of environmental research off
Panama City, Florida, by Roy Gaul. 25 January 1963.
108. TURNER, H. J. Jr. Marine Biological Laboratory, Woods Hole,
Massachusetts. Personal communication. 1964.
109. URICK, R. J. Acoustic effects of marine fouling on transducers.
NOLTR #62-185, U. S. Naval Ordnance Laboratory, Washington
D. C. November 1962.
110. U. S. OFFICE OF NAVAL OPERATIONS. The mark 6 moored minefield
at Casablanca, French Morocco. Washington, D. C.
13 December 1945.
111. U. S. MARE ISLAND NAVAL SHIPYARD. Fouling conditions at test
stations Point Reyes, California. Mare Island test #305.
Vallejo, California. 1957.
112. U. S. NAVAL OCEANOGRAPHIC OFFICE. Research in progress.
Penobscot Bay, Maine. 1962.

113. U. S. NAVAL OCEANOGRAPHIC OFFICE. Research in progress. Puget Sound, Washington. 1963.
114. U. S. NAVAL OCEANOGRAPHIC OFFICE. Research in progress, Argentina, Newfoundland and San Juan, Puerto Rico. 1964.
115. U. S. NAVAL ORDNANCE LABORATORY. Report #1035. Washington, D.C. January 1946.
116. U. S. NAVAL ORDNANCE LABORATORY. Mine warfare and marine fouling. NOL report #957. Washington, D. C. 1944.
117. U. S. NAVAL ORDNANCE LABORATORY. Interim report on recommendations regarding anticorrosion and antifouling measures for mines. NOLM #4145, by C. E. Moritz. August 1943.
118. U. S. NAVAL STATION, GUANTANAMO. Investigations of the periodicity of fouling attachment. Letter to Bureau Construction and Repair. C and R 19-1-(3). October 1936.
119. U. S. NAVAL SHIPYARD, MARE ISLAND. Results of panel test of periodicity of fouling at Dutch Harbor, Alaska. Letter to Construction and Repair. October 1940.
120. U. S. NAVY BUREAU OF YARDS AND DOCKS. Marine boring and fouling organisms at 56 important harbors. NAVDOCKS TP-Re-1. Washington, D. C. 1951.
121. VALENTINE, JAMES W. Biogeographic units as biostratigraphic units. Bull. Amer. Assoc. Pet. Geol. Vol. 47 (3) Pt. I 457-466. March 1963.
122. VISSCHER, J. PAUL. Nature and extent of fouling on ships bottoms. Bull. U. S. Bureau Fisheries, Vol. 43 (2): 193-252. 1928.
123. VISSCHER, J. PAUL. Report of fouling experiments at Pearl Harbor Navy Yard, Honolulu, T. H. Bureau of Ships library R-12 to R-21 inclusive. 1937.
124. VISSCHER, J. PAUL and R. H. LUCE. Reactions of the cyprid larvae of barnacles to light with special reference to spectral colors. Biol. Bull. Woods Hole Vol. 54, 335-350. 1928.
125. WALDRON, LEO J., M. H. PETERSON, and B. F. BROWN. Preliminary experiments on Deep-Sea corrosion and corrosion prevention. NRL Memorandum Report 1242. Washington, D. C. November 1961.
126. WEISS, CHARLES M. The effect of illumination and stage of tide on the attachment of barnacle cyprid. Biol. Bull. Woods Hole Vol. 93, 240-249. 1947.

