Marine Environmental Conditions off the Coasts of the United States, January 1977-March 1978—Introduction

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Fishermen have long recognized that changes in the marine environment can have pronounced short-term effects on the distribution and abundance of fish. Even the novice weekend angler knows that the chances of catching fish can be drastically affected by weather and weather-induced changes within the sea. Commercial and experienced recreational fishermen learn to "read the weather" and are guided by weather and sea conditions in their fishing activities.

The longer term, larger scale changes in oceanic environmental conditions, commonly referred to as climate, can have even more lasting effects on the state of marine fisheries resources. Just as cycles of drought and flood or heat and cold can limit terrestrial crop yields, so cycles of suitable and unsuitable ocean currents, temperatures, etc., can limit marine populations. Superimposed on naturally occurring environmental fluctuations are those changes attributable to man, such as fish harvesting and pollution. Failures of fisheries such as Japanese sardine, California sardine, Hokkaido herring, Norwegian herring, and Pacific mackerel are largely attributed to a combination of heavy fishing and long-term changes in environmental conditions.

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At times the changes in the oceanic environment can have devastating effects. For example, "El Niño" conditions (a shift in wind-driven currents that results in diminished upwelling of nutrient-laden productive water) off the coast of western South America during 1972 was associated with the collapse of the Peruvian anchoveta fishery.

On the other hand, locating ocean areas with optimal oceanographic conditions for particular species can serve as a valuable tool in the fishermen's search for productive fishing areas. This is particularly true of the highly mobile oceanic species such as tuna. For example, albacore, in their eastward migration in the spring of the year from the central North Pacific and later during the summer in the nearshore waters off the coast of California, tend to associate themselves with the fronts between different water masses which have sharp horizontal gradients of temperature and salinity (Laurs and Lynn, 1977). At such frontal locations the dynamic processes which produce and maintain the gradients also enrich the waters, rendering them more productive from a biological viewpoint (McGary and Stroup, 1956). There the prevailing conditions tend to provide in abundance the food that is sought by predator species.

Because tuna fishermen recognize the usefulness of timely sea surface temperature charts as well as other environmental information in their search for optimal fishing areas, the Southwest Fisheries Center of the National Marine Fisheries Service regularly provides such information in several forms. These include *Fishing Information*, a monthly publication with a biweekly supplement containing environmental charts and narrative information; the Cooperative Tropical Tuna Advisory Programme, which broadcasts environmental charts by radio facsimile (FAX) to fishing vessels; and the Albacore Advisory Program, which provides weekly sea surface temperature charts and narrative texts of fishery conditions to albacore fishermen.

A number of species off the U.S. coast, including shrimp, menhaden, and others, spawn offshore and require onshore surface currents to transport the eggs and larvae into estuarine nursery areas. When onshore currents occur at the appropriate time to facilitate such transport, a good menhaden year class may be expected (Nelson et al., 1977).

As early as 1899, when the Council for the Exploration of the Sea met in Christiania (now Oslo), Norway, to consider North Sea fisheries problems, they recognized the importance of environmental research in seeking their solution. The Council's concern at the time was the failure of a number of North Sea fisheries due to a vast increase in fisheries harvests which had resulted from the introduction of the steam trawler and the otter trawl, and associated over-exploitation of the fisheries. Their approach to the problem was to support two lines of research: One on the problem of over-exploitation of the stocks, and the other on the effects of the environment on the variability of the stocks. These early deliberations resulted in the establishment of the International Council for the Exploration of the Sea and served as the forerunner of numerous international bodies and agreements designed to conserve oceanic fisheries resources.

In recent years many nations have begun unilaterally to manage the fishery resources off their coasts. The United States, for example, by implementing its Fishery Conservation and Management Act (FCMA) in March of 1977, now regulates domestic and foreign fishing within a 200-mile wide fishery conservation zone adjacent to its shores. Since the implementation of FCMA there has been a vastly increased awareness and concern regarding the scientific basis for projecting annual fisheries yields and hence the quotas that can be assigned to domestic and foreign fishermen.

Generally, environmental effects are not included in such yield determinations. This, in large part, is due to the lack of sufficient information on the impacts of changing oceanic environmental conditions on specific resource species. Yield estimates upon which fisheries management strategies are based have traditionally been developed for single species assuming a stable environment or one described by the long-term average of environmental conditions.

