ARTICLES

FISHERY OCEANOGRAPHY

Felix Favorite

This is the first of a series by Dr. Favorite who, for over a decade, has been in charge of an oceanographic program to define the ocean environment of the Pacific salmon (genus Oncorhynchus). The purpose of the series is to show how oceanographic research can aid in locating areas of profitable fishing and in solving problems of fishery research.

The meteoric rise in popularity and funding of oceanographic research in the United States has caught most fishery biologists by surprise. Funds for biological studies have increased somewhat proportionately to those of other fields, but little effort has been made to influence oceanographers outside the agency concerned to conduct research directly related to fishery problems--except perhaps for the efforts of the Eastern Pacific Oceanic Conference. Nevertheless, in most national oceanographic programs, it is clearly stated that the research to be conducted will benefit the fisheries. Several years ago, while participating in a U.S.-USSR Oceanographic Exchange Program, I discovered that Soviet oceanographers also claimed that their research was beneficial to fisheries; however, fishery groups were somewhat skeptical about the extent to which it really aided their operations.

The Ocean Is Many Things

To the oceanographer, the ocean is a number of things: a three-dimensional, stratified fluid, on a rotating earth, subject to a variety of internal and external forces; a vast reservoir of heat which has a great influence upon the earth's weather and climate; a sink for excess CO_2 spewed into the air by modern industry and for dissolved and particulate fractions of the earth carried into the sea by river runoff; a medium for transportation of people and things, subject to destructive waves and storms; a reservoir of vast mineral wealth; and a highly complex biological environment.

The environment includes an intrica food cycle that starts with chemical nutrien and specific physical conditions and advanc from microscopic unicellular plants to ma roscopic herbivores (or plant-eating plankto and then to carnivorous plankton (which is t prey of small and large fishes, and whales Thus, fisheries are only a small portion of t spectrum of interest to the oceanographe To the marine fishery biologist, also, oce nography is only one aspect of the total li history of fishes. But the oceanographer b lieves that all oceanographic research h some bearing on fishery research, ev though specific relations are not sought him; for his part, the fishery biologist oft believes that it is too early to consider ser ously the effects of the ocean environme until more research is accomplished in phy iology, behavior, distribution, and morta of fishes.

Fishery Oceanography

Man has always considered the enviro ment to have an effect on fish. The use surface temperatures on the Grand Banks an excellent example that goes back sever centuries. But it has been only during t last decade or two that a small group of d dicated people--known as fishery oceano raphers--has tried to merge the fields of fis eries and oceanography. The term 'fishe oceanography' is purported to stem fro 'fishery hydrography', which was coined the beginning of this century. 'Fishery ocean ography' is not only relatively new, but it almost impossible to define--as witness th

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riety of about 100 opinions obtained by Dr. M. Chapman[1/] from leaders in marine ence.

Perhaps the most-pertinent definition ginates with Dr. O. E. Sette, Director of BCF Ocean Research Laboratory and irman of the Eastern Pacific Oceanic ference:

"Fishery oceanography is the study of ng resources of the sea and of natural nomena directly or indirectly influencing n in a manner potentially or actually sig-cant to their use by man, including any rmation gathering needed for such stud-."

This definition includes two aspects: the t is basically fishery biology; the second, study of natural phenomena, is oceanog-hy. It is expertise in this field that the anographer brings to fishery research to and our understanding of the distribution, avior, and abundance of fish. It is this se of fishery oceanography that will be ussed in the series of articles.

More often than not, it is the physical anographer, rather than the biological or mical oceanographer, who expands the zon of the fishery biologist. This is be-se the biologist has already received ex-ive training in chemistry and biology. eone has coined an apt phrase, fish-ical, er than physical oceanographer. In some ects it is a good one. To be effective, person must not confound his cohorts with rous hydrodynamical solutions--but ge the gap between the two fields. Chem- and biological oceanography, however, nextricably interwoven with the physical cts; all must be considered in solving lems in fishery oceanography. For ex-le, fish will not usually be in an area of l physical conditions if the water is pol-d, or if there are no food organisms. ertheless, "fishery oceanographer" is not rticularly popular title because those that ate from the pure-science aspects of r field are not looked upon favorably by r peers. This is perhaps particularly true pan, where a great deal of fishery ocean-phy is accomplished.

gress Has Been Slow

rogress in fishery oceanography has been fully slow. The fishery oceanographer is often forced to work without the extensive facilities that are available aboard a vessel designed exclusively for oceanographic research. Usually, he must share vessel time with the fishery biologist, who has a specific assignment to obtain a certain amount of data on fish catch regardless of the environmental conditions. The fishery oceanographer would like to change these circumstances. Unless one knows the environmental conditions under which the catch was made, the information does not contribute much to our knowledge of locations of profitable pelagic fishing. One might as well indicate the fishing location with an X on the water fished as on a chart, because it would be impossible to find that spot again. Of course, this shortcoming does not apply specifically to groundfish, because their distribution may be directly related to bottom topography. Nevertheless, most groundfish perform spawning and seasonal migrations that are probably triggered by environmental conditions; so the same statement can apply.

