

Sonderdruck aus : „Internationale Revue der gesamten Hydrobiologie und
Hydrographie“, 39, 464—471. 1939
Akademische Verlagsgesellschaft m. b. H., Leipzig

[Contributions from the Scripps Institution of Oceanography.
New Series, No. 51.]

The growth of a marine observatory.

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With 1 figure.

It has been five years since I attempted to stress the idea¹) that marine observatories, as such, had not received the attention and encouragement warranted by their scientific importance and the need for them in marine investigations. Mainly as a matter of general interest at that time, I confined my remarks to the occurrences of incidental observations of spectacular aspects of marine biological phenomena at the Scripps Institution pier instead of discussing existing practices and the prospects for sustained programs of observation. As a result of recent suggestions from persons actively interested in marine researches as well as because of my own continued interest I offer this paper for the purpose of bringing the discussion up to date so far as the scientific work of the Scripps Institution of Oceanography is concerned.

La Jolla Point, about which the village of La Jolla is centered, is the seaward, and western, land termination of the ridge descending from Mt. Soledad (about 900 feet above sea level three miles landward). The northern slopes of Soledad together with those descending from the mesa situated immediately northward form a small semilunar basin open a little north of west and continuing under the sea before losing its identity in La Jolla Canyon which is continuous from land and under water near the southern margin of the basin and the bay. The Scripps Institution pier extends one thousand feet from shore at the northern border of this small bay, being located at the southern end of the cliff formed by the cutting back of the seaward edge of the encircling mesa (Fig. 1). On a direct north and south line it is only a little more than a mile from the southern side of the bay. Scripps Canyon, the submerged canyon extending

¹) W. E. Allen, The Scripps Institution Pier as a Marine Observatory. *Scientific Monthly* **37**, 371—375. 1933.

under the sea from a break in the cliff wall some hundreds of yards north of the pier, forms the northern boundary of a submerged triangle of relatively shallow bottom included between La Jolla and Scripps canyons (which meet off shore) and the shore line. Exposed to the open ocean as it is and located as it is in relation to these prominent submerged canyons, the institution pier is in a position peculiarly favorable for observing a wide variety of aspects of localized circulation, sedimentation, and erosion, and of physical, chemical, and biological characteristics and their changing conditions. At the same time, the rarity of severe storms in its



Fig. 1.

Southern part of La Jolla Bay, near San Diego, California, U.S.A. Showing laboratories of Scripps Institution of Oceanography, the pier, and the beach shore line. La Jolla and part of Soledad ridge in the distance.

latitude renders it possible to make many marine observations under conditions of remarkable quiet and stability.

The Scripps Institution of Oceanography originated as a "Marine Biological Station"²⁾ but the biologists who attempted to investigate the conditions of existence of life in the sea soon became so impressed with their lack of information about physical, chemical, and hydrologic phe-

²⁾ W. E. Ritter, The marine biological station of San Diego. Univ. Calif. Publ. in Zoology 9, 137—248. 1912.

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nomena that they demanded more emphasis upon expansion of basic oceanographic investigations. The first Director of the Institution, Dr. W. E. Ritter, was so strongly convinced of the need for such researches that he took a leading part in changing the "biological station" into an institution of Oceanography. In accordance with this attitude of the Director the pier erected in 1915 was equipped from the first with an official "tide gauge" giving a continuous record. Although no other instruments continuously recording were installed at once, the prominence of the observatory idea was indicated by starting a series of collections of zooplankton which at one time ran at four hour intervals for more than two years³). Similarly, series of water samples and temperature records were taken at high frequency. A little later phytoplankton sampling at short intervals was begun and a beginning was made at frequent chemical observations at the pier. At one time and another in these and later years a number of other things were tried, e. g. a continuous record of north and south flow of currents of sea water at the outer end of the pier and continuous records of surface and bottom temperatures. Meteorological records were made daily from the first and from time to time specific attention was given to evaporation problems and to light penetration. An increase in the number of different kinds of daily chemical observations was made about ten years ago at about the same time that a nine year series of studies of "fouling organisms" was begun. A little later studies of bacteria in samples of sea water taken frequently at the pier were placed on a routine basis. Although some of the above mentioned activities were abandoned later and others never got beyond a considerable frequency of direct observation, their aggregate showing is definitely in support of the idea that a marine observatory is desirable, is necessary, is practicable, and that it offers facilities for fundamental work in Oceanography.