Thus yield estimates and derived quotas do not yet adequately reflect the effects of environmental variation, either short or long term. Nor has it yet been possible to include adequately intraspecies or food web interactions, although research is presently underway to develop comprehensive ecosystem models which consider such factors (Laevastu and Favorite [1,2]).

Though the importance of including environmental inputs in yield determinations is recognized by many fisheries scientists, the task of amassing sufficient information to understand such effects is not a simple one. Nor can it be resolved exclusively by workers in any one scientific discipline. Instead, it will require the labors of many specialists, including fishery biologists, oceanographers, meteorologists, and others.

This scene, in general, indicates the complex interaction with entrainment by the California current off the Pacific coast, with the upwelled waters. This upwelling is driven by the alongshore winds from the north during the summer months and the regime is a classic manifestation of offshore Ekman transport. This image was received from the Very High Resolution Radiometer (VHRR) aboard the NOAA-5 satellite during the 1977 upwelling season. Cloud cover is minimal and self-evident. The approximate range of sea-surface temperature here ranges from about 11°C near the central California coast to perhaps 20°C at the southern end. NOAA photograph.

The problems involved in providing quantitative environmental inputs in fisheries yield determinations are numerous and difficult, but they appear resolvable using present technologies. Perhaps the greatest need is that of greater understanding of those oceanic and atmospheric processes, both short and long term, that control the environments of commercial resource species and the productivity of such environments. Though development and testing of fisheries yield models has begun, future models will require much greater understanding and more refined data. Thus, it will be necessary to evaluate research efforts

[1]Laevastu, T., and F. Favorite. 1978. Numerical evaluation of marine ecosystems. Part 1. Deterministic bulk biomass model. Processed Rep., 22 p. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[2]Laevastu, T., and F. Favorite. 1978. Numerical evaluation of marine ecosystems. Part 2. Numerical marine ecosystem model (DYNUMES III) for evaluation of fishery resources. Processed Rep. 29 p. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

and the plans for future data acquisition in terms of anticipated model requirements.

This report is intended to furnish to fishermen and fishery scientists some of the needed information concerning marine environmental variations in 1977 and early 1978, citing the anomalous conditions which may have impacted on stocks of marine organisms. Earlier reports were prepared for 1974 (Goulet, 1976), 1975 (Goulet and Haynes, 1978), and 1976 (Goulet and Haynes, In press). The present report deals with naturally occurring environmental fluctuations without attempting to discuss effects of man's activities, and is not intended as a detailed study of oceanographic processes. Instead it provides an overview of the large-scale oceanic environmental events during the period and describes environmental variations which may affect fisheries yields. Our goal is to provide this type of summary annually, both to fishing interests and to others concerned with the possible impacts of environmental factors on marine living resources off the coasts of the United States.

Since environmental changes can affect fish populations over a broad range of spatial and temporal scales (ranging from days to decades and from meters to hundreds of kilometers), this report cannot cover events occurring in all time and space scales of possible interest. For example, on the Pacific coast, environmental events have been described on monthly or seasonal time scales first on large oceanic scales--and then on smaller, regional space scales by coastal areas proceeding southward, with conditions in Canadian waters off British Columbia included for continuity. The Atlantic coast is similarly discussed from north to south, continuing into the Gulf of Mexico.

For timely monitoring of marine environmental conditions with the necessary continuity in time and space, the primary data available are sea surface temperature (SST), wind, and pressure observations made routinely by ships and transmitted ashore by radio. These observations are numerous along major shipping lanes, but offer poor coverage in other areas where ship traffic is scarce. Various oceanographic analyses are made with data from these and other sources (see Appendix 1 in McLain et al., 1979) including satellite observations. Other measurements of ocean parameters are made nonroutinely by research vessels. These observations and data summaries are provided in various periodicals (see Appendix 2 in McLain et al., 1979).

Only in a few instances do the oceanographers who contributed to this report know enough about the nature of the interactions between environment and the living resources of the sea to enable predictions of the variance in year class strength due to environmental influences. Perhaps the information provided here will stimulate exploration by fishermen and scientists on the effects of environmental interactions on the abundance or distribution of resource species. The contributors to this report welcome comments on any bioenvironmental interactions or other aspects of environment-fisheries interactions that readers of this report may wish to suggest.

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