127. WEISS, CHARLES M. An observation on the inhibition of marine wood destroyers by heavy fouling accumulation. Ecology Vol. 29 (1):120. 1948.
128. WEISS, CHARLES M. The seasonal occurrence of sedentary marine organisms in Biscayne Bay, Florida. Ecology Vol. 29 (2): 153-172. 1948.
129. WHARTON, C. W. Report of the biologist, Norfolk Navy Yard. June 1941 - October 1942. Unpublished report to Bureau Construction and Repair. 1942.
130. WHEDON, W. F. Investigations pertaining to the fouling of ships' bottoms. Biological Laboratory, Navy Fuel Depot, San Diego, California. 1937.
131. WHEDON, W. F. Seasonal incidence of fouling at San Diego. Biological Laboratory, Naval Fuel Depot, San Diego, California. 1943.
132. WILSON, D. P. The influence of the nature of the substratum on the metamorphosis of the larvae of marine animals, especially the larvae of Ophelia bicornis. Annales Inst. Oceanography. Vol. 27 (2). 1952.
133. WISELY, B. Factors influencing the settling of the principal marine organisms in Sydney Harbour, Australia. Australian Jour. of Mar. and Freshwater Res. Vol. 10, 30-44, 1959.
134. WOOD, E. J. FERGUSON. Investigations on underwater fouling 1. The role of bacteria in the early stages of fouling. Australian Jour. of Mar. and Freshwater Res. Vol. 1 (1): 85-109. 1949.
135. WOODS HOLE OCEANOGRAPHIC INSTITUTION. Marine fouling and its prevention. U. S. Naval Institute, Annapolis, Md. 388p. 1952.
136. ZENKEVITSCH, L. A. Some observations on fouling in the Barents Sea. Bull., de la Soc. des Nat., Moscow, Sect. Biol., n.s. 44, 103-112. 1935.
137. ZEVINA, G. B. Caspian fouling communities and changes in them over the past 10 years (1951-61). Okeanologiya 2 (4): 715-726. 1962.

Appendix I

MARINE FOULING COMMUNITY STUDIES

REMARKS

LOCALITY

Western Atlantic Ocean
Argentina, Newfoundland

1964-continuing; wood-asbestos panels exposed offshore at depths of 50 to 140 feet for monthly and cumulative intervals up to one year; data expressed as numbers per panel per unit time, percent coverage, relative occurrence, dry weight in air, and rate of growth; temp and salinity data also collected.

114

Lamoine, Maine

Summer months 1943-44; weekly and cumulative shallow collections on asbestos panels exposed at pierside; data expressed as percent coverage, wet weight in air, dry weight in air, and numbers per panel per unit time; temp data also collected.

39

Rockland, Maine

1960-64; monthly and cumulative asbestos panels exposed offshore and pierside at several depths to 450 feet; data expressed as percent coverage, wet weight in air, dry weight in air, thickness, growth rate, and numbers per panel per unit time; temp, salinity, plankton, and transparency data also collected.

25

Duxbury, Mass.

1942-continuing; various materials exposed at pierside and beneath shallow rafts for monthly and cumulative periods; data expressed as percent coverage, relative abundance, and numbers per panel per unit time; temp and salinity data also collected.

95

Woods Hole, Mass.

Summer months 1922-32; short-term collections on glass slides, mollusk shells, stones, and bricks exposed at pierside; data expressed as numbers per panel per unit time, relative numbers, and rate of growth.

44

LOCALITY

REMARKS

REFERENCE #

Western Atlantic (Contd)

Woods Hole, Mass.

61

1940-41; monthly collections on glass slides exposed at pierside; data expressed as numbers per square foot per month; temp data also collected.

Narragansett Bay

81

1955-57; monthly and cumulative collections on mine cases and glass test panels exposed at pierside and in shallow water to depths of 28 feet; data expressed as wet weight in air, displacement volumes, and relative numbers; temp, salinity, plankton, and bottom sediment data also collected.

Patuxent River, Md.

17

1962-64; monthly and cumulative pierside collections on wood-asbestos panels; data expressed as percent coverage, numbers per unit area per unit time, ash weight, organic carbon content, and relative occurrence; temp, salinity, nutrients, and oxygen data also collected.

Chesapeake Bay

61

1940-41; monthly collections on glass slides exposed at pierside; data expressed as numbers per square foot per month; temp data also collected.

Chesapeake Bay

23, 70

1956-59; monthly and cumulative offshore collections (38 and 68 feet) on painted steel panels, metal stakes driven into the bottom; data expressed as numbers per square foot per unit time, wet weight in water, wet weight in air, dry weight in air, rate of growth, seasons of attachment, and relative occurrence; temp, salinity, transparency, and current data also collected.

Chesapeake Bay

129

1941-42; monthly pierside collections on glass panels; data expressed as wet weight in air; temp data also collected.

Beaufort, N. C.

61

1940-41; monthly collections on glass slides exposed at pierside; data expressed as numbers per square foot per month; temp data also collected.

LOCALITY

REMARKS

REFERENCE #

Western Atlantic (Contd.)

Beaufort, N. C.

