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APPLICATIONS OF OCEANOGRAPHY TO NAVIGATION

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Navigators, concerned with the task of maintaining safe and efficient sea communications and faced with everyday difficulties of wind and weather, have to maintain a more practical outlook than oceanographers, who want to understand everything that goes on in the oceans however long they are about it. Oceanographers, being continually under the spell of the spectacular advances in scientific methods and techniques made in laboratories on shore, are keen on trying new methods. Nevertheless there is collaboration: navigators are not slow to adopt the results of academic research, and oceanographers are not slow to appreciate the value of established practices and the need for some caution in introducing new methods. Progress is made by what seems to be a fairly healthy mixture of personal enthusiasm, pressure from government departments, commercial enterprise, and guidance of professional associations; but strong government support is as essential to progress in navigation and oceanography as it is in several other branches of science which require facilities that are beyond the ordinary reach of Universities and that have not yet been provided by industry.

Although the chief justification for continued public support of oceanographic research must be the results and by-products of the work, the long-term nature of the necessary studies is sufficient to justify those engaged in them in relying to some extent on a plain statement of what they are about. The opening of a new laboratory is a suitable time for such a move, and it is my privilege to speak about the promise of oceanographic research for navigation.

Tides. The excellence of tidal predictions for ports of any size is sufficient to raise doubts as to whether there is justification for further theoretical research which is necessarily of a complicated nature. However, there are plenty of projects involving salvage, construction, beach landing, and other tasks which require accurate tidal information for places where no tidal records and analyses have been made and which may be far removed from the nearest standard port. Such demands are likely to call for someone with an active understanding

of tidal theory who is able to calculate the probable direction and changes in the tidal wave and to insure that such measurements as can be made on the spot are those which will give the most information. Moreover, there is little doubt that our knowledge of tidal streams is not as satisfactory as that of the times and levels of high and low water, hence much theoretical and practical research is needed to improve our understanding of them, particularly of the tidal streams in estuaries and channels. However, probably the most outstanding need is for detailed investigation of surges and other movements of water due to meteorological factors which disturb the normal rise and fall of tides.

Currents. The whole problem of the effect of wind on the sea is still in a most unsatisfactory state. We have reliable charts of average directions and speeds of surface currents and we know that they are caused by the effect of local and distant winds, but the charts often emphasize the variability of the currents. Too little is known about the rate at which wind drifts grow and decay to allow an estimate of the variation of movement in particular weather conditions which may make the actual set very different from the monthly average. Active research aimed at a better understanding of wind drifts is being carried on in most marine laboratories, but the subject is more difficult than the study of tides, since the forces involved, particularly the drag of the wind and the effect of friction and viscosity on the water, are themselves complex and scarcely understood. The new radio aids to navigation are making it much easier to fix the position of a ship, but they are not yet universal and undoubtedly it would be useful to know how the current is likely to change with varying wind and weather conditions. For example, it would be a good thing if the task of estimating the drift of a raft or wreckage at sea could be made easier and more precise.

Waves. Although ships manage very well in all weather conditions, storm waves are still one of their worst enemies, and it is reasonable to maintain that something must be gained from a better understanding of ship movement in relation to complex wave patterns. The master of a ship learns by experience how the pitching and labouring of his vessel varies with her speed in relation to the heights and lengths of the waves, but he would be the first to admit that there is plenty of scope for more information about the growth and decay of waves and about their effect on ship motion. This is particularly true for aircraft carriers in which the angle of pitch is of great importance. It is only during the past 15 years that realistic studies have been made of complex wave patterns, and, although we have made re-

markable discoveries about the distribution of energy over a range of wavelengths and about the rate at which the energy travels away from a storm, this is only a beginning. The detailed information that is being obtained about waves should be useful to ship designers; they have to allow a good margin of safety, but it would be surprising if more precise information did not lead to some improvements in design.

In addition to ordinary waves and swell there are several types of long waves which are of some importance to navigation. In certain harbours they may be a contributory cause to resonance effects, usually known as "range action," in which ships moored at a quay respond so actively to a backward and forward oscillation of the water that the mooring ropes are snapped and the ships damaged. The energy for the oscillation in the harbours is derived from several sources: it may come from surf beats (long waves caused by the alternation of groups of high and low swell) or from long waves transmitted directly from a distant storm; also, it may be derived from long-period oscillations of water level in the neighbouring coastal region relative to onshore or offshore water movements or from the partial deflection of the tidal stream. A detailed understanding of the sources of energy and of the processes by which such energy is transferred to the harbour could not fail to be useful in planning the position and design of new harbours, and it might facilitate improvements.

The study of processes which cause coastal erosion and changes in offshore bars and harbour approaches and which in turn affect landing operations on a beach might be regarded as belonging to the field of hydraulic engineering, but oceanographers who already deal with waves and sources of energy and who are interested in the interaction between water movements and topographical details on the sea bed can do much to help. Collaboration between oceanographers and engineers has already done much to improve our understanding of the processes which change the waves as they approach the coast. If the underwater contours and tidal streams are known, then variations in the height of surf from point to point along a coast can be predicted with reasonable accuracy. There is no doubt that the methods of wave prediction have reached a stage when, with the necessary meteorological information and some local knowledge, predictions of waves and swell will allow better timing in the transfer of cargo in an exposed anchorage, the passage of vessels across a bar, landing operations, salvage or construction. Further studies will undoubtedly aid coastal and harbour engineers in determining the best measures they can take to retain sand and

shingle or prevent it from being deposited where it is likely to become a hindrance.

Further examples can be found of ways in which studies of sea conditions, at present more or less academic, might find profitable applications in the future. One outstanding problem is the interchange of energy between the atmosphere and the oceans; as well as being essential to our understanding of water movements in the oceans, it is important to long-range weather forecasting, and meteorologists and oceanographers are collaborating in its study.

It is reasonable to maintain that the great amount of effort spent in using the sea and in defending our lives and possessions against it demands as detailed an understanding of its behaviour as may be gained by application of ever-improving scientific methods to supplement experience and simple interpretation of observations.

In conclusion I might mention that I prepared my talk a month ago in a small ship on the Atlantic Ocean when the weather was too bad for oceanography and when careful navigation was the order of the day. But with this caution, and remembering also that it is difficult to urge new work without the risk of undervaluing what has been done already, I feel no hesitation in urging new studies, however long they may take. I believe that most oceanographers will agree with a plea that the problems should be approached in a systematic long-term manner rather than by too direct attack. At the end of a direct attack it is often found that the target has moved so that only a wider spread of observations could have found the mark. However, the spread must not be too wide to get the range. It must be fairly general experience in oceanography, as in other sciences, that an academic approach often produces the knowledge, method or apparatus required for a particular application just when it is most needed.