PHYSICAL OCEANOGRAPHY

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Contents

Summary

This chapter on the topic of *Physical Oceanography* gives an overview of physical phenomena – motion, temperature, density – occurring in the sea. The set of waves that may propagate is fundamental to the motion in any physical system; these are treated in a dedicated chapter *Waves in the oceans* covering spatial scales from centimetres to those of an ocean basin, and temporal scales from seconds to a year. Surface waves with scales of metres interact strongly with sea-ice, the subject of *Sea-ice interactions*. Most of the energy in the open ocean is associated with features on scales 10-500 km and 10-200 days, often bounded by sharp property changes where mixing is enhanced. These features are discussed in *Synoptic/mesoscale processes* and *Fronts and mixing processes*. The topic is concluded with a comprehensive overview of *Coastal Oceanography* and the motivation for its study.

The treatment is primarily descriptive. Methodological aspects are mentioned in passing but receive more specific treatment under other topic headings. These include measurements – remote sensing, acoustics, instruments and engineering – in *Ocean Engineering*, and models in *Modeling the Ocean System in a Sustainable Development Perspective*.

As the title implies, this topic focuses on physical aspects. Other disciplines in oceanography, including human uses and management, are described in later topics under the *Oceanography* theme.

1. Other Aspects of Physical Oceanography

An overview of the seas including physico-geographic aspects is given in the preceding topic *The Oceans*, along with a discussion of the larger *Role of the oceans in the global climate system*. Evolution of the oceans is also described in *The Oceans* and later in *Geology of the Oceans*. Some specific marine areas are also described later: hydrothermal vents (where hot chemical-rich water issues from the sea-bed) in the topic *Chemistry of the Oceans*; reefs in *Coral Reefs as a life supporting system*. Locationtypes and processes close to the shore are described under an entirely separate area and theme *Coastal zones and estuaries*.

2. Inter -relations

2.1. Inter-relations – Ocean and Shelf-sea

The chapter *Coastal Oceanography* outlines influences of the ocean on shelf and coastal seas through surface gravity waves, tides, equatorial and Rossby waves and eddies, circulations including strong currents offshore (eg. the Gulf Stream and Kuroshio) and intermittent phenomena such as El Nino. Although shelf and marginal seas are important for their high primary productivity and physical energy levels, their influence on the ocean should also be remarked. As noted in *Coastal Oceanography*, they are the route (albeit often circuitous) by which materials from land ultimately reach the open ocean. Dense water from extra winter cooling (as heat is extracted from a shallower depth of water), supplemented by brine rejection as ice forms at high latitudes, descends from shelves to deeper ocean levels; water from Antarctic shelves forms bottom water for much of the world ocean. Mixing over steep slopes, especially those at mid-ocean ridges and bounding shelves, is now thought to be an important contribution (as yet poorly quantified) to overall ocean-interior mixing and hence to water-property distributions and the overturning circulation. The steep slopes of coastal seas, and the ultimate barrier of the coast itself, form an obvious constraint on depth-integrated ocean circulation, which must turn along-shore (constraints on the circulation's vertical structure are still a research topic).

2.2. Inter-relations – Processes and Phenomena

Physical oceanographic phenomena are controlled by the geographically complex and stratified domain, epitomized by natural wave modes, by frictional forces – predominantly turbulence and themselves influencing stratification – and by forcing. The latter includes tides, solar heating and radiational cooling, atmospheric pressure and winds, from global scales downwards. Winds in particular are sensitive to the presence of mountains, islands and land-sea boundaries; they are turbulent and show important variability on scales from thousands of kilometers down to metres; they also modulate heat transfer between ocean and atmosphere on all these scales. Secondary forcing within the ocean results from the consequent lateral gradients of density.

Turbulence: random, small-scale rapid fluctuations of flow

Bibliography

Baumert, H., Simpson, J.H. and Sündermann, J., eds. (2005). Marine Turbulence: Theories, Observations and Models. Cambridge University Press, Cambridge. [This book focuses on modeling turbulence, but includes descriptions of consequences of turbulence, including dispersion, mixing and marine boundary layers].

Steele, J.H., Turekian, K.K. and Thorpe, S.A., eds. (2001). Encyclopedia of Ocean Sciences. 6 volumes. Academic Press, London. [These volumes comprise many articles describing ocean processes and phenomena, treated alphabetically in more detail than can be given here].

Biographical Sketch

John M. Huthnance was born in 1948 in Reading, England, and graduated in mathematics from Cambridge University in 1969, with a PhD in mathematics applied to tidal currents over topography (1973). After a postdoctoral year at the Institute of Geophysics and Planetary Physics (Scripps, San Diego) and three years as a Post-Doctoral Research Assistant and Lecturer in the Department of Oceanography, University of Liverpool, he moved in 1977 to the Institute of Oceanographic Sciences, Bidston (now the Proudman Oceanographic Laboratory in Liverpool) where he is now Deputy Director.

During this time, other roles have been Honorary Secretary, (UK) Challenger Society for Marine Science, Scientific coordinator of the UK Natural Environment Research Council (NERC's) North Sea Project, Coordinator of the EU-MAST project "Processes in Regions of Freshwater Influence" and components of the large-scale "Ocean Margin Exchange" project, and service on several NERC committees. He has held an Honorary Professorship of the School of Ocean Sciences, University of Wales and is currently a Visiting Professor of the Department of Earth and Ocean Sciences, University of Liverpool.

Research interests are in marine dynamics, especially of the seas over the continental shelf and slope; waves over topography and their implications for residual circulation, sediment movement and ocean-shelf coupling and exchange; promotion of coupled models (physics-sediment-biology).