1941-42; monthly and cumulative collections made on wooden and glass panels and hearth tiles; data expressed as numbers per panel per unit time, growth rates, and relative occurrence; temp data also collected.

71

Wilmington, N. C.

1940-43; monthly cumulative pierside collections made on wooden panels; data expressed as numbers per square foot per month.

97

Daytona Beach, Fla.

1942; monthly and cumulative collections made on wooden panels exposed at pierside; data expressed as numbers per square foot per unit time.

96

Fort Lauderdale, Fla.

1962-continuing; monthly and cumulative offshore collections at depths from 50 to 300 feet on wood-asbestos panels, data expressed as numbers per panel per month, thickness, growth rate, percent coverage, dry weight in air, and relative occurrence; temp, salinity, and current data also collected.

29

Biscayne Bay, Fla.

1945-46; monthly and cumulative pierside collections on glass panels; data expressed as numbers per square foot per month, percent coverage, and growth rates; temp, salinity, oxygen, and plankton data also collected.

105

Biscayne Bay, Fla.

1943-47; monthly and cumulative shallow water collections on glass panels; data expressed as number per square foot per unit time and rate of growth; temp and salinity data also collected.

128

<u>LOCALITY</u>	<u>REMARKS</u>	<u>REFERENCE #</u>
Gulf of Mexico		
Pensacola, Fla.	1940-41; monthly collections on glass slides exposed at pierside; data expressed as numbers per square foot per month; temp data also collected.	61
Port Aransas, Tex.	1940; collections made on glass panels exposed beneath a barge for various periods of time; data expressed as numbers per square centimeter per unit time.	89
Eastern Pacific Ocean		
Balboa, Canal Zone	1957-59; steel panels exposed pierside and offshore at depths from 10 to 50 feet for monthly and cumulative periods up to one year; data expressed as numbers per panel per unit time, percent coverage, thickness, wet weight in air, dry weight, relative occurrence, and growth rates; temp, salinity, and bottom sediment data also collected.	26
San Diego, Calif.	1939-43; concrete blocks exposed for one month periods at pierside; data expressed as numbers per square foot per month and wet weights in air; temp data also collected.	130, 131
LaJolla, Calif.	1928-32; wood and concrete panels exposed for varying lengths of time at pierside; data expressed as numbers per square foot per month, relative occurrence, and growth rates; temp data also collected.	14
LaJolla, Calif.	1926-35; glass and concrete panels exposed bimonthly and cumulative at pierside; data expressed as total volume; temp data also collected.	15
La Jolla, Calif.	1956; wood, plexiglas, vinyl, glass, brass, zinc, stainless steel, copper exposed for three months at a depth of 45 feet; data expressed as numbers per panel.	1

LOCALITYREMARKSREFERENCE #Eastern Pacific Ocean

San Francisco, Calif.

1934-45; monthly collections on concrete blocks exposed at pier side; data expressed as wet weights in air; temp and salinity data also collected.

111

Oakland, Calif.

1940-42; monthly and cumulative wooden panels exposed beneath a bridge; data expressed as numbers per square foot per unit time, total volume, rates of growth; temp and salinity data also collected.

43

Friday Harbor, Wash.

1928-30; monthly and cumulative wooden panels exposed at shallow sites; data expressed as relative abundance and seasonal occurrence.

60

2

Admiralty Inlet, Wash.

1963-continuing; monthly and cumulative wood-asbestos panels exposed offshore at various depths, 50 to 300 feet; data expressed as numbers per square foot per month, dry weight, percent coverage, and rates of growth; temp and salinity data also collected.

113

Caribbean Sea

Kingston, Jamaica

1960; various plastic materials exposed beneath rafts for periods of two and three months; data expressed as percent coverage, relative occurrence, and numbers per square foot per unit time; temp data also collected.

41, 42

Guantanamo Bay, Cuba

1936-38; wooden panels exposed at pier side for one month periods; data expressed as alcohol wet weights, dry weights, and relative occurrence; temp data also collected.

68

San Juan, Puerto Rico

1964-continuing, wood-asbestos panels exposed offshore at depths to 140 feet for monthly and cumulative intervals up to one year; data expressed as numbers per panel per month, percent coverage, relative occurrence, dry weight, and rate of growth; temp and salinity data also collected.