Progress will be slow as long as the fishery oceanographer is limited to taking observations along a predetermined or arbitrary fishing track, or only at fishing stations. It is important to know conditions in the general vicinity of the fishing location. Rather than striving for an equitable division of time aboard a single ship, it would be best to have two ships working together, one observing environmental conditions before and during fishing operations. Actually, both vessels should be capable of either phase of operation. I have not witnessed the routine used during Soviet fishing operations, but I was informed that areas of 80 by 120 miles were blocked out for fishery investigations. At times, 4 or 5 of the 10 vessels in an area of this size made extensive environmental observations during their fishing. This comparative effort could be considered fishery oceanography in the real sense of the term; the oceanographers involved in these studies are attached to the fishery institutes. The general large-scale oceanographic investigation that provides the background for selecting general fishing areas should continue. More effort, however, should be expended on small-scale investigations at the time of fishing.

The Pacific Salmon

If one is attempting to ascertain relations between fish and ocean conditions, perhaps

ments on "Fishery Oceanography," Vols. I-III. Prepared for working party on Fishery Oceanography of Scientific Committee on eanic Research, International Council of Scientific Unions, 1962.

one of the most rewarding to study is the Pacific salmon. Like the Atlantic salmon (Salmo salar), the Pacific salmon are anadromous: they spawn in fresh water and, after a residence in fresh or brackish water (depending on species), they migrate downstream and far out into the ocean. There they grow and mature during a 1- to 3-year residence before returning to fresh water to complete the life cycle. But, unlike Atlantic salmon, Pacific salmon die after spawning. Only young salmon, or fry, make up the downstream migrants. It is not too difficult to obtain an estimate of the progeny from major river systems. Furthermore, it is fairly well documented that most will return to parent streams. Some stocks can be identified by chemical and biological techniques, as well as by tagging methods. Studies on the ocean environment of these salmon have been made at the BCF Biological Laboratory over the past decade in conjunction with exploratory fishing in the Pacific Ocean. Some results of these studies will be the subject of future articles.

WHAT CAUSES HURRICANES AND HOW DO THEY DIFFER FROM TYPHOONS?

Hurricanes are great heat engines, much like the gasoline engine in a car. The moisture in the humid air over the sea is analogous to the gasoline in the gas tank; it contains the potential energy (or fuel) for the hurricane. Once the hurricane is born, it draws moist air up from the sea surface in a counterclockwise spiral to the condensation level. Here cooling of the air, due to reduced pressure, condenses water vapor in the air. This can be equated to the combustion cycle in the gasoline engine; it converts potential energy to kinetic energy.

The latent heat of condensation (597 calories per gram of water) heats the air, which then accelerates in its upward spiralling journey. It literally goes "up the chimney" formed by the relatively cooler air around it. At the top of the chimney of cooler air, the warm air spreads outward in a clockwise spiral (when viewed from above). As air spirals upward, through and out of the chimney, it draws more warm, moist air into it from below. This self-perpetuating process intensifies the circulation, causing the engine to run faster and causes the hurricane to increase in size.

The exact mechanism of hurricane formation is still unknown. Scientists know that very warm ocean water is required. The warmer the water, the greater will be the volume of moisture (potential energy) carried aloft. A storm must be some distance away from the Equator in order to start spinning, because the spin of an object on the earth varies directly with the sine of the latitude. There must be an outward (divergent) flow of air in the high atmosphere; otherwise the chimney would be closed off.

The origin of a hurricane is associated with an area where air converges and showers occur. This may be a remnant of low pressure from a cold front which moved far south; it may be an area of lower pressure moving westward in the Trade Wind Belt (easterly wave); or it may be an area where air from the two hemispheres converges (intertropical convergence zone). The origin could be due to oscillation of the great high pressure system which dominates the ocean.

Hurricanes and typhoons are alike in origin, structure, and features, their only difference being the area of the world in which they occur. Hurricanes occur in the waters adjacent to North America (North Atlantic Ocean, Gulf of Mexico, Caribbean Sea, and Southeastern North Pacific Ocean); typhoons occur in the Western North Pacific Ocean. Because of the vast expanse of warm water in the Western Pacific, typhoons occur more often than hurricanes and are frequently larger and more intense. ("Questions About The Oceans," U.S. Naval Oceanographic Office.)