The history of the Scripps Institution oceanic researches also shows that the pier is an essential feature in the development of high frequency, or of full continuity in time, of marine observations. Under the leadership of its present Director, Dr. H. U. Sverdrup, the appreciation of the importance of the pier for oceanographic observations has received new impetus, with the result that the variety of concurrent observations is much greater than it ever has been. The extent and importance of these activities may be understood better and evaluated more accurately if considered according to groupings fairly well distinguishable at present in Institution operations.

³) C. O. Esterly, The periodic occurrence of copepoda in the marine plankton of two successive years at La Jolla, California. Bull. Scripps Inst. Oceanography. Technical series 1, 247:345. 1928

Water movement.

Soon after becoming Director of the Scripps Institution in 1936, Dr. Sverdrup demonstrated his active interest in problems of movements of sea water by installing at the end of the pier an electrically operated device for recording the highly localized movements observable there. Later replacement by equipment of sturdier construction put continuous observation of local currents on a permanent basis. Except for interruptions due to heavy surf or clogging of submerged parts by sea weeds operation of this apparatus has been maintained for more than a year.

Certain peculiarities in the records of narrowly localized currents at the end of the pier indicated the desirability of obtaining more positive and detailed knowledge of the characteristics of wave movements. Under the guidance of the Director, Mr. E. C. La Fond designed a wave recorder which was installed at the outer end of the pier in February 1938. Damage to the apparatus by heavy surf has prevented obtaining a fully continuous record so far, but runs of several hours have been made and shorter records have been frequent. At any rate, enough has been done already to indicate that the pier is highly useful as an observatory in the study of wave movements.

Physical oceanography.

Observations on local characteristics of tidal movements through the use of "tide gauge" records accumulating continuously since 1915 are progressing under the supervision of Dr. G. F. McEwen. For some years, continuous temperature records (both bottom and surface) were obtained also by use of special equipment at the end of the pier, but most records of temperatures, salinities, and densities have been obtained from direct observations at the end of the pier, made at least once in every twenty-four hours, a frequency sufficient to justify the idea of a marine observatory. Since 1915, a full set of meteorological instruments installed at the pier and the laboratory on shore have enabled Dr. McEwen and his associates to keep a close watch on the relationships between conditions observable in the ocean of water and those observable in the superimposed ocean of air.

Topography and oceanic geology.

A few years ago Dr. F. P. Shepard of the University of Illinois used the Institution pier as a base of operations in making detailed observations on bottom topography of La Jolla Bay and the immediate vicinity. In 1937 he and his associates began more intensive studies on bottom and shore line characteristics of the locality in connection with

comprehensive researches on the topography of the Southern California continental shelf. Included in the routine of these local studies has been high frequency use of the pier not only as a base of operations in making nearby soundings and dredgings in the submarine canyons, but notably in daily observations on changes in level and contour of the sand bottom at intervals of ten yards alongside the pier for its full length. The pier has also been used by them for observations on speed of travel of breakers, the variations in direction of their movement, and the fluctuations in bottom level and shoreline erosion related to the local system of wave, surf, and current activities. The successful operation of the current recorder installed by Director Sverdrup has been helpful in interpreting the effect of water movements on the sand level and other conditions near the pier. I make particular mention of this point because it illustrates so well the importance of harmonizing all kinds of observations in a marine observatory.

Chemistry.

For more than ten years Dr. E. G. Moberg and his associates have used the pier in getting samples of sea water for studies of carbon, oxygen, nitrogen, phosphorus and other contents with considerable frequency, sometimes daily, or even hourly.

Marine phytoplankton.

Since 1919 Professor W. E. Allen and his associates have been obtaining daily collections of plankton diatoms and dinoflagellates by use of the pier. Experience has shown that over a period of years this continuous frequency of observations is sufficient for satisfactory quantitative researches on distribution of phytoplankton populations according to seasons, years or long term cycles, as well as for all kinds of qualitative studies.

Marine zooplankton.

In recent years Dr. M. W. Johnson and his associates have revived the use of the pier for collection of zooplankton. Inasmuch as most researches on this material at present are limited to life history and taxonomic studies, collections are not always daily in frequency but there is no doubt of the value of the pier for such observations.

„Fouling organisms.“

In 1926, Dr. W. R. Coe of Yale University installed submerged blocks along the southern side of the pier by suspension from the pier rail in order to make experimental observations on the sedentary organisms

which attach themselves to submerged surfaces. With the assistance of Prof. W. E. Allen and his associates of the Scripps Institution, observations were continued on modified and improved equipment up to 1935. In 1937 Dr. Coe revived this work to the extent of suspending one set of blocks near the end of the pier.