114

LOCALITY

REMARKS

REFERENCE #

Mid-Pacific Ocean

Oahu, Hawaii

1940-44; monthly and cumulative wood, glass, and various materials exposed at pierside; data expressed as numbers per panel per month, relative occurrence.

34, 35

Oahu, Hawaii

1935-36; wooden panels exposed at pierside for periods of one and two months; data expressed as wet and dry weights of individual foulers.

123

Western Pacific Ocean

Cavite, Philippine Is.

1936-38; wooden panels exposed at pierside for one month intervals; data expressed as alcohol wet weights, dry weights, and relative occurrence; temp data also collected.

68

Japan, Korea, and the
Pescadores Islands

1925-27; glass, steel, and wooden panels exposed at pierside and offshore to 45 feet for monthly and cumulative periods up to one year; data expressed as numbers per square foot per month and dry weights.

99

Japan

1935-36; calcareous plates used for monthly and cumulative pierside exposures; data expressed as numbers per panel per month and relative occurrence; temp data also collected.

77

Japan and Pescadores
Islands

1934; glass plates used for monthly pierside exposures; data expressed as dry weights.

58

Aburatsubo Bay, Japan

1951; glass panels exposed daily and for cumulative periods at shallow locations; data expressed as growth rates and sequence of attachment; temp and salinity data collected.

52

LOCALITY

REMARKS

REFERENCE #

Western Pacific Ocean (contd)

Inland Sea, Japan

1957-58; concrete panels exposed at protected, unprotected, and intermediate shallow locations for varying periods of time; data expressed as numbers per unit time and sequence of attachment.

57

Japan

May to November 1954; slate panels exposed in shallow water for short periods of time; data expressed as numbers per square centimeter per unit time and relative occurrence with variously oriented surfaces.

51

Indian Ocean

Gulf of Mannar

1952; wooden blocks used for monthly and cumulative exposures beneath rafts; data expressed as total volume.

65

Visakhapatnam, India

1955; asbestos, glass, wood, and cement used for semi-weekly and cumulative pier-side exposures; data expressed as numbers per panel per week, relative occurrence; temp and salinity data also collected.

40

Madras, India

1940; glass, wood, cement, and iron panels used for monthly and cumulative pier-side exposures; data expressed as numbers per panel per month and relative occurrence; temp and rainfall data also collected.

87

Persian Gulf

Mina al-Ahmadi, Kuwait

1950-53; bakelite panels used for monthly and cumulative exposures at pier-side; data expressed as relative occurrence, percent coverage, and numbers per square inch per unit time; temp data also collected.

48

LOCALITY

REMARKS

REFERENCE

Mediterranean Sea

Haifa, Israel

1955; steel panels used for monthly and cumulative exposures beneath rafts; data expressed as relative abundance and seasonal sequence.

63

Golfo di Palmas,
Sardinia

1963-continuing; wood-plexiglas and asbestos panels exposed for periods of up to 6 months offshore, from surface to bottom at 180 feet; data expressed as numbers per panel per unit time, size, thickness, and relative occurrence; temp and salinity data also collected.

30

English Channel and
Irish Sea

24

Mersey Estuary,
England

1946-47, flooring tiles and scallop shells used for monthly and cumulative pierside exposures; data expressed as numbers per square inch per month and seasonal settlement.

16

Millport and Caernarvon,
England

1940; painted steel panels exposed for short periods at pierside; data expressed as numbers per square foot per unit time.

8

Norwegian and Barents Seas

Western Norway

1961; wooden panels exposed for various intervals at shallow locations; data expressed as numbers per panel, time of settlement, and vertical zonation; temp data also collected.

5

Spitzbergen

June to August 1921; oyster shells exposed at pierside; data expressed as occurrence or lack of occurrence only.

85

<u>LOCALITY</u>	<u>REMARKS</u>	<u>REFERENCE #</u>
Ekaterininskaya Bay, Barents Sea	June to September 1934; concrete panels exposed at shallow locations for various short periods; data expressed as wet weight in air; temp data also collected.	136
<u>Caspian Sea</u>		
Various sites, Caspian Sea	Observations of occurrence and distribution of fouling organisms attached to ships, underwater structures, and glass panels exposed for varying periods of time during 1951-61.	101, 13
<u>South Atlantic Ocean</u>		
N Table Bay Harbour, South Africa	1946-49; experimental plates exposed for short periods at shallow locations; data expressed as numbers per panel, rate of growth, and sequence of settlement.	74
<u>South Pacific Ocean</u>		
Lyttleton, Australia	1954-55; test panels exposed at shallow locations for long and short periods; data expressed as numbers per panel, rate of growth, and sequence of settlement.	102
Sydney, Australia	1947-57; bakelite and perspex panels used for monthly and cumulative exposures under rafts; data expressed as relative occurrence, numbers per panel per unit time; temp and salinity data also collected.	56
Sydney, Australia	1948; glass panels exposed for short periods at pier side; data expressed as numbers per panel per unit time and relative occurrence.	134

