sideration of authorization by the Congress, and through the process of submitting estimates and getting project appropriations.

We assure you that we are putting in our oar at each of these steps on projects now in the planning mill. But you will have to take this on faith, because these projects, many of them, will not reach the construction stage for a decade or more. Consequently, the results of our efforts will not be apparent until then. Nevertheless, what we do today will determine how effective we are 10 or 15 years from now.

The role of the Fish and Wildlife Service in its river basin studies work is to lock the barn doors 10 or 15 years in advance of the horse's disappearance. We hope that we have the wisdom and the foresight to do the job.

Plankton and Fisheries in the Gulf of Mexico[1]

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We hope that before long it will be possible to start from Texas A. and M. a widespread survey of the plankton in the offshore waters of the Gulf of Mexico. Such a project could well be justified on academic grounds alone. Dr. Galtsoff has already reminded us that productivity studies in the open Gulf are amongst our most pressing needs. Clearly, considerable improvements in our current knowledge of standing crops and seasonal cycles of both phytoplankton and zooplankton will be necessary before such studies can become meaningful.

But the preparation of regular synoptic charts of plankton distributions may well also provide direct and indirect information of considerable importance to the Gulf fisheries; or, at least, this would seem likely from experience in the North Sea and adjacent waters.

Firstly, the use of automatic sampling gear from a variety of shipping should reveal concentrations of larvae in the plankton catches and so help to delimit more closely the spawning grounds of shrimp and commercially important fish. At the same time aggregations of species which are not at present exploited might be demonstrated by the distribution of their eggs and young. Unsuspected stocks of Blue Whiting, *Gadus poutassou,* were found by Henderson (1957) in this manner in the Atlantic, 200-300 miles west of Scotland.

Secondly, it seems likely by analogy with the North Sea that the natural fluctuation in the yields of the Gulf fisheries may be greatly effected by the interchange of water between the offshore and coastal waters and between the Atlantic and the Gulf. That is, by factors which, although they are tied in some way to these water movements, are not readily recognizable by conventional hydrographic techniques. As an example, one can cite the well documented collapse of the herring fishery in the western reaches of the English Channel during the 1930's (Kemp, 1938). Here, it was the younger age groups of fish which first declined in numbers, so over-exploitation could not account

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for the drastic reduction in catch per landing. The contemporaneous change in the species of *Sagitta* in the area suggested to Russell (1939) that less Atlantic water was entering the western end of the channel and he proposed that the corresponding reduction in phosphates had led to less production of phytoplankton and so less food available for the fish fry. However, more recently, work by Wilson (1951) and Wilson and Armstrong (1952, 1954) has raised the alternative possibility that water of Atlantic origin may contain "growth factors" of vital importance to the healthy development of the young of some species. Whatever these factors may be, they are not at present recognizable by conventional techniques; their presence can only be deduced by the planktonic fauna that the water supports.

Such an idea has been very much in mind in studying the plankton surveys undertaken by the Edinburgh Laboratory of the Scottish Marine Biological Association. From the regular samples collected by the Hardy continuous plankton recorder it is possible to show a progressively earlier appearance of indicator species in the Atlantic Drift off the west coast of Ireland from 1948 to 1953. This entails a change in timing amounting to two months, from June in 1948 and 1949, to May in 1950 and 1952, to April in 1953 (Rae 1954).

Over the same period, the arrival of one of these "indicators," *Clione*, on the herring fishing grounds off the northeast coast of Scotland advanced by a corresponding time from August in 1949 to June in 1953 (Glover, 1955). Glover also demonstrates a southerly shift of about 150 miles in the most productive fishing grounds for herring during the same five years. It seems quite reasonable, therefore, to suppose that the spawning migrations of the herring are in some way affected by the advancing front of Atlantic water; a model which would equally explain the earlier observations in the channel. It may be that the mature herring can recognize the presence of those "growth factors" in the environment which are conducive to good survival of the larvae and so, within limits, select their spawning grounds.

There is further circumstantial evidence of the importance of Atlantic water to fish stocks in the North Sea. During each winter of the last 10 years, it has been possible to trace the movements of another planktonic indicator species, *Metridia lucens*, that is carried into the northern North Sea during the previous autumn. Along one axis, this movement can be correlated closely with the prevailing wind. Wind data are available for many years and so one has presumtive information on the orientation of Atlantic water relative to the haddock spawning grounds for the 32 years for which there are estimates of brood strengths of haddock. Comparison between the two sets of data suggests that strong broods—or good recruitment to the fishable stock somewhat later—do not occur in those years when relatively little Atlantic water covers the spawning grounds (Rae 1957). Here it is the conditions prevailing before the onset of spawning which appear to influence the subsequent survival of the young. Thus, again we may reasonably suspect that an adequacy or inadequacy of some beneficial factor that is carried into the spawning area each year from the open Atlantic, can have a controlling influence.

It seems to me, therefore, that although the major fisheries in the Gulf are concentrated near the coast, we cannot be confident that we will ever understand them by studying only the coastal waters. More effort should be devoted to investigations of the open Gulf. It may, indeed, prove necessary to learn a great deal more about the variations in the circulation within the Gulf, the interchange between the Gulf and the Atlantic and the general ecology of the offshore fauna, if we are to answer the many questions already posed about inshore fisheries. We hope that the proposed studies of the plankton from our Galveston Laboratory will make one preliminary step toward this end.

REFERENCES

HENDERSON, G. T. D.
1957. Continuous plankton records: the distribution of young *Gadus poutassou* (Risso). Hull Bull. Mar. Ecol., 35: 179-202.

KEMP, S.
1938. Oceanography and the fluctuations in abundance of marine animals. Rep. Brit. Assoc. Adv. Sci., 1938: 85-101.

GLOVER, R. S.
1955. Science and the herring fishery. Adv. Sci., 44: 426-434.

RAE, K. M.
1954. The continuous plankton recorder survey: plankton around the British Isles during 1953. Ann. biol., Copenhague (1953) 10: 95-99.
1957. A relationship between wind, plankton distribution and haddock brood strengths. Bull. Mar. Ecol., 38: 247-269.

RUSSELL, F. S.
1939. Hydrological and biological conditions in the North Sea as indicated by plankton organisms. J. Cons. Explor. Mer., 14: 171-192.

WILSON, D. P.
1951. A biological difference between natural sea waters. J. Mar. biol. Ass. U-K., 30: 1-26.

WILSON, D. P. AND F. A. J. ARMSTRONG
1952. Further experiments on differences between natural sea waters. J. Mar. biol. Ass. U-K., 31: 335-349.
1954. Biological differences between sea waters: experiments in 1953. J. Mar. biol. Ass. U-K., 33: 347-360.

Oceanography and Fisheries

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MANY PAPERS HAVE BEEN WRITTEN about this subject, but few of them seem to stress what we consider to be the essential points. Many of the papers have been written by oceanographers who have attempted to show the successful use of hydography in fishery science. We would like to present a more critical view of some of the work which has been carried out by oceanographers, biologists, or both together, in order to suggest solutions to some of the difficulties which the fishery science has encountered. To do so, we must first clarify the objectives of oceanography and fishery science.

Physical and chemical oceanography has as its objectives the study of the sea itself: the physics and chemistry of the water masses, the currents, and (what are certainly the most important in connection with fishery science), the mixing processes in the ocean.

The ultimate aim of fishery science, in turn, is to increase the yield of fish per unit of fishing effort.