U. S. Navy researches on „fouling“.

Working for the Bureau of Construction and Repair of the U. S. Navy in 1937 Mr. W. F. Whedon installed special equipment for continuous observation of characteristics of growth of "fouling organisms" involving tests of different kinds of materials and surfaces with most particular attention to the problem of initial film formation (organic or inorganic) which had been emphasized by the experience of Coe and Allen⁴). At present Mr. Whedon has two sets of experimental equipment installed at the outer end of the pier, which he has found surprisingly favorable for continuous observations of this type. Apparently, this use of the pier by the U. S. Navy is more likely to be extended than it is to be restricted in the future.

Marine bacteriology.

Throughout much of the time for several years, Dr. C. E. Zobell and his associates have made daily collections of water samples at the end of the pier for the purpose of determining the size and characteristics of the bacterial populations. In addition, equipment suspended from the pier has been used for studying the accumulations of bacteria on submerged surfaces and their relationship to populations in suspension in the surrounding water.

Physiology of marine organisms.

For a number of years Dr. D. L. Fox and his associates have been studying nutritional and other functional problems of mussels growing on piles beneath the pier. As is the case with typical "fouling organisms" the pier affords excellent opportunities for observations on these and animals of similar habit.

Institution aquarium.

Of the considerable number of local species of marine fishes constantly represented in the Institution aquarium many are obtained by the Curator

⁴) W. R. Coe and W. E. Allen, Growth of sedentary marine organisms on experimental blocks and plates for nine successive years. Bull. Scripps Inst. Oceanog. 4, 101—136. 1937.

Mr. P. S. Barnhart, by fishing from the pier. In addition, there are many days of the year when there is enough clearness of the water near shore to permit direct observation of these kinds from the pier and to compare behavior with and without confinement. The same is true of starfishes, mussels and other animals living about the pier. Occasionally, rare specimens are observed from or obtained at the pier.

Miscellaneous.

In my earlier paper I gave so much attention to miscellaneous observations that it seems hardly necessary to do so now. Perhaps the most striking one is that there are fewer fish to be seen near the pier, especially sardines, than there were a number of years ago. However, in view of the fact that there is no observer continuously on the pier, the objection might be made that a statement concerning relative numbers is pure guess work. And, it is true that there are still notable numbers of different kinds of fishes, birds, mammals and other creatures worth observing. For example, not long ago a small group of whales was easily visible from the pier, as recorded by one of the pier workers. Two or three years ago, I saw three orcas ("killer whales") pass near the pier, the only time they have ever been noticed in La Jolla Bay so far as I know.

Relation to boat work,

Even to those having little experience with the sea, it should be clear that a fixed observatory does not permit an intimate acquaintance with most of the truly oceanic conditions. However valuable observations at a pier may be, they may be just as misleading, at times, in relation to Oceanography as laboratory studies may be in relation to undisturbed phenomena of Nature. Boats or ships are absolutely necessary, not only to learn oceanic conditions directly, but also to gather information with which to verify or to rectify that which is gathered from a fixed point. On the other hand, the pier observations may increase enormously the reliability of interpretations of boat observations at the same time that they supplement those observations by continuous records of phenomena during periods in which the boat is not operating in the same region. On more than one occasion it has been found that both the abundance of diatoms and the specific composition of diatom populations observed daily at the pier was notably like that found in a few days of operation of the boat off shore at the same time. The new research ship of the Institution, the E. W. Scripps, has made (up to November) five oceanographic cruises in 1938 and it appears to be certain that the information obtained by her will help toward answering some vexing questions raised by pier observations. At the same time, it is understood that records of

seasonal and other phenoma observed continuously at the pier are highly useful when considering times and places of operation of the ship and in choosing the kinds of operations most promising or most needed. It is to be expected that the highest usefulness to Oceanography of observations in a fixed location will be as aids to interpretation of observations at sea rather than as affording bases for direct conclusions concerning oceanic phenomena.

Concluding remarks.

Doubtless, most people who read the foregoing statements concerning actual observations being made by the Scripps Institution as routine procedure will be surprised at their number, extent, and importance. Nevertheless, it is true that in nearly all of these lines of activity the routine observatory use of the pier could be both improved and extended. In general, it may be said that observatory uses of piers, lighthouses, lightships, and the like will always lag behind their possibilities until the same system of maintaining staffs of observers in continual attendance as in astronomical and meteorological observatories is adopted. Of course, such maintenance of qualified staffs is expensive and difficult, but so it is with observatories of any type. Therefore, I stick to my original contention that we should have fixed marine observatories, well equipped and continuously provided with competent observers. I believe that the progress shown in use of the Scripps Institution pier for observatory purposes warrants the view that we need more and better equipped marine observatories in representative localities.