FISHERIES OCEANOGRAPHY

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In considering how to summarize the oceanographic aspects of the papers we have just heard, I found my thoughts falling into several distinct categories—the definition and goals of fisheries oceanography, current practice in this field, and the success of this approach.

Some may feel that fisheries oceanography is nothing more specific than the broad assemblage of problems being studied by oceanographers working for fishery laboratories. The interests of marine fisheries scientists and those of oceanographers overlap in so many areas that almost any marine research can be included in a suitably broad definition. But unfortunately such broad definitions have little operational value.

One might speak, however, of a somewhat restricted area of marine research which could be called ecological oceanography. This deals with the relationship between the ocean as a physico-chemical environment and the populations of organisms inhabiting it. A special case exists in which the populations consist of species of commercial interest. This point of view leads to the following definition:

Fisheries Oceanography—the study of oceanic processes affecting the abundance and availability of commercial fishes.

Obviously populations of commercial fishes are affected by other than oceanic processes. In particular they are subject to the pressure of an aggressive non-environmental factor, the fisherman. Much of fisheries research has resulted from the fear that this pressure was excessive and would soon lead to decimation of the stock; thus it has concentrated primarily on the dynamics of the populations involved. The working hypothesis of the fisheries oceanographer, on the other hand, is that variations in apparent abundance are due primarily to changes in the environment. These changes must be described and understood before the role of man can be properly evaluated.

The relationship is traced out in a model which starts with the observation that significant changes in the atmospheric pressure field occur from place to place and from time to time. These changes lead to variations in the stress applied to the sea surface by the wind. It is now generally believed that the major near-surface circulation of the ocean is wind driven, so that the changing wind stress causes changes in the velocity, depth, breadth, transport or other characteristics of the surface currents. Furthermore, the processes whereby the surface layer is fertilized with nutrient elements from below appear to be either directly wind-produced (for example, wind stirring and coastal upwelling) or secondary effects of the wind-driven circulation (for example, doming or ridging).

The near surface circulation may affect directly the distribution or abundance of organisms at all trophic levels. In addition, changes in the intensity of the refertilizing processes are reflected in the time and space distribution of primary production. This in turn affects production in the next higher trophic level, and so on, with assorted time and space lags, to the desired fish. At each step in this line of reasoning, refinements and complications are involved, but the basic theme of the model remains:

"Changes in the wind field lead eventually to changes in the success of fishing."

The goal of investigation of this model is often considered to be prediction. Certainly if one could forecast accurately the changes in abundance, distribution and availability of fish, this would be of great economic significance. But, conceivably, a useful prediction could result from the blind statistical treatment of a large number of variables, rather than from a fundamental understanding of the interplay of the pertinent atmospheric, oceanic, and biospheric processes. It is the acquisition of this fundamental knowledge which is the scientific goal of fisheries oceanography.

Current practice in fisheries oceanography has concentrated on documenting and trying to interpret the changes in the marine environment. One of the leaders in this field in the United States was the late Townsend Cromwell, who originally proposed this symposium. His first important work, in Honolulu, was a study of wind-induced upwelling along the equator. Subsequently, the Honolulu group has examined the mechanisms of surface enrichment near the Hawaiian Islands and to the north. At Scripps Institution and the Tuna Commission, there have been studies of coastal upwelling, oceanic fronts, and of processes such as those Cromwell labelled "doming" or "ridging". Dr. Sette and his colleagues have been examining past weather and the marine climate, looking for long-term changes related to those in the fisheries. All of these investigations have been facilitated by the presence of certain conspicuous features or discontinuities. As Henry Stommel has suggested, studying the oceans resembles dissecting a lobster—if is easier to do at the joints.

What has been the success of fishery oceanography in recent years? Certainly in the Pacific it has had no dramatic impact on the commercial fisheries. And if the goal be considered prediction, very little success can be recorded. Yet the fund of basic knowledge of

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the ocean has increased tremendously. The near surface circulation and the distributions of properties such as temperature, salt and oxygen have been much more adequately described. The theory of wind-driven circulation is well established. The variations in time and space of coastal upwelling are recognized, and other important surface-enriching mechanisms are known. In short, the general scheme by which atmosphere, ocean and biosphere are interrelated is taking form, and we are ready to formulate and test hypotheses having bearing on important and specific problems in fisheries science.