Chronobiology of Marine Organisms

Do intertidal organisms simply respond to the rise and fall of tides, or do they possess biological timing and navigation mechanisms that allow them to anticipate when conditions are most favourable? How are the patterns of growth, development and reproduction of some marine plants and animals related to changes in day length or to phases of the moon? The author describes how marine organisms, from single cells to vertebrates, on seashores, in estuaries and in the open ocean, have evolved inbuilt biological clockwork and synchronization mechanisms that control rhythmic processes and navigational behaviour, permitting successful exploitation of highly variable and often hostile environments. Adopting a hypothesis-testing and experimental approach, the book is intended for undergraduate and postgraduate students of marine biology, marine ecology, animal behaviour, oceanography and other biological sciences and also as an introduction for researchers, including physiologists, biochemists and molecular biologists entering the field of chronobiology.

ERNEST NAYLOR is Professor Emeritus at the School of Ocean Sciences, Bangor University, where he was Lloyd Roberts Professor of Marine Zoology and Head of School of Ocean Sciences. He has published over 160 scientific publications and has been a Council Member of the UK Natural Environment Research Council, the UK Marine Biological Association, the Challenger Society for Marine Sciences, and a President of the Society for Experimental Biology and the Estuarine and Coastal Sciences Association. He has participated in a House of Lords Select Sub-Committee and various UK and European Commission co-ordinating committees for Marine Science and Technology. He has been involved in reviews of scientific programmes of several marine laboratories in the UK and France, and of UK-supported fisheries projects in the developing world. In 1998 he was appointed OBE. This is his third book.

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ERNEST NAYLOR
Professor Emeritus,
School of Ocean Sciences,
Bangor University, Wales

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For Gillian

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Preface

There is increasing recognition of chronobiology in our understanding of the time-base of ecology, behaviour and physiology of plants and animals. However, much of the scientific effort so far in this field of study has focussed on daily and seasonal rhythmicity associated with solar periodicity of the environment. Impressively, this has led to the concept of heritable circadian biological clocks and a search for their molecular basis in the genetic makeup of living systems. Partly because of early and perhaps lingering scepticism, the possibility that some organisms might also innately phase their behaviour to lunar events has lagged behind as a field of study. Yet, living organisms in many seas and coasts are repeatedly exposed to lunar cycles, indirectly through oscillations of ocean tides. Moreover, marine animals and plants have been in existence for greater lengths of evolutionary time than have the terrestrial organisms that are often the material for classical studies of circadian rhythmicity. It is therefore reasonable to consider the extent to which marine organisms have adapted to tidal oscillations driven by lunar gravity, and also to ask whether lunar and semilunar events exhibited by such organisms are related to fortnightly variations in tidal height or even to moonlight cycles directly. Accordingly, alongside the concept of circadian and circa-annual rhythms in marine organisms, it is necessary to consider the existence of innate biological clocks of circatidal, circasemilunar and circalunar periodicities.

Against the background of the physical basis of tides, and adopting a hypothesis-testing and experimental approach, this book explores the phenomena of biological rhythms and clocks in coastal, estuarine and open sea organisms in an ecological context. It considers the role of the diverse physical variables associated with tidal oscillations in synchronizing biological clocks of tide- and moon-related periodicities. It then assesses the relevance of innate biological timing capability to the

cyclical changes of orientational and navigational behaviour of some marine animals, which permit them, after wide dispersal, to return to optimal zones on a seashore or to preferred locations in an estuary or in the open ocean, ensuring their occurrence in the right place at the right time. Finally, it outlines aspects of the search for the nature of biological clockwork, leading from the techniques of classical endocrinology to those of modern molecular biology. A fuller understanding of the molecular nature of circatidal clockwork and its relationship with better understood circadian molecular clock mechanisms remain challenges which curiosity–driven science has yet to resolve. It is hoped that this book will help to stimulate that scientific endeavour.

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E. N.