LOCALITYREMARKSREFERENCESouth Pacific Ocean (continued)

Sydney, Australia

1947-57; bakelite and perspex panels used for monthly and cumulative exposures under rafts; data expressed as relative occurrence, numbers per panel per unit time; temp and salinity data also collected.

133

Deep-Sea Areas

Atlantic Ocean

1961-continuing; wood-asbestos panels exposed for periods of 48 to 57 days at various depths to 5,500 meters; data expressed as relative occurrence with depth.

108

26

Atlantic Ocean - Bahama Islands

1961-continuing; wood-asbestos panels and various materials exposed for periods up to 111 days at various depths to 1700 meters; data expressed as relative occurrence with depth, size, and thickness.

27, 28

Pacific Ocean

1962-continuing; various materials exposed for 4 months on the bottom at 5,640 feet; data not yet reported.

46

Pacific Ocean

1962-continuing; panels exposed for extended periods of time at deep-sea test sites; data not yet reported.

11

APPENDIX II
SUPPLEMENTARY FOULING INVESTIGATIONS

LOCALITY

REMARKS

REFERENCE #

Western Atlantic Ocean

Atlantic Coast U. S.

Pre-1928 studies of fouling attached to hulls of ships docked at various ports of U. S.; period of attachment and substrate preferences noted.

122

Duxbury, Mass.

1955-continuing; wood, slate, plastic, asbestos, and steel panels exposed at pier side and beneath shallow rafts for monthly and cumulative periods, studies conducted with antifouling paint and corrosion tests; data expressed as numbers per panel per month, percent coverage, and relative abundance; temp, salinity, and oxygen data also collected.

84

Woods Hole, Mass.

Fouling observed on metal panels exposed at pier side during summer months only; data expressed as occurrence; study in connection with corrosion tests.

86

Woods Hole, Mass.
Narragansett Bay,
New York Sound

1937-40; fouling observed on channel buoys exposed for various periods up to 17 months at depths of 30 to 234 feet; data expressed as weight, thickness, and relative occurrence.

4, 45,

Boston, Mass.
New York, N. Y.
Baltimore, Md.

Fouling observed on wooden panels exposed at pier side for monthly and cumulative marine borer studies; data expressed as relative occurrence of major groups.

78

Narragansett Bay

Fouling observed in conjunction with research directed toward sonic control of fouling; data expressed as occurrence of various species.

82

Chesapeake Bay

Fouling observed on pilings removed from local harbor area; data expressed as occurrence only.

3

<u>LOCALITY</u>	<u>REMARKS</u>	<u>REFERENCE</u>
Wrightsville Beach, N. C.	Fouling observed in conjunction with research toward thermal control of fouling; data expressed as occurrence of various species.	95
Wrightsville Beach, N. C.	See Duxbury, Mass. above (Appendix II).	84
Charleston, S. C.	Fouling observed on floating drydock removed from local harbor area; species and wet weight in air noted.	69
Biscayne Bay, Fla.	Fouling observed in conjunction with research directed toward electrical control of fouling; data expressed as occurrence of various species.	12
8 Biscayne Bay, Fla.	See Duxbury, Mass. above (Appendix II).	84
Greenland	Early 1900 observations of fouling on buoys.	88
<u>Mid-Atlantic Ocean</u>		
Bermuda	Studies of the effects of deep-sea environment on rubberized fabrics exposed at depths from 200 to 16,000 feet; data not yet reported.	103
Atlantic Ocean	Studies of the effects of deep-sea environment on General Electric Corporation array components at depths to 5,500 meters; data not yet reported.	10
<u>Caribbean Sea</u>		
Guantanamo Bay, Cuba	Fouling observed in relation to periodicity of attachment to metallic samples; data expressed as occurrence of major groups.	118

REMARKS

LOCALITY

Caribbean Sea (contd.)

San Juan, Puerto Rico

116, 1

Fouling observed on mine cases and cables exposed for periods up to 6 months offshore; data expressed as relative occurrence of major groups.

Bahama Islands

75

Fouling observed on cable and hydrophone mounts exposed on the bottom at 5100 feet for 16 months; data expressed as occurrence of major groups with depth.

Gulf of Mexico

50

Texas Coast

1948-49; fouling observed on steel legs of offshore oil drilling platforms in shallow water; data expressed as relative occurrence and zonation; legs were protected with varying amounts of paint, asphalt, antifouling coatings, and sacrificial anodes.

30

Eastern Pacific Ocean

2

Balboa, Canal Zone

Fouling observed on metal panels in conjunction with corrosion tests; data expressed as occurrence of major groups.

84

San Diego, Calif.

See Duxbury, Mass. above (Appendix II).

13

Redondo Beach, Calif.

Fouling observed in conjunction with thermal control of fouling research; data expressed as occurrence or absence of fouling attachment.

33

San Clemente Island

Fouling observed on mine cases and cables exposed for various periods of time at offshore locations; data not yet reported.

<u>LOCALITY</u>	<u>REMARKS</u>	<u>REFERENCE</u>
<u>Eastern Pacific Ocean (cont'd)</u>		
San Francisco, Calif.	Fouling observed on wooden panels exposed at pierside for monthly and cumulative marine borer studies; data expressed as relative occurrence of major groups of fouling organisms.	78
Dutch Harbor, Alaska	Fouling observed in conjunction with corrosion studies; data expressed as occurrence of major groups and season of attachment.	119
Pacific Ocean	Studies of the effects of deep-sea environment on rubberized fabrics exposed on the bottom at 5,000 feet for periods of 6 months to 2 years; data not yet reported.	103
<u>Eastern Atlantic Ocean</u>		
English Channel	Fouling observed on a sunken ship recovered after 6 months on the bottom at 280 feet; data expressed as relative abundance.	47
English Channel	Fouling observed on submarine cable recovered after varying periods of time at 500 to 1200 feet between Falmouth, England and Lisbon, Portugal; data expressed as occurrence only.	59
Plymouth, England	Fouling observed on metal panels used as controls in anti-fouling paint studies at shallow locations; data expressed as occurrence, season of attachment, and numbers per square foot per unit time; temp data also collected.	54, 7
Tamar and Mersey Estuaries, England	1930-37; fouling observed on channel buoys exposed for various periods from 12 to 15 months in shallow water; data expressed as relative occurrence; salinity, tidal, and pollution data also collected.	38, 7

<u>LOCALITY</u>	<u>REMARKS</u>	<u>REFERENCE</u>
<u>Eastern Atlantic Ocean (contd)</u>		
Portsmouth, England; Trondheim, Norway; Drobak, Norway; Cuxhaven, Germany; Der Helder, Netherlands; Ostend, Belgium; Cherbourg, France; La Pollice, France; Abidjan, Ivory Coast.	See Duxbury, Mass. above (Appendix II).	83, 84
<u>Mediterranean Sea</u>		
23 Casablanca, Morocco	Fouling observed on mines exposed for various lengths of time up to 2 years offshore at depths of 25 to 90 feet during 1942-45; data expressed as relative occurrence.	110, 111
Haifa, Israel; Rovinj, Yugoslavia; Genoa, Italy; Toulon, France; Marseille, France	See Duxbury, Mass. above (Appendix II)	83, 84
<u>South Pacific Ocean</u>		
Sydney, Australia; Auckland, New Zealand	See Duxbury, Mass. above (Appendix II).	84

LOCALITY

Sea of Azov

Various Sites, Sea
of Azov

66

REMARKS

Pre-1961; studies of fouling attachment to ships hulls; data expressed as periods of attachment and wet weight in air; temp, salinity, and light penetration data also collected.

General

160 sites in North and South America, the Caribbean Sea, the Mediterranean Sea, the Pacific Islands.

120

Fouling organisms reported on wooden panels exposed at pier side for monthly and cumulative marine borer studies; data expressed as relative occurrence of major groups (occasionally to species) and percent coverage; occasional temp and salinity